Patterns of Sustainable Innovation in the Building Industry. Towards a Strategic Management Perspective on Environmental, Social, and Economic Values.

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Patterns of Sustainable Innovation in the Building Industry

Towards a Strategic Management Perspective on Environmental, Social, and Economic Values.

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Turin, December 02, 2018

Summary

This thesis investigates the role of sustainable innovation in the building industry. Since the concept of sustainability was formalized with the Brundtland's Report in 1987, the building industry, as many others, had to review and re-consider the use of resources and the transformative outputs, as well as the nature of products and processes. Yet, the building industry has been widely described as adverse to change and lacking of the strategical ability to introducing innovation in a structured manner. This might be due to the nature of the industry, which is characterized by unique products and processes, as well as by high degree of socio-technical fragmentation. The understanding of such nature and its development trajectories can contribute to understand conditions, factors, type of stakeholders that can facilitate the introduction of sustainable change. To achieve this understanding, this work is aimed at exploring the nature and the impact that sustainable innovative design solutions can have on the environmental, social and economic context in the building industry. To do so, this thesis identifies the nature and relation between innovation types and impact, stakeholders' roles and behavior, and social environmental and economic value of design in buildings, by conceiving these latter as complex systems. The identification of these aspects can help define management methods, design solutions, and strategic approaches to the introduction of sustainable innovation in the industry. The methodological approach adopted to conduct such work is the case study theory, which is, in this instance, applied to thirty case studies of sustainable building projects. These latter are explore by understanding: their degree of change from standard practice (innovation types and impacts); the crucial actors who played significant roles in their deliveries; and the types of results generated, within the environmental, social and economic domains. Such exploration sheds light on variables, behaviors, and contextual characteristics that have generated changes, and therefore allows to read patterns of sustainable innovation in the buildings

analyzed. The results of this investigation set the premises for the definition of strategic approaches to introduce sustainable innovation in the programming phases of building projects, in the organization of delivery processes and management systems. The contribution of this work is to be found: in the knowledge expansion on the theory advancing sustainable industrial dynamics in the building industry, in the contributing to industrial context by providing strategic models for sustainable innovation policies; and in the provision of positive example of sustainable innovation introduction in the industry by shedding lights on economic, environmental and social advantages that these examples have produced so far in the industry.

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*To all my monsters,
losses, and fears.*

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Chapter 1

Introduction

This research focuses on the role of innovation and sustainability in the building industry. Despite innovation is largely recognized as a medium of advancement within classical economics models, and sustainability a necessary approach to the future of practice, the building industry seems to lack the ability of strategically fostering and promoting the introduction of sustainable innovation as an advancement trajectory. This seems to be due to its inherent characteristics, particularly concerning the relation with the industry. The investigation of the industrial unique characteristics and its innovation dynamics is critical to the understanding of factors that can facilitate (or limit) the ability to introduce changes, foster innovation, and support a sustainable approach to the practice. To this end, this thesis seeks to identify and explore the nature and the impact that sustainable innovative design solutions have on the environment, social and economic context. To do so, the work sheds light on actors, factors and dynamics that facilitate or limit the ability to innovate/introduce sustainable changes; defines a design method aimed at assisting innovation introduction by identifying the relation between design solution and delivery process; and suggests guidelines in support of the definition of innovation introduction strategies in the building industry. To this end, the work relies on the ontological position of considering building projects as complex systems; and on the methodological approach of case study theory. This methodological approach allows the analysis of a number of specific case studies, exploring individual and unique characteristics of building products and yet contributing to produce knowledge that can describe wider industrial dynamics. This is achieved by analyzing, comparing and contrasting 30 case studies of innovative case studies to shed light on the degree of impact that each innovative design solutions have on the supply chain, and their ability of producing changes. These case studies are organized into a working frame to assess their type of innovation (irrelevant, incremental, modular, architectural or radical), impact of innovation (competence enhancing and competence destroying), stakeholders' roles and responsibilities, sustainability results (environmental, social, and economic). This assessment allows to tease out design variables that generated changes in the building delivery processes, by mapping and discussing patterns describing the relation between different design solutions and consequential changes impinging on the delivery process. The results contributes to define guidelines and design organization models that can be strategically utilized to foster sustainable innovation policies, and establish good practice trends.

This work is structured in seven chapters. The current chapter is an introduction of the work and explains the structure of the dissertation. The second chapter sets the theoretical backbone of this work. In particular, it focuses on the meaning and role of sustainable innovation in the building industry. To do so, the chapter discusses the state of art of the role of innovation within neoclassical economic principles and the relation with the building industry and its nature. Moreover, the chapter identifies the barriers to innovation introduction in the industry and the challenges that the call for sustainability has introduced in practice. Specifically, the chapter highlights how sustainability concepts generated critiques to the neoclassical economic models, as well as how it triggered opportunities for innovation generation. Lastly, by discussing the state of art on sustainable innovation management in the building industry, the chapter highlighted the limits of the studies and the opportunities for further works.

The third chapter defines the aim, objectives, research questions and ontological position of this work. The hypothesis of this work, is that, despite the structural difficulties of the industry of strategically designing innovation introduction processes as advancement policies and practice, strategic innovation is critical to the sustainable advancement of the building industry. The thesis of this research is that the ability of shedding light on actors, factors and dynamics that limit (or facilitate) the introduction of sustainable innovation in the industry can help define guideline in support of strategic sustainable innovation introduction, planning and management in the industry, as development advancement strategy. The main research question is therefore: Is it possible to identify key stakeholders, design variables and methods, and delivery process characteristics that can assist in the introduction, management and promotion of sustainable innovation in the building industry, as a structured advancement strategy, rather than as ersatz dynamic? The objectives of this research are:

1) Exploring the degree and the nature of impact that sustainable innovative design solutions analyzed can have on the supply chain, on the environment, social and economic context, in building projects.

2) Shedding light on actors, factors and dynamics that facilitate or limited the ability to innovate/introduce change.

3) Understanding the relation between design variables, delivery method, contextual characteristics, and social, economic and environmental results achieved in building projects. The ontological position for this work is to consider building projects as complex systems, and therefore to attempt understanding

links and influences between deign variables, innovations, actors' roles, and type of sustainability results. The chapter therefore explains also the nature of complex systems and the rationale of how to consider projects as such.

The fourth chapter explains methodological approach and method. In line with Yin (2018) this work is organised around the following working steps: research design, research preparation, data collection, analysis, and sharing results. Each of this phase is connected to the others in a verification process that allowed to validate the methodological approach used, as well as the methods applied to carry out the research. To achieve the established objectives, this work relies on the case study methodology, conducted by analysing thirty contemporary public and semi-public buildings that have been recently awarded and recognised as successful sustainable endeavours. These case studies are explored by analysing types and impacts of innovation utilized in each feature of the building and delivery process; role of actors involved in introducing sustainable innovation; and results achieved. The purpose of this analysis is to highlight the relation these former aspects. The understanding of these links can help in reflecting on the nature of innovation against project objectives, and ultimately in assisting to define the type of future built environment we are envisioning.

The fifth chapter presents the analysis conducted on the thirty case studies selected. The chapter is organized by presenting case studies according to their geographical context. Specifically, the chapter presents the following contexts: Europe, Australasia, South America, Africa, and North America. For each geographical area, a brief introduction on the approach of sustainability in the socio-technical context is presented. Within these contexts, the case studies are presented by describing a summary of the building characteristics and delivery processes. Moreover, the analysis of type and impact of innovation, actors involvement and sustainable results are presented for each case study.

The sixth chapter reads the patterns formed by all the analysis conducted in the previous chapter. The chapter discusses the type and impacts of innovation exploring the role and relation between incremental, modular, architectural, system and radical innovation and the impact that each of these types generate, either requiring the creation of new competences or adding to existing ones to the core activities of each of the actors involved. The chapter also discusses the role and behavior of each actors in the management of sustainable innovation introduction in the projects analyzed. The eco-innovation and sustainability model is here utilized to tease out characteristics and behaviors of each actors involved. The chapter discusses the role of institutions, clients, designers, builders, industry, and users in relation to limits and opportunities that each actors might have in fostering sustainable innovation. The chapter also discusses the relation between different design and organization forms and type of sustainability results achieved in the projects. This discussion shed light on critical aspects that can be managed to foster sustainable innovation and limit the risk of failure due to the innovativeness of such endeavors. Moreover, the chapter explains the design opportunities for sustainable innovation introduction both in the building characteristics, and in the delivery processes. The chapter concludes the discussion with considering external important aspects that might limit of enable sustainable innovation, such as the role of context, the one of the internationalization of the practice, and the role of building development strategies in the programming phase.

The seventh chapter concludes the work by teasing out considerations based on the observed patterns. In particular the chapter, attempt to shed light on the role and nature of sustainable innovation in shaping the built environment. To do so, the rationale of considering building projects is discussed, by highlighting limits and opportunities of such approach, as well as considerations on the methodological approach are made. The core part of the this chapter discusses the importance of economics and sustainability in design organization, and in particular shed light on design variables, roles, links and external factors that need to be consider to implement structured strategies to introduce sustainable innovation in the industry. The chapter concludes by identifying future studies and suggesting future discussions regarding the role of the building industry in shaping the future of our built environment.

Chapter 2

Sustainable Innovation in the Building Industry

This chapter sets the theoretical backbone of this work, by explaining: the concept of innovation within classical economic models; the significance of such concept for the development dynamics of the building industry; the introduction of concepts of sustainability in the industry; and the impact that such concepts generated on the processes of design and delivery. The chapter explains therefore how the concept of sustainability has trigger new innovation management approaches and needs, forced to rethink to some development assumption, and highlights the limits of such studies and the innovation gaps.

2.1 Innovation

Neoclassical economics studies define innovation as primary source of economic growth (Schumpeter 1942; Solow 1956; Schmookler 1966; Freeman 1974; Scherer 1982; Ruddock and Ruddock 2009), as well as a key component of company competitive advantage in market economies (Barney 1986; Bettis & Hitt 1995; Teece 2007). Moreover, Kajander (2016) explained that innovation can have a positive impact on the stock market value of company (Chaney et al. 1991; Sood & Tellis 2009) as the market valuation of a company should be a forward looking indicator of firm performance (Hall et al. 2005). Neoclassical models explain that the output of countries depend upon capital's stock, labour supply, and production technology. Such models rely on the assumption that supply, labour, land and capital are unlimited because unlimited natural resources exist (Lewis 1954). Innovation is therefore crucial to advance economies output by increase technological progress and innovation. Seaden (1996) explained that while neoclassical economics model conceive technological advancement and innovation as exogenous outcome of the scientific breakthrough, more recent approaches (Romes 1986, 1993; Lucas 1998) described innovation as an endogenous explicit factor of growth that enable the creation of economic value. Moreover, Rosenberg (2004) added the nature of innovation is characterised by uncertainties, and therefore its related activities and output are extremely difficult to forecast. So it is the market response to any innovation introduction. Rosenberg (2004) explained that this might be due to the difficulties in anticipating consumers preferences; as well as highlighted that the success of a technological innovation. Beside depending upon its inventors, innovation is largely depending on the ability of consumers to use and understand new technologies. Despite these uncertainties, it is since the War World II that neoclassical economic models are the mostly widely accepted. Gauvin (2011) explained that economic growth is recognised as an absolute necessity in advancing the human condition.

2.2 Innovation in the building industry

Innovation plays a significant role for many sectors, including the building industry. This latter is often described as potential producer of up to 18% of the GDP of developed countries (Gann 2000), and therefore its development and functioning dynamics are important for countries' economies and ability to grow. Yet, conversely to other industries, building is characterised, to certain extent, by unique idiosyncratic aspects, which makes the innovation management and development strategies far from being a linear process.

2.2.1 The nature of the building industry

Building industry is a transformative industry, characterized by unique products and complex production processes (Winch, 1998; Veshoskey, 1998). Turin (1980) explained that buildings are one-off, fixed, heavy bulky products and expensive long lasting goods; built with relatively cheap materials; and bound to the nature and location of the site (climate conditions, availability of local materials, skills and labor). Beside the uniqueness of each project, the outputs of this industry depend on a number of structural variables, such as the industrial milieu, the normative framework, the professional firms involvement, and the socio-technical context characteristics. The process to produce buildings is complex and relates on various levels to a number of actors, entities and sub-production processes involved. This process requires time and high involvement of technical skills.

Building delivery processes call for ad-hoc strategic coalitions, project definition, production and assembly processes that vary (to certain extents) on each project (Turin, 1980). Teams at work on these projects need to vary and adapt on each job, not only in their internal organization, but also in their roles and responsibilities in relation to the procurement method utilized. This sociotechnical fragmentation and ad-hoc nature of production contributed to depict an image of construction as complex but comparatively under-productive, under-capitalized and risk averse sector (Tombesi, 2008). This is due to the fact that the industry outputs depend on the interrelationship between all the variables involved (components, individual, framework development, et cetera) in their delivery processes, and changes and development are influenced by the dynamics between these variables. This aspect impacts heavily on the roles of the various actors involved in building design and delivery. This seems to be particularly true for the manufacturers and suppliers, whom are exposed to a very high degree of risk in undertaking innovative endeavors. Gann and Salter (2000) explained that construction firms ability to get work is based on their reputations, and therefore the previous experiences are very important to build credibility. Also buyers (.e. clients, or owners) in the building industry play a role which is different from other industries. For instance, rather than just being buyers or final products, in the building industry clients and/or owners play an active role in taking programming decisions, and defining technical matters, throughout the entire delivery process (Nam and Tatum 1997). Moreover, Nam and Tatum (1997) explained that successful project deliveries is often enabled by high level technical knowledge held by committed managers – and to some extent consultants, and designers – which help overcome the difficulties generated by the socio-technical fragmentation typical of the industry.

The uniqueness of individual project and the socio-technical fragmentation that characterize the sector influences development process of the industry, which seems to follow unstructured or partially structured innovation trajectories (Bowley, 1960).

2.2.2. Innovation definition and characteristics in the building industry

The role of innovation in the building industry has been largely discussed since the 1960s, when first studies, such as the ones of Bowley (1960, 1966) explored reasons and factors that allowed changes in the British industrial building realm over the 20th Century, and pointed out that many changes happened as ersatz rather than through active innovation implementation strategies. Since then, many streams of research have been developed. Wolfe (1994) identified at least three major areas, such as innovation as phenomenon; determinants of innovativeness; and processes of innovation. Yet, Manseau (1998) explained that innovation in the building industry did not attract the same attention that other industries had. Nevertheless, Dickinson, Cooper, and McDermott (2005) pointed out that since the late 1990s an increasing attention led to produce many publications, book, and special Journal Issues (Gann, 2000; Jones and Saad 2003; Miozzo and David, 2004) focusing on the role of innovation in the industry. Among these studies, many definitions of innovation have been elaborated. Yet, Freeman (1989), Koskela and Vrijhoef (2001), Slaughter (1998), Slaughter and Shimizu (2000), and Dickinson, Cooper, and McDermott (2005) relied on the following:

'...Innovation is the actual use of nontrivial change and improvement in a process, product, or system that is novel to the institution developing the change (Freeman, 1989)'.

Slaughter (1998) elaborated on such definition by defining a spectrum of innovation types, from incremental to radical, introducing the concept of system innovation. Slaughter (1998) places radical and incremental innovation at the extremes of the spectrum. In the case of incremental innovation, the improvement refers to individual components, but the core design concepts and their relationships remain unchanged (Henderson and Clark, 1990). Slaughter (1998) adds - referring specifically to the construction industry - that incremental innovation is a small change, built on existing knowledge and experience, whereas radical innovation is a breakthrough in science or technology that often changes the character and nature of an industry. According to Slaughter (1998), the impacts of different types of innovation vary: incremental innovation produces predictable impacts within a limited range of interaction with other components; conversely, radical innovation generates impacts that may affect both the system and the structural organisation, due to its inner nature of entirely modifying the approach and the solutions to given phenomena. Modular, architectural, and system innovation are progressively positioned within the spectrum, between incremental and radical innovation at both ends. They indicate the degree of changes, either in core design concepts and/or their relationships, and their increasing impacts. Pries and Janszen (1994) explained that incremental innovation is the most relevant in occurrence in the building industry. Yet, Lundvall (2007) explained that a distinction exists between technical innovation and organizational innovation. Specifically, Lundvall (2007) argues that technical innovation depend upon market conditions and organizational characteristics. Other authors have then extended this concept by exploring innovation in products, processes and systems (Gambatese and Hallowell 2011; Koskela and Virjhoef 2001; Shilling 2010; Becattini 2013; Lindgren, 2016).

Many studies (Bygballe and Ingemansson 2014, Miozzo and Dewick 2004; and Seaden and Manseau 2001) explained that the emergence of innovation depend upon mostly R&D activities, or innovation programs fostered by government and public institutions. Moreover, the emergence of innovation seems to be generated within specific conditions, such as the existence of 1) socio-technical relations among participants; 2) project-based opportunities; 3) knowledge based firms participation; 4) and existence of innovation introduction regulations (Bygballe and Ingemansson 2014).

The 1) socio-technical relations are critical to the generation and diffusion of innovation as actors with different technical knowledge are generally involved in building projects, and the mutual collaboration can help fill the gaps among roles. For instance, Blayse and Manley (2004) explained that while clients are often recipients of innovation, they generally do not have the knowledge to implement it, and although manufacturers, designers or industrial partners are key sources of technological innovation, they require opportunities to trigger processes of innovation generation. Also entities recognized as 'innovation brokers' – such as universities and/or research institutions – seem, in theory, to contribute to the generation of innovation. Yet, they seems to be seen with skepticisms by the industry (Bygballe and Ingemansson 2011, 2014). To overcome these gaps, many authors suggested long-term relations between parties involved on projects as fruitful strategy to develop and disseminate innovation (Harrison and Waluszewsky 2008).

The 2) project-based opportunities are seen as unique areas to generate and test new solutions (Bygballe and Ingemansson 2014; Tombesi 2008, Slaughter 1998). Moreover, Winch (1998) explained that innovation depend upon coincidence of aims, motives, and opportunities, which often can be found in project-based experiences. Yet, March (1991) explained that innovation might benefit some actors involved on project but not others, and therefore the benefits need to be split across coalitions.

The 3) the knowledge based firms participation to projects might be critical to the generation and management of innovation. Such firms are the ones able to include within their business scope, aspects of culture of innovation, absorptive capacity, innovation champions, knowledge codification systems, and innovation development strategies (Bygballe and Ingemansson 2014; Nam and Tatum 1997). These firms are the one that better manage the knowledge transfer across projects, without feeling the threat of new knowledge shacking the robust routine of the organization.

The 4) existence of innovation introduction regulation can facilitate the generation and diffusion of innovation (Blayse and Manley 2004 and Seaden and Manseau 2011). While restrictive regulations seems to limit the spur of innovation, performance-based seem to facilitate it (Bygballe and Ingemansson 2014). Moreover, Bygballe and Ingemansson (2011) specified that if regulation fails to stimulate collaboration, and pushed instead for price competition, the generation of innovation would be greatly hindered.

2.2.3 Barriers to innovation introduction in the building industry

Although, many studies have been conducted on the significance of innovation in advancing the construction sector, punctual analyses on innovation implementation processes and dynamics in the industry are limited. Moreover, a very limited number of studies seem to focus on the exploration of principles of innovation and sustainability as variables for systemic and structured design approaches.

Many authors have identified in the nature of the building industry the major barriers to innovation. Specifically, characteristics that seem to limit the innovation diffusions are the uniqueness of the outputs and processes; socio-technical fragmentation; length of processes and product life; technical regulations; and culture (Dickinson, Cooper, and McDermott 2005).

The uniqueness of the output of the building industry (Veshoskey, 1998) represents opportunities to innovate. Yet, such uniqueness has also been described as hindrance for construction innovation due to the inability of creating economies of scale and re-use of knowledge, which fail to be transferred (Pries and Janszen 1995; Dickinson, Cooper, and McDermott 2005).

The fragmented nature of the industry (Pries and Janszen 1995; Gann 2000) is characterized by the separation of contractors and consultants, which are often of small sizes, as well as by the presence of high specialized number of professionals (Nam and Tatum 1992; Winch 1998). Moreover, the lack of long terms work relations, and the call for interaction between actors who operates at different levels and under different economic logics impinge on their ability to establish a favorable environment for innovation development and dissemination (Bygballe and Ingemansson 2014).

Moreover, the long life span of construction products (buildings) contribute to shape the perception of their development endeavors as too risky to apply trial and error methods typical of innovative processes, and therefore actors involved tend to prefer traditional solutions. Moreover, many authors (Bygballe and Ingemansson 2011, 2014; Blayse and Manley 2004; Veshosky 1998; and Ling 2003) mention that regulation might limit innovation. Nam and Tatum (1995) and Dulaimi (2005) explained that the industry culture represents also a great barrier to innovation. In particular, the industry is characterized by conservatism that perceive change as a threat to standard robust practice. This is due to the fact that building companies, suppliers and manufacturer build their own competitiveness upon previous successful experiences, and therefore they might be reluctant in undertaking innovative endeavors characteristics by high risk and uncertainty of success. Yet, innovation, as widely discussed, is important and even more in recent times, due to sustainability which has called for many changes in practice.

2.3 The challenges for sustainable development in the building industry

It is since 1987, with the publication of the Brundtland Report (WCED 1987), that the global community has formally recognised the necessity of sustainable social, environmental and economic development. Since then, many efforts have been made to implement strategies to apply sustainability principles to many fields. Sustainability is conceived as the ability to produce balanced changes in the exploitation of the primary resources, in the economic models, in the direction of technological development and in the institutional development, and at the same time ensure the satisfaction of current and future human needs and aspirations. Such approach has triggered many changes within the building industry, as well as has opened a debate on the validity of the assumptions on which the innovation theory and the classic economic models were based on.

2.3.1 Paradoxes between concepts of economic growth, progress and innovation, and sustainable development

Higgin (2013) explained that the interest in the connection between economic growth and the limits of Earth’s natural resources had been lacking up until 1972, when members of the Club of Rome (politics, business people, and scientist) published an alarming report regarding the potential collapse of physical growth on earth due to pollution, depletion of resources, and excessive population growth. Since then, many authors explained that paradox exists between the concept of economic growth, progress and innovation, and the one of sustainable development (e.g., Higgin 2013; Gauvin 2011, Meadows, Meadows, and Randers 1972; Chomsky and Polk 2013; Haapanen, Liisa & Tapio, Petri, 2016). Haapanen, Liisa & Tapio, Petri (2016) categorized the critique to economic growth as: phenomenon, institution and ideology. They explained that growth as phenomena is criticised for growing negative effects such as the impact on the environment, the lack of well-being increase, and the inability to decouple its positive effects from the those negatives. Moreover, growth as institution is conceived as a mutual dependency between consumer culture and societies, and this lead to the 'dilemma of growth' (Jackson 2009). Such dilemma is given by the fact that unsustainable growth can be due to its increasing negative effects while de-growth would lead to instability under present conditions (Haapanen, Liisa & Tapio, Petri, 2016). The last major critique is the conception of growth as ideology, and in particular in relation to the idea that growth is equal to well-being. The core of such critiques can be summarised in two concepts: the assumption of the existence of unlimited resources (Lewis 1954), and the idea that individuals would act according to rationale behaviour (Seaden 1996). This latter concept has been already criticized by a vast of behavioural economists, as well as discussed by Rosenberg (2004) arguing about the difficulties is anticipating the users' response within markets and economic models in general. Moreover, Gauvin (2011) explained that it seems to be very difficult to establish the boundaries of the concept of satisfaction and therefore of limits of consumption. Whereas the concept of unlimited resources seem to be the key of the critiques to the dominant economic model. Daly (2013) explained further that the Gross Domestic Products (GDP), which is the measuring system for growth of countries, does not take into account the concept of physical limits. This aspect increases the tension between the matter-energy relation, which Daly (2013) described as starting with depletion and ending with pollution. Moreover, Higgin (2013) explained that although the concept of growth is characterised by a number of benefits - such as the relation between business and nations profit and the individual availability of jobs, resources and quality of life – yet, it also feeds on natural resources, produces waste, pollutes the air, and put at risk the climate. Moreover, Higgin (2013) argues that such characteristics produce a reinforcing loop created by the constants call for technological advances and innovation that requires ruthlessly the consumption of resources leading to the progressive collapse of the economy, environment and society. Yet, Gauvin (2011) explains that at least three directions have been suggested to attempt overcoming such contrasts: 1) continues economic growth; 2) economic growth up to certain limits; and 3) economic growth reduction. The first approach is the one suggested by neoclassic economist (Solow 1993), which advocate for growth as the medium to solve poverty and trigger environmental productions. The second approach is the one of the steady state economist (Georgescu-Roegen 1975; Daly 1993) which consider economies as limited by biophysical realties and that they should rather adjust to steady sates. The last approach, called 'the de-growth movement' (Martinez-Alier, Pascual, Vivien, & Zaccai, 2010) suggest instead to embrace simpler life outside of the economy. Haapanen, Liisa & Tapio, Petri (2016) tried instead to overcome those positions by suggesting to shift the focus from the debate of increasing or describing growth, to the one of supporting human well-being and alleviate environmental degradation. Haapanen, Liisa & Tapio, Petri (2016) argued that: *'…Positioning economic growth as a constituent of sustainable development unnecessarily and counterproductively narrows down the selection of means by which sustainability is pursued'.*

2.3.2 Sustainability as trigger for changes and innovation generation

In the context of sustainable development, the challenges in the field of architecture and construction are widely discussed and influenced by the actions proposed in Agenda 21 of the United Nations Conference on Environment and Development in Rio de Janeiro in 1992 (UN, 1992a) to address a range of social, economic and environmental challenges (Cardonna, 2014; Hensel and Nilsson, 2016). The United Nations Framework on Climate Change in 1997 (UN, 1992b) and the subsequent Kyoto Protocol (UN, 1997) for reducing emissions of greenhouse gasses (GHG) in the countries which signed it, focused on reducing the causes of climate change. The Kyoto Protocol objectives were reiterated and extended in the Paris Agreement in 2015 (UN, 2015). As a result, many countries have developed frameworks and regulations with the aim of contributing to this environmental challenge. In 2013, the European Commission released the European Performance of Building Directive (EC, 2013), a legislative document that promotes the improvement of energy performance in buildings. The building sector is responsible for almost 40% of total primary energy consumption in developed countries (Berardi, 2017; Orme, 2011). This percentage includes energy demand for space heating and cooling, hot water production, lighting, cooking and other appliances. In addition, considering the global warming effect of a persistent increase of GHG emissions, the energy consumption for space cooling is rising in several countries (Givoni, 1994; Santamouris, 2007). Yet, building activities play a crucial role in the economic development of countries (Ruddock, 2009) by generating links on multiple levels: firstly, with the activities carried out around a specific building project; secondly, with other industries related or connected to these activities; and thirdly, with the economic environment in the long-term (Pearce, 2003; Turin, 1980). Pearce (2003) suggests that improving the built environment is critical to social sustainability and improving quality of life. Woodcraft et al. (2012) explain that there is a need for *'… a process for creating successful places that promote wellbeing, by understanding what people need from the places they live and work. Social sustainability combines design of the physical realm with design of the social* *world – infrastructure to support social and cultural life, social amenities, systems for citizen engagement and space for people and places to evolve'*.

In response to these environmental, economic and social challenges, the actors involved in the building industry are producing innovative design solutions that convey the values of sustainability and aim to achieve related performance targets. The field of building has therefore faced a paradigmatic shift in many instances, from the proposals for new design strategies to the development of novel management systems for emerging social, environmental and economic challenges (Hensel and Nilsson, 2016; Kibert, 2016). This is due to the tight relation that the industry has both in its resources consumption and in its outputs. The building industry is not only responsible for a significant percentage of countries' GDP, but also is a vehicle of means and methods that connect economics, conceived as discipline to manage resources, and design organization meanings. Therefore, the call for sustainability and the debate with the economic principles that shapes most the countries activities had and is having a strong reflection on the practice on many levels. One of these level is the innovation management in design and delivery processes in buildings. Innovation is recognised as crucial to foster changes and stimulate progress (Latin: *progressus* - to advance, to go forward). Radical innovation, in particular, is recognised as a medium of advancement, a source of growth for economies and a trigger of progress (Sood and Tellis, 2005; Gambatese and Hallowell, 2011, Coccia, 2017). Often, this type of innovation is linked with technological advancement, disruptive phenomena and the creation of new systems and dynamics (Tellis, Prabhu, Chandy, 2009; Winch, 1998). Ahlstrom (2010) associates radical innovation and deconstruction of existing systems in favour of technological advancement with development models based on unlimited growth and resource exploitation (Ahlstrom, 2010). The awareness of the limits of growth, raised in the '70s by Meadows, D., Meadows, D., Randers, J. and Behrens, W. (1972), is influencing approaches to innovation which consider resources as limited (Becker, 2013) and require types of innovation which contribute to sustainable development. The number of design approaches proposed in the field has progressively increased. Guy and Farmer (2001) identified at least six approaches to sustainability in architecture: eco-technic, eco-centric, eco-aesthetic, eco-cultural, eco-medical, and eco-social. Lee (2011) highlighted at least twenty-five approaches to design changes required in the context of sustainable architecture. Each of these approaches proposed design changes (innovation) in different categories of the projects and processes, resulting in often non-uniform design solutions and leading to the discussion and definition of debated positions on design changes and approaches to the design of sustainable architecture (Hosey, 2012). For instance, Hosey (2012) points out that the aesthetics of sustainability – defined here as a set of principles conveying the idea of sustainability - is not easily definable within purely design boundaries. This seems to be due to a number of reasons: the complexity and multi-disciplinarity of the concept of sustainability; the plurality and fragmentation of design approaches; contradicting political views on sustainability itself; and challenges in re-organising and evolving the practice around the stimulus that sustainability generates (Hensel and Nilsson, 2016; Kibert, 2016). Yet, the production of successful innovative and sustainable buildings can contribute in improving the existing built environment, by: 1) improving sustainable technical efficiency and aesthetic of the environment, 2) accommodating social changes throughout time, improving life quality, and 3) produce economic expansion and positive results (Pearce 2003).

2.3.3 State of art on sustainable innovation in the building industry

Bossink (2011) explained that the importance of sustainability has triggered a shift of paradigm among the industry. In line with this position, Huovila and Koskela (1998) explained that: '…*while traditional design and construction focuses on cost, performance and quality objectives, sustainable design and construction adds to these criteria minimization of resource depletion, minimization of environmental degradation, and creating a healthy built environment (Kibert 1994). The shift to sustainability can be seen as a new paradigm (Vanegas et al. 1996) where sustainable objectives are within the building design and construction industry considered for decision making at all stages of the life cycle of the facility… However, it must be said that a solid methodology for implementing sustainable construction still lacks*'. Such gap also exist in the literature about sustainable innovation management. While on one side the innovation studies are characterised by the complexity of the sector itself, on the other side the role of sustainability seems to make the ability to researching the topic even more complex and complicated. Yet, Bossink (2011) and Kajander (2016) identified at least three research streams that explore sustainable innovation management in the construction industry. The first one is concerned with role of government in fostering sustainable innovation in buildings. Such role is found to be covered by different strategies, such as: the implementation of national environmental policy plans; the issue of laws and regulations; the negotiation of sustainability with the firms in the industry; the financial incentives and pressure; and the use of project as demonstration or best practice. The second stream of studies focuses on the role of firms, which may not await for the government intervention, rather they trigger sustainable processes. This might be due to a number of reasons, such as conceiving sustainability as a business opportunity for new cost-effective services and products (McKinsey & Co., 2009), or the results of the emergence of a number of sustainability assessment tools to assist the practice such as LEED, Greenstar, BREAM, NABER, and many other (Kibert 2006; Cole 2000; Toss et al. 2001). Also the emergence of environmental management system seems to support firms in integrating sustainability within their corporate strategies, core business, or market strategies (Bryson and Lombardi 2009). For instance, Kajander (2016) highlithed that investors and developers benefit from buildings with environmental certification due to additional occupier benefits, increased rental income of about 3% (Eichholtz et al. 2009; Kajander 2016). A third stream of research focuses on the cooperation between private and public entities. Bossink (2011) explained that great degree of participation processes characterises these endeavours, as well as they allow organisations to acquire competitive advantage in the field of sustainability, and to shape market niche for environmental aware customers.

2.4 Limitations of the studies and knowledge gaps

A review conducted by Dickinson, Cooper, and McDermott (2005) explained that the dominant research stream is the one exploring determinant of innovation, yet they suggest the importance to conduct further studies also on the other streams identified by Wolfe (2014). In line with Bossink (2011), Kajander (2016) explained that, although many studies focused on the economic value of sustainability for the construction sector (Turner & Frankel, 2008; Fuerst & McAllister, 2008; Eichholtz et al., 2009; Fuerst & McAllister, 2011; Sayce et al., 2013; Bryson & Lombardi, 2009; Nousiainen & Junnila, 2008), most of the sustainability innovation studies in the sector focus on the role of government (Bröchner et al., 1999; Dewick & Miozzo, 2004; Manley, 2008). Beside such limited focus of analysis, Dickinson, Cooper, and McDermott (2005) explained that another great limitation for the studies of innovation in the building industry is the accessibility to information. This seems to be due to the ability of researcher to discover and describe innovation, as well as to the reluctance in the industry to share information due to the competitive intelligence that innovation-related data might represent. A consequence is the lack of empirical studies in innovation in the construction industry (Wolfe 1994; King and Anderson 1995). This seems to be due to at least three reasons: the first one is the length of the data collection activities; the second one is the scattered nature of type of data that needs to be collected; and the third reason is the plurality of units and level of analysis. For instance, some authors relied on practitioners experience to explore innovation (Ling 2003; Sexton and Barrett 2003), others used projects as unit of analysis (Nam and Tatum 1997; Pries and Janszen 1995), or firms and business (Bossink, 2002). Moreover, Betts and Landsey (1993) identified at least six level of analysis, namely individual, projects, firm, client, product, and industry characteristics. Although among these levels, the firms have received most of the analytical attention (Seaden and Manseau 2001), a number of authors has suggested adopting multi-level approaches to study innovation (Gann and Salter 2000; Blayse and Manley 2004; Winch 1998; Bossink 2004; Dickinson, Cooper, and McDermott). Such approach could also allow the understanding on the role of innovation across different stages of project cycles, which are otherwise studied independently.

In line with Dickinson, Cooper, and McDermott (2005) suggestions on further studies, this work is aimed at contributing to the knowledge on innovation management in the building industry under the aegis of sustainability. To do so, this work proposes the ontological position of considering buildings characteristics and delivery process as complex systems, and therefore to explore such systems as unit of the analysis. This approach - that will be further explained in the next chapter - allows to consider different constituents of sustainable innovation in the industry, as suggested by (Dickinson, Cooper, and McDermott 2005); to rebalance the focus of level of analysis moving from firm-based studies to multi-level approaches (Slaughter 2000; Sidwell et al. 2001); and to understand the type and impact of innovation within its operating context. In line with Ling (2003), the ultimate objective of this work is to contribute to the studies on sustainable innovation management with knowledge to support the future definition of robust models that can predict potential outcomes of successful innovations within the aegis of sustainability (Dickinson, Cooper, and McDermott 2005).

Chapter 3

Sustainable Project-Based Experience as Complex Systems

The previous chapter has introduced the concept of innovation in classical economic approaches and its influence in the development of the building industry, through describing drivers and barriers. These concepts have been also discussed in light of the call for changes brought by the recognized need of sustainable development. The critical reading of the tension between concepts and economic growth, lead to consider the role and nature of innovation in the development of sustainable projects, and question if alternative strategies, actors involvement and objectives might be more suitable to foster sustainable development through innovation introduction. The objective of this chapter is to define the research aim and questions of this work, and to set the ontological position of this research.

3.1 Aim and research question

The aim of this work is to explore strategic dynamics of introduction of sustainable innovation in the building industry. Specifically, this work attempts to shed light on development paths that can be alternative to the idea of radical innovation as key medium for progress generation within a paradigm that assume unlimited resources, disruptive phenomena, and deconstruction of existing systems (Sood and Tellis, 2005; Gambatese and Hallowell, 2011, Coccia, 2017; Tellis, Prabhu, Chandy, 2009; Winch, 1998; Ahlstrom, 2010). Moreover, this work wants to highlight strategies that might have their theoretical backbone in alternatives economic models and therefore that might call for different types of resources organizations for the building industry. With the terms 'economics', in fact, the author refers in this work, to all the activities to manage production, distribution, and consumption of goods and services, as well as on the interactions and behaviour between all the actors involved. In the context of building, the terms economic refer therefore to the organization of projects, design decisions, and delivery processes, as examples of instances that can make an impact in terms of sustainability management dynamics in the industry. By looking at strategic sustainable innovation management projects in the building industry this work wants to explore options and opportunities for the industry to contribute to shaping a better built environment. Specifically, the overall research question for this work is: Is it possible to identify patterns of sustainable innovation in the building industry?

To answer this question, this work will explore the aspects that characterise the economic activities related to the resources management within the building industry, such as design decisions, innovation characteristics, people's role and behaviour, and links between all these aspects.

To this end, this research will try to answer are the following sub-questions:

1. Which types and impacts of innovation can generate sustainable results?
2. What actors and behaviour can facilitate the introduction of sustainable innovation?
3. Which type of building characteristics can be used as a strategic ground for creating sustainable buildings?
4. Is it possible to identify links between types and impacts of innovation, building design characteristics and sustainability results achieved?

These questions set their premises within the studies on innovation in the building industry but are aimed at extending their meaning under the aegis of sustainability, and attempt to understand whether changes in the industry required by sustainability are hindered or facilitated by the nature of the industry.

3.2 The ontological position: sustainable project-based experiences as complex systems

In attempting to overcome the limits of the studies of sustainability innovation in the building industry highlithed in the previous chapter, this work focuses on considering different constituents of sustainable innovation in the industry, as suggested by (Dickinson, Cooper, and McDermott 2005); on defining a multi-level research approach (Slaughter 2000; Sidwell et al. 2001); and on understanding the type and impact of innovation within its operating context. To do so, this work relies on the ontological position that conceive buildings and delivery processes as complex systems.

The following sections will define the concept of complex system, the conception of building projects as concept systems, and explain research methods and approaches to explore such systems. These latter will set the base for the definition of the methodological approach that will be described in the following chapter.

3.2.1 Defining complex systems

Complexity theory is generally utilised to describe phenomena that do not respond to linear trajectories, show unique behavioural pattern, are composed by high degree of components and interconnections, and are highly responsive to external and internal input. A complex systems is defined as system with a large number of elements, which are capable of exchanging stimuli with one another and with their environment (Ottimo 2003). It is since the 1960s that the scientific community has been at work to define and explore the concept of complex system, as well as its application in many disciplines and fields. Senge (1990) explained that complex systems are dynamic and are characterized by subtle cause and effect relations, over time. Later, Sterman (2000) further explained that dynamic complexity arises because systems are: dynamic; tightly coupled; governed by feedback; nonlinear; history-dependent; self-organizing; adaptive; counterintuitive; policy resistant; and characterized by trade-offs. Moreover, Gandolfi (2008) and De Toni and Comello (2005) also identified characteristics, such as: high number of constituting elements; interaction between elements; delayed effects; existence of feedback; open system; network based systems; multi scalar nature; dynamic; both robustness and fragility of connections; innovative; unpredictable in their feedback loops; responsive to external and internal input; hierarchy organized and/or self-organized; dynamic equilibrium between order, disorder and chaos; partial autonomy of its constituting elements; and existence of internal paradoxes. These systems are also characterised by the inner contradiction of fragility and robustness. The more complex the systems are and the more robust. Yet the more complex the system is and the higher is the probability that a punctual failure could generate the entire system failure. Every change can represent both an advancement opportunity and a potential threat to the system. Although, the concept of complex system has been and still is evolving, it is only in the beginning of the 1990s that the discipline of engineering management has largely relied on the concept of complex system to elaborate and define management strategies both for products and supply chain (Hobday 1998). Only in the early 2000, a number of authors (Choi, Dooley, Rungtusanatham , 2001) formally demonstrate how supply chain and networks can be conceived as complex systems, and therefore managed with customized management models according to the complexity systems characteristics. This management approach has been often utilized for a vast range of fields, including the building one, which been already described as complex systems, since many years.

3.2.2 Building projects as complex systems

Many authors (e.g. Turin, 1980, Groak 1992; 2003; Winch 2000; Nightingale 2000; Allen 2008; Bachman 2008) have recognised and described building projects as complex systems. In the early 1980s, Turin (1980) pointed out the complexity of buildings - which are characterized by a large number of constituting elements - by defining them as unique products that are fixed, large, bulky, long to produce, overall expensive, but produced with relatively cheap materials, and long-lasting. Moreover, Turin (1980) explained that buildings are products that interact with their boundaries, climatic conditions, supply chain of their components - or constituting elements - and larger system such as single buildings, towns, cities. This latter aspect confers to buildings also the ability to establish links, loops and producing effects in a multi-scalar and multi-nature manner. They also interact with the social, economic, and environmental context, by being container of human activities. Turin (2003) also highlighted the complexity of building delivery processes by pointing out a number of variables, such as nature of products, function of professionals, and contractual relationships; identifying at least four models of type of processes; and highlighting over fifty 'critical relationship' (in large projects today could be even more), i.e. tendering or contract type, highlighting therefore different organizational types. Moreover, building processes are also characterised by on and/or off site production of different components – each one characterized by its own supply chain - which are subjected to a logistic process of individual components, since the end product is in most of cases fixed on the ground on a specific site. The construction itself of a building is a peculiar manufacturing process that calls for different procurement methods and everchanging building systems, developed in different places, and organized with specific timings, constrains and requirements. Building supply chain is also considered as socio-technical fragmented, since every project is characterized by the involvement of different professional coalitions that re-form and vary on each project. The nature of the role of these coalitions is variable and the type of contractual relations and hierarchical organizations need to be defined, to a certain extent, for every project. These variables depend, not only on the type of projects, but also on a number of contextual characteristics. These latter are related to political contexts, economies characteristics, codes and norms, social needs, and environmental aspects, as well as projects produce back into the context social, economic and environmental impacts. Lastly, a very significant aspect that remarkably impinges on the complexity of building projects and their supply chains is the design process. This latter is strongly influenced by the creative contribution of individual designers, and it can trigger a very high number of variables and changes throughout the entire building development process (Marfella and Nigra 2014). Bachman (2008) highlighted at least four encountered between architecture and complexity, namely wicked, messy, ordered, and natural. In the latter, Bachman (2008) highlighted at least five reasons and dimensions of complexity that embrace architecture in general and buildings. The first one the ecological dimension of complexity, which concerns the relation between buildings and their environmental context. This conception shows the interactive relation between buildings and environment, and describes buildings as if they were themselves an organism of nature. The second dimension is the one that conceive complexity as organization flow (Groak 1992). This conception describes complexity in buildings in terms of flows of '….*people, light, heat, air, information, products, gravity, sounds, and so on*' (Bachman 2008). The third dimension is the morphological one, which define the approach of appropriation of biological orders into artificial forms. The fourth dimension is the so called synergistic, which discusses the difference between the whole and the sum of its parts, and that explain the crucial importance of the former. The last dimension is the one that Bachman (2008) defined in relation to the Gestalt psychology. In this instance, complexity refers to importance of human perception in of recognizing self-organization tendencies and interrelationships.

All these aspects contribute to portray building projects and their delivery processes as complex systems, in which – as depicted in the image below – building and process characteristics are constituting elements of the systems; the links between those elements are internal and external relations that influence the behaviour of the system; and mutual influences and impacts between the system and the social, environmental and economic context establish a series of feedback loos that help the system evolving over time.

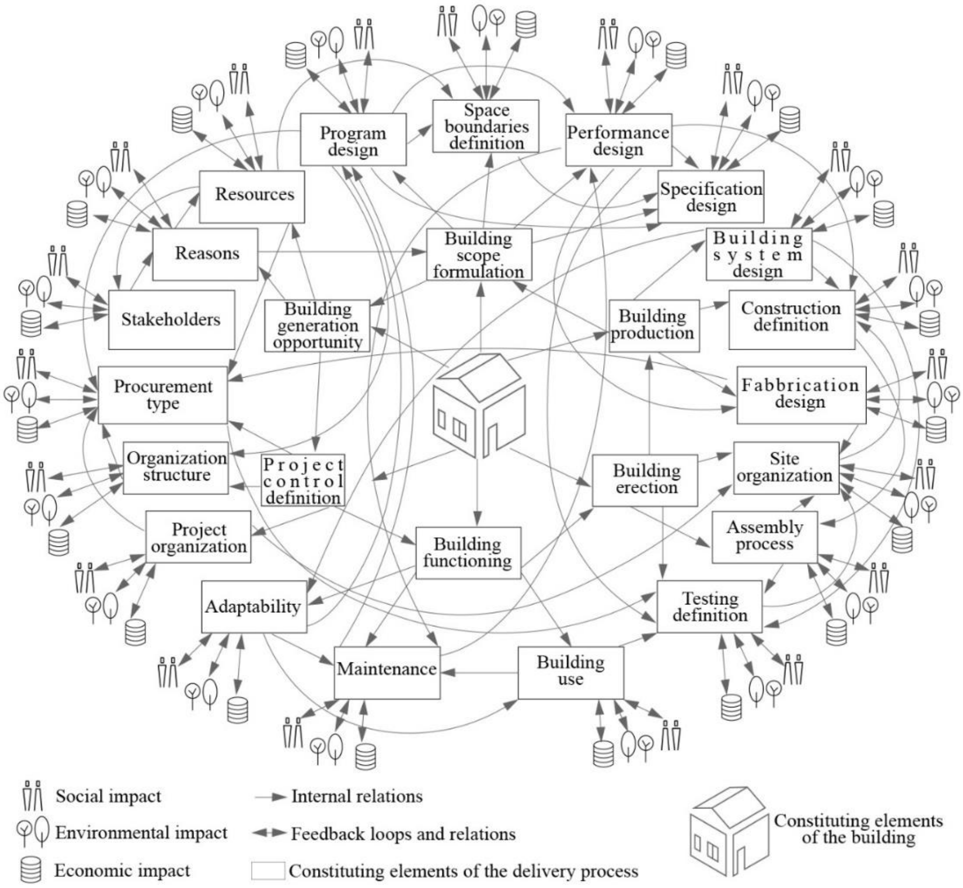


Figure 1: : The image shows a model of complexity for sustainable building projects and their development process. The building is composed by a number of constituting elements, which can all relate differently to the delivery process. Each of the characteristics of both the building and the delivery process is connected by a non-linear relation and establish a connection and a feedback loop with the context, in the environmental, social and economic domain.

3.2.3 Sustainability and Complex Systems

The concept of sustainability calls for innovative solutions to face the social, economic and environmental changes that our built environment is facing. The field of architecture and building have tried to respond to this call by envisioning design solutions, pushing boundaries of technologies, and searching for new delivery processes. In order to understand the degree of these changes and their development opportunities, it is significant to fully gauge the nature and the dynamics that characterise the field. The built environment is described by Allen (2008) as:'*…multi-layered historical patchwork of structures and links that express individual and contextual requirements at a given time, but which shape the evolution of the future in a typical path-dependent process of complex evolution'*. Moreover, Nightingale (2000) identified the importance of considering sustainable innovation processes in the building industry as complex systems as they show systemic behaviour, which link technologies, organizations, and knowledge. Therefore, in the specific instance of building projects and their delivery process, sustainability introduces degrees of change – innovation - that can represent both a system disruption and advancement opportunity. Innovation could lead to technological advancement, markets opening, social improvement, and better design solutions. Many authors (Ciza, Rendhir, Minu 2016; Taleb 2012 Bertuglia and Vaio 2011; and De Toni, Comello 2005) identified the internal paradox of fragility and robustness of complex systems. Gandolfi (2008) explains that a complex system is robust because of its adaptability, but at the same time Ciza, Rendhir, Minu (2016) argue that the more complex a system is, the more fragile it becomes, and any external punctual changes could potentially threat the status of the whole system. In consideration of these aspects, Ciza, Rendhir, Minu (2016) pointed out that sustainability is very critical to complex systems, because it can be considered both as a negative disruptor for complex systems, and an innovation required for the system to advance. For instance, climate change can generate environmental criticalities such as flood, draught, heat increase that could create negative impacts on the equilibrium of the environment, and at the same time such phenomena can trigger technological advancement to respond to such problems, more accurate environmental planning system, and determine methods to increase the resiliency of territories through times.

Ciza, Rendhir, Minu (2016) recognized in fact both the importance of the emergent role of sustainability, as well as its ability to produce change and therefore a potential for system disruption. Sustainability in the field of architecture calls for changes that can produce disruption to the consolidated practice and at the same time can represent great advancement opportunity to improve the built environment. This work calls, therefore, for the importance of shedding light on the complexity of sustainable building projects and their delivery process, with the aim of mapping their characteristics, warning on the risk of system disruptions, and highlighting developing opportunities. This is important because policy makers can better understand value and make informed choices, designer can understand the range of their design opportunities, and the industry reduce the risk of embarking into innovative projects that are often portraited as high risk (Slaugther 1993).

Yet, if innovation is not managed properly, it could also lead to difficulties for the industry to absorb the changes; to the generation of unexpected environmental and social effects; and/or to emergence of possible economic mismanagement. Considering that innovative sustainable building projects are always different, so their delivery processes are, it is critical to attempt reducing the risk of system disruption. To this end, it is fundamental to map and observe the system characteristics and dynamics.

Specifically, by observing buildings as complex systems, it is necessary to map innovation patterns, responsibilities, results, impact on delivery process in order to understand the relation cause-effects between innovative sustainable design solution and effects environmental, social and economic results achieved. Moreover, it is important to identify the mutual relation between these aspects, and the ability to read these connections, in order to provide feedback and inform designers, policy makers, and industrial participants. The more systems are observed, the more accurate is the prevision of the cause-effect relation between sustainable innovation introduction and effects produced. This is important to define better strategic sustainable development strategies, envision better design solutions, and reduce the industrial risk of undertaking innovative endeavour.

Understanding the complexity and the dynamics of sustainable building projects is therefore significant to contribute to the development of our built environment and to respond to emerging social, economic and environmental changes.

3.2.4 Assessing complexity and sustainability

Together with the efforts of defining complex systems, the scientific community has been heavily at work on the exploration of methods to assess complexity (Ciza, Rendhir, Minu 2016; Taleb 2007; Bertuglia and Vaio 2011; and De Toni, Comello 2005). These efforts soon identified the limits related to the reductionist approach to undertake measurement and/or phenomena assessments. As Ciza, Rendhir, Minu (2016) explained, reductionism is based on the principles that every phenomena can be simplified and explained by analysing the most basic components; every phenomena is the exact sum of its part; and there exists a linear connection between the starting point of a phenomena to its mature state. These principles seem to be not applicable to complex systems, since many studies have identified that the measurement of complexity is depending upon: number, variety, and links of constituting elements, as well as subjectivity principles, such as the role of the observer, and the aspects of complexity observed (Bertuglia and Vaio 2011). As a consequence, methodological assessments in this field seems to suffer of the same limits related to the reductionist approach. In particular, measuring and assessing complex systems such as building design projects remains a mutable and difficult operation to effectively undertake, considering that sustainability principles span across environmental, economic, and social systems. Since the UN released the Agenda 21 in 1992, many assessment methods have been developed, achieving to different extent, satisfying results, particularly in the assessment of the quantitative aspects of the building components (what we conceive here as constituting elements of the complex system). Yet, many methods tend to focus on only parts or one characteristic or dynamic of the system, rather than trying to gauge the interconnections between the overall projects characteristics. Only within the area of the environmental discipline, Caradonna (2014), for instance, identifies at least twenty two assessment methods, such as the Ecological Footprint Analysis (EFA), Carbon Footprint, Life Cycle Analysis, Index of Social Health, Leadership in Energy and Environmental Design (LEED), Triple Bottom Line (TBL), and many others. Each of those focus on specific components of the complex system. Yet, the social and/or economic interconnections seem, to a certain extent, to fall behind considerations. This may be due to the fact that the ability of measuring the social aspects is probably a field that already explored vastly the contradiction between the needs of quantifiable Key Performance Indicators and their qualitative nature (Lawther and Nigra 2014). Colantonio (2007) argues that many social sustainability assessment methods are still influenced by the tension between the holistic and reductionist approach, which seems unlike to produce significant data. This latter is also difficult therefore to collect and analyse. Yet, recent works in practice (i.e. the work presented at the 2016 Biennale of Architecture in Venice) have witnessed an emerging importance of the social sustainability approach in designing our built environment, by exploring buildings and delivery development processes as an opportunity for social change. The call for sustainability has influenced also the economic aspects, calling for a shift toward sustainability principles also in this discipline. Although, in fact, many authors (Ruddock 2009, De Valence 2011) have identified the importance of the paradigm shift from the principle of classic economy to a complex and more sustainable one – embedding also aspects of social behaviour and environmental awareness and the concept of limited resources - the leading economic dynamics field still respond to the rationale of the classic economy, in which competitive advantage, supply and demand, market expansion are the parameters that are relevant to assess the results achieved on projects.

Yet, the importance of gauging the complexity of our changing world and our built environment seem to be a significant task under constant evolution (Ciza, Rendhir, Minu 2016; Taleb 2007; Bertuglia and Vaio 2011; De Toni and Comello 2005; Grosso 2009, 2011, 2018). As an attempt to overcome the structural limits of the traditional assessment methods – naturally characterized by either the reductionist approach - and yet to maintain their efficiency in describing and assessing components and characteristics, this work suggests an approach to gauge complexity in sustainable building projects. Gauging such complexity is relevant to understand and respect differences, to enhance relations and interconnections, and therefore to highlight development opportunities.

The next chapter will explain the methodological approach and methods utilised for this work, attempting to consider the complexity of building characteristics and development processes under the introduction of sustainable innovation as change to the system.

Chapter 4

Methodology and Methods

The previous chapter has explained the ontological position if this work, as well as has stated the research questions, being:

1) Which types and impacts of innovation can generate sustainable results?

2) What actors and behaviour can facilitate the introduction of sustainable innovation?

3) Which type of building characteristics can be used as a strategic ground for creating sustainable buildings?

4) Is it possible to identify links between types and impacts of innovation, building design characteristics and sustainability results achieved?

To answer to these questions, this chapter will explain the methodological approach, rational of analytical parameters, and the methods utilised to produce the analysis showed in chapter five and the findings and discussion in chapter six. In line with Yin (2018) this work was organised in a number of reiterative steps, as showed in Figure 1, namely: research design, research preparation, data collection, analysis, and sharing results.

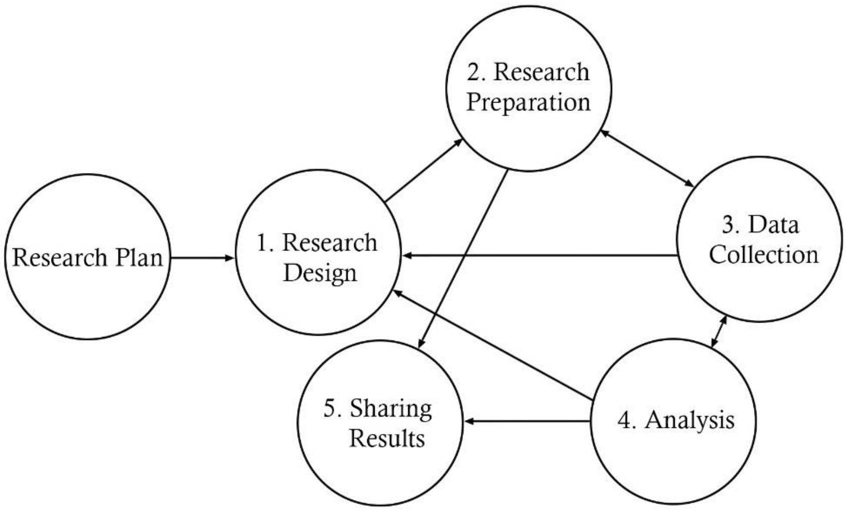


Figure 2: The image above is an adaptation from Yin (2018) that show the path to define the methodology and methods adopted on this work.

4.1 Research Plan

The methodology selected for this work is the case study approach. The rationale to select such strategy is multi-fold. In line with Yin (2018), case study research was selected since it is a method that allow the exploration of contemporary phenomena within their context, in particular when their boundaries are not evident. This epistemological position that would allow the exploration of sustainable projects as complex systems as ontologically defined in the previous chapter. Moreover, as Yin (2018) and Schramm (1971) explained the essence of case study research is to shed light on decisions and answer to questions such as:'*…why they were taken, how they were implemented, and what results*' (Yin, 2018). Such questions are in line with the research questions posed for this work.

This is due to the need of: exploring all the opportunities that projects development process offers to foster sustainability; and understanding the nature of the simultaneous effects that sustainability could generate. In doing so, this work highlights the importance of the complexity of making sustainable decisions within a context of a changing world. The premises of this approach are to be found in the variety of models proposed by many authors to assess complexity adaptive systems (Edmonds, 1999; Bertuglia and Staricco, 2000; Dioguardi, 2000), which are based on description of the system and its behaviour. These two descriptions are fundamental to the possibility of identifying a structure of the system that can be observed, studied, and eventually statistically measured.

The methodological approach proposed in this work focuses therefore on the description of the building case studies as complex system and on the analysis of the system behaviour under the introduction of change. Specifically, the work focuses on building projects and development processes in the case of the introduction of sustainability design decisions, conceived as changes from standard practice. To this end, this work explores the simultaneous and mutual relation between principles of economic, social and environmental sustainability in building projects, by relying on the qualitative reading of their interconnections. These relations are explored both for constituting projects elements, and dynamics of development processes, trying to understand the relation between design decisions and roles and responsibilities, and sustainable effects produced.

This methodological approach is aimed at proposing a possible method to map, visualize and highlight the complexity within the context of sustainable building projects development, in order to understand system characteristics and dynamics, and eventually define effective design and management strategies. This understanding can be critical both in practice and in the academic context, to gauge the potential of the design process and the responsibilities and opportunities that lie behind the development of projects, and to understand the variables that can influence the system behaviour. In particular the methodology is aimed at gauging both the characteristics of the constituting elements of the complex system as well as detecting their interconnections. Such method could be used to assess existing projects, and to understand the nature of the design decisions adopted during the preliminary design phase, by mapping possible social, environmental, and economic effects.

4.2 Research Design

Yin (2018) highlighted a number of crucial aspects that need to be addressed in designing a research, namely: case study definition and design, theory and proposition development in analysing the data and generalising the findings, and testing against selected analytical criteria. In this sections these aspects will be addressed and explained by defining the rationale for study selection, case study description, analytical parameters definition and framework, and patterns analysis and criteria of discussion utilised in this work. Each of these steps will rely on different theories that allowed constructing the methodology and methods defined for this work. Each of these theories will be explained in the following sections as following: 1) case study selection, 2) case study description, 3) identification of innovation type and impact, 4) identification of roles and responsibilities, and 5) identification of sustainable social, economic and environmental results. These descriptions will help constructing the base for the analysis which is aimed at understanding the relations between building and process characteristics, type and impact of innovation, roles and responsibilities and sustainability results, as showed in the scheme below.

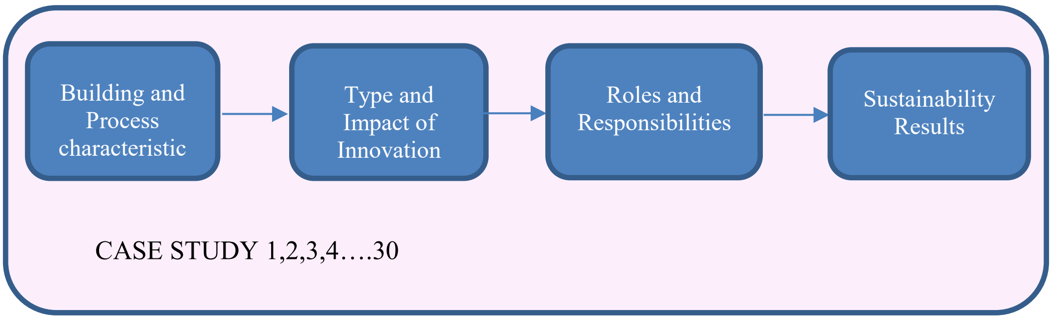


Figure 3: The image shows the research steps

Understanding these links can facilitate the direct feedback of the design decisions in relation to the social, economic and environmental effects generated or to be generated, and therefore to inform design and delivery processes (Figure 1). Doing so, it would be critical to both define better strategic policies and design solution, as well as to reduce the risk of the industrial participation of innovative sustainable projects endeavours.

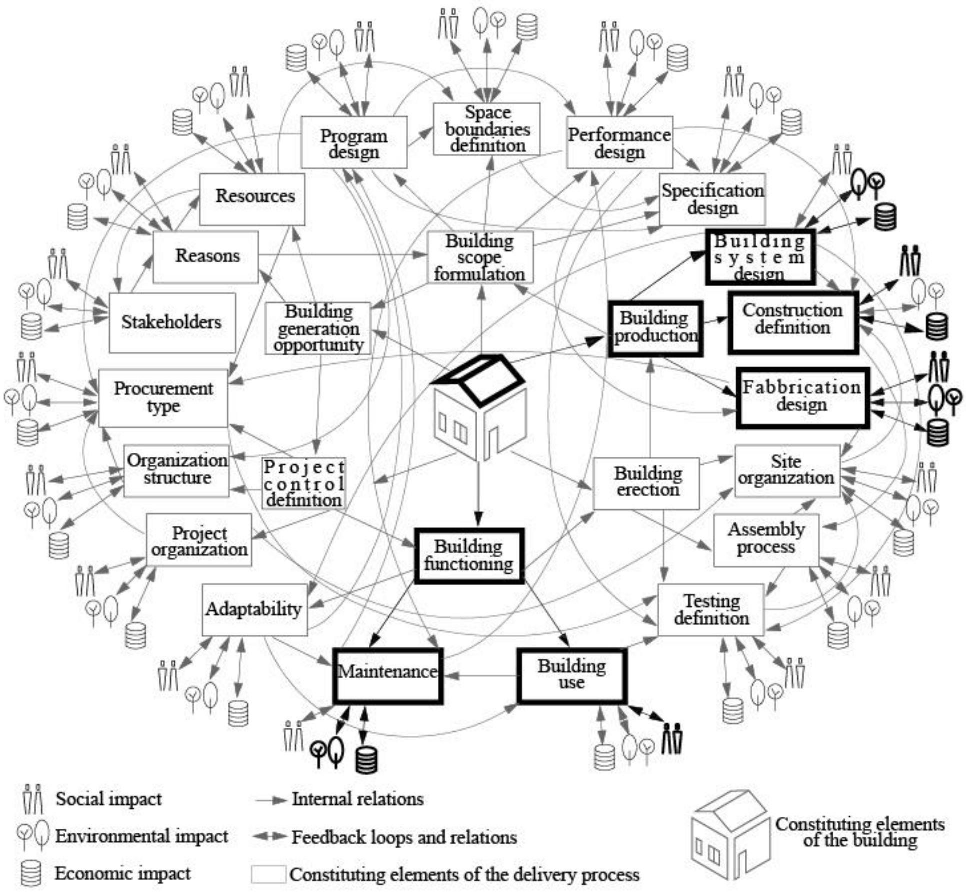


Figure 4: The image highlights, in the model of complexity for sustainable building projects, the relations between design change and impact produced. The image, by highlighting areas of the system, shows the example of the relation between a design change in a building element (for example the roof), the areas of delivery process impacted by such decision, as well we the nature of the impact achieved within social, environmental, and economic domain.

4.2.1 Case Study Selection

The case studies selected are contemporary public or semi-public projects. The rationale for this selection is that public projects are described by Groak and Krimgold (1989), Nigra (2010), and Tombesi (2007) as project-based experiences that represent a critical and significant way in which the construction industry brings together its output and tests its procedures, then buildings stand as the physical outcomes of the processes involved, and should be used to verify the validity of the decisions made within them, and therefore represents examples of innovative endeavours. The ability to establish a connection between as-built products and underlying processes by looking at the evidence embodied in the former could provide critical insight into the industry dynamics (Nigra, 2010). In the initial stage of this work, the selection was focusing on projects that had achieved high ranking within the major energy certification agencies (such as LEED, BREAM, or GBC, and others), yet it soon became clear that the scope of the research was going to be broader than then the one offered by only targeting energy efficient projects, as the aim of the work is also to understand the role of economic and social aspects in building projects. Therefore, the selection of case studies was undertaken by choosing projects that were either developed within specific sustainable normative framework, awarded by international sustainability recognitions and prizes, and/or developed with the explicit scope of addressing economic, social, and environmental issues in a sustainable manner. The number of project selected is thirty in such way to allow the possibility of reading patterns in the observation of such number of case studies. Yet, the number does not allow the application of statistical methods to analyse the results, but offers the possibility to highlight path of sustainable innovation introduction and to understand variables, roles and factors that can facilitate or inhibit the innovation development. The projects were selected in different geographical context in order to be able to understand the role of the socio-technical context in which each project was developed. Moreover, the scope of the projects varied in order not to have the bias of the typological boundaries of projects, as well as the year of development was selected within the last ten years, so to understand the contemporary dynamics of innovation in relation also to the technological advancement.

Table 1: : The table below shows the projects selected as case studies for the analysis.

Building	Place	Year	Scope	Architect
EUROPE				
Culloden Battlefield Visitor Centre	Inverness, Scotland, UK	2007	Visitor Centre	Hoskins Architects
South Lanarkshire College	East Kilbride, Scotland, UK	2014	College	Austin-Smith: Lord
Robert Burns Birthplace Museu,	Ayr, Scotland, UK	2010	Museum	Simpson and Brown,
The Edge Office Building	Amsterdam, The Netherlands	2015	Office	PLP Architecture
Ecopolis Plaza,	Madrid, Spain	2010	School/Publi c space	Ecosistema Urbano,
Alder Hey Children's Hospital	Liverpool, UK	2015	Hospital	BDP
The Guastalla Kindergarten	Guastalla, Italy	2015	Kindergarten	MCArchitects
AUSTRALASIA				
The Ch2 Office Building	Melbourne, Australia	2006	Office	Arch. Mike Pierce
41Exhibition Street	Melbourne, Australia	2013	Office	Lyons Architects

The Cardboard Cathedral	Christchurch, New Zealand	2011	Church	Shigeru Ban
The Cassia Coop Training Centre	Sumatra, Indonesia	2011	School	TYIN Tegnestue Architects
The Pixel Building	Melbourne, Australia	2010	Office	Studio 505
Children's Land	Gaza Strip, Palestine	2011	School	MCArchitects
The Sieeb Building	Beijing, China	2006	Office	MCArchitects
The Liyuan Library	Beijing, China	2015	Library	Li Xiaodong Atelier
SOUTH AMERICA				
Hotel Patagonia	Torres del Paine, Chile	2011	Hotel	Cazù Zegers Arquitectura
The Rainbow Desert	Ventanilla, Perù	2013		51-1 Aquitectots
The Earthship School	Juarreguiberr y, Uruguay	2016	School	Michale Reynolds
AFRICA				
The Primary School of Gando	Gando, Burkina Faso	2001	School	Francis Kerè Architecture
The Makoko Floating School	Makoko, Nigeria	2013	School	NLE' Architecture
The ECDC Centres	Various location in Rwanda, Africa	2016	School	ASA Studio
The Library of Muyinga	Muyinga, Burundi, Africa	2012	Library	BC Architects
The One Airport Square	Accra, Ghana, Africa	2015	Office	MCArchitects
NORTH AMERICA				
The Balard Library	Seattle, WA, USA	2005	Library	Henderson Ryan
The Bullit Centre	Seattle, WA, USA	2012	Office	Robert Hull
West Branch Berkley Library	Berkley, CA, USA	2013	Library	Harley Ellis Devereaux
The Jacob Institute of Innovation, UC	Berkley, CA, USA	2015	Office	Leddy Maaytum Stacy Architects
The Dixon Water Foundation Pavilion	Decatour, TX, USA	2014	Mix-used	Lake Flato Architects
The Newbern Library	Auburn, AL, USA	2015	Library	Rural Studio
Albion Public Library	Toronto, Canada	2017	Library	Perkins+Will

4.2.2 Case Study Description

In line with the methodological approach proposed, the first step of this work is to describe building characteristics and delivery process of each case study selected. The identification of building characteristics relies on the index provided in the European Standard UNI EN 16627:2015 (CEN, 2015) which identifies the building design characteristics, elements and services that are considered when making decisions about the design of sustsinable buildings. They are: dimensions, shape, floor number, access and circulation, structure, environmental control systems and water treatment. The index is used as a base for completing the description, yet a degree of flexibility is maintained in case of critical innovative features not covered by the index. The reason for this flexibility is based on the fact that every building is different (Turin, 1980, Lindgren 2016), and therefore flexibility is needed in order to gauge the complexity of each project. To this end, other aspects such as environmental context, orientation, and architectural characteristics (e.g. relation between opaque and transparent components, or volumetric configuration) have been added to the list, as they may generate impacts regarding social, environmental and economic aspects. For each project analysed, all building design characteristics, elements and services have been described on the basis of both architectural documents provided by the architects, and interviews carried out with them, as well as by conducting at least one site visit to each building project. The delivery process was also described, in order to relate the impact that each design decision might have on the supply chain, and therefore to understand if specific design decisions cold trigger particular sustainability changes and results (Nigra, 2017). Many authors have described building delivery as a fragmented process in which a variety of skill, knowledge and materials flows interacts during different phases acting within certain regulatory and institutional framework (Gann and Salter, 2000). Moreover, every delivery process is different, as projects are (Turin, 1980), yet Tombesi (2008) and Nigra and Marfella (2014) explained that the crucial phases that are organized around projects are: building opportunities generation, building scope and formulation, project definition and control, building production, building erection and building functioning. Each of these phases have been described for each case study selected. In line with the model proposed by Tombesi (2008), and later discussed by Nigra and Marfella (2014) for each project, the building opportunity generation was described by looking at commissioning characteristics (promoter, land owner, client type, type of bid), financing system, and programming process. The building scope and formulation was described by the explanation of the project boundaries, scope, and design characteristics, whereas the project definition and control phase was described by the management and organizational forms used in developing the project. The phases of building production and erection were described by exploring manufacturing processes, supply chains, suppliers and builders roles, building sequences, and worksites organizations. Lastly, the building functioning phase was described by exploring building use dynamics, maintenance aspects, and spatial flexibility where relevant. The rationale of using such model to describe the building process is two-fold. Firstly, the model allow flexibility, both to gauge all the specificity of the each project analysed and to detect path of innovation, by defining broad conceptual areas of analysis rather than relies on guidelines or standard management and delivery systems procedure. Secondly, the model is intrinsically characterised by an epistemological backbone that portrays the delivery process and the relation with the project design as a complex system.

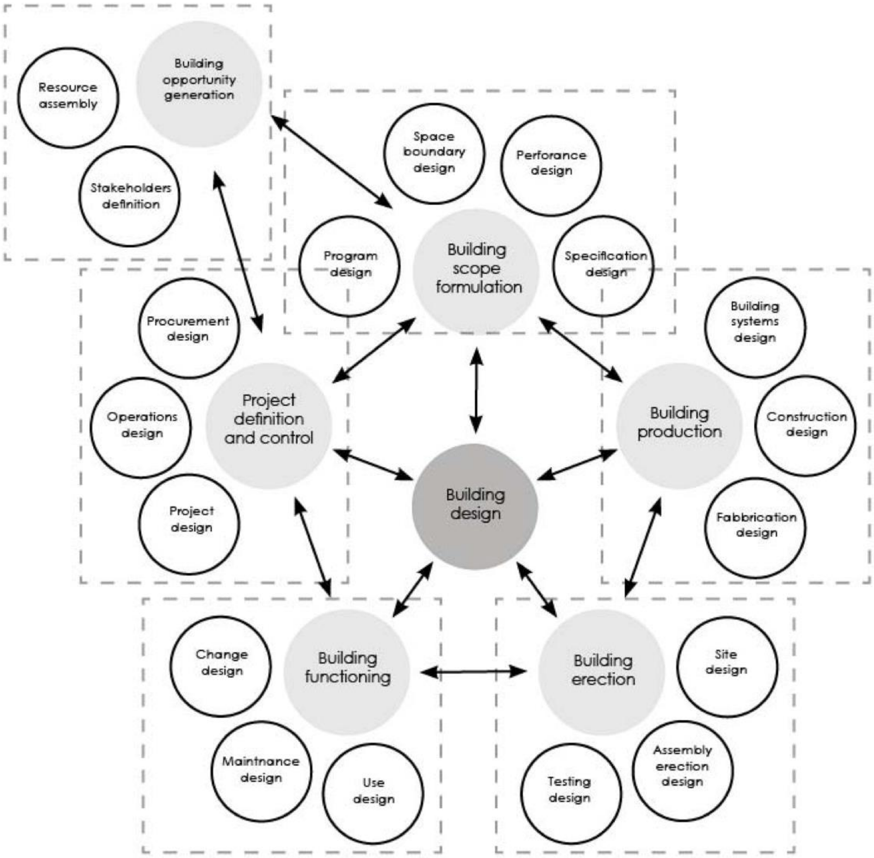


Figure 5: The image shows the areas that describe the delivery process according to the model proposed by Tombesi (2008).

4.2.3 Identification of innovation Type and Impact

The understanding of the types and impacts of innovation is aimed at answering to first research question of this work. The type of innovation is explored for each building characteristics identified (site, concept, orientation, architectural characteristics, dimension, shape, construction systems, internal partitions and windows, environmental control systems and water treatment and sewage connections), by relying on the innovation theory by Slaughter (1998). The impact that such innovations on the delivery processes (building opportunities generation, building scope and formulation, project definition and control, building production and erection, and building functioning.) is explored by relying the theory expanded by Shilling (2010).

Slaughter (1998), by developing the theory of innovation types by Henderson and Clark (1990), defined five types of innovation in the building industry, namely, incremental, modular, architectural, system and radical. These types of innovation were defined by Slaughter (1998) as follow:

Incremental: this innovation is a small change, based upon current knowledge and experience.

Modular: this type of innovation is a significant change in the design concept of specific component without impinging on the nature of the other components or on the links between them.

Architectural: Such innovation is not necessarily characterised by significant changes in the components but by remarkable variation in the links between them.

System: this type of innovation is the integration of multiple innovation that work in synergy to increase the performance of the whole system.

Radical: this is a type of innovation that is described a breakthrough in the industry, science, or technology and that often can change the nature of the industry.

The ability of understanding the type of innovation on a building project can help determine development strategies and understand the implications and the impacts that such innovation might have both on the project itself and on its delivery. To this end, this work relies on these categories to identify the type of innovation of each building characteristics previously described, In particular, for each building characteristics the question whether they adhere to one of these definition will be posed and the answer will provide the map of innovation type on a building project. For instance, if in the case of the analysis of a public school building in Italy, a foundation system is built with a traditional reinforces concrete slab system, the innovation type to describe such design decision will be 'incremental' as this is a system that can be considered traditional practice and therefore relies on *'..current knowledge and experience*', as per definition by Slaughter (1998), the specific degree of innovation will be therefore found only in the adaptation of such system to the specific site. Conversely, the use of smart technologies, for example in office buildings, as interface between the building users and the environmental control systems will be considered radical innovation, as it represents a '*…breakthrough the industry'* that could potentially change the way on which users experience the built space and environment.

To understand the impact that each of these innovation generated, the theory of Shilling (2010), later elaborated by Becattini (2013) was used to determine the analytical parameter for such topic. The two descriptive parameters are the ability of the innovation to trigger either competence enhancing activities or competence destroying activities. Specifically:

Competence creating/enhancing activities: are those which are based on the existing knowledge within the corporate boundaries and that are core activities of such entities. In this instance, innovations are generated stemming from such existing knowledge as a development process, which does not impinge on the integrated system and activities of the entities that are developing such innovations.

Competence destroying activities: are those which are triggered by innovations which are generated by different sources of knowledge that, as Shilling (2010) explained:'*…that turn into an obsolete set of notions of a corporate that could be still poorly exploited in the industrial field'.* The importance of detecting the need for such activities is that it could warn and eventually limit the risk of actors who are embarking innovation endeavours, as this might require a higher innovation absorptive capacity than the one available within corporate boundaries.

4.2.4 Identification of roles and responsibilities

The definition of roles and responsibilities in the introduction of sustainable change or innovation can help understand the development opportunities and responsibilities that each of the actors involved has, in both the definition of building components and delivery process. This understanding will determine the answer to the second research question of this work regarding actors and behaviour that can facilitate the introduction of sustainable innovation. This would be possible by understanding the connections and the impacts that each decisions can produce both in terms of influence on the supply chain and/or results achieved. To do so, each design decision is explored in terms of responsibilities with the aim of understanding who played a crucial role in the introduction of innovation. The actors explored are institutions, clients, designers, consultants, builder, industry and other, in case of any particular individual or entity that does not fall into the previous actor definitions.

Table 2: The table provides the definitions of the types of actors involved in building projects

TYPE OF ACTOR	DEFINITION
Institutions	Any public or private organization, establishment, foundation, society devoted to the promotion of particular program, i.e. National, Regional or Local Government
Client	Any person or group that relies on the professional advice to achieve the development of a program
Designer	Architects, Interior Designers, Landscape Architects, Urban Designers
Consultants	Mechanical Engineers, Service Engineers, Civil Engineers, Any other type of engineering or professionals services
Builder	Construction/Building Companies
Industry	Supplier and Manufacturers
Users/Other	Any person or group that is likely to use directly or to be indirectly connected to the life of the project, i.e. primary users, local communities

In order to understand the roles and the behaviour of such actors, this work relies on the use of the eco-innovation sustainability management model by Bossink (2013). Such model describes types of individuals, organizational forms, and business environments that favour the development of innovative sustainable ideas. Moreover, the model identifies actions and level of management that that connect the innovation development dynamics between individuals, organizations and environments. These levels are co-ideation, co-innovation and co-institutionalization. For each of these levels, the model specifies actors, styles, and characteristic that can facilitate the introduction of sustainable innovation at many levels. The first level is the co-ideation which describes the activities of developing sustainable innovative ideas, that can later be turned into solutions for business. The key actors in at this level are leaders, champions, and entrepreneurs. Bossink (2013) defines 1) leaders as individual or entities who can stimulate the emergence of sustainable innovative ideas; 2) entrepreneurs as entities or individuals who are able to recognize the opportunities for success and are not driven by risk aversion, and 3) champions as the creative drivers for innovative ideas and initiatives. They create links, form teams, and act as knowledge brokers. Bossink (2013) explained further that the eco-ideation level is characterized by management challenges such as the integration of sustainability concepts into corporate strategies of business or firms; as well as by opportunities such as the ability to lead firms or business into new markets and develop their growth potential. The second level is the co-innovation, in which innovative sustainable ideas turn into business proposals. The organizational forms in this management level are: 1) teams (groups in which leaders, entrepreneurs, and champions meet); 2) projects: opportunities, which are the opportunities to experiment and test sustainable innovation ideas, co-innovate and test results; and 3) business, or firms, that are the aggregation of individuals that hold the knowledge to perform co-innovation on a number of different projects. These entities need individual profit but have to cooperate with other individuals to achieve sustainable innovation. This level of management is characterized by challenges such as development of sustainable and profitable business; as well as by opportunities such as firms developing firms with long-term competitive positions. The third level is the co-institutionalization that is characterised by business environmental forces that enable commercial firms to grow and have an impact on industries and societies. These forces are market and society, knowledge and technology, and policy and regulation. Bossink (2013) explained that firms are able to innovate based on market demand. Sustainability has a lot of market potential, as well as the one of market opening. Markets and governments have the responsibility of sustainability towards societies. Societal discussions are open and have great potential to influence firms and business.

Knowledge and technology have the ability to foster continuous technological progress influence firms to innovate. Within this context, firms that are able to refresh their ideas and change through time are the ones who have sustainable innovation capability. The firms that have this capability are major change agents in the industry. Moreover, depending on political climate, the government is in the position of plan and execute regulation and policies to promote sustainability. When government are positive towards sustainability can either stimulate innovators, or define performance-based regulations. The main management challenge of these environmental forms is to reinforce the demand for sustainability; as well as the main opportunity is support the emergence of sustainable industries and societies.

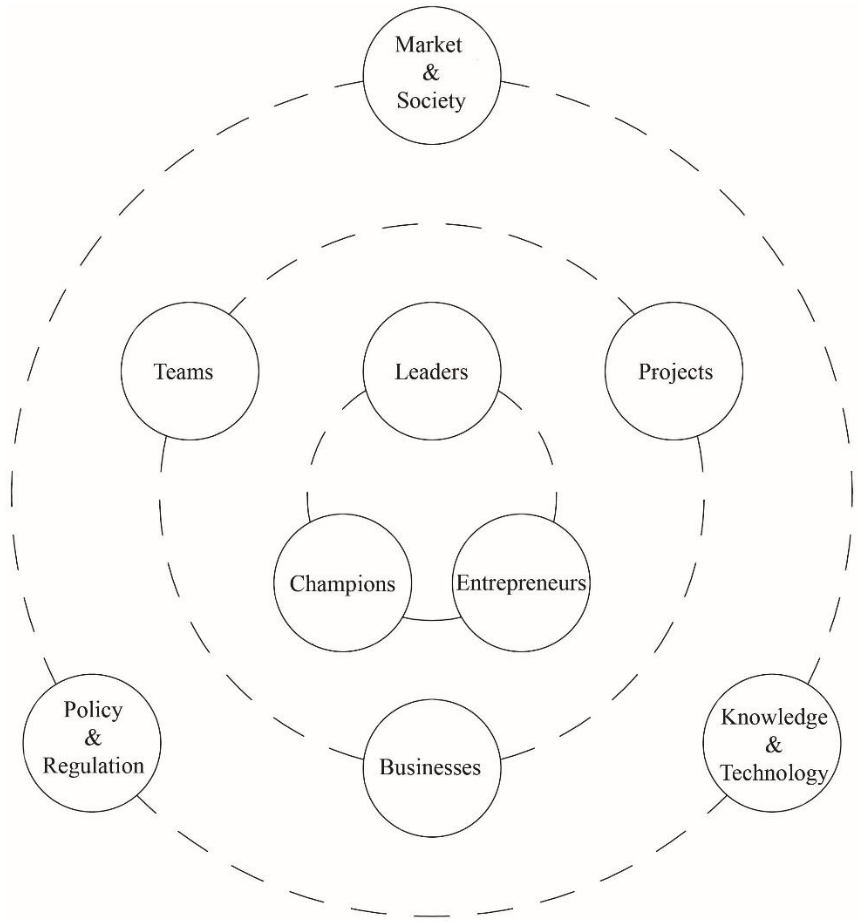


Figure 6: The figure above shows an adaptation of the Eco-Innovation Sustainability Model by Bossink (2009)

The eco-innovation sustainability model is use as lenses to understand the role of each actors analysed within the three levels of the model. This model is used because it allowed to understand which are the behaviour and the management levels that can be crucial beyond the traditional organizational structures of projects. Therefore the model will be used to understand the opportunities of fostering sustainable innovation that actors can generate beyond their traditional roles.

4.2.5 Identification of sustainable social, economic and environmental results

After defining the building characteristics and delivery processes (as described in section 4.2.2), the types and impacts of innovation (see section 4.2.3), the role and actors involved in the delivery of sustainable innovation (see section 4.2.4), this work proposed to qualitatively detect the sustainability results achieved in each case study analysed. To do so, by relying on post-occupancy evaluations, energy rating certifications, interviews carried out with the designers and participants in the design development process. This understanding is critical to be able to explore the relation between sustainable design decision and results achieved, in order to explore the cause-effect relation between innovative sustainable design decision and influence on the delivery process. The results were explored within the social, environmental and economic domains on the basis of the sustainability goals, in line with some of the sustainability goals defined by the United Nation Development Program 2017, The World Green Building Council (2016-2018), the International Association for Impact Assessment (IAIA, 2018), as well as in line with the work conducted by Dimitrijevic and Langford (2017), Lawther and Nigra (2013), Jones, (1989), Maneschi, (1998), and Ruddock (2009). Examples of these types of results are listed above for each of the sustainability domain.

Environmental domain:
Greenhouse Gas emission reduction
Use of renewable energies
Reduction of potable water consumption in building
Carbon emission reduction
Waste reduction
Environmental sustainable strategy introduction
Technological performance increase
Indoor environmental quality satisfaction
Health control indoor
Psychological well being
Clean water and sanitation
Affordable and clean energy
Social domain:
Social inclusion
Wealth and Health
Quality education
Safety
Poverty and hunger reduction
Gender equality
Decent work and economic growth
Industry innovation and infrastructure
Reduced inequalities
Responsible consumption and production
Peace, justice, and institution
Resilience to change and flexibility
people's way of life
Culture
Community cohesion
Political system
Personal and property rights
Fear reduction and aspiration development
Contextual relevance and respect
Economic domain:
Market expansion

Competitive and comparative advantage
Knowledge acquisition
Property/land value increase
Saving on energy spending
Job creation
Increase of assets value over traditional buildings
Circular economies generation

These types of results were explored by relying on the results parameters listed in table 3. Such parameters served as guideline to detect and report the results that were described on the projects by documents analysed. In particular in each case study, the design decisions were explored within each sustainability domain (environmental, social, and economic) to see whether they generated problems, did not create any impact, introduce any specific sustainability strategy, achieved sustainability results, or created extra benefit on the project or its context. These parameters, as described in table 4, are defined according to the work conducted by authors such as Dimitrijevic and Langford (2017), Lawther and Nigra (2013), Jones, (1989), Maneschi, (1998), and Ruddock (2009), who since at least ten years are at work to define and critical read assessment parameters for the built environment. This reading is important to understand the relation between design decision, innovation and possible result to achieve. This system therefore in not aimed at assessing results, rather at reading the existing results (already assessed by specific methods, such as BREAM or LEED, Post-

Occupancy Evaluations, and other typical of the industry), to be able to link those to the design decision taken on the projects.

Table 3: Area of impact, type of results, and parameters (Nigra and Dimitrijevic, 2018)

AREA OF IMPACT	TYPE OF RESULTS	RESULTS PARAMETERS
Environmental	emission reduction, resource generation, waste reduction, indoor environmental quality, outdoor environmental quality, embodied-energy, material use	Environmental problems
		No environmental change
		Knowledge acquisition
		Sustainability results achievement
		Technological performances advancement
		Resources generation
Social	social inclusion, wealth, education, safety, cultural diversity, personal development, cultural development	Social problems
		No social changes
		Knowledge acquisition
		Social objectives achievement
		Social Improvement
		Extra benefit generation
Economic	competitive advantage (lower production cost), comparative advantage (lower price and/or improved usability) property/land value increase, reduced maintenance cost	Economic Loss
		No economic change
		Savings achieved
		New jobs created
		Increased revenue
		Market expansion

Table 4: Definition of sustainability results parameters

AREA OF IMPACT	PARAMETERS	DEFINITION
Environmental	Environmental problems	Negative environmental impacts of the project
	No change in the environmental impact	No change in the local natural environment during and after the project development
	Knowledge acquisition	Knowledge acquisition related to environmental performance of the project (e.g. post-occupancy evaluation)
	Sustainability results achievement	Achievement of the goals set during the phase of project's objectives definition
	Technological performances advancement	Patent acquisition or generation of technological innovative systems
	Resources generation	Generation of resources from renewables or through recycling of resources not present before the project development (e.g. energy from renewables, recycling of water, etc.)
Social	Social problems	Negative social impacts of the project
	No change in the social impact	No change in local social relationships during and after the project development
	Knowledge acquisition	Knowledge acquisition related to the social impact of the project (e.g. through surveys of the building users, local community or/and nationally)
	Social objectives achievement	Achievement of social goals set during the phase of projects objectives definition
	Social Improvement	Reduction or elimination of negative social behaviours (e.g. crime, vandalism, sectarianism, etc.)
	Social benefit generation	Increase of positive social behaviours (e.g. strengthening of community relationships, increased volunteerism, increased social tolerance, etc.) on local or/and national level; public recognition of positive social impacts
Economic	Economic Loss	Negative revenue balance
	No economic change	No change in local or/and national economy during and after the project development
	Savings achieved	Reduced costs/m2 of the building construction, use and maintenance compared to similar buildings
	New jobs created	New jobs created internally and/or in the community to provide products and/or services for the continuous use of the building
	Increased revenue	Increased revenue (e.g. through improved performance in building use) in comparison with similar buildings/uses
	Market expansion	New products or services offered to a wider section of an existing market or a new demographic, psychographic or geographic market

4.3 Research Preparation

As suggested by Yin (2018), the research proposed and the methodological approach should be tested on a pilot study to allow the refinement and the validation of such approach. In order to test the research approach proposed for this work, a pilot study was conducted during a visiting period at Strathclyde University, Glasgow, Scotland, under the supervision of Professor Branka Dimitrijevic from the Department of Architecture. During such visiting time, the methodology was tested by applying it to three case studies of contemporary sustainable building projects, as well as by scrutinizing the method with local architects, namely Hoskins Architects, GAIA Architects, Simpson&Brown, Austin-Smith:Lord, and John Gilbert Architects Ltd, so to have the validation from a number of professional figures operating in practice. This test was important to prove the ability of this methodological approach to produce meaningful insight both for the industry and the academic environment, as its output was published in the following article on a highly ranked International Journal:

Nigra, M., Dimitrijevic, B., (2018). Is Radical Innovation critical to Sustainable Architecture? Lessons from three Scottish Contemporary Buildings. *Architectural Engineering and Design Management*. Vo. 14, Issue 4. Pp. 272 – 291.

Moreover, the methodological approach was further refined during a second visiting research period at The Vrije Universiteit in Amsterdam, The Netherland, supervised by Professor Bart Bossink from the Department of Science & Business Innovation. During such period, it was specifically tested on a number of case studies the eco-sustainable management model utilised to assess the role and behaviour of actors involved in the introduction of sustainable innovation. A publication about the output of such test is currently under preparation.

4.4 Data Collection and Research Methods

After testing and validating the research approach, the step of data collection was carried out by collecting and cross checking the information required by different sources for each case study selected. The types of information required was the one that could help describe the building and process characteristics (as described in section 4.2.2), the innovation type and impact (section 4.2.3), the role of actors (section 4.2.4), and the results achieved (4.2.5).

As showed in table 4, the types of sources utilized were: technical documents, bibliography, building observations and interviews. Once the information was collected, a framework was structured to conduct the analysis, as showed in Appendix A and B.

Technical documents, such as conceptual sketches, architectural drawing, construction drawings, shop drawings, specifications, meeting minutes were utilised to describe the building characteristics (as defined in section 4.2.2), as well as the building delivery process. These information were completed by the data available in the press documents of every projects, in the publications available for each building analysed. Often these sort of sources were used to complete the information regarding the building delivery process, as industry partners often published reports on projects experiences, describing their role in the delivery. Other sources of document utilised were energy certificates, post-occupancy documents, and award reports. In these two types of documents it was possible to tease out the sustainability types of results achieved by each project.

Building observations were also conducted, where possible, to test and check the information previously collected on both the building characteristics described, and the sustainability results achieved. As Nigra (2010) explained:'…*As physical artefacts, buildings provide material evidence of the process that led to their realization and the effectiveness of the decisions made prior to it: construction details implicitly reflect the knowledge of production factors embedded in the work and the efficacy of the contractual methods employed to structure underlying socio-technical relations; building use patterns validate or reject choices made at program definition and development stages; building maintenance requirements give an indication of the depth of thinking that* *went into the operational life of the building, or help assess the administrative and labour structure that put it together*'.

The interviews were conducted by verifying the building characteristics explored in the technical documents, understand role and responsibilities of the actors involved, as well as by recording the building delivery experiences reported by the architects, and by assessing with the architects the degree of innovation of each building characteristic in relation to the context. The interviews were semi-structured to allow flexibility in the narrative of the uniqueness (Turin, 1980) of each project experience analysed. Such interviews were approved by the Strathclyde University Ethical Approval System. Sample of starting questions were the following:

1. What is your most innovative sustainable building projects?
2. What is the most innovative sustainable feature/strategy of this project?
3. What was your design and management approach to sustainability on this project?
4. What positive or negative impacts this innovation has generated? Where these impacts social, economic, and/or environmental?
5. What strategy have you used to avoid negative impacts?
6. What innovative design decisions impacted the project development? How?
7. Who had an important role in the introduction of sustainable innovation?
8. What have you learned from this project experience?
9. What impact working on this project has had on your practice?
10. In general, what do you think are the major criticalities and opportunities in introducing sustainable innovation in the building industry?

The table below shows the type of sources that were utilised for each case study. As result of the structural fragmentation of the project-based, and the difficulties in defining uniform knowledge transfer mechanisms typical of the industry (Gann, 2000; Tombesi 2008; Nigra 2010), the types of sources varied for each project. For instance, interviews were carried out for the majority of projects, except for example, for the North American case studies, due to the difficulties in reaching out some of the largest firms in the country. Yet, the information required was found in the extensive reports published by the American Institute of Architect (AIA), which produced yearly analytical documents for the most sustainable building projects in the country, where the innovation type, the role of actors, the results and the impact on the local contexts are largely discussed. For other case studies, such as the African one, it was not possible to conduct the building observations in person, due to the logistic difficulties of reaching some remote areas, as well as due to the shortage of funds available to conduct such field trip. Yet, validation of the case study description was done in such cases by the interviews conducted with the local architects, as well as by the observation of the post-occupancy photographic reports carried out by the architects themselves.

Table 5: The table below shows the type of sources utilised for each of the case study analysed.

Building	Technical Documentation	Bibliography	Building Observation	Interview
EUROPE				
Culloden Battlefield Visitor Centre, Scotland, Inverness, UK	Conceptual sketches Architectural Drawings Construction Drawings Shop drawings, Specifications, Meeting Minutes, Post-occupancy evaluations, Awards reports	Press Publication	Yes	Arch. Nick Domminey, Hoskins Architects, Glasgow, Scotland, UK
South Lanarkshire College, Scotland, East Kilbride	Conceptual sketches Architectural Drawings Construction Drawings Shop drawings, Specifications, Meeting Minutes, Post-occupancy evaluations, Awards reports	Press	Yes	Arch. Catherine Cosgrove, Austin-Smith: Lord, Glasgow, Scotland, UK
Robert Burns Birthplace Museum, Scotland, UK	Conceptual sketches Architectural Drawings Construction Drawings Shop drawings, Specifications, Meeting Minutes, Post-occupancy evaluations, Awards reports	Press	Yes	Arch. Jenny Humphreys, Simpson and Brown, Edinburgh, Scotland, UK
The Edge Office Building, Amsterdam, The Netherlands	Conceptual sketches Architectural Drawings Construction Drawings Meeting Minutes, Post-occupancy evaluations	Press Publication	Yes	Arch. Kevin Flanagan, PLP Architecture, London, UK
Ecopolis Plaza, Madrid, Spain	Conceptual sketches Architectural Drawings Construction Drawings, Awards reports	Press	No	Luis Vallejo, Ecosistema Urbano, Madrid, Spain
Alder Hey Children's Hospital, Liverpool, UK	Conceptual sketches Architectural Drawings Construction Drawings Meeting Minutes,	Press Publication	Yes	Arch. Benedict Zucchi, BDP, London, UK

	Post-occupancy evaluations, Awards reports			
The Guastalla Kindergarten, Guastalla, Italy	Conceptual sketches Architectural Drawings Construction Drawings Meeting Minutes	Press Publication	Yes	Arch. Alberto Bruno, MCArchitects, Bologna, Italy
AUSTR ALASIA				
The Ch2 Office Building, Melbourne, Australia	Conceptual sketches Architectural Drawings Construction Drawings Shop drawings, Specifications, Meeting Minutes, Post-occupancy evaluations, Awards reports	Press Publication Government Public Document Review	Yes	Arch. Mike Pierce, Botswana, Africa
41Exhibi tion Street, Melbourne, Australia	Conceptual sketches Architectural Drawings Construction Drawings Shop drawings, Specifications, Meeting Minutes, Awards reports	Press Publication Government Public Document Review	Yes	Arch. Nick Bourns, Lyons Architects, Melbourne, Australia
The Cardboard Cathedral, Christchurch, New Zealand	Conceptual sketches Architectural Drawings Construction Drawings Shop drawings, Specifications, Meeting Minutes	Press Publication Governent Public Document Review	Yes	Extensive reports have been conducted by the Local Government
The Cassia Coop Training Centre, Sumatra, Indonesia	Conceptual sketches Architectural Drawings, Awards reports	Press Publication	No	None
The Pixel Building, Melbourne, Australia	Conceptual sketches Architectural Drawings Construction Drawings Shop drawings, Specifications, Meeting Minutes	Press	Yes	Arch. Dylan Brady, decibel(Architectur e))), Melbourne, Australia
Children's Land, Gaza Strip, Palestine	Conceptual sketches Architectural Drawings Construction Drawings Shop drawings	Press Publication	No	Arch. Alberto Bruno, MCArchitects, Bologna, Italy
The Sieeb Building, Beijing, China	Conceptual sketches Architectural Drawings Construction	Press	No	Arch. Alberto Bruno, MCArchitects, Bologna, Italy

	Drawings Shop drawings			
The Liyuan Library, Beijing, China	Conceptual sketches Architectural Drawings Construction Drawings	Press	No	None
SOUTH AMERICA				
Hotel Patagonia, Torres del Paine, Chile	Conceptual sketches Architectural Drawings Construction Drawings Shop drawings, Awards reports	Press	No	Cazù Zegers, Cazù Zegers Arquitectura, Santiago, Chile
The Rainbow Desert, Ventanilla, Perù	Conceptual sketches Architectural Drawings Construction Drawings Shop drawings, Post-occupancy evaluations	Press	No	Arch. Cesar Becerra, 51-1 Arquitectos, Lima, Perù
The Earthship School, Juarreguiberry, Uruguay	Conceptual sketches Architectural Drawings Construction Drawings Shop drawings	Press Publication	No	None
AFRICA				
The Primary School of Gando, Burkina Faso	Conceptual sketches Architectural Drawings Construction Drawings Shop drawings, Post-occupancy evaluations, Awards reports	Press	No	Extensive reports have been conducted by the architects
The Makoko Floating School, Nigeria	Conceptual sketches Architectural Drawings Construction Drawings Shop drawings Preliminary studies, Awards reports	Press	No	Extensive reports have been conducted by the architects
The ECDC Centres, Rwanda, Africa	Conceptual sketches Architectural Drawings Construction Drawings Shop drawings, Post-occupancy evaluations	Press	No	Arch. Francesco Stassi, ASA Studio
The Library of Muyinga,	Conceptual sketches Architectural Drawings	Press	No	None

Burundi, Africa	Construction Drawings Shop drawings, Awards reports			
The One Airport Square, Ghana, Africa	Conceptual sketches Architectural Drawings Construction Drawings Shop drawings	Press	No	Arch. Alberto Bruno, MCArchitects, Bologna, Italy
NORTH AMERICA				
The Balard Library, Seattle, WA, USA	Conceptual sketches Architectural Drawings Construction Drawings Shop drawings, Post-occupancy evaluations, Awards reports	Press AIA Reports	No	Extensive reports have been conducted by the AIA
The Bullit Centre, Seattle, WA, USA	Conceptual sketches Architectural Drawings Construction Drawings Shop drawings, Post-occupancy evaluations, Awards reports	Press AIA Reports	No	Extensive reports have been conducted by the AIA
West Branch Berkley Library, Berkley, CA, USA	Conceptual sketches Architectural Drawings Construction Drawings Shop drawings, Post-occupancy evaluations, Awards reports	Press AIA Reports	No	Extensive reports have been conducted by the AIA
The Jacob Institute of Innovation, UC Berkley, CA, USA	Conceptual sketches Architectural Drawings Construction Drawings Shop drawings, Post-occupancy evaluations, Awards reports	Press AIA Reports	No	Extensive reports have been conducted by the AIA
The Dixon Water Foundation Pavilion, Decatour, TX, USA	Conceptual sketches Architectural Drawings Construction Drawings Shop drawings, Post-occupancy evaluations, Awards reports	Press AIA Reports	Yes	Arch. Heather Holdridge, Lake Flato Architects, San Antonio, TX, USA
The Newbern Library, Auburn, AL,	Conceptual sketches Architectural Drawings Construction	Press	Yes	Natalie Butts-Ball, Rural Studio, Auburn, AL, USA

USA	Drawings Shop drawings, Post-occupancy evaluations			
Albion Public Library, Toronto, Canada	Conceptual sketches Architectural Drawings Construction Drawings Shop drawings, Awards reports	Press AIA Reports	Yes	Extensive reports have been conducted by the AIA

The collected data were then organized into a working frame that created two matrixes as showed in the following figures, one referred to the building (Appendix A) and the second one to the building process (Appendix B). These frameworks were used to conduct the analysis in which, after describing building components and delivery process, each aspect was analysed according to type an impact of innovation, actors responsibilities, and sustainability results (Appendix C). In particular for each building characteristic analysed the following questions were explored:

- Which type of innovation definition this building characteristic correspond to? Is it incremental, modular, architectural, system or radical innovation? (please refer to definitions in section 4.2.2)
- Who was the actor who introduced such innovation? (please refer to definitions in table 2)
- Has the innovation produced any environmental, social or economic result?

For the building process, the questions posed were instead:

- Were the actors required to undertake competence enhancing and/or competence destroying activities to deliver the project?
- Who took such decision on the delivery process?
- Which environmental, social and/or economic results the delivery process has achieved?

In order to answer to such questions, the context of each case study was explored to understand the degree of development in the socio-technical charactertics. To do so, research was conducted to understand the normative framework and policies, the technological systems ustilised in the area, and the organizational forms typical of each context. Also, the material availability and the industrial participation and availability was explored. These information served to provide a basis for the analysis, and therefore to understand the degree of innovation departing from the standard practice of each context.

As suggested by Yin (2018), the output produced by the frame works previously explained were organised into a visual display to allow the simultaneous reading of all the case studies analysed. For each case study, the innovation type and impact was summarised and graphically represented as follow:

Table 6: The table below shows an example of visual representation of innovation type used on each case study

	Incremental	Modular	Architectural	System	Radical
Context Characteristics					
Architectural Design					
Construction Systems					
Secondary Elements					
Environmental Control Systems					

Table 7: The table below shows an example of visual representation of innovation impact generated on each case study

	Competence Creating	Competence Destroying
Public Insitittution		
Client		
Designer		
Builder		
Industry		
User		

The sustainability results were, for each case study, summarised and visually displayed as showed in table 7. The pie charts represent the number of results achieved both for the building and the delivery process according to environmental, social, and economic domain.

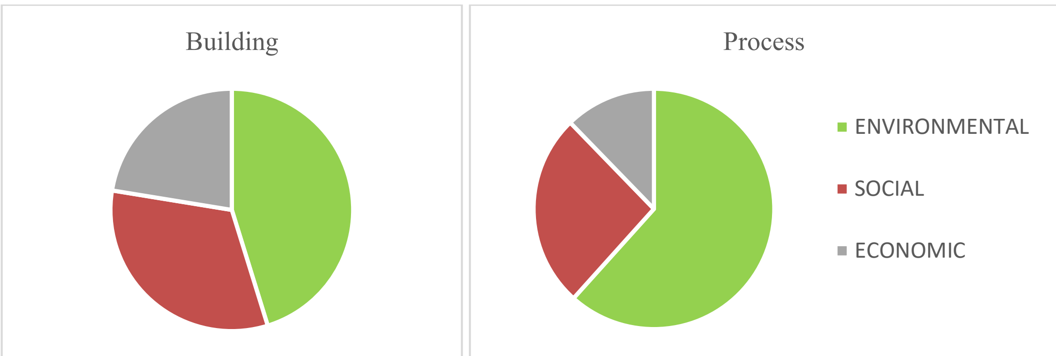


Figure 7: The pie charts represents a visual example for showing the types of results achieved on each project analysed.

The role of actors was expressed by the application of the eco-innovation and sustainability model (Bossink 2013). By counting the number of decisions on the project, the position of each actor within the eco-innovation levels and represents with a graphical output to help visualise the behaviour on each actor according to the eco-innovation and sustainability management model, explained in section 4.2.4.

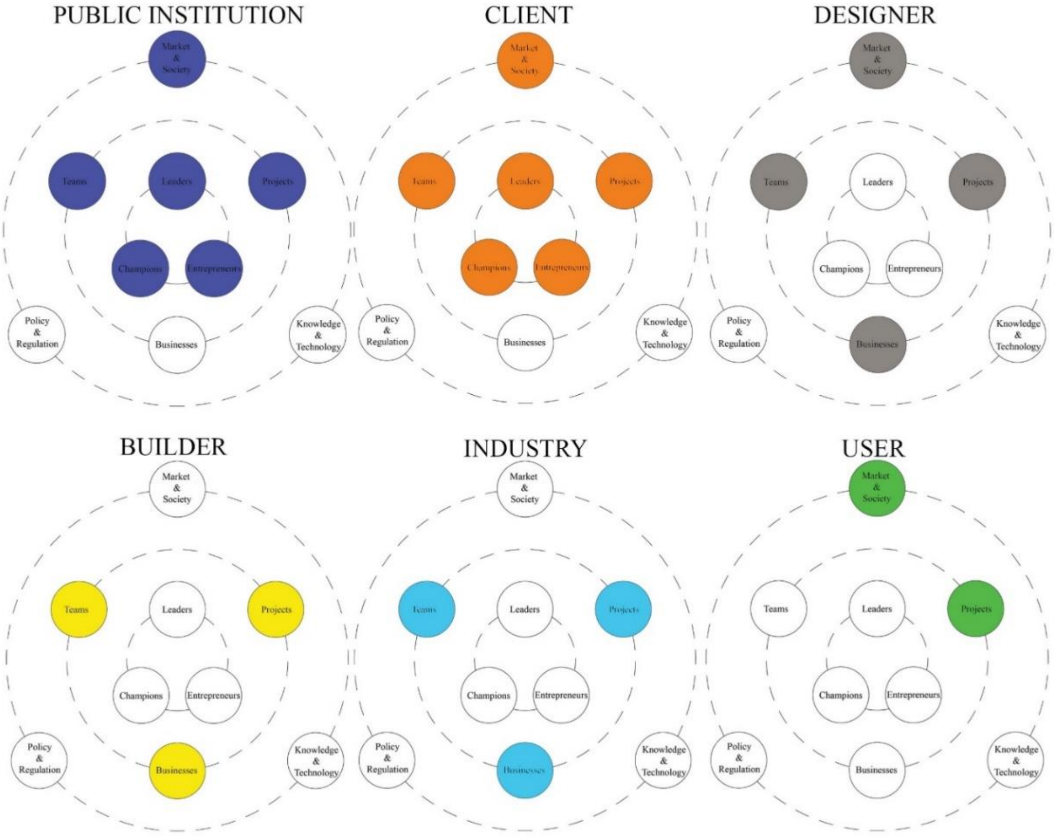


Figure 8: The image above shows an example of graphical output of the role of each actors within the eco-innovation levels of the eco-innovation and sustainability management model

4.5 Analysis and discussion

Once all data were collected and assessed, the evidence produced for each case study was analysed and discussed. The analysis of the outcomes produced were analysed according to a collaboration of two of the five analytical techniques explained by Yin (2018). Specifically, the techniques utilised were 'pattern-matching' and 'explanation building'. Pattern-matching is defined by Millis, Durepos and Wiebe (2010) as:'*...the comparison of two patterns to determine whether they match (i.e., that they are the same) or do not match (i.e., that they differ). Pattern matching is the core procedure of theory-testing with cases'*. For all the case studies analysed, patterns of innovation types and impacts, roles of actors, and sustainability results were explored. Moreover, such patterns were integrated by the analysis conducted with the 'explanation building' technique, in which each case study was explained by building an explanation about it, through the narrative of its development. This type of technique was crucial to understand the role of context in influencing the patterns explored with pattern-matching. In conjunction with these two types of analytical techniques, it was also carried out an observation of the relation and links between building process characteristics and process and the emergence of specific patterns of innovation (type and impact), roles and responsibilities and sustainability results (as showed in the scheme below). These analysis were crucial to the possibility of teasing out the importance of the links and dynamics that contributed the introduction of sustainable innovation in the case study selected and to determine a final chart of significant connections between all these aspects that can be used as base to determine guidelines for the strategic introduction of sustainable innovation in the industry. Such chart will be presented in chapter 6, together with the other findings of this work.

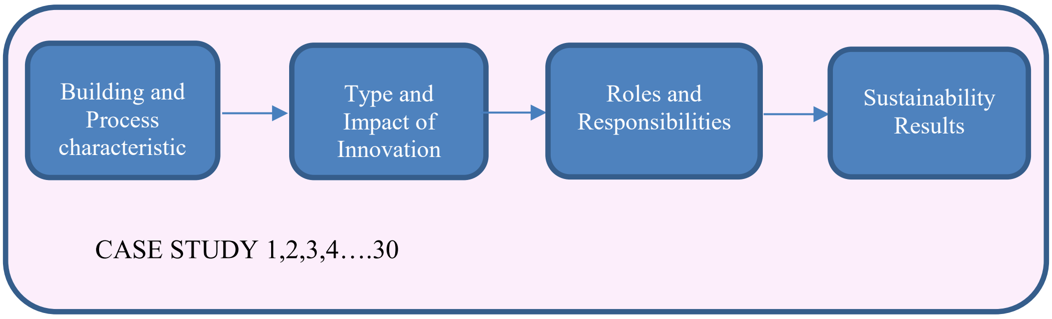


Figure 9: The image shows the research steps

4.5 Sharing Results

As suggested by Yin (2018), the methodology developed was shared among fellow academics in International Conference and International Journals, in order to test further its validity. The work explained in this chapter was progressively tested, presented, and published in the following conferences and publications:

Nigra, M., Dimitrijevic, B., (2018). Is Radical Innovation critical to Sustainable Architecture? Lessons from three Scottish Contemporary Buildings. *Architectural Engineering and Design Management*. Vo. 14, Issue 4. Pp. 272 – 291.

Nigra, M. (2017). Complexity Theory as an Epistemological Approach to Sustainability Assessment Methods Definition. IN: *Proceedings of the 21st International Conference on Engineering Design (ICED17*), Vol. 5: Design for X, Design to X, Vancouver, Canada, 21.-25.08.2017, ISBN: 978-1-904670-93-3, ISSN: 2220-4342

Nigra, M., Grosso, M. (2018). *Design of Complexity in Sustainable Projects. Fifteen Final Design Thesis of Architecture and Sustainability*, Maggioli Editore

Nigra, M. (2017). Fifty Shades of Green; an empirical analysis of sustainable design approaches in fifty case studies of contemporary architecture. IN: *Proceedings of the of 33rd PLEA International Conference*, Vol. 1: Design to Thrive, Edinburgh, 2th-5th July 2017

Nigra, M., Grosso, M., Chiesa, G., (2015). Integrated Approach to Sustainable Building Design Programming IN: *Sustainable Built Environment, Towards Post-Carbon Cities*, Dipartimento Interateneo di Scienze e Politiche del

Territorio Politecnico e Università di Torino, Torino 18-19 February 2016, pp 7, 25-31, SBE2016 SPECIAL ISSUE JULY 2016 ISSN 2283

Nigra, M., Chiesa G., Grosso, M., (2015). Exploring methods to increase the Efficiency of the integration between design process and environmental systems: an education and research experience, IN: *Living and Learning: Research for the Better Built Environment.* Architectural Science Association and Faculty of Architecture, Building and Planning, The University of Melbourne, Australia, Living and Learning: Research for a Better Built Environment, 49th International Conference of the Architectural Science Association, Melbourne, AU 2-4 December 2015, pp 10, 778-787, ISBN: 978-0-9923835-2-7

Grosso, M., Chiesa G., **Nigra, M.,** (2015). Architectural and Environmental Aspect for Technological Innovation in the Built Environment IN: *Heritage and Technology. Mind Knowledge Experience* La Scuola di Pitagora XIII International Forum Le Vie dei Mercanti, Capri 11-13 June 2015, pp 10, 1572-1581, ISBN: 9788865424162

In line with Yin (2018), the chapter has explained the methodological approach and methods defined to undertake this research (figure 1). The chapter has explained the rationale of selecting the case study approach. The case study approach is here utilised in its qualitative meaning. Specifically, such approach is aim at emphasizing the characteristics and value of the inter-relation between elements of a building as complex systems and the nature and impacts of sustainable innovation, rather than undertaking a quantitative assessment of these latter. Yet, as it will be explained in the conclusions, the quantitative assessment of such inter-relations will represent a possible direction of future research topic, and in particular to set the basis for the analysis of a statistically significant set of samples of building projects.

Moreover, in this chapter, the research design was demonstrated by breaking down all the theoretical backbone that formed the overall approach. The chapter has also explained the research preparation and the pilot study conducted, and the methods used to collect data and carried out the research. It was also discussed the analytical logic utilised to read the evidence and output for the case studies analysed, and lastly it has mentioned the list of academic output produced to share the rationale and outcomes of the methodological approach. The next chapter will present the analysis carried out on each case study, according to the methods explained in this chapter.

Chapter 5

Case Study Analysis and Results

The chapter presents the analysis of the innovation type, sustainability results, and actors involvement in each case study analyzed, as explained in the previous chapter. In this chapter, the case studies are organized according to geographical context, starting from the European context, and following by the Australasian, South American, African, and North American contexts. For each context a brief introduction on the local sustainability policies and approaches in the building industry are presents, to set the premises to understand the rational of the strategies and the decisions made in terms of innovation introduction for each project.

5.1 The European Context

In the European context, the evaluation of sustainability of buildings is dealt with a suite of European Standards, Technical Specifications and Technical Reports developed within the CEN Technical Committee 59.

These European Standards are intended to support the decision-making process and documentation of the assessment of the environmental performance of a building according to the framework shown in Figure 10.

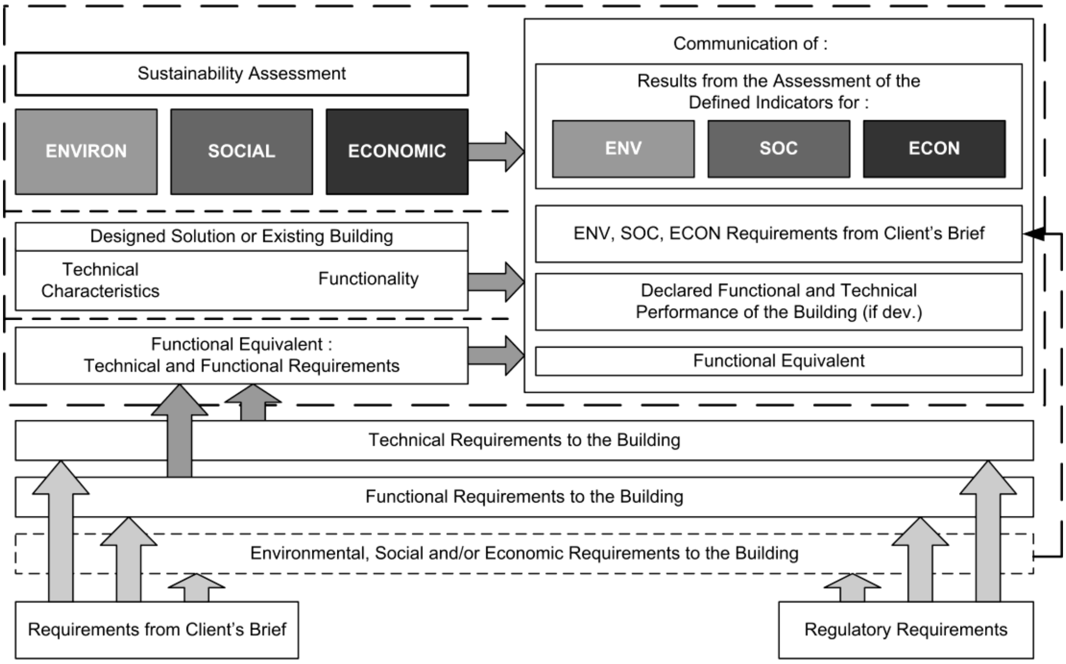


Figure 10: Concept of sustainability assessment of buildings

In these European Standards, the assessment method for the quantitative evaluation of the environmental performance of the building is based on a life cycle approach. These standards are divided in various levels as shown in Figure 11.

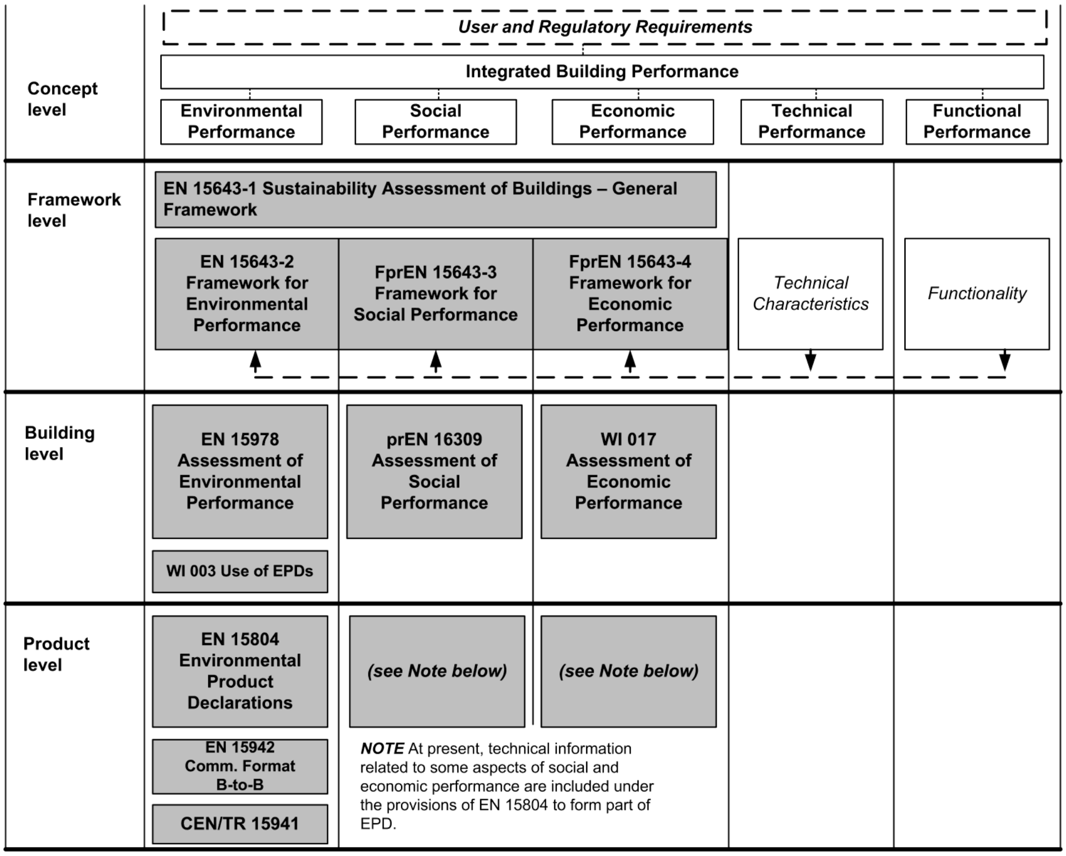


Figure 11: Work program of CENT/TC 350

Data and information related to the various indicators are documented and classified based on a modular scheme. These standards do not consider application of aggregated indicators nor weighted assessment, which are deemed possible at countries' legislation level. Aggregation and weighting of indicators for performance scoring and classification are typical of assessment tools such as BREEAM, LEED, ITACA, etc.

England, UK

With the Climate Change Act, the United Kingdom adopted in 2008 the first legally binding framework to tackle climate change. Such act set the premises for the creating of new powers, defining institutional frameworks, and establishing a system to ensure accountability in resilience to climate change. Moreover, The key provision is the creation of a legally binding commitment to cut emissions of greenhouse gasses by at least 34% by 2020 and by 80% by 2050 compared with 1990 levels. (Design Building, 2018). The legislative framework in UK is organized with Primary legislation (Acts or Orders), Secondary Legislation (Regulations), and Policies. Among the primary legislation, UK adopted a number of Acts such as: Climate Change Act, Environment Act, Agricultural Land (Removal of Surface Soil) Act, Clean Air Act, Clean Neighbourhoods and Environment Act, Natural Environment and Rural Communities Act, Flood and Water Management Act, Water Act, and a number of other local specific orders. The secondary legislation spans from the Building Regulation, to the Building Regulations, Conservation of Habitats and Species Regulations, Contaminated Land (England) Regulations, Control of Asbestos Regulations, Control of Noise (Codes of Practice for Construction and Open Sites) (England) Order, Control of Substances Hazardous to Health Regulations, Controlled Waste Regulations Energy Efficiency (Refrigerators and Freezers) Regulations, Energy Performance of Buildings (Certificates and Inspections) (England and Wales) Regulations, Energy Related Products Regulations, Environmental Permitting (England and Wales) Regulations, Environmental Protection (Controls on Ozone-Depleting Substances) Regulations, Fluorinated Greenhouse Gas Regulations., Hazardous Waste (England and Wales) Regulations, Notification of Cooling Towers and Evaporative Condensers Regulations, Site Waste Management Plan Regulations, Town and Country Planning (environmental impact assessment) (England and Wales) Regulations, W (England and Wales) Regulations, Waste Management Licensing Regulations, Waste Management (England and Wales) Regulations, and Volatile Organic Compounds in Paints, Varnishes and Vehicle Refinishing Products Regulations. A number of policies and institutions have also been set up to assist in the actualisation of such legislative framework. Policies such as the CRC Energy Efficiency Scheme, the Zero Carbon policies, and the Carbon Remission Reduction Target Policy have been set to provide instruction and guidelines to the industry, Moreover, organizations such as the Building Research Establishment (BRE) have been set up to help set best practice for the environmental performance of building, through design, specifications and construction. BRE adopted the environmental assessment method named BREEAM, which set benchmarks for standard categories of development, by scoring aspects such as: energy, land use and ecology, water, health and wellbeing, pollution, transport, materialism waste and management.

Italy

In the last decade, the regional energy consumption and sustainability norms for buildings in Italy have been extensively developed, on the basis of the input provided by the European Community with the directives 2002/91/CE and 2006/32/CE, as well as by the National legislative decertation D.Lgs. 19 August 2005, n.2005, n.192, and s.m.i.. The evaluation of sustainability of buildings in Italy follows the European track by adhering to the work carried out by CEN TC59 through the dedicated working group 2 of UNI's Technical Committee on building construction. In addition, UNI developed a PdR (Prassi di riferimento) – a procedure easier to be applied than a standards – related to the operational assessment of environmental sustainability of buildings (UNI/PdR 13:2015). This procedure includes a protocol developed and applied at regional level, called ITACA, based on a multicriteria approach using weighted indicators and a quantitative scoring system.

Regarding legislation, two Decrees – the Legislative Decree n. 28/2011 and a Ministries' decree of 26 June 2015 – converted, respectively, the European Directives 2009/28/EC on the promotion of renewable energies, and 2010/31/EU on the energy performance of buildings. The latter is implemented though the UNI technical standards of the series 11300.

Another legislative act – Decree 11/10/2017 of the Ministry of Environment – regards environmental minimum criteria (CAM) to be applied to the commission of services for design and new construction, refurbishment, and maintenance of public buildings.

While the latter, for public buildings, and the decree on building energy performance, for all buildings, set mandatory rules and criteria to be compliant, the application of all other standards is voluntary as the European ones. This poses serious hindrances for the growth of actual and diffused sustainable construction projects

Scotland, UK

Scotland, like many other European countries, has responded to the call for sustainable development with a number of strategies that included the engagement of public institutions, private entities, professional practices and universities. The Scottish Government has published a number of laws, policies and strategic recommendations for creating more sustainable built environment such as the Low Carbon Building Strategy for Scotland in 2007 (updated in 2013) (Scottish Government, 2013a), the Climate Change (Scotland) Act 2009 (Scottish Government, 2009a), Scotland's Climate Change Adaptation Framework (Scottish Government, 2009b), and the Energy Efficiency Action Plan (Scottish Government, 2010). These recommendations aimed to revise and set new building standards and stimulate innovation, by exploring a wide range of topics, such as setting CO2 emissions reduction targets, defining sustainable delivery processes, suggesting more inclusive delivery processes, promoting the design of low carbon buildings, and suggesting technological solutions. Scotland's architectural practices have responded by establishing the Scottish Ecological Design Association (SEDA) which aims to promote "design of communities, environments, projects, systems, services, materials and products which enhance the quality of life and are not harmful to living species and planetary ecology" (SEDA, 2010) by undertaking research and producing publications, and by supporting a high number of projects developed under the aegis of sustainability. The recent SEDA publication '100 Sustainable Scottish Buildings' (Atkins and Stephen, 2017) presents a number of contemporary building projects that evidence the efforts of Scottish architects in answering the call for sustainable development, in the social, economic and environmental areas. Scottish universities undertake research in sustainable building design and collaborate with practitioners through knowledge exchange projects such as CIC Start Online (2009-2013), which produced 70 reports on feasibility studies and academic consultancies and disseminated them through interactive webinars, online conferences and articles, including a book which provides an overview of all the outputs (Dimitrijevic, 2013).

Spain

The Eco-Innovation Observatory of the European Commission (2015) explained the sustainable innovation introduction in Spain remains one of the worst within the European context, due to lack of investment in R&D. Although, this lack of investment, Spain performs better in the eco-innovation output with regards to resource efficiently, material productivity, greenhouse gas emissions. Moreover, the Eco-Innovation Observatory of the European Commission (2015) reported that Spain performance in the socio-economic outcomes is 5% above the European average. The policy to support the introduction of innovation is embedded in the first and second generation codes in National and Regional policies. Such policies target pollution control, energy efficiency, environmental innovation, clean technologies, and production. Moreover, The National Plan for Waste Management 2016-2020 set a framework for circular economy, by calling for eco-design, waste management strategies, green engineering, energy efficiency, urban greening, sustainable construction, urban water system, and water management. Yet, the lack of public and private funds, the loss of qualified human capital due to the recent recession and to emigration represents major barriers in Spain for the introduction of sustainable innovations.

The Netherland

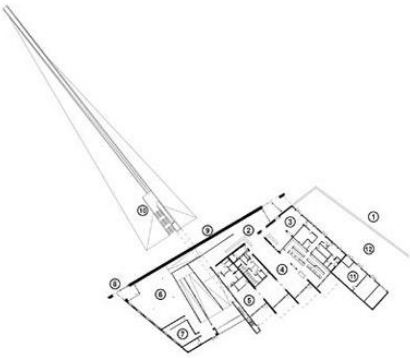
The environmental legislation in The Netherland is derived for the 80% from the EU legislation. In particular, the EU regulations that have major impact in The Netherland are the Climate Change Agreement, in which the target of reducing the greenhouse gases in 2020 by 20% on 1990 levels have been set; and the

Sustainable Consumption and Production Plan to stimulate sustainable production and consumption in key economic sectors such as food, transport, and energy (Government of the Netherlands, 2018). Bossink (2011) explained that since 1989, a number of policies have been released to limit the natural resources exploitation, which used to be 44% of the national energy consumption. The Brundtland's report (1989) inspired the government to promote more than 200 green initiatives from 1989 to 2008, between demonstration projects, and dwellings. Over this time, as explained by Bossink (2011) the role of the Dutch Government moved from the one of driving forces to the one of innovation controller, by releasing policies to encourage traditional approaches in the industry to embrace the search for sustainable innovation.

5.1.1 Culloden Battlefield Visitor Center, Culloden Moor, Scotland, UK – Building characteristics

Culloden Battlefield Visitor Centre
Culloden Moor, Scotland, UK
Gareth Hoskins Architects
2007

Context Characteristics:	Rural
Concpet Characteristics:	Integration with landscape and Jacobites moves during battle
Orientation:	North-West/South-East
Dimension:	2400 sqm
Shape:	Double L plan layout. The volume follows the main orientations of the landscape
Floor number:	Single floor with accessible roof
Access and circulation:	Circulation is either external or internal to see the battlefield or the building as part of the visiting experience to recreate the movement of the battle of the Jabobite clans
Structure:	Steel frame on concrete slab
Construction systems:	Highly insulated timber walls and roofs. External walls are mainly clad with untreated Scottish Larch and Caithness Stone
Evironmanetal control systems:	Natural light and high efficiency lighting with automatic lighting controls Massive Insulation and a fully automated woodchip boiler system A passive ventilation system was developed, combining opening windows and low-level vents, with high-level ventilation via parapets and roof cowls.
Water treatment:	Low flush toilets, infrared controlled urinals and water saving taps are used throughout the building
Awards:	The Civic Trust & Commendation, RIAS Andrew Doolan Award Best Building in Scotland, World Architecture Festival, the Wood Awards, Inverness Architectural Association Award, Glasgow Institute of Architects Award, RIBA Awards Regional Awards, Scottish Design



Project delivery

The Culloden Battlefield Visitor Centre was designed by Gareth Hoskins Architects and completed in 2007. The brief for the project was to highlight the huge impact the Battle of Culloden had on the history of Scotland. Specifically, the brief called for the restoration of the Battlefield to how it looked in 1746 and the construction of a state-of-the-art visitor centre with an interactive exhibition that could enhance the historic value of the site, celebrate the memory of a very significant event in Scottish history, and introduce principles of sustainability in its design.

The building was awarded, mentioned, and shortlisted for a number of prizes including: the Civic Trust & Commendation, RIAS Andrew Doolan Award Best Building in Scotland (Special Mention), World Architecture Festival (Culture - Shortlisted), the Wood Awards (Highly Commended), Inverness Architectural Association Award (Shortlisted), Glasgow Institute of Architects Award (Winner), RIBA Awards Regional Awards (Shortlisted), Scottish Design Awards (Finalist for Best Public Building and Northern Exposure). These awards highlighted a range of achievements such as: the building's completion within budget; an interpretative journey of the historic events through well-designed circulation in and outside the building to celebrate the memory of the historic event; application of environmental design principles in the building orientation; optimal use of the micro-climatic characteristics of the site; and the use of local building materials and passive environmental design strategies.

As the building is situated in a conservation area, Historic Scotland, Scottish National Heritage, the Royal Fine Arts Commission and The Highland Council had to be consulted. The consultations greatly influenced the design choices due to a number of strict parameters for building location, height, views and materials (Sust. Architecture + Design Scotland and Forestry Commission Scotland, 2010). The orientation of the building was decided according to the passive house design approach, the relation between space organisation and lighting, heating and ventilation. Specific decisions, such as the building orientation, contributed to the overall design and functions of the environmental control systems, allowing the passive house approach, which led to positive environmental results in terms of reduction of GHG emissions and quality of both indoor and outdoor spaces. The building layout and circulation routes in internal and external spaces are organised around the narrative of the progression of the historic events of the Culloden Battlefield. These design decisions enhanced the communication of historic facts (Bennet, 2008). The design aspects contributed to creating a significant social impact as the building is recognised as an important monument commemorating a battle that is identified as significant for Scottish identity and history. Local building materials, such as stone and timber, were largely used. This design decision affected other decisions regarding the construction systems and details, as well as manufacturing and construction methods. The use of local timber produced positive results in terms of sourcing materials within a limited radius, and therefore reducing GHG emissions, as well as stimulating local economy and industry by triggering new manufacturing processes, exploring new products, and learning new building techniques.

Innovation types and impacts

The analysis undertaken showed no radical innovation in the building design. System innovation occurred in the building concept, shape, building services and type of construction. The integration of building systems, orientation, shape and type of construction contributed to achieve sustainability results, such as the GHG emission reduction, as well as to provide a pleasant indoor environmental quality, which contributed to the positive results on the social level as well. The social results are very significant in this project, which represents an achievement in trying to fill the gap between the historical perceptions of the battle of the parties involved. This was possible because of the architectural characteristics, such as the volumetric organisation of the building and its size, as well as the building shape and the circulation, which represent architectural innovations. All these aspects enabled creating a unique space for the visitors, who are guided through internal and external spaces to understand better the meaning of the Culloden battle. The selected construction materials contributed both to the application of a passive energy system, and to the increased economic activity of the local industries. This latter benefitted from the generation of both comparative and competitive advantage (Maneschi, 1998), by participating in a new innovative project and by augmenting their output in terms of production. Modular innovation occurred in specific components such as in the use of oiled British oak doors and windows. The building concrete slab and steel frames can be categorized as incremental innovation, as they comply with the standard practice, and therefore generate minimal impacts in terms of economic (Norman and Verganti, 2014).

Table 8: The table below shows the innovation type in the main areas of building characteristics. Architectural and system innovation are the most relevant on the project.

	Incremental	Modular	Architectural	System	Radical
Context Characteristics					
Architectural Design					
Construction Systems					
Secondary Elements					
Environmental Control Systems					

Table 9: The table below shows the impact that the innovation introduced in the building had on the actors involved. Designer and Builder had to undertake competence destroying activities.

	Competence Creating	Competence Destroying
Public Insitition		
Client		
Designer		
Builder		
Industry		
User		

The impact that the introduction of sustainability innovation had on project participant and process falls mostly within the category of competence creating. Although, the actors involved had to performe activities of problem solving, based on the implementation of their existing knoweldge, other aspects of the project triggered competence destryoing impacts on the activities of the actors involved. Such aspects were site characteristics, changes during construction process, contract type and maintenance. The peculiarity of the site characteristics pushd the architect and the client to expand knoweldge toward the historical characteristics, and the socio-political context in which the building was to be developed. The contract characteristics and the changes occurred during constructioin impacted onto the architect and the construction company, which both had to develop experience regarding efficiency of contractual matters, and sustainability technical solutions. These latter also impacted the maintenance process. For instance, leaking issues on the roof triggered the need of both architect and construction company to explore further technical solution and maitenance processes to overcome such problem.

Sustainability results

The type of sustainability results achieved in this case study are predominantly of environmental nature, both in building and process. The design approach of the building envisioned a number of environmental sustainability strategy that lead to the satisfactory results of the natural ventilation, the use of local materials. These aspects also impacted on the process, which was characterized by the stimulation of the local construction companies, manufactures and raw materials' suppliers, who participated to the project. Although, the architect highlighted that the contract type utilized on the project lead to a lack of economic advantage in the work organization within their firm, the other actors involved in the project had comparative and competitive advantage. The economic impact was therefore more characterized by the cost saving strategy on the building specification characteristics, rather than a strategic development in the building process. Significant result were also the social ones. The building characteristics were designed with the aim of communicating the socio-historical value of the building. This value was communicated in the visible feature such as accesses and circulation, beside the exhibition organization itself. The social value of the process is instead to be found in the inclusion of the local industry.

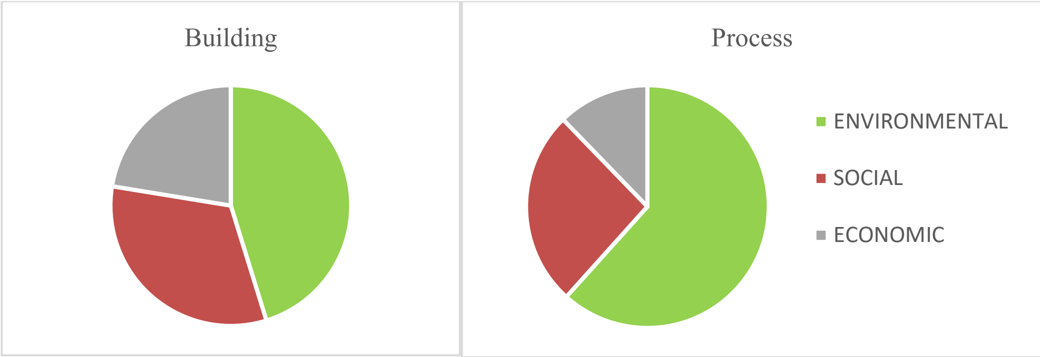


Figure 12: The images show the summary of the sustainability results in the project. The project is strongly characterised by environmental positive results.

The actors and the eco-innovation sustainability model

The actors involved on this project were public institution – that performed both the institutional role the one of client - architect and consultants, builder and industry. Despite, this project was of public interest, the community was not directly involved in the delivery process, but rather it was taken into consideration by the institutions and by the strategic social sustainability intent developed both by the client and by the architect.

The co-ideation level of this project was characterized by the public institution wanting to develop a project to commemorate one of the most crucial battle of the Scottish history, the one hold at Culloden, Inverness. The client was the National Trust of Scotland, which is a public entity that decided to launch the design competition for the new building. The public institution both in term of policy and client body acted as leaders in promoting the idea, entrepreneur and champions in setting the formal procedure to seek funds and launch the design competitions.

The co-innovation level was mostly characterized by the efforts of the architects, who had to negotiate the sustainability decisions, as well as collaborate on them, with the builders, Historic Scotland, Scottish National Heritage, the Royal Fine Arts Commission and The Highland Council. All these entities worked together on the project, and the builder mostly had a competitive advantage for its business, whereas the architects, despite the comparative advantage, suffer of a loss of time due to the type of contract they had which did not guarantee their experimental work in terms of sustainability.

The co-institutionalization level was characterized by great impact on a social level in the society due to the scope of the project, as well as the design characteristics that facilitate the communication of the project's aim. The project also represented an opportunity for knowledge and technological learning for the parties involved on the project.

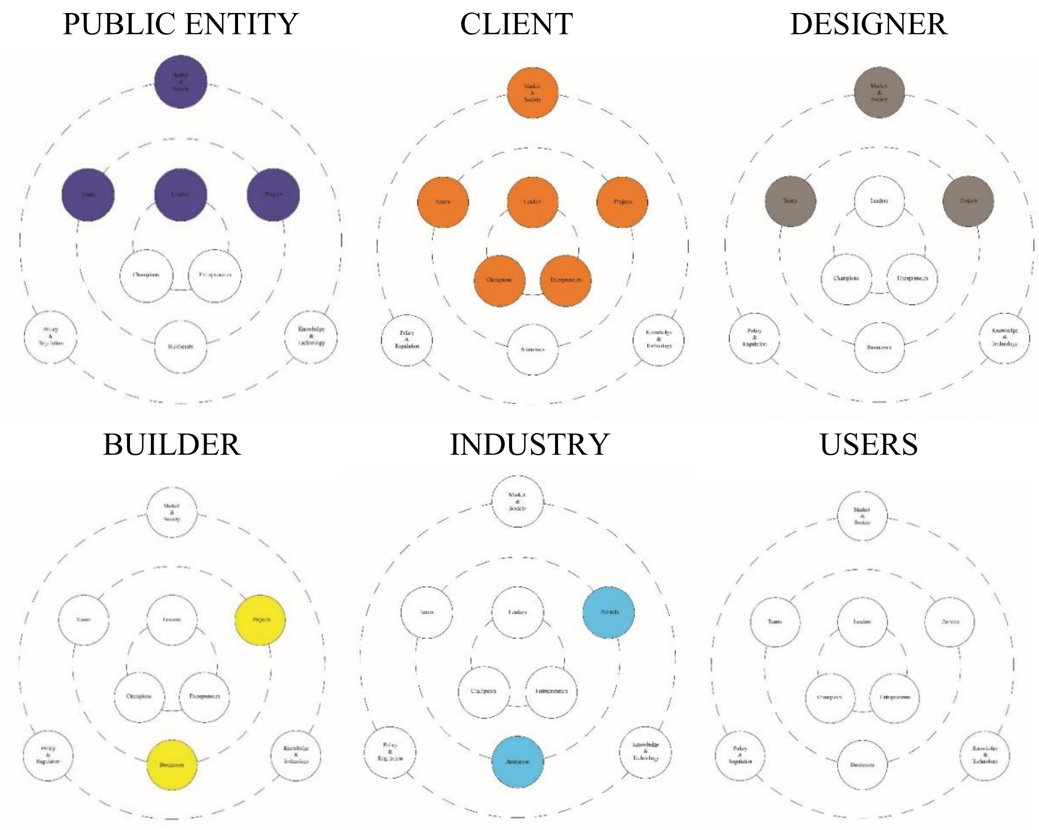


Figure 13: The images above show the role of actors in the project according to the eco-innovation and sustainability mode

5.1.2 South Lanarkshire College Low Carbon Teaching Building, East Kilbride, Scotland, UK – Building characteristics

South Lanarkshire Low Carbon Teaching Building
East Kilbride Scotland, UK
Austin-Smith:Lord
2014

Context Characteristics:	Within campus in a semi-rural area
Concpet Characteristics:	IBREEAM as environmental guidelines
Orientation:	North-East/Sout-West
Dimension:	above 500 sqm
Shape:	L-Shaped
Floor number:	Three floors
Access and circulation:	Stairs and main corridor located to optimize solar exposure
Structure:	Steel frame on concrete slab
Construction systems:	Facing brickwork, cavity, breath membrane, plywood, recycled paper insultation, timber battens, gypsum duraline plasterboard
Evironmanetal control systems:	Natural Ventilation via openeable windows in the North, East and West, combined with stack ventilation in the corridor and in the atrium Assisted mechanical ventilation is also provided Underfloor heating system with heat pump LED lighting fittings BMS system to control and monitor the rest of the building service
Water treatment:	Dual flush toilets, flow restrictors on all taps, leak detection on all incoming water supplies Rainwater harvesting collection
Awards:	BREEAM 'Outstanding' rating for the design stage

Delivery process

The South Lanarkshire College Low Carbon Teaching Building was designed by the Scottish firm Austin-Smith:Lord. It achieved the BREEAM 'Outstanding' rating for the design stage under the 2014 Scottish Building Standards, and opened in 2016. The building achieved significant positive environmental, economic and social results. Specifically, it achieved a 100.8% reduction in CO2 emissions compared to the 2010 legislative requirements for reducing emissions of GHG (South Lanarkshire College, 2016). It was completed within the budget. The project and the building were and still are used as a learning experience both by the client team and the students who monitored the building performance as part of their teaching and learning curriculum. The reduction in CO2 emissions was achieved by ensuring that building orientation enables an optimal use of the micro-climatic site conditions, as well as by installing high levels of thermal insulation, a ground source heat pump, photovoltaic panels and a rainwater harvesting system. The selection of building materials aimed to reduce the heating load requirements by using building thermal mass to prevent internal overheating. The reduced heating load and the installation of renewable energy generation systems make the building 'carbon neutral' in operation. To achieve these results, the design focused on optimal building orientation and internal layout (specifically, by distributing corridors and rooms so to take a maximum advantage of micro-climatic site characteristics). In addition, the selection of construction systems and specification of building materials and elements (by relying on the use of traditional technologies such as steel structure, plywood sheeting boards, recycled concrete blocks, brick, weatherboard, recycled paper for insulation); and high-quality doors and windows (openable windows and electrically secured door locks) contributed to the achievement of environmental goals. The solutions adopted represent examples of careful architectural design accompanied by innovative construction system, ventilation and heating systems, and windows that, as a whole, contribute to the desired environmental results without impinging on the economic aspects of the project, established in the initial budget. As the client and the end users participated in the project development (at many design reviews, in the briefing stage of the project, and during construction through a number of site visits planned as teaching and learning experience for the future building users), there was a greater social inclusion both in envisioning, developing and using the building, which is perceived today as a learning experience in the application of sustainable design principles.

Innovation types and impacts

In the case of the South Lanarkshire College Low Carbon Teaching Building no radical innovation in architectural design was identified. Most of the innovation in the building corresponded to the definition of 'system innovation' (Henderson and Clark, 1990; Slaughter, 1998). For instance, innovations in building services, such as the use of heat pumps, the underfloor heating system, the ventilation system, the walls stratigraphy and rainwater treatment created a system of multiple innovations to increase the environmental performance of the building. Beside contributing to the indoor quality of the environment, this system of innovation also had an impact on the social level by becoming an example for the teaching and learning activities undertaken in the building. Modular and architectural innovation also occurred in architectural characteristics (e.g. dimensions and shape) or structure (construction details) that maintained, in the instance of innovation impact, their independence from the rest of the building. Building components such as the roof, the partitions, and the outer envelope contributed to the environmental performance of the building, as well as to the social domain, both by contributing to the indoor quality of the environment, and by providing visible features to communicate the sustainability principles on which the building design was based. Construction systems such as a concrete slab for foundations and steel frame as a loadbearing system fall into the category of incremental innovation, as they are standard solutions commonly utilized in the industry. Within the economic domain, the project had a positive impact in terms of complying with the set budget and by providing an experience for the team at work (knowledge acquisition), and therefore developing a comparative advantage.

Table 10: The table shows that incremental, modular, architectural and system innovation types were introduced into the building

	Incremental	Modular	Architectural	System	Radical
Context Characteristics					
Architectural Design					
Construction Systems					
Secondary Elements					
Environmental Control Systems					

Table 11: The table below explains that competence destroying activities were undertaken by the client, the designers (architects), and by the users

Actor	Competence Creating	Competence Destroying
Public Insititution		
Client		
Designer		
Builder		
Industry		
User		

The innovative feature of the building triggered competence creating processes for the actors involved in the process. To a certain extent the client had to undertake some competence destroying activities, since they have to become familiar with the design and delivery process of a building through the numerous workshops and meeting done during the design process. Similarly, the architect had to learn new competencies in terms of people management within the workshops, as well as in the process of designing the building according to the BREAM requirements. The users, namely the students of the future Low Carbon College, undertook competence destroying activities in learning from the building construction, and from the use and maintenance of the built project.

Sustainability results

The sustainability results of this project are largely of environmental nature. This project had in fact achieved one of the highest score in the BREAM scheme in the last decade within the UK. Most of the design decisions were taken with the aim of optimizing the micro climatic conditions and utilize low impact locally sourced materials. The project both in the building design feature and in its process had a strong social characterization. From its early phase the client and the users were involved, not only during meeting and design phase, but also during construction and throughout the building life cycle as part of the learning and teaching program of the school. The economic results were also positive, as the project was reported to be completed within budget and by representing a significant knowledge acquisition experience for all the actors involved in its development.

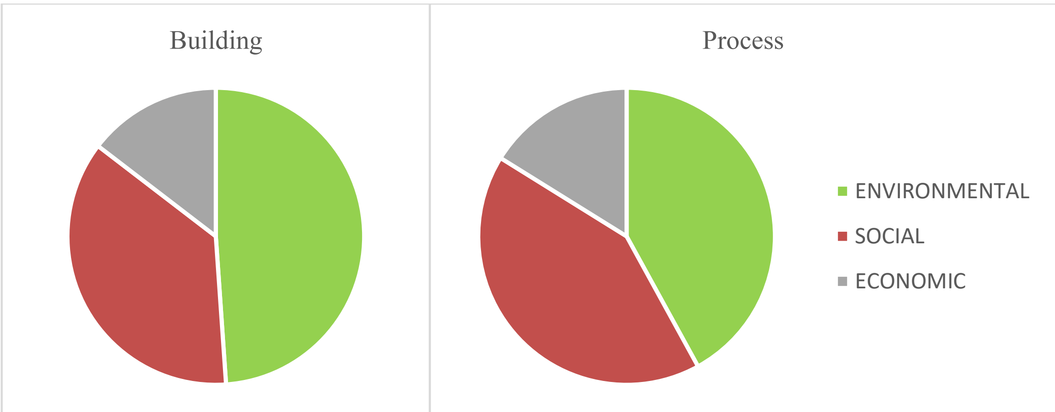


Figure 14: The images show the summary of the sustainability results in the project. The project is strongly characterised by environmental positive results, as well as social inclusion especially during the delivery process.

The actors and the eco-innovation sustainability model

The actors involved in the South Lanarkshire project took part into a participated design and delivery process, which involved client, designer, builder, industry and users. During the co-ideation phase the client undertook the role of leader, champion and entrepreneur. The South Lanarkshire College acted as promoter for the project, as well as determined specific line guides and requirements in the briefing process. They also created the links and teams that were required to achieved the desired objectives. The co-innovation phase represented the most innovative part of the delivery process of this project, in which extensive collaboration have been done between designers, builder, industry, users and client. This intense collaboration generated an impact on the co-institutionalization phase, which was characterized by knowledge and technology development.

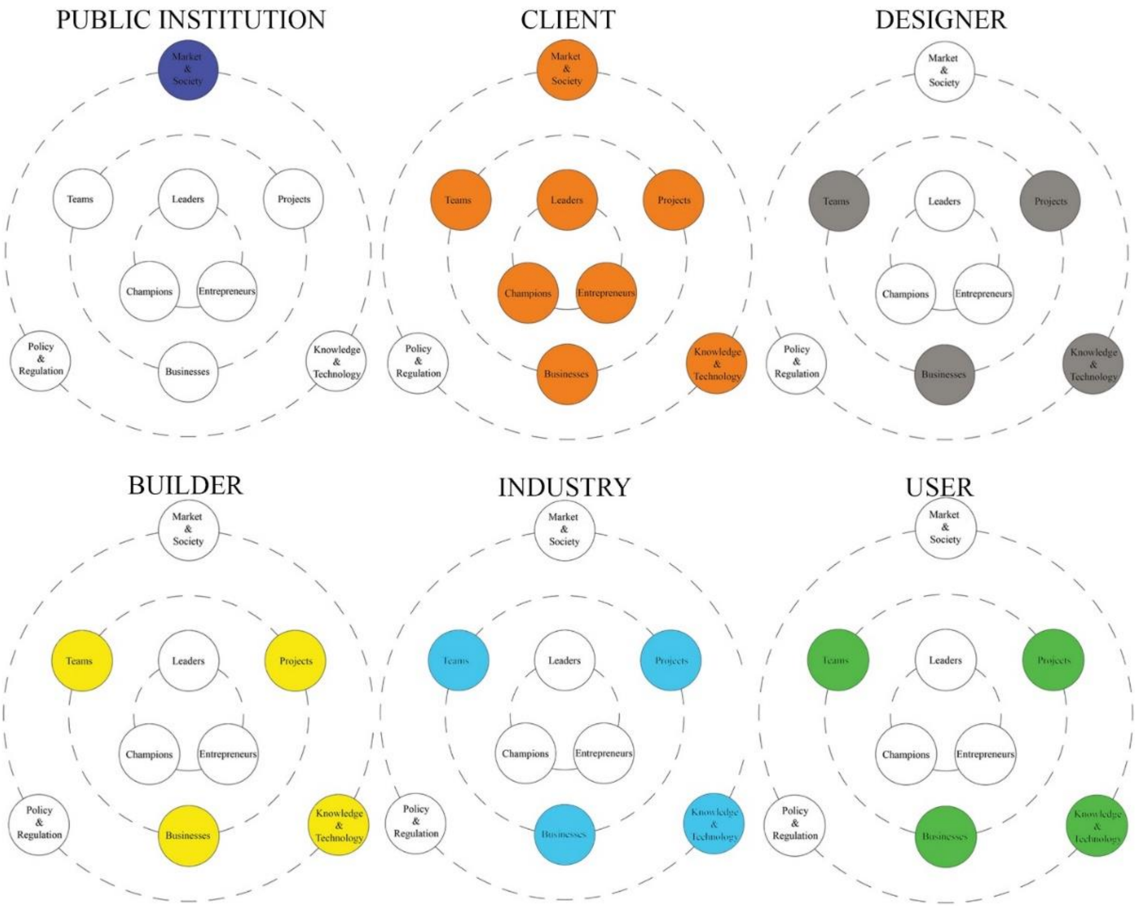


Figure 15: The images above show the predominant role of the client in all the phases of the innovation introduction process. The public entity had a limited role by only setting the ground for future project development, while designer, builder, industry and users had an equal role in the participated design and delivery process of this building.

5.1.3 The Robert Burns Birthplace Museum, Alloway, Ayr, Scotland, UK – Building characteristics

Robert Burns Birthplace Museum
Alloway, Ayr, Scotland, UK
Simpson & Brown Architects
2010

Context Characteristics:	Semi-Rural
Concpet Characteristics:	Orientation of building axes in relation to other significant places of the life on Robert Burns in the close area of its birthplace and passive house strategies
Orientation:	North-West/South-East
Dimension:	500 sqm
Shape:	Rectangular symmetric plan
Floor number:	Single floor
Access and circulation:	The existing walkway bordering the main road and linking the Cottage Site at the north end of the village and the New Museum Site at the south end, has been enhanced, as well as access points to existing paths
Structure:	Timber strcuture on concrete slab
Construction systems:	South-East elevation is glazed, while the rest of the envelope is clad with untreated Scottish Douglas-fir horizontal boards
Evironmanetal control systems:	This naturally tempered air enters the building via a basement plant room where additional cooling or warming is provided by the ground source heat pump system installed under the new car park on the North-east side of the site. The air filling the gallery space circulates by natural convection, or 'chimney stack effect' assisted by fans when required. Black box quality of the space has offered absolute control to lighting of the exhibition space
Water treatment:	Standard

Delivery process

The Robert Burns Birthplace Museum was designed by Simpson & Brown Architects and commissioned by the National Trust of Scotland to celebrate the birthplace of the Scottish poet Robert Burns. The brief for this project called for a high degree of attention toward sustainability, encompassing environmental, economic and social aspects in the design of a new museum, as part of the master plan for the Burns National Heritage Park. The aim of the master plan was to link together and enhance the experiences of visiting the places related to the poet's life. The building is designed on the intersection of the axes that symbolise the connection between the museum and the existing Burns Cottage (the original place of birth of Robert Burns), which is located not far away in Alloway, Ayr. The sustainability goals were achieved by using passive house environmental control strategies and local materials; carefully designing the building orientation to maximise the exposure to natural light and ventilation; expressing aesthetics that relate to sustainability principles, such as the use of local materials; and including the local community by providing educational, recreational and gathering spaces. Local building materials, such as untreated timber, communicate the environmentally sustainable design approach. The orientation of the building made it possible to organise the layout and spatial distribution in order to optimise natural lighting and ventilation by exposing the opening to favourable wind directions and lighting conditions, e.g. the window in the South-East elevation. The context characteristics and the building orientation influenced the specification of environmental control systems, the selection of doors and windows, and architectural design. The Main Gallery has an open plan in which natural light and lighting systems are combined to control their impact on the artifacts exhibited in the museum. The shape of this gallery also enables natural ventilation through a 'stack effect' in combination with fans. This system brings air from the gardens and circulates it through the building via concrete pipes buried two meters below ground, providing cooler air in summer and warmer air in winter due to the constant temperature of the ground at this depth. Moreover, this process allows for a better control of humidity levels and reduces heating input. The ground source heat pump also provides warm water for the underfloor heating system in public spaces. The reception hall and the café have natural ventilation and light. The whole structure is clad with untreated Scottish Douglas-fir horizontal boards, sourced and processed in Moray, which is close to the museum. Timber is also largely used in the building to underline the transition between spaces and to create links with the overall architectural design characteristics. As in the previous case study, the use of Douglas-fir stimulated local production and manufacturing. The architectural shape and layout are organized in a way that enables different circulation and use of the building. The main hall, café and an external pergola facing the gardens are used largely by the community for a number of events during the year, independently from the regular museum activities. These design features support social inclusion and sense of belonging, not only due to the building's role in celebrating a local poet, but also by providing a gathering space.

Innovation types and impacts

Radical innovation was not found in the project. Instead, system innovation was detected in the areas of architectural design characteristics and building services. For instance, the building orientation contributed to develop a passive energy design approach for the building, which was actualised also by using natural ventilation and heat pumps. These individual innovations, by working as a whole system, contributed to the achievement of positive environmental sustainability results, such as the GHG emission reduction, and the achievement of a positive indoor air quality as by code. Moreover, the architecture characteristics of the building, such as the spatial organization and the relation between opaque and transparent envelop surfaces helped defining a space for the local community use within the museum. Positive environmental impact is achieved by the use of local materials such as the Douglas-fir, mainly for the structural elements, or the European redwood panels and recycled paper for thermal insulation in external walls. Along with the positive environmental impacts, the selected materials had a positive economic impact for the local industry and a positive social impact as they contribute to create an image of sustainable architecture to communicate its value to the users. Architectural and system innovations have produced not only positive environmental results, but also beneficial social and economic impacts. As in the previous case study, the use of local materials has produced both comparative and competitive advantage for the local industry participants who took part in the building realization. Moreover, the project had a strong social impact by generating extra benefit for the community, providing not only a museum but also a gathering space.

Table 12: The table shows the innovation type on the project. System innovation is present in the architectural characteristics, access and circulation and environmental control systems, whereas the other part of the building components are either characterised by modular, architectural or incremental innovation.

	Incremental	Modular	Architectural	System	Radical
Context Characteristics					
Architectural Design					
Construction Systems					
Secondary Elements					
Environmental Control Systems					

Table 13: The table shows that competence destroying activities were undertaken by the designer, the builder and the industry.

Actor	Competence Creating	Competence Destroying
Public Insititution		
Client		

Designer		
Builder		
Industry		
User		

The innovative features of the project, such as architectural characteristics, access and circulation, and construction systems, influenced the process in the coordination of local production, worksite organization and project management. This influence triggered competence destroying activities for the architects and to some extent for the builders and the industry, which had to acquire new knowledge regarding the specificity of the local material characteristics, as well as in their manufacturing and delivery processes. For all the other participant to the project the activities required only called for competence creating, based on their existing knowledge.

Sustainability results

A previously mentioned, the building project is characterized by a strong environmental approach, which can be identified in the use of local materials, and in the work conducted with the local industry. These strategies allowed the project to reduce GHG emission, as well as to stimulate the local industry, which could have market openings, knowledge acquisition, and comparative and competitive advantage, by participating on the project. This result is critical to show that environmental innovation can represent a medium to generate profit or benefits for the industrial partners on the project. The building is also characterized by strong social nature. The results in this area span from the celebration of the birth place of the National poet Robert Burns, and therefore help strengthening the national identity and its cultural value, to the inclusion of the community in the use of the project also beyond the scope that was initially envisioned for the building.

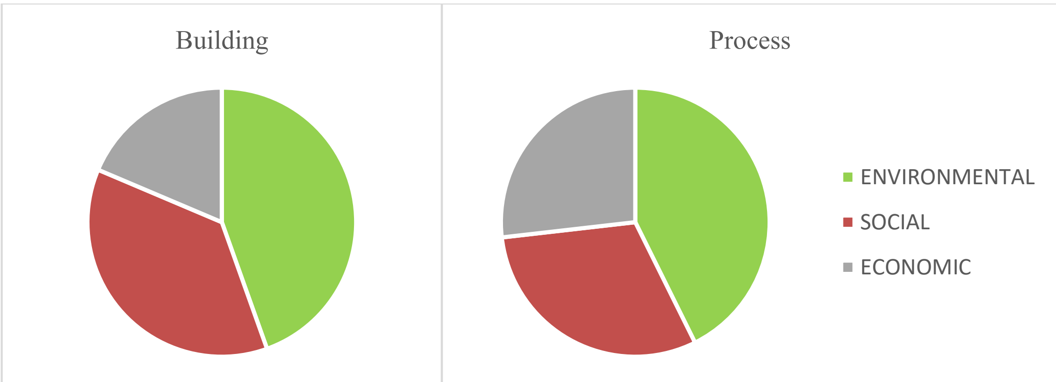


Figure 16: The diagrams show the distribution of environmental, social and economic results on the project.

The actors and the eco-innovation and sustainability model

The actors involved on the project were to different extent public institution, client, designer, builder, industry, and users. The co-ideation phase was dominated by the client, who acted as leader, champion, and entrepreneur. The National Trust of Scotland, as client, invested in the ideation, development and opportunity generation activities for a number of project to develop the cultural asset of the country. Among many, this project represented the celebration of one of the most relevant poet in the history of the country. With this aim, the National Trust of Scotland decided to promote the project for the birthplace museum and established the ground for the project definition, teams creation, and building delivery. The co-innovation phase was characterized by extensive collaborative work by the designers, builder, and industry (suppliers and manufacturer). They collaborated to design, define and deliver the specified technological system required on the building, which represented the main innovations on the project. The co-institutionalization phase was characterized by a remarkable impact on the society, both in terms of project nature and meaning, and in terms of community participation. Moreover, the project allowed the development of knowledge and technology for the participants, who could acquire new set of skills, as well as developing new technological system by relying on the use of local traditional materials, such as the Douglas- fir.

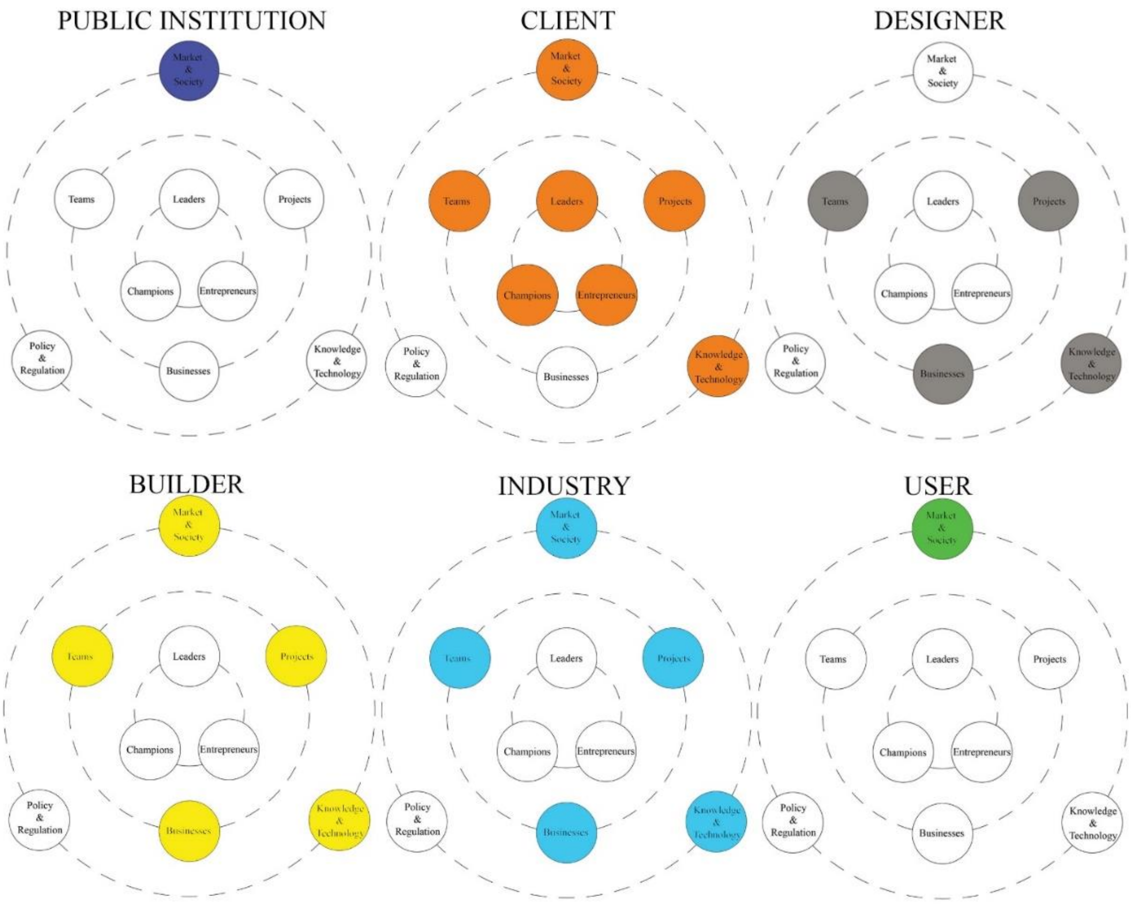
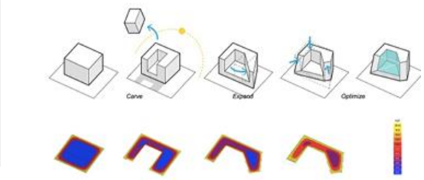
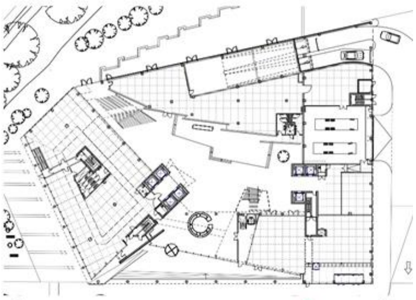


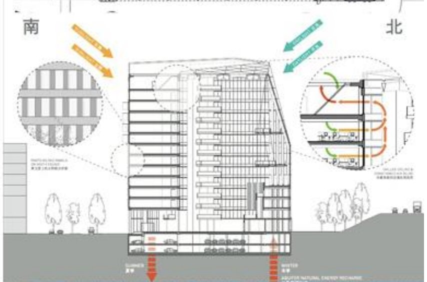
Figure 17: The image shows the distribution of actors involvement in the eco-innovation and sustainability model. The client had a predominant role in the eco-ideation phase, whereas a more collaborative environment characterised the eco-innovation phase. The project impacted the eco-institutionalization phase by generating positive benefits on the society, as well as knowledge acquisition and technological development for the participants on the project.

5.1.4 The Edge Office Building, Amsterdam, The Netherlands – Building Characteristics

The Edge
Amsterdam, The Netherlands
PLP Architects
2015







Context Characteristics:	Urban
Concpet Characteristics:	Orientation as volumetric shape generator
Orientation:	North/South
Dimension:	40000.0 sqm
Shape:	The building shape is the result of the orientation optimization from a bulky volume to an open shape toward the North side and work as environmental buffer and light diffusion enhancement
Floor number:	15 Storeys
Access and circulation:	Different access and flows for bikes, electric cars,
Structure:	Load bearing walls to the south, east and west
Construction systems:	East and West load bearing walls have smaller openings to provide thermal mass and shading, and solid openable panels for ventilation. Louvers on the south facades are designed according to sun angles and provide additional shading for the office spaces, reducing solar heat gain. The North facades are highly transparent and use thicker glass to dampen noise from the motorway. The Atrium façade is totally transparent, allowing views and steady north light in.
Evironmanetal control systems:	Smart technologies to control the environment and use Chilled ceilings and conditioned air reuse Solar Panels Waste collection system Smart lighting Thermal energy storage (Two 129m deep wells reach down to an aquifer)
Water treatment:	Rainwater collection and storage for flushing toilets and plants and garden watering
Certification:	BREEAM - 'Outstanding' with a score of 98.36 %

Delivery process

The office building 'The Edge' is a 40000 Sqm building developed by OVG Real Estate and designed by PLP Architects, mostly for the tenant company Deloitte. It was completed in 2015, and it is located in southern Amsterdam. Such project was awarded with BREEAM - 'Outstanding' with a score of 98.36 %, placing this building among the most sustainable ones currently developed Europe and rated by such certification agency. Part of this outcome is due to the use of smart technologies in the building and their ability to enhance the environmental control and the social experience of the users. One of the most remarkable smart technological feature in the building is the LED panels designed by Philips to pack in one system a number of sensors able to control motion, light, temperature, humidity and infrared (Randall, 2015). As Randall (2015) explained, the entire building is connected with 28,000 sensors with the aim of monitoring the life of the building and its use. This is thanks to a central dashboard, which monitors all the data detected by the sensors, analyzing from the overall energy use of the building, to the daily activities of the users (such as coffee machine uses, movement within the building, or desk use pattern). This system helps facilitate the energy optimization and building use, by shutting down portion of the building to reduce heating, cooling, lighting and cleaning on less busy times. The system relies on the use of smartphones by the building users, which can all be constantly charged with a built-in wireless charger system that can be find in every desk of the building. By doing so, the tenant company Deloitte can collect very large amount of data regarding its employees interaction patterns, working dynamics, and indoor characteristic preferences. This data allows the company to experiment the use of the Hot Desking system, proposing an innovative arrangement of the working environment, by optimizing the use of space providing only 1,000 desk for over 2.500 employees, and by ensuring the needs and preferences of the workers are met. For instance, the application on the employees smartphones does not only indicate which room in the building meets at a certain moment the indoor quality preferences of each works, but also looks after their health by flashing lights to encourage the use of the on-site gym, in which some of the work stations can harness energy from the workout and send it back watts to the central grid. Moreover, also the restrooms can be operated by relying on the use of sensors. These latter inform towel dispenser, hand drying and cleaning stuff about the most efficient use and need of each these aspects. At night, the sensor system also allows the use of robots to patrol the building and check, If an alarm goes off, the camera-equipped automaton can identify any intruder or let the security know if there was a false alarm, by cruising around the building. The LED panel system plays also a crucial role in managing the energy consumption of the building. The system is able to report real time temperature and humidity across each floor of the building, and sending the data to the central dashboard to determine and inform the users on the areas of the building which offers the most suitable indoor quality condition in relation to the workers' preferences. This is possible also because the building itself was designed by relying on innovative environmental engineering and control systems. As Randall (2015) points out, the building is wired with a two set of pipes: one that hold data (Ethernet cables), and the second one that hold water. This latter delivers water from and to the water storage for radiant heating and cooling of the building, exchanging heat with the aquifer beneath the building for a depth of about 120 meters. Under an architectural point of view, the building is organized around an atrium space, which is extended to the full height of the building, providing the physical conditions to generate a loop for natural ventilation, as well as providing natural light through any day of the year. The construction systems utilised are standard steel frame and concrete structure, as well as extensive use of glass. As Randall (2015) continues to explains the building features by explaining that the southern side of the building is a transparent envelope covered by solar panels; load-bearing concrete is used to control the heat; and that the recessed windows generate guarantee the shading control and the sun exposure. The roof of the building is also covered by panels, which allow the Edge to use 70% less of electricity that a standard office building in the same microclimatic conditions (Randall, 2015; OGV Real Estate, 2015; PLP Architects, 2017).

Innovation types and impacts

The innovation type identified in the 'The Edge' project are of many natures. Although, the contextual characteristics and the building type are an incremental innovation – as many other office building are already built in this area of Amsterdam - the implementation of smart technologies and the users' experience in the building is of radical type of innovation. The smart technologies in the building are a radical system to control the energy consumption as well as establishing an interaction with the users, by empowering people with the careful use of the building and a sense of belonging of their work place. Although to some extent the smart innovation itself can be considered a modular innovation, the way in which impacts on the building use, the energy consumption and on the users' experience is radical and unique. The architectural characteristics, such as dimensions, shape floor height, and layout fall into the category of architectural innovation. Internal partitions, access and circulation, and doors and windows can be considered modular innovation, whereas the construction systems and construction details can be considered architectural innovation. Although, the foundation system is a complex engineering example of heat exchanger with the aquifer beneath, this technologies is not of radical innovation in the context of The Netherland, where the structural engineering practice and its relation with water is highly advanced.

Table 14: The table shows the type of innovation that was developed in the building. Radical innovation was present in the use of smart technologies to control the indoor environmental quality and the overall building energy consumption. Although, this radical innovation was introduced, the building and the architectural and construction characteristics were of architectural and modular type of innovation.

<table>
<tr><th></th><th>Incremental</th><th>Modular</th><th>Architectural</th><th>System</th><th>Radical</th></tr>
<tr><td>Context Characteristics</td><td style="background:#00b0f0"></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Architectural Design</td><td></td><td></td><td style="background:#00b0f0"></td><td></td><td></td></tr>
<tr><td>Construction Systems</td><td></td><td style="background:#00b0f0"></td><td></td><td></td><td></td></tr>
<tr><td>Secondary Elements</td><td></td><td></td><td style="background:#00b0f0"></td><td></td><td></td></tr>
<tr><td>Environmental Control Systems</td><td></td><td></td><td></td><td></td><td style="background:#00b0f0"></td></tr>
</table>

Table 15: The table shows that competence destroying activities were required on the project to the client and to the users.

<table>
<tr><th>Actor</th><th>Competence Creating</th><th>Competence Destroying</th></tr>
<tr><td>Public Insititution</td><td style="background:#ffc000"></td><td></td></tr>
<tr><td>Client</td><td></td><td style="background:#cc0099"></td></tr>
<tr><td>Designer</td><td style="background:#ffc000"></td><td></td></tr>
<tr><td>Builder</td><td style="background:#ffc000"></td><td></td></tr>
<tr><td>Industry</td><td style="background:#ffc000"></td><td></td></tr>
<tr><td>User</td><td></td><td style="background:#cc0099"></td></tr>
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These types of innovation triggered both competence creating and competence destroying activities for the participants involved on the project. Despite the company Philips developed the smart technology that was identified as radical innovation in the project, for the company this represented a competence creating activities since they utilised and create an innovation by implementing their existing knowledge. The implementation and use of the smart technologies represented though a competence destroying activity for the client – Deloitte - and the users. These latter had to learn to use and interact with the building and to adjust their behaviour in order to optimise the micro climatic condition of the indoor environment, and maintain the energy consumption in balance. The client Deloitte, as main tenant of the building, had to reorganize the office living system by relying on hot desking approach and office management space in order to facilitate the effective use of the building space. The other actors involved built on their existing knowledge to deliver the project and therefore undertook activities of competence creating.

Sustainability results

The building characteristics contributed to obtain equally social, environmental, and economic results. The building delivery process, including the building use show predominantly environmental results. As Schneider Electric (2017) reported, the building the Edge is a net zero energy building, which produces 102% of its own energy. Moreover, it is reported that no employee has filed a comfort complaint since the building opened, rather 72% of employees utilizes efficiently the smart phones app, reporting a sense of enjoinment in having a sense of control over their environment. This sense of control contributes to empower the users and rise their awareness in regard to a sustainable use of the building, and therefore contributing heavily in maintain the building energy consumption within satisfactory parameters. Schneider Electrics (2017) reported that the total primary energy consumption is 67.6 kWh PE/m2 year; the fossil primary energy consumption is 56.7 kWh PE/m2 year; the renewable energy production (PV) is3 kWh PE/m2 year; and the level of final energy consumption of the building will vary between -0.3 and 40.7 kWh/m2 year depending on the availability of the renewable energy supply by the PV production. The OVG Real Estate company obtained a comparative and competitive economic advantage in investing in sustainability as commercial strategy for their development, as well as the main tenant Deloitte acquired prestige among other firms by showcasing a headquarter among the most sustainable building in Europe. It is also reported that a high number of Deloitte employees asked to be transferred to The Edge from all over Holland, to be part and experience the working conditions in this building.

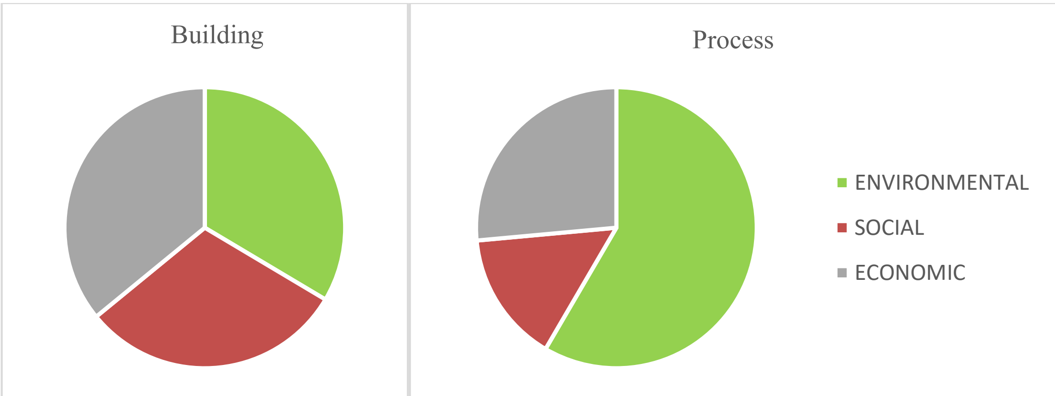


Figure 18: The pie charts above shows that the social, environmental and economic results in the building characteristics were equal, whereas in the process the results were predominantly of environmental nature.

The actors and the eco-innovation and sustainability model

The eco-ideation phase of this project was characterised by the OVG Real Estate company, which acted as leaders, entrepreneur and champion, in the definition of the program for the building The Edge. Also Deloitte, as major tenant (user) of the future building, understood the business opportunity and joined the eco-ideation phase and become a champion on the project in terms of promoting a sustainable program.

The eco-innovation phase was characterised by extensive collaboration between client, designers, builder, industry and future users. The architect PLP collaborated with a local firm in developing a sustainable building that could host the smart technologies developed at this stage by Philips, Mapiq and Schneider Electric. These technologies were developed on the basis and with the interaction with the client and the future users, as these latter were the promoter of the use of such technologies. All the parties involved invested strategically in this sustainable smart feature in order to use the project to develop an individual profit, competitive advantage and market opening.

The eco-institutionalization stage is characterized by great impact on the society and on the users of the building. The Edge building has got international fame and many award recognition in terms of sustainability and as example of positive example for our future built environment. In terms of knowledge and technology, the project served to develop and test new knowledge and technology that will further be incorporated in future building, such as in the next timber tower in London, currently being designed by PLP Architecture.

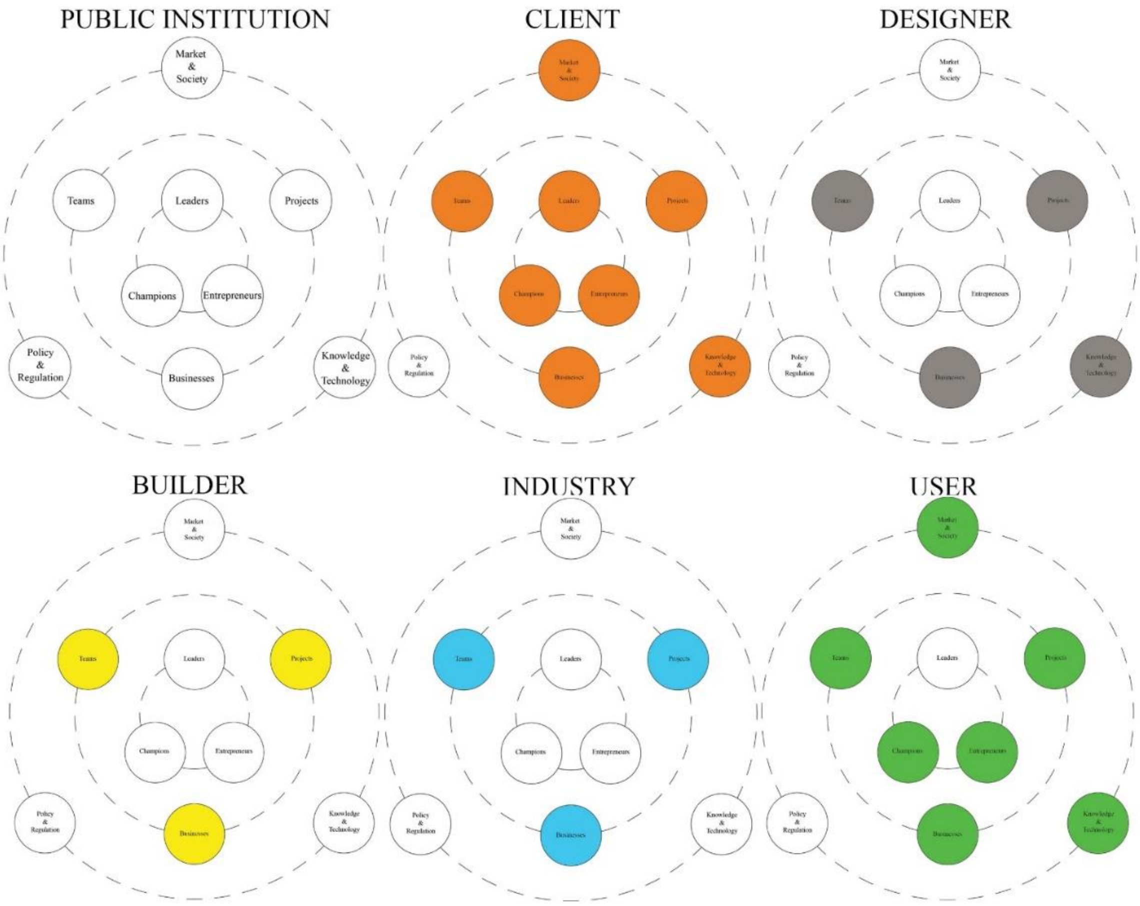
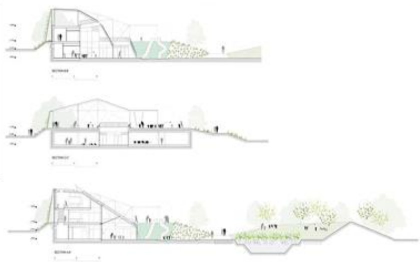


Figure 19: The image above shows the actors' role within the eco-innovation and sustainability model. The client and the users were in the eco-ideation phase. The eco-innovation phase was characterised by the cooperation of client, designer, builder, industry and users.

5.1.5 Ecopolis Plaza, Madrid, Spain – Building characteristics

Ecopolis Plaza
Madrid, Spain
Ecosistema Urbano
2010



Context Characteristics: The project is placed at Rivas Vaciamadrid, a middle sized city located in the Metropolitan area of Madrid with a low urban population density, surrounded by industry and heavy traffic transportation infrastructures

Concpet Characteristics: The concept is to incorporate the idea of sustainability into daily life

Orientation: East-West

Dimension: 3000 sqm

Shape: L-Shaped

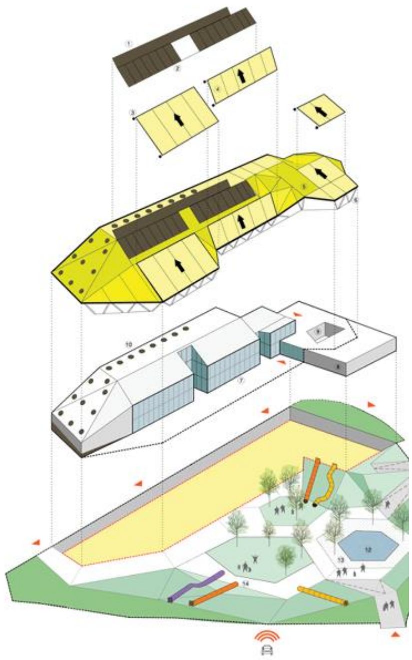
Floor number: Three floors

Access and circulation: The circulation within the building is designed in a very simple way: a north-facing corridor distributes to the different rooms of the building

Structure: Steel frame on concrete slab

Construction systems: Glazing in the south facade and concrete and steel walls strcuture

Evironmanetal control systems: The heating system is managed by a heat pump, but thanks to the termal inertia there is a good control of the heating trasmission. Natural lighting and ventilation in the building, as well as advaceclim system to control the perfomance



Water treatment: The treatment of the water is one of the strongest point of the project, the designers introduce an innovative system for the water management as the lagoon with the macrophytes plants. This strategy allow to not waste the grey waters from the building.

Delivery process

Ecopolis Plaza is a kindergarten located in the metropolitan area of Madrid called Rivas Vaciamadrid, Spain. This area is a low urban population density zone, which yet required to be implemented with school facilities, leisure and cultural services. The project is the result of a local public government initiative to embrace sustainability development strategies. Susch approach was established in 2010 when the City Council of Rivas Vaciamadrid adopted the Sustainable Urban Mobility Plan (SUMP). Such plan was connected to the Rivas Zero Emissions Plan (R0EP), which was a city's strategic approach aimed at reducing 50% of the GHG emissions by 2020, and at achieving the carbon neutrality by 2030. Moreover, the financing was provided by the government thanks to The Spanish Plan for the Stimulation of the Economy and Employment (PLAN E), which provided 2.887.931,03 euro for the project delivery. The final cost was 2.700.000 euro, which represented a 6.5% saving on the initial cost. In 2009 the Local Energy Agency of Rivas Vaciamdrid launched a design competition for the design and delivery of the kindergarten and the related urbanization of the plot 4-1 of the OSR ED-07. The competition was won by the architectural firm Ecosistema Urbano. This firms is based in Madrid, Spain and they are specialized in urbanism architecture, engineering and sociology. The winning scheme aimed at creating a vision of urban sustainability to reduce energy consumption and to raise the awareness of the users towards their responsibilities in using energy resources. The layout of the building create a public space, as well as the teaching spaces are conceived as 'open environmental classroom' in order to integrate knowledge about the environment into the teaching program. During the design phase, the Ecosistema Urbano firm carried out a number of participation activities, which spanned from regular meeting with the City Council's staff, informative meetings with the public, and training meeting with the future users to discuss the correct use of the building. Moreover, Ecosistema Urbano drafted a booklet to explain the correct building management, as well as established a tw-year monitoring activity to conduct comparative analysis of the energy consumption between the kindergarten and other projects of similar surface and scope. The building was developed by relying on traditional procurement method, and a public bid assigned the construction to H.M s.a, which collaborated with a number of subcontractors and suppliers such as Emetal s.a., Arcelor Mittal, Bat Spain Textile, AICIA Climatic Control, Targhetti Poulsen, and Sicesal Window System. Most of these companies and supplier were local, whereas other were located in Germany. The building management is run by an ad-hoc company named Rayuela-Luna s.a.. The project achieved the eco-label called 'Grade A' within the Spanish scheme for energy regulation. Moreover, the project Ecopolis Plaza received a number of award, among which the Best Practice Award by the United Nations Habitat Program. The results reported on this project are many: the transformation of an ex-industrial land into public space; definition of a public space and kindergarten aimed at raising awareness on environmental sustainability, optimisation of financial and technical resources in the design scheme, introduction of a water strategy that reduce heavily its consumption, social inclusion, and determination of gathering space in which is possible to explore the relation between sustainability and daily life. The project is aimed at being a benchmark for the development of future sustainable projects in Spain.

Innovation types and impacts

The Ecopolis Plaza project shows radical innovation, system innovation, and to certain extent architectural innovation. Radical innovation is found in the water treatment of the project that is aimed at recycling water and at the same time to display the role of wise usage of the natural resources. This is achieved by the lagoon feature in the public square. Even if this system might not be radical innovation in other context, for the Spanish area is a new approach that join together technical environmental approach to social inclusion through visually displaying the sustainable feature of the re-use of grey water. The environmental control system, as well as the construction system and the structure can be considered system innovation, as they all contribute to augment the performance of the building in terms of environmental sustainability. The orientation, the shape and the dimensions fall into the category of architectural innovation, as well as the context characterises and the concept.

Table 16: The table shows the innovation type in the Ecopolis Plaza. Radical innovation is found in the water treatment that is used as architectural feature to deliver an inclusive project for the community. The strong environmental aim of the project is actualised in the system innovation that can be found both in the architectural characteristics, and in the environmental control systems.

	Incremental	Modular	Architectural	System	Radical
Context Characteristics					
Architectural Design					
Construction Systems					
Secondary Elements					
Environmental Control Systems					

Table 17: The table shows that builder and users had to undertake competence destroying activities to deliver and use the building.

Actor	Competence Creating	Competence Destroying
Public Insititution		
Client		
Designer		
Builder		
Industry		
User		

The actors involved in the project had to undertake competence creating activities, doing problem solving based on their existing knowledge. Competence destroying activities were undertaken by the users and the building managers, who both needed to do specific training to learn the appropriate way to utilise the building, by understanding their role and responsibilities in using efficiently environmental resources.

Sustainability results

The building was designed to achieve environmental and social results within limited budget. The awards received by the project – such as the nomination for the architects to the Mies Van Der Rhoe Proze for Emerging Architects, the Silver Award Europe by the Holcim Foundation for sustainable construction, the Next Generation Award from the Arquipa Proxima Foundation – confirmed the importance of the environmental and social results achieved by the project. As previously mentioned, the local community has achieved a public square, and a sustainable teaching environment for the kids. The process, in particular the construction process, contributed to the achievement of cost saving in comparison to the initial budget. The use of mostly local materials and local suppliers helped reduce the impact of logistic, and the participated process in the design phase contributed to achieve social results also during the delivery process. The greatest achievement, according to Vallejo (2011) was to deliver a sustainable building that rather than 'renouncing to anything' as design approach, could instead *'….educate the next generation in better practices; usually buildings hide lots of things related to their function and their use of resources. We are trying to make these issues more transparent to the kids and their families'.* The building therefore, through its environmental design achieved the social result to communicate the value of sustainable behavior to its users and to the community.

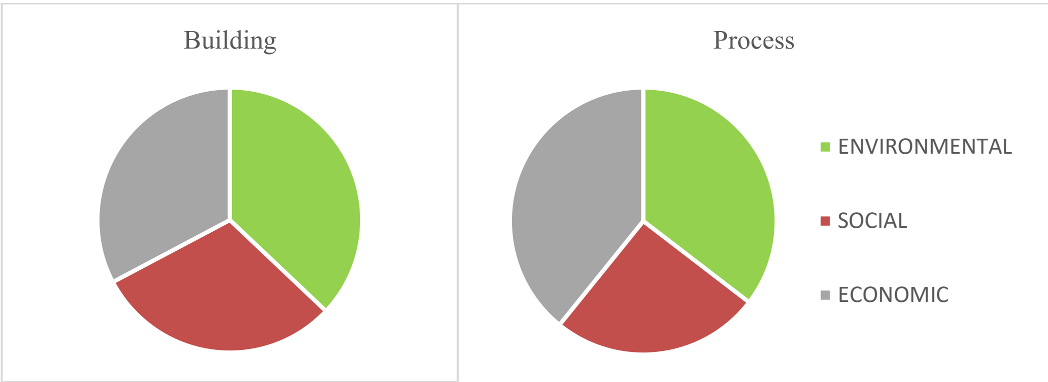


Figure 20: The figures above show the results both in building and process. The building features show a predominance in social and environmental results, while the process is characterised also by a significant economic component, which is demonstrated by the cost saving occurred during the construction phase.

The actors and the eco-innovation and sustainability model

The project delivery process was carried out with the collaboration of public institution, client, designer, builder, industry and client. Despite the traditional procurement method would normally allocate responsibilities to the client, the designer and the builder, in this instance the responsibilities were spread among all the others actors involved in the project.

In particular, the eco-ideation phase was characterized by the public institution and the client, which was as well the public entity of the City Council of Rivas Vaciamadrid acted as leaders, champions and entrepreneur by establishing a number of plans to promote environmental projects, and in this instance to launch the competition for the kindergarten in Vaciamadrid.

The eco-innovation phase was characterised by the role of the designer, which through the design and the project organization could collaborate with the builder, the industry and the users. These actors collaborated on the project as common purpose, and at the same time obtaining individual profit.

This project involvement had an impact on the eco-institutionalization phase by producing market and society benefits, and well as knowledge and technology generation. The role of public institution, client and users contributed to the development of market and society benefits; whereas the designers, by following the plans and the requirements defined by the public institution and the client, achieved knowledge and technological development. Moreover, through the design decisions made by the designers the environmental decisions were also turned into a social impact by defining a communication strategy of their value that could reach users and society and therefore raise the awareness about the environment and the optimal behaviour in terms of resources use.

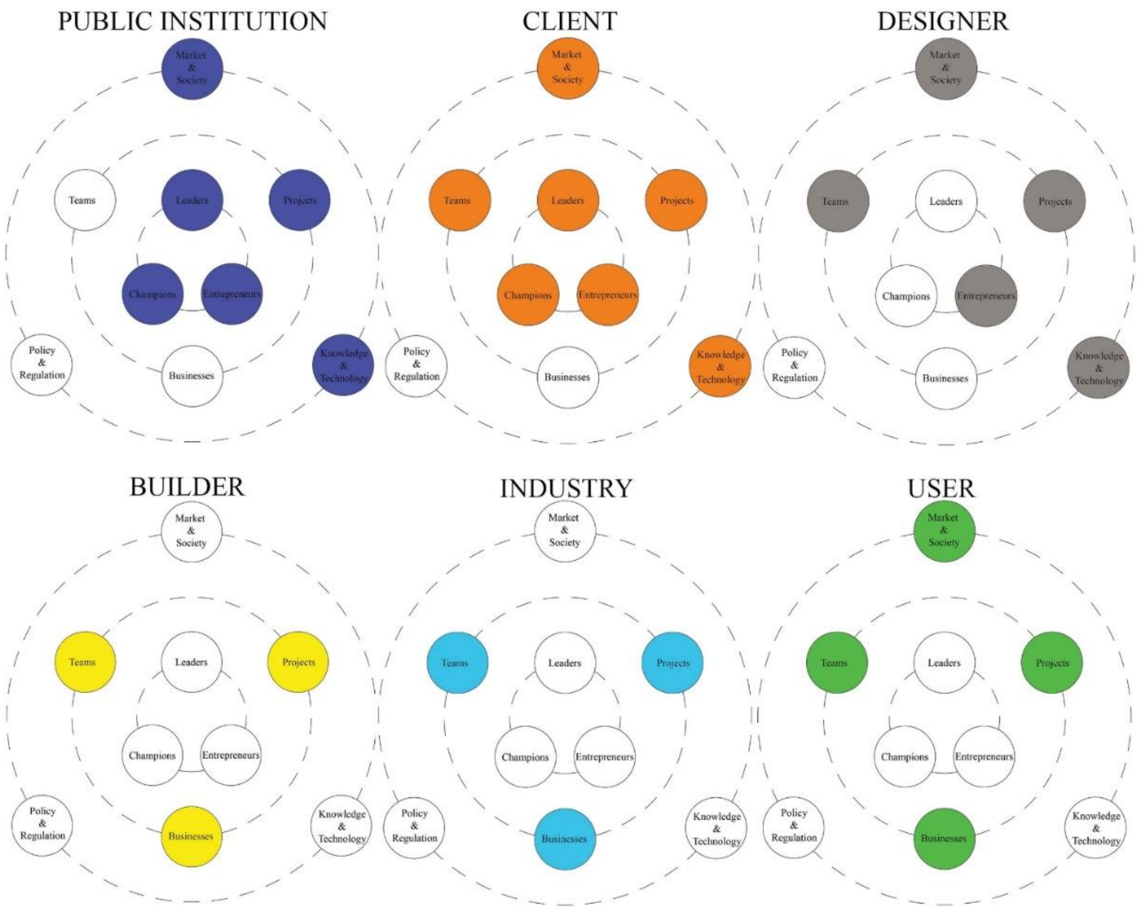
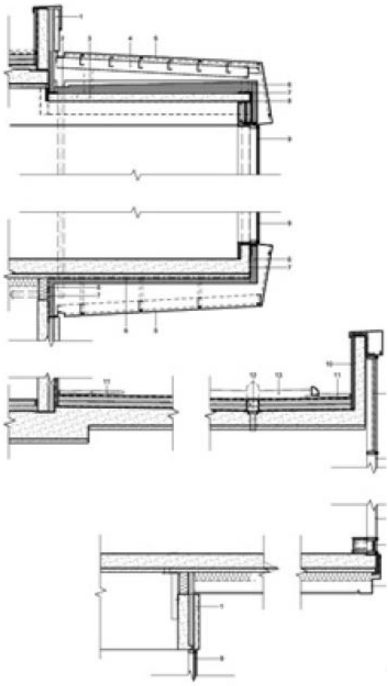


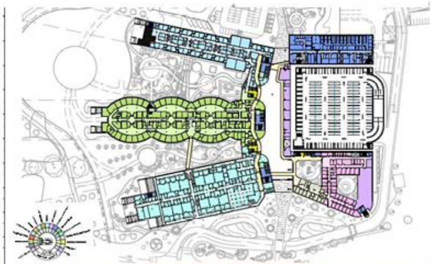
Figure 21: The image above shows the eco-innovation and sustainable model for the Ecolpolis Plaza project. The public institution and the client played an important role in fostering sustainability initiatives, and the designers and users played a significant role in determining an impact on the market and society, and to certain extent also to the knowledge and technological development. The builder and the industry took part on the project collaborating and at the same time obtaining individual profit.

5.1.6 Alder Hey Children’s Hospital, Liverpool, UK – Building characteristics

Alder Hay Children’s Hospital
Liverpool, UK
BDP
2015



Context Characteristics:	Urban
Concpet Characteristics:	Integration with landscape
Orientation:	North-West/South-East
Dimension:	60.000 sqm
Shape:	The building shape reminds of a hand palm
Floor number:	6 Floors
Access and circulation:	Public circulation through the atrium experiencing art The internal circulation is organized differently for sick kids, jealthy kids, staff, and parents
Structure:	Precast load bearing walls
Construction systems:	Precast concrete panels, double-glazed velfac windows, sprandrel glazed panels, pressed aluminium capping
Evironmanetal control systems:	Loop ground source heat pump to produce heating and cooling. Tri-generation via an absorption chiller to maximise CHP run times when use of heat elsewhere in the hospital is low. Air source heat pumps to a number of air-handling units to contribute to carbin saving
Water treatment:	Low flush toilets, infrared controlled urinals and water saving taps are used throughout the building.
Certification:	BREEAM - ‘Excellent’



Deliver process

The Aldery Hey Children's Hospital was completed in 2015 and started about five years earlier with the initiative of the City of Liverpool and the local NHS Health Trust to convert part of the Springfield Park into the new building for the Alder Hay hospital, an existing institution, since the 1914 Slessor (2015). The architecture firm who designed the building was BDP from London. Its director Benedict Zucchi (2015) explained that the design was strongly connected to the natural location and therefore it aimed at maintaining the contact with nature through natural light, visibility and natural ventilation for as many room as possible inside the hospital. The layout of the building is shaped as a hand palm so to give to each room visibility toward the park, and a sense of openness throughout every area of the hospital. The building itself it was conceived as a 'hill in the park', in such way to become part of the common public space of Springfield area. Moreover, the main hall was designed to be public and to serve as connection between two different areas of the park. The building structure is made of concrete columns and load-bearing dark pink precast panels, shaped to follow the building volume that is gently shaping down as a hill descending into the park, and reminding of the color rock strata of the surrounding land (Slessor, 2015). With the aim of emphasizing this approach, the building is entirely covered by a green roof, which visually connect with the natural souring context. The environmental sustainability strategy for the building was organized around four main points: energy, carbon, onsite renewables, and on-site energy generation (Slessor, 2015). To achieve these objectives, the building relies on a large close loop ground heat pump; a tri-generation absorption chiller to maximize CHP run when required; air source heat pumps to air-handling unites to carbon saving; and photovoltaic panels installed on large portions of the roof to provide renewable electricity. This project was assigned to BDP through competitive tender in 2010, and since then extensive collaborative work was undertaken by the designers to tailor a design that could satisfy the client and all the family groups of the children that represented the future users of the hospital. In 2009, nearly 1.000 children took part in a consultation with the client to express their need for a building in which they could recover, play and have fun, as well as have their parents close to them, be connected with nature, and generate positive outcomes for the natural environment. Starting from these premises, BDP worked closely with Children and Young People's Design Group, designing, working and engaging with the staff to create the environment that all the users desired to have. The building construction started in 2013 and it was completed in two years. The main contractor was Laing O'Rourke with a contract value of $187m. The contract was design and build, and the project was carried out relying on BIM so to save time and increase control on the coordination between design and construction. Schunman (2014) explain that this was of the fastest hospital construction ever delivered in the UK. The project was awarded with the 'Excellence' BREEAM certificate.

Innovation types and impacts

The project is characterised by many architectural innovations. This is the reflection of the extensive work conducted by the architects in trying to address the users' needs and requirements. One of the aim of the firm BDP was to respond to those needs by setting up a design which could deliver a sensitive architecture able to assist in the recovery of the young patients of the hospital. To this end many decisions were taken to satisfy the requirement of being in contact with the surrounding nature, such as the building orientation, the access and circulation, the building layout and the volumetric shape, as well as the window type and dimensions. The context characteristics to a certain extent can be considered architectural characteristics, as they contribute to the definition of the overall building layout and positioning. The environmental sustainability strategies and control fall into the category of system innovation, as by working together, these systems contribute to increase the energy performance of the building. The construction systems, construction details, and choice of materials in this project can be considered modular innovation, as they are individual systems that do not impact on other elements of the building, rather than allowing shorter construction time and ease of construction.

Table 18: The table shows the distribution of innovation type in the building, which was largely characterised by architectural innovation, and to some extent also by system innovation.

	Incremental	Modular	Architectural	System	Radical
Context Characteristics					
Architectural Design					
Construction Systems					
Secondary Elements					
Environmental Control Systems					

Table 19: The table shows competence destroying activities undertaken by the designers and users.

Actor	Competence Creating	Competence Destroying
Public Insititution		
Client		
Designer		
Builder		
Industry		
User		

The innovation introduced in the building triggered competence destroying activities for the designers and for the users. Specifically, the architects and the groups of children and young adults groups had to collaborate during workshop and consultations, and therefore acquiring new skills to carry out the design activities.

Sustainability results

The building and process of the Alder Hey Children's hospital achieved many environmental results. The environmental control systems defined for the building allowed achieving energy use of 42J/100 cu/year; carbon at 2.25 tones/100 cu m/years; and the generation of 60% of onsite electrical generation, and 10% of total renewables. These achievements allowed the project to obtain the excellence certification by BREEAM, as previously mentioned. The materials and the construction systems impacted on the construction process that could be reduced remarkably so to save costs and time, and therefore producing economic results for the companies involved on the project. The social results are to be found in the social aim of the design itself, as well as in the participated consultancy and design process undertaken by users, client and designers. Social inclusion was achieved during the design process, as well as in the design decisions of delivering an inclusive space that could facilitate the recovery of the children. Positive social impact was also found in the relation with the surrounding park. The opening of the windows and of the space allowed the view toward the park and therefore generated the perception of the relation with the surrounding nature. The permeable access of the building also represented a continuity of the park for the local community that could appreciate and live the building as a part of the park itself. Sustainable economic results were also achieved with the design solution of utilizing load-bearing pre-cast concrete panels, which allowed time saving during construction.

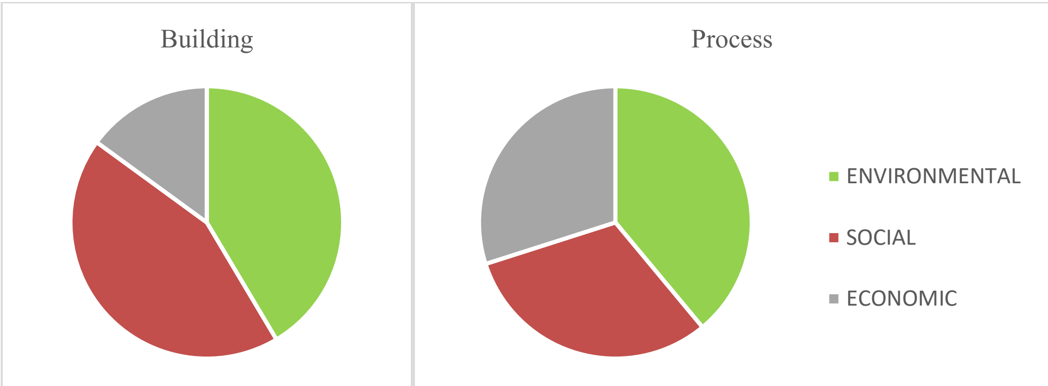


Figure 22: The pie charts above shows the types of results in building and process. The main focus of the building was to design a social and environmental building artefact, whereas during the construction process the economic aspects increased their importance.

The actors and the eco-innovation and sustainability model

The eco-ideation phase on the Aldery Hey Children's hospital project was characterized by intensive role of leader, champion and entrepreneur of both public institution and client. The City of Liverpool and the local NHS Health Trust promoted the project, funded it, and through public bidding process formed the links to bring together expertise required for the project delivery. The eco-innovation phase was characterized by the collaboration between institution, client, designer, builder, industry and users. This was due to the extensive work that the architect conducted in conjunction with the children's group during the design phase, as well as the collaboration with builders and suppliers during the detailing and building phase. These actors met together on this project for the collective aim of the project scope, as well as the designer, builder and industry parties had economic return to be part of the project. The overall design decisions made were therefore the result of extensive collaboration during the delivery process between all the parties involved. The impact of the project on the eco-institutional level was on the area of market and society, as the nature of the project itself is for the health of the community. In particular, the public institution and the client had a role in defining this aim and therefore in producing this impact, as well as the designer, who, through the involvement of users in the design process, enhanced the sense of engagement of the community. The users as well, by expressing their needs, helped contributing to the impact on the social level.

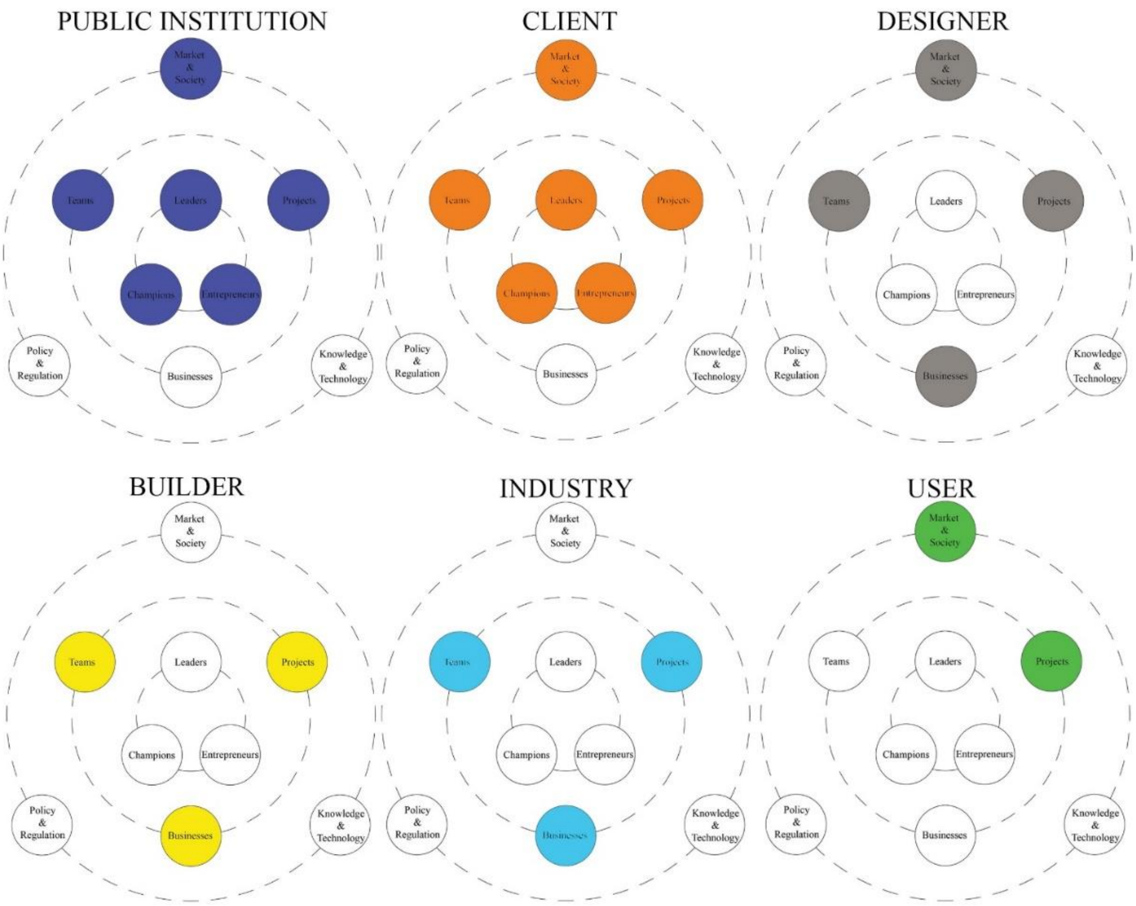
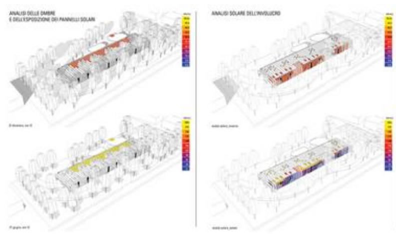


Figure 23: The image above describes the actors role in the introduction of innovation in the project. The eco-ideation phase was led by the role of public institution and client who acted as leaders, champions and entrepreneurs. The eco-innovation phase was characterised by collaboration between all the actors involved, and such collaboration led to an impact on the eco-institutionalization level thanks to the aim of the project defined by the public and the client, as well as by the users involvement in defining in conjunction with the architect design solutions that could satisfy the community.

5.1.7 The Guastalla Kindergarten, Guastalla, Italy – Building characteristics

The Guastalla Kindergarden
Guastalla, Italy
MCA - Mario Cucinella Architects
2015



Context Characteristics: Semi-Rural

Concpet Characteristics: Pinocchio's whale belly

Orientation: South-East/North-West

Dimension: 1400 sqm

Shape: Cucinella's idea is to create an environment that is the scene of many occasions of the stimulus and fantasy experience for children, a space constituted by the parallel succession of fifty frames structural laminated wood imagined as the Pinocchio whale.

Floor number: 1 Floor

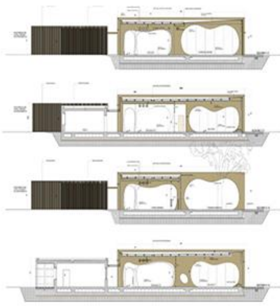
Access and circulation: Main access for kids

Structure: Sequence of timber portals

Construction systems: Series of bearing frames (18×4,8 m) placed at a distance of 1,56 m allow to switch between opaque and transparent walls.

Evironmanetal control systems: Controlled mechanical ventilation with heat recovery combined with the disposition of the glazed openings which can create a natural circulation of the air from the bottom to the top (stack effect).
System for the self-production of solar panels and photovoltaic panels (with a peack power of 35 kWp) which cover the 40,5% of the total energy required for heating and cooling. The solar system installed as a supplement of the heat pump for the production of sanitary hot water, consists of 4 vacuum tube collectors and 1 vertical steel kettle, equal to 1,500 liters of capacity, able to meet the 60% of the needs of hot water

Water treatment: Rain water collection in order to be used in no-domestic uses (such as toilet flushing, cleaning and irrigation)



Delivery process

The Guastalla Kindergarten is a project of 1400 mq built in 2015 and designed by MCA Architects, in conjuction by the consultancy team composed by: Geoequipe Studio Tecnico Associato (structural engineering), Area engineering s.r.l. (electrical and mechanical design), Marilena Baggio (landscape design), and Enrico Manzi (acoustic engineering). The firm MCA Architects won the competition for this new school in the Guastalla district (Reggi Emilia, Italy), to replace the two existing schools, which got damaged by the earthquake that struck the area in May 2012. The competition was launched by the local and regional government (Comune di Guastalla and Unione Comuni Bassa Reggiana) and later it was built with the funds provided by regional and local government, as well as by the a number of funds raising events and organizations established after the earthquake. The project was developed through public tender and design and build type of procurement (*gara di evidenza pubblica di appalto integrato*). The project was built by Scisciani e Frascarelli (construction works), Rubner Holzbau S.p.a (wooden strcuture), Saitec Company s.r.l. (suppliers), and Promo s.p.a. (doors and windows). The concept for the building design was related to kid novel 'Pinocchio' and in particular to the whale character and shape of its belly. Chierici (2018) explained that: *'…Swallowed by a whale, Pinocchio finds, inside its huge belly, Geppetto, and that image then turns into a mother's womb. This is how we see the kindergarten, as a place to explore, as a place that stimulates the imagination of children, who discover a place where they can imagine other things, such as a big fish, a whale, a game, a slide'.*From this idea, the architect envisioned a space that was designed with the main driver of emphasizing and assisting the pedagogical experience of the kids, in the building. This idea was actualized in the shape of the entrance and of the rooms, in the circulation system, and in the relation between indoor and outdoor space. The building is built with a sequence of timber portals, which are externally shaped with regular orthogonal profiles and internally curved. These portals are connected by glass walls, Also, the natural materials, such as the local wood utilised largely in the building, contributed to emphasise the kids perceptions in relation to the light, colours and sounds of the surrounding environment. The idea of developing the building as a sequence of structural timber portal allowed ease of construction, structural optimization, as well as to use the timber characteristics to provide thermal insulation to the indoor space. The distribution of walls allowed to allocate spaces for rainwater harvesting and the insertion of photovoltaic systems on the roof, so to minimize the mechanical systems in the building. The total building cost was 3000000 euro, and the entire building was built in forty-five days. The building was selected for Special Mention in the Architizer A+ *Awards* for the Typology Categories, Institutional: *Kindergartens; as well as it was nominated for the EUmiesaward19.*

Innovation types and impacts

The design of the building is characterised predominantly by architectural and system innovation. In terms of architectural innovation, aspects such as the concept, the shape of the timber portals, and the access and circulation system are the aspects where innovation are the most significant aspects in which innovative features were designed and characterised entirely the nature of the building. Aspects such as the materials of the portal, their physical thermal characteristics, the presence of photovoltaic panels and the rainwater collection strategy represents the system innovation in the building, as they, by working together, contribute to increase the environmental performance of the building. Such performance is also perceived by the users: the kids, who are able to understand the relation between indoor and outdoor environment and micro-climatic conditions, and therefore are able to develop an understanding and awareness towards the natural environment and the respect toward it.

Table 20: The table shows the innovation type in the project of Guastalla Kindergarten. The project is largely characterised by architectural and system innovation.

	Incremental	Modular	Architectural	System	Radical
Context Characteristics					
Architectural Design					
Construction Systems					
Secondary Elements					
Environmental Control Systems					

Table 21: The table shows that the users have to undertake competence destroying activities in the use of the building.

Actor	Competence Creating	Competence Destroying
Public Insititution		
Client		
Designer		
Builder		
Industry		
User		

In terms of process, the actors involved in the process followed the standard procedure required by the Italian building code, and as specified by the tender process, so competence creating was required to undertake such process without major impact on the standard activities normally carried out by the actors involved. Competence destroying activities were to a certain extent carried out by the users, whom are invited by the design of the building to experience and learn an interaction and behaviour with the built environment that can deviate from the standard experience they had in the past. The architect Mario Cucinella (2015) has underlined that kindergarten space is the first encounter, beside the private house, that we, as kids, have with the built environment, and therefore training young people to understand potential, characteristics and functioning of the built space is critical to a sustainable future.

Sustainability results

The building achieved the Class A (top grade) of the Regional and National Energy Certification System. The building produced 40.5% renewable energy from solar and thermal solar power, and saves 1.343 liters/day achieving a saving of 57% of water thanks to the rainwater recovery system. The GHG emission was reduced in the building thanks to openable skylight that allowed natural ventilation through chimney effect, and the jointed system of natural recycle materials of low impact and high thermal insulation and the heated flooring system installed throughout the entire building. Chierici (2018), also explained that: '*…It is built with laminated wood and set on a reinforced concrete base that guarantees 100% seismic security and 100% environmental safety. The supporting structure in particular is made up of wooden frame: a safe and ideal material to keep the thermal insulation of the building. The high insulation, the optimal distribution of transparent surfaces, the use of advanced systems for rainwater harvesting and insertion of a photovoltaic system on the roof, allow the building to minimize the use of mechanical equipment to meet the energy needs of the school. This is all a fundamental part of the educational project, which is that of raising new generations of individuals who will know how to face the environmental challenges of tomorrow. The building is one of the first attempts to introduce environmental education'*. The results in the building project were mostly of environmental nature, as it can be seen in the technical decisions taken in the building. These technological solutions had an impact on the social results as well, by promoting the kids ability to appreciate the environmental conditions and the building functioning in relation to the microclimatic conditions of the context. The design also achieved the requirement of the 'most advantageous economic offer' that was required as criteria in the public bid and therefore also achieved economic results by allowing cost saving on the production and assembly process. The design of the building, and especially the concept idea of the 'belly whale' had a strong impact on the local community and the users, who, as often is reported in the local press are appreciating the building, which is defined '*the most beautiful kindergarten of the world*' (Mosello, 2016). The process is characterized by high degree of environmental decisions, especially in regard to the materials characteristics and their embodied energy, as well we in relation to availability in the local area of those. The construction systems and the procurement system used, allowed the cost saving in relation to the prefabrication and the ease of assembly of the project. The project combined very innovative concept and economic sustainable construction and production choices, and therefore it created competitive and comparative advantage for all the companies involved in its delivery.

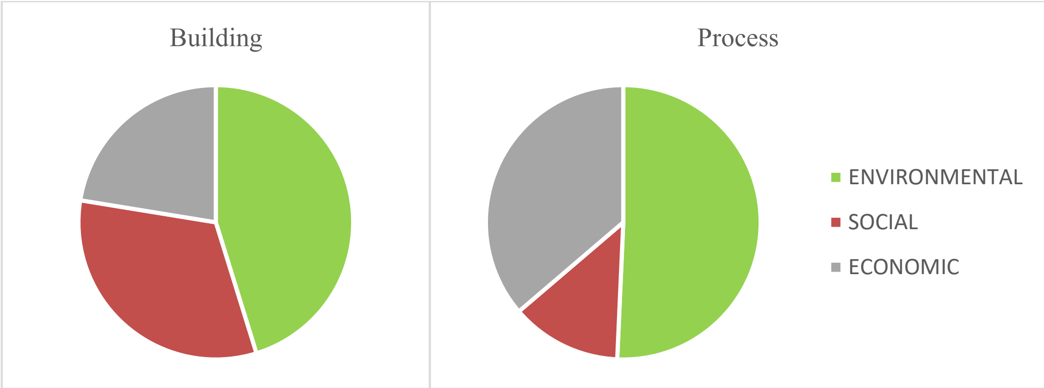


Figure 24: The pie charts above shows the predominance of environmental and social results on the project. Yet, in the process the economic component has a significant role.

The actors and the eco-innovation and sustainability model

The co-ideation phase was characterized by the role of client and public institution acting as leaders, champions and entrepreneurs. The community also had a significant in the promotion and financing of this project, which was partially funded by an NGO developed ad-hoc for the reconstruction support of the area of Guastalla, as well as private donors who donated contribution for the project development. The co-innovation phase was characterized by the role of designers (architect and consultants), builder and industry partners, who all joined efforts to deliver a building characterized by strong environmental aims, innovative construction systems and limited budget and time. These teams work on the project with a collective aim, as well as achieved their private profit. The co-institutionalization phase was characterized by the impact that the public institution and the client had in wanting to promote and invest in a unique school for the reconstruction of Guastalla, as well as by the role of the users in utilizing the building as a learning experience. These impacts tackled into the area of market and society, highlighting potentials of public buildings both within the environmental and social domain. The architect, the builder, and the industrial partners contributed to both the generation of impact on market and society, as well as on the knowledge and technology development. This is was due to the aesthetic and technical building characteristics, as well as by the development of an ad-hoc building system developed for the project.

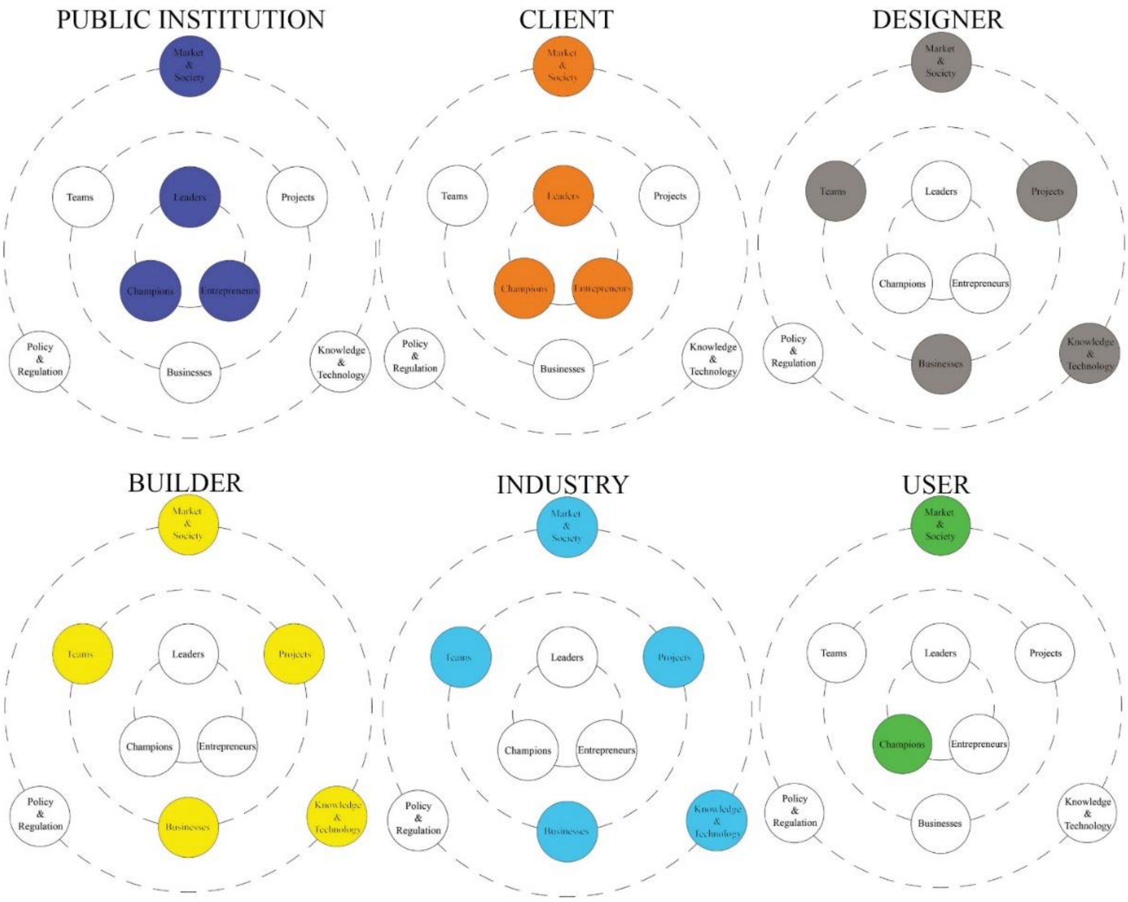


Figure 25: The image above shows actors and roles in the introduction of innovation on the project. The eco-ideation phase was characterised by the role of the community and the public institution. The eco-innovation phase was characterised by the collaboration between the designer, builder and industry. Whereas the eco-institutionalization phase was characterised by impact on the market and society domain, as well as on the knowledge and technology development.

5.2 The Australasian context

Australia and New Zealand

The Australian Government, with the Environment Protection and Biodiversity Conservation Act 1999, set the legal framework for the protection and management of flora, fauna, ecological communities, heritage places as matter of national environmental significance (Department of Environment and Energy, 2018). Such Act covers a wide range of topics, from the Aboriginal and Torres Strait Island Heritage, to the Antarctic Marine Living Resources Conservation Act. Among this very wide variety of topics, the building industry is tacked with Acts such as the Building Energy Efficiency Disclosure Act 2010, the Carbon Credit Acts 2011, the Climate Change Authority Act, the Greenhouse and Energy Minimum Standard Act, Renewable Energy Act 2000, Water Act 2007. At the regional level, each state in Australia adopted their own Acts, for example the State Government of Victoria adopted a Building Reform Program, released by the Department of Environment, Land, Water, and Planning. Ashe (2003) explained that National Australian Building Environment Rating System (NABERS) project currently being undertaken by Environment Australia is a clear signal from the Federal Government of its intention to lift the bar of environmental performance of Australian buildings. National conferences being convened by the ABCB in conjunction with the Institute for International Research (Green Buildings, 23-25 June 2003) and the Australian Institute of Building Surveyors (Building for a Global Future, 15-17 September 2003) are complementary signals of changing attitudes to sustainable development in general and buildings in particular. Both the International Council for Research and Innovation for Building and Construction (CIB) and the International Standards Organisation (ISO) hold regular meetings and conferences on sustainable building issues and have various working groups and technical committees on elements of sustainable construction. Introduced in 2003 by the Green Building Council of Australia (GBCA), the Green Star rating system provides a systematic framework to quantify the degree to which ESD principles have been incorporated into a building design. The system considers assesses and rates buildings, fitouts and communities against a range of environmental impact categories, and aims to encourage leadership in environmentally sustainable design and construction, showcase innovation in sustainable building practices, and consider occupant health, productivity and operational cost savings. In 2013, the GBCA released a report, *The Value of Green Star*, which analysed data from 428 Green Star-certified projects occupying 5,746,000 million square metres across Australia and compared it to the 'average' Australian building and minimum practice benchmarks. The research found that, on average, Green Star-certified buildings produce 62% fewer greenhouse gas emissions and use 66% less electricity than average Australian buildings. Green Star buildings use 51% less potable water than average buildings. Green Star-certified buildings also have been found to recycle 96 per cent of their construction and demolition waste, compared to the average 58% for new construction projects (GBCA, 2013). New Zealand has a similar legislative system, and in 1991 has adopted the Resource Management Act to set the framework for sustainable development. The following year the Energy Efficiency and Conservation Authority (EECA) was established to encourage and promote energy efficiency and GHG emission. In 2003, the Government announced the Sustainable Development Programme of Action. In 2005, the New Zealand Green Building Council was formed. Such Council introduced formally in the country the Green Star Rating System as design and assessment tool for the building sector in the country.

Indonesia

In 1993, in the Declaration of Interdependence for Sustainable Future at Chicago, the country of Indonesia stated that the country will apply sustainability principles to a number of sectors and activities, including the building sector. Since then, only two regulations were released by The Ministry of Environmental Decree Number 8 Year 2010 on Criteria and Certification of Eco-friendly Building, The Regulation of the Minister of Public Works and Public Housing No. 02/PRT/M/2015 on Green Building and The Governor of Jakarta Decree Number 38 Years 2012 on Green Building (Virgayanti, 2017). Adiningsih Adiwoso, Prasetyoadi, Perdana (n.d) explained that in Indonesia the National Development Performance targets are set by the non-profit organization named Green Building Council of Indonesia (GBCI). Such Council's is to support, promote and maintain the goal of market transformation, changing industry and public behaviour, creating a forum and dialogue, build community and expertise in building and environmentally friendly construction. The two main institution that set the legislative framework for sustainability are the Ministry of Public Works (PU), and the Ministry of Environments (KHL). The Green Building Council of Indonesia set the use of the tool named 'Greenship': a rating system aimed at achieving best practice in designing, constructing and operating sustainable buildings.

Palestine

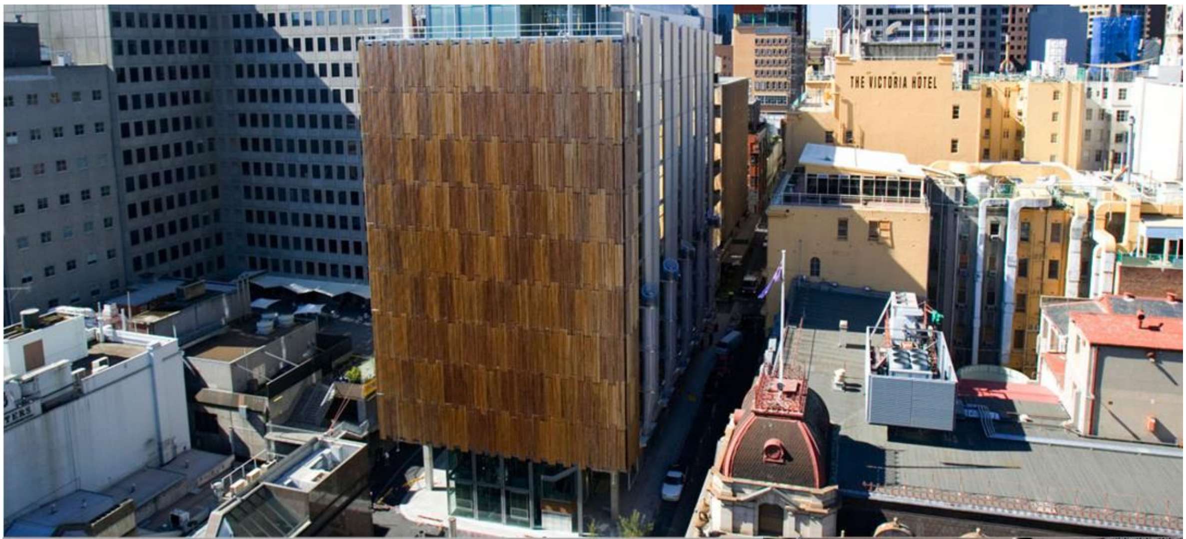
The Palestine's Report to the United Nation Conference on Sustainable Development help in Rio de Janeiro in 2012 discusses and explains the sustainable development status under the Israeli occupation in Palestine. In this document, two major difficulties to sustainable development are highlighted: the first one are difficulties related to the Israeli occupation, and the second one are difficulties triggered by the lack of institutional framework in place. The report (page 8) explains that:…' *The Israeli occupation-related measures have caused physical harm to people and property, as well as economic and environmental damage. Over the past 45 years, i.e. since the beginning of the Israeli occupation, the residency status of nearly 250,000 Palestinians was revoked, which means they were de-facto deported. Since 2000 some 12,400 Palestinian houses and structures were demolished in the occupied Palestinian territory, thus forcibly displacing tens of thousands of Palestinians. The Israeli occupation regime has confiscated Palestinian land, has extracted Palestinian water resources, and has polluted the soil and water through extensive industrial activities in illegal Israeli settlements, military training grounds and the disposal of radioactive waste. Furthermore, the constraints imposed by the Israeli occupation regime on our economy have obstructed the private sector and thereby its ability to create employment opportunities. As a result the occupied Palestinian territory remains heavily dependent on aid and exposed to poverty, unemployment, and food* *insecurity. The long-standing presence of the Israeli military occupation has also increased disparity between various regions of the occupied Palestinian territory, especially between the West Bank and the Gaza Strip'.* Yet, some achievements in terms of economic, social, and environmental sustainability were reported. For instance, under the social point of view, the enrichment rate in primary education in 2008/2009 achieved the 95.6% for males and 98.7% for females, and the pupils who completed the primary school was about 99.4% in the same range of time. Within the health system, maternal mortality was significantly reduced to 38 per 100,000 in 2009; and the immunization coverage among children aged 12-23 months stood at an impressive 96.5% in 2006. In terms of social protection, the Palestinian National Authority provides targeted cash-assistance to some 85,000 poverty-affected households in the West Bank and Gaza Strip. The economic development is reported to remain heavily compromised and limited by at least three aspects: 1) The lack of control over boarders and import export dynamics; 2) the siege of Gaza Strip; and 3) …' *land confiscation, excruciating permit regime, Israeli exploitation of natural resources, and the physical destruction of the Palestinian economic facilities*'. These aspects generated high poverty rates and unemployment, especially in the Gaza Strip. Overall, only 33% of the population is food secure. The environmental domain is by far the weakest domain in the Palestinian context. The Palestine's Report to the United Nation Conference on Sustainable Development (2012) explained that the access limitation to natural resources by the Israeli occupation and the progressively action of polluting such resources are the major limitation to the environmental sustainable development tin the country. Civil organization and NGO are the only source of funds for any environmental actions.

China

Xue et al. (2012) explained that China is experiencing a fast economic and urbanization development, and that in particular that: *'...existing buildings is more than 40 billion m2 in China (Yang and Zhou, 2010; Sun, 2010). Every year the total floor areas of new buildings are up to 2 billion m2, consuming 40% of the world's cement and steel (Qiu, 2010). Besides, buildings in China have a relatively shorter life expectancy, that is about 30 years, while such a figure in European countries is around 80 years, and 44 years in the USA (Hu et al., 2009). According to Li and Yao (2009), the urbanization rate in China will increase from 47% in 2008 to 50% in 2012, and 74% in 2050, indicating a significant demand for new buildings in urban areas. Consequently, it is critical to initiate green building efforts so as to alleviate the potential impacts from the building sector'.* Xue et al. also explained that, although many countries rely on green building standards – for instance BREEAM (UK), CASBEE (Japan), LEED (USA), and others – China has adopted a number of energy efficiency assessment methods or design codes, yet they have not been scrutinized, nor translated or assessed by the International scientific community. The most utilised assessment method and codes are reported by Xue et al (2012) to be the Chinese Green Building Standards, China' s Eco-house Technical Evaluation Handbook, Green Building

Assessment System for Beijing Olympic (GBASBO), Green Buildings Evaluation Standard (GB/T 50378 –2006), the Three-Star Standard. Xue et Al. (2012) also reported that: '…*Social and economic benefits can also be obtained, such as better ventilation, better working and living environment, increased working productivity, and even higher rents, sale prices and occupancy rates (Fuerst and McAllister, 2008, 2009; Pivo and Fisher, 2009)*'. Xue et al. (2012) stated that: '…*Chinese standards indicate that several challenges have impeded the successful implementation of such standards, such as a lack of indicators for responding to climate change, lack of region-specific indicators, lack of quantitative indicators, higher costs for receiving certification and lack of applying innovative green technologies. The development of green buildings in China is still at the initial stage'.*

5.2.1 The Ch2 Office Building, Melbourne, Victoria, Australia – Building characteristics



CH2 Melbourne
Melbourne, Australia
Design Inc. and Mike Pearce
2006

Context Characteristics:	Urban
Concpet Characteristics:	Biomimicry
Orientation:	North-West/South East
Dimension:	12500.0 sqm
Shape:	Parallelepiped
Floor number:	10 Floors
Access and circulation:	Main access from ground floor with public functions
Structure:	The concrete structure is relatively conventional insitu construction, except for the use of precast curved concrete ceiling panels. Two rows of concrete columns are located at 8200mm centres just inside the north and south facades, with a further row of columns offset from the centre of the floor plate
Construction systems:	Each facade is differently characterised. The main facade is characterised by timber shading system. The other facades displays precast panels and green planting system
Evironmanetal control systems:	Nature is used as inspiration for façades that moderate climate, tapered ventilation ducts integrate with day lighting strategies and an evocative undulating concrete floor structure that plays a central role in the building's heating and cooling. The environmental control systems are many and characterise the nature of the entire building
Certification:	The building was utilised to establish the six star rating system in Australia

Delivery process

The CH2 Building was designed with the aim of replacing the existing CH1, the former office building utilised by the Council House. The building was design by Mike Pearce and the local firm Design Inc. The project was carried out as a collaborative environment with the contribution of the City of Melbourne (Project-Director: Rob Adams), the architects, the project architect, the interior designers, and the users. The approach was to follow an holistic system to promote the interaction between city and nature, and to integrate such concept into the ESD strategy for the building. The brief for the building was to reduce as much as possible the GHG emission, as well as rely on passive energy systems. To do so, the Ch2 Building was one of the first projects in Australia in which the six star rating system was applied. The design approach refers to biomimicry and it incorporates a number of architectural features inspired to nature. A ventilation system is designed to provide air flows throughout the entire building with the help of five shower towers to cool the air. The heating and cooling system relies on hybrid solutions working with chilled panels running through the building. Natural lighting is provided in the entire building. These strategies are actualised by designing construction systems and utilising materials that could facilitate the use of natural resources. The synergy between cooling, ventilation and lighting system helped achieve the reduction of 87% of the gas consumption, and the85% of the electrical consumption compared to similar facilities. This design was developed with an integrated design team over a period of two weeks in 2002, by conducting charrette. After this phase, the project was developed individually by each companies, and yet at the same time maintaining the integrated team approach. The construction was delivered by including the construction company in the early design decision phase to ensure that the ESD strategies were feasible and sources of materials, logistic and manufacturing methods were undertaken according to the design approach of the entire project.

Innovation types and impacts

The CH2 building is characterised by a number of remarkable innovations, which characterised the nature of the building. Its concept and architectural characteristics are of radical innovation by relying heavily on the biomimicry approach and in the attempt of utilising this approach as a communication strategy of the environmental value of such choices. This approach was radical for the context as this was the first building in the context of Australian cities to follow such design approach. The project dimension and the accesses remained border line between incremental innovation and modular innovation, as they followed the standard practice with minimal alterations. While, the structural elements were in line with the standard practice and the surrounding buildings, the construction systems, the material utilised and the ESD strategy adopted characterised a solid approach to system innovation in the building. The synergy between construction systems and passive energy approach determined a remarkable energy consumption reduction and therefore the improvement of all the building performance. Such increase was also reflected in the users' wellbeing and productivity.

Table 22: The image above shows the innovation type in the building. The building was predominantly characterised by system innovation, due to the aim of integrating the design strategies with the ESD strategies and determine a system of innovations that could perform in synergy and improve the performance of the building.

	Incremental	Modular	Architectural	System	Radical
Context Characteristics					
Architectural Design					
Construction Systems					
Secondary Elements					
Environmental Control Systems					

Table 23: The initial phase of the design process called for competence destroying activities for all the actors involved in the project.

Actor	Competence Creating	Competence Destroying
Public Insititution		
Client		
Designer		
Builder		
Industry		
User		

The introduction of such innovation called for activities of competence destroying by all the actors involved in the initial charrette, namely the client, the public institutions, the builder, and the users. This first phase required by all the learning and understanding of the value of the ESD and design approach adopted by the designers, as well as this latter ones had to include in their standard design processes the collaborative approach of the entire team. After the first phase, the actors involved worked again individually by following the directions of the team. At this stage, the actors involved returned to the application of their pre-existing knowledge and therefore to competence creating activities.

Sustainability results

The sustainability results in the building design had a predominant environmental nature do to the achieving of the main aim of the project. The building design also allowed to achieved social results such the improvement of productivity in the working environment, having therefore a positive impact also on the economic results. The delivery process of the building, as well as the life and use of the building had a strong economic result, beside achieving the highest level of certification by the Green Building Council of Australia.

The Green Building Council of Australia awarder the CH2 building with the six start certification, and underline the importance of the passive energy approach in the building, which was able to provide 100% of fresh air to all the occupants with one total air change every half hour.

The City of Melbourne (2018), after conducting post-occupancy evaluation in conjunction with CSIRO (an independent auditing group), reported that the productivity of the occupants was enhanced thanks to the provision of high quality indoor space, which could take into consideration the users' needs. Specifically, CSIRO reported that he staff productivity increased by 10.9% (CSIRO, 2018).

Moreover, The City of Melbourne (2011) explained that he total building cost was $51.045 million, including $29.9 million of the base building, $11.3 million for sustainability features, $2.8 million for education, and 7.1 million for special design and communication. The financial saving reported was $1.45 million per year, including: $1.12 million in productivity and wellbeing improvement, as well as $330,000 in electricity, water and gas consumption.

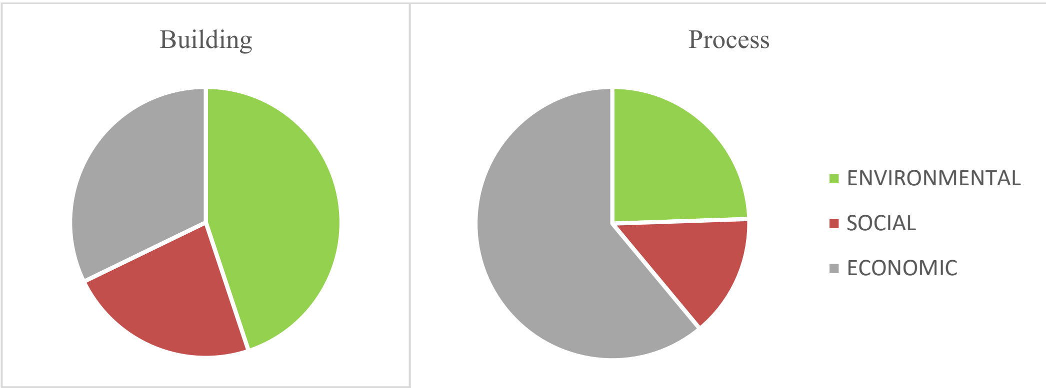


Figure 26: the pie charts above shows the sustainability results in the project. The building achieved great environmental results, which allowed the process to obtain a number of positive economic results related to the increase of productivity in the building by its users.

The actors and the eco-innovation and sustainability model

The co-ideation phase of the building was characterized by the role of the public institution and the one of the client (as well part of the institutional body). They acted as leaders, champions and entrepreneurs, as they promoted the project, provided the funds and organized the charrette to create links and share ideas among the project participants. The collaborative nature of the design team characterized the co-innovation phase, which was carried out firstly as a design charrette and then in a more standard manner to carry out the individual group. This strategy allowed all the teams that were formed on the project to have a collective contribution and guideline definition, and at the same time to maintain their own independence and the ability to have a private profited for their firms. The impact of the project on the co-institutionalization phase was on the market and society, on knowledge and technology production, and on policy and regulation. The impact of the this project was to improve and communicate the sustainability results of the building and to transfer the knowledge to the community, by setting a successful example for the industry. The ESD strategy applied to the building developed technological knowledge that could be communicated to the larger industry by the local government, which uses the building to set standards. On the policy and regulation level, this project became a benchmark for the six star rating system, which started to be considered essential for the good practice after the use in this project.

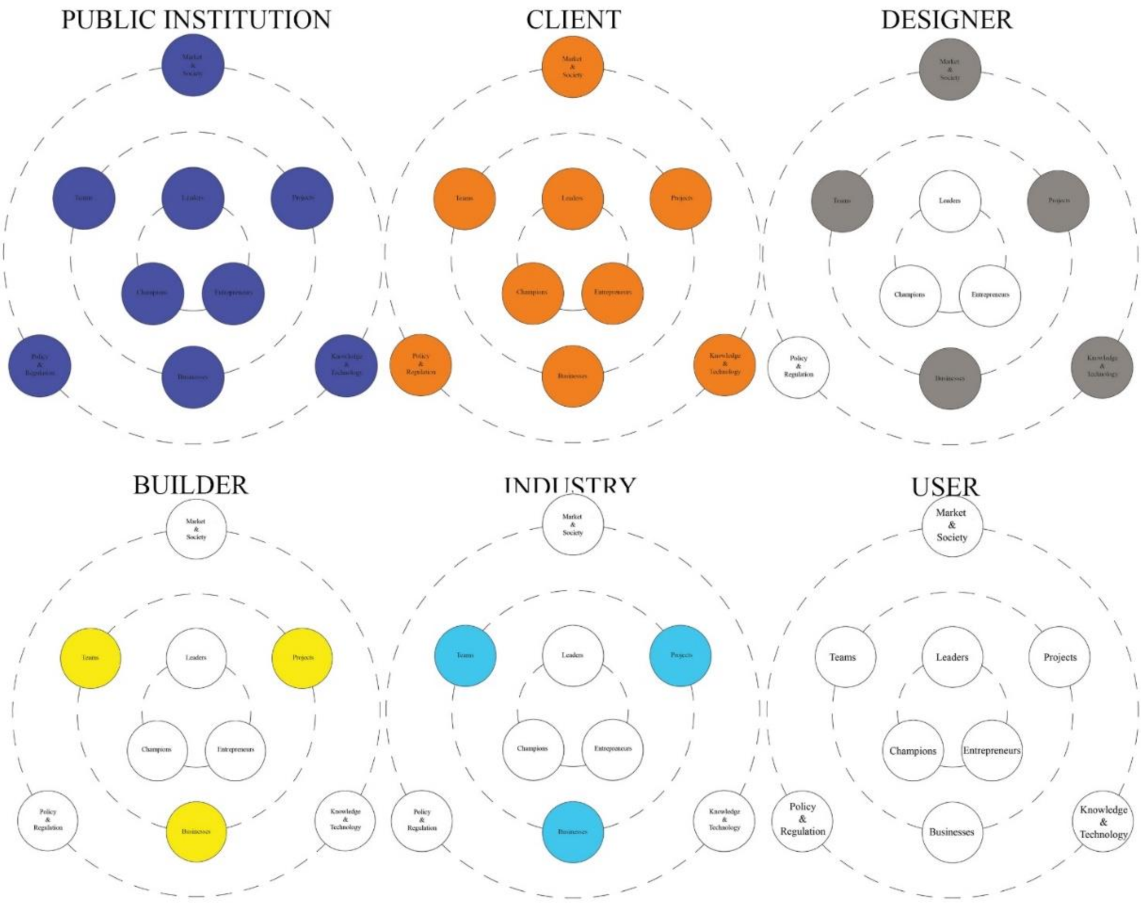
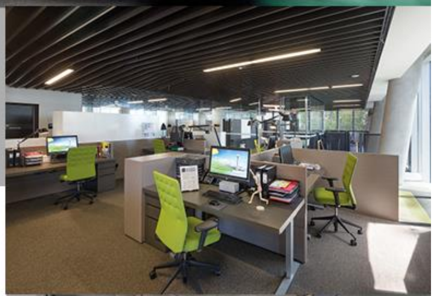


Figure 27: The image above shows the eco-innovation and sustainability model for the CH2 project in Melbourne, Australia. The involvement of the public institution and client. Through collaborative practice during the eco-innovation phase, they achieved to generate impact on all the domain of the eco-institutionalization level.

5.2.2 41 Exhibition Street, Melbourne, Victoria, Australia – Building characteristics

41 X
Melbourne, Australia
Lyons Architects
2013



Context Characteristics:	Urban
Concpet Characteristics:	The design explores the idea of a hybridized public and commercial building, placing focus on the activities of the Institute located on the lower levels of the tower, and maximising their public engagement
Orientation:	South-East/North-West
Dimension:	5880 sqm
Shape:	Parallelepiped with dynamic segment in the facede and in the main stair design
Floor number:	21 Storeys
Access and circulation:	Public engagement by conceptually and spatially extending the city street up into the building through a major stair at the buildings edge. In order to optimise the space, one core only is present in the building
Structure:	Bubbledeck precast floor panels and precast concrete columns
Construction systems:	Precast concrete, high performance glazing, anodised aluminium supported by structural steel
Evironmanetal control systems:	HVAC strategy is a floor-by-floor variable volume low temperature system with demand control ventilation and 50% increase in outside air rate. Thermal plant comprises roof top air cooled chiller, tenancy closed circuit heat rejection plant and a forced draft boiler
Sustainability strategy:	Measures of energy, materials, transport, waste and certified carbon offsets, the goal is carbon neutrality over a thirty-year period: from design through construction and occupancy
Certification:	5 Stars over the 6 stars certification scheme

Delivery process

The 41X Office is the building designed by Lyons Architects and delivered in 2013 with the aim of providing a new building for the Australian Institute of Architects in Victoria, Australia. The building is also aimed at being a hub for architecture, comprising of public spaces, cafes, and retails. The building achieved the five starts over the six starts certification system and the five start NABERS Energy (base building) rating, as well as it is the first strata-titled commercial building in Melbourne to target carbon neutrality over thirty-year functioning. The design approach for the building was to incorporate public functions into a commercial building. To do so the designers created a public space at the bottom floor to allow access and use to the community, as well as designed a green band that runs up to the building as a *fil rouge* of trade union between the city and the commercial facility. Lyons Architects (2017) explained that: *'…the 21 level building, on its small 330m2 site, creates a distinctive vertical urban form, also enabling other owners or occupiers to create their own identity within the building – forming a unique vertical business community'*. The development of this building started in 2006, when the Australian Institute of Architects engaged professionals to carried out a feasibility study to search an appropriate site for the future building. In 2008 a two-stage competition was launched and won by Lyons Architects. The Institute of Architects was closely involved in the design process throughout project resulting in a significant partnership between the client, the architect and the contractor and the contractor Hickory Constructions. A design and construct process continued the innovations on the project, including unique construction methods suited to a small site, with minimal space for onsite materials handling. During construction, Hickory used custom-designed components in the protection screen to navigate the perimeter of the intricate facade. Because the site was on such a constrained footprint, and in an extremely high-traffic (both vehicle and pedestrian) area, options were limited for scaffolding, craneage and access systems beyond the building envelope, with one elevation literally adjoining another building. Guaranteed Maximum Price contract for the construction of the new building, subject to finance, final planning approval and review of the final contract conditions by the Project Control Group; formal agreements, including related deeds of novation, with the architect and other key project consultants, and arrangements to obtain project finance up to an agreed limit from a bank or other approved financial institution were the contractual systems utilised on the project. To achieve the target of carbon neutrality, the designers run an assessment over thirty years of building functioning and demonstrated the effectiveness of materials, waste recovery systems, and predicted associated transport, at each stage of the life-cycle. Lyons teamed up with AECOM to devise solutions that took a holistic approach to a building's carbon cycle. The team considered that a building, through its construction and operation, builds up a balance sheet of carbon that is displaced to the environment. Moreover, the project provided extensive bicycle parking and shower and change facilities instead of car parking and the façade system achieves a 40% higher efficiency than what is required under the Building Code of Australia, as explained by Lyons

Architects (2017). Moreover, Lyons (2017) explained that the AIA initiated a 'sustainability charter' as part of the Body Corporate, through which annual carbon offsets are assessed, and implemented thereby making the development 'carbon neutral' over its operational lifecycle. The Sustainability Charter binds tenants to the sustainability agenda for the building to monitor and, where needed, change behaviours. On an annual basis, the measured operational carbon footprint of the building's tenants will be independently assessed. Combined with the quantified embodied carbon of the physical building, the operational carbon will be offset annually.

Innovation types and impacts

The context in which the building was developed can be described as incremental innovation because, even if the floor plan was particularly small compared to others in the central business district of Melbourne, the lot is characterised by standard characteristic for a retail an office building. The building aspects such as the typology, the shape, the geometry, ad access and circulation can be defined as architectural characteristics of the artefact. This is the predominant type in the project. System innovation can be found in all the building elements that contribute to environmental control strategy, such as the roof top air chillers, the glazing system designed by optimizing the shape in relation to the microclimatic characterises, the hybrid HVAC system, and the thermal plant set on the roof. Significant role was also played by the material selection to ensure their embodied energy. By providing mutual effectiveness, these innovations improved as a system the entire environmental building performance. Other building elements such as water system, lighting system, sewage connection, and structure fall between the category of standard practice and therefore are categorized as incremental innovation.

Table 24: The table shows the types of innovation on the project. The 41 Exhibition Street Building was predominately characterised by architectural innovation and system innovation.

	Incremental	Modular	Architectural	System	Radical
Context Characteristics	■				
Architectural Design			■		
Construction Systems	■				
Secondary Elements		■			
Environmental Control Systems				■	

Table 25: As showed in the table below, the project was developed by relying on competence creating activities.

Actor	Competence Creating	Competence Destroying
Public Insititution	■	
Client	■	
Designer	■	
Builder	■	

Industry		
User		

The development of this building did not required activities of competence destroying, but mostly competence creating. Even if for the building company Hickory, great technological challenges were posed by the site dimension, their knowledge allowed them to overcome with technological solutions such limitation.

Sustainability results

The sustainability results achieved on this project were predominantly environmental, both in the building and in the process. The majority of design decisions taken contributed achieving five starts over the six starts certification system and the five start NABERS Energy (base building) rating. The decisions that allowed the achievement of GHG emission reduction, and plan to achieve zero carbon over thirty years' time were the ones related to the environmental control system, as well as material selection and behaviour of those over time. The social results achieved were a higher degree of public inclusion into the building functioning thanks to the accessible floor plan. Also, economic results were achieved by producing comparative advantage for the designers and competitive advantage for the builders and suppliers involved in the project.

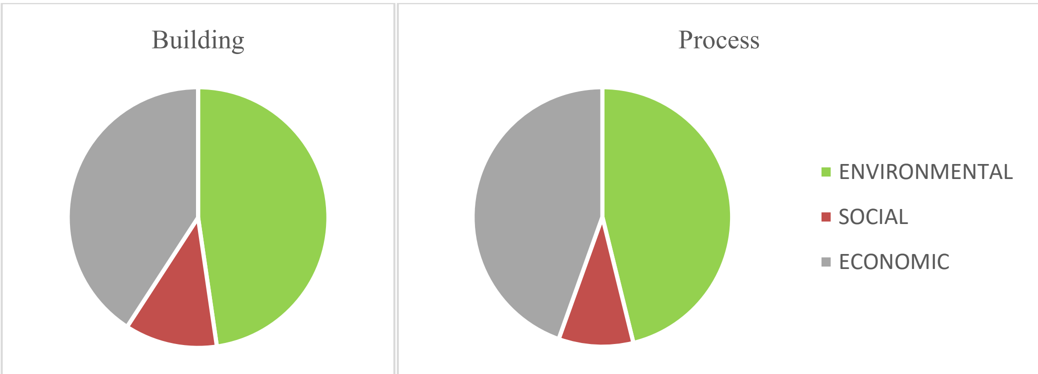


Figure 28: The pie charts above show that the majority of results achieved on the project were of environmental and economic nature.

The actors and the eco-innovation and sustainability model

The actors who were predominantly involved on the project were the client, the designers (architects and consultants), and the builder. These actors are the one that characterize the traditional procurement method. In the case of this project the co-ideation phase was carried out by the client, who promoted, funded and organized the processes to start the delivery process for the building. After setting up the design competition, the designer and the consultants characterized the co-ideation phase. The builder as well took an important role in enabling the delivery of the building project by defining appropriate construction methods for the project. The co-institutionalization phase was characterized by the impact that the project on the development of knowledge and technology. This was due to the communication of the results achieved both in terms of building decisions made and in terms of technological solutions applied during construction.

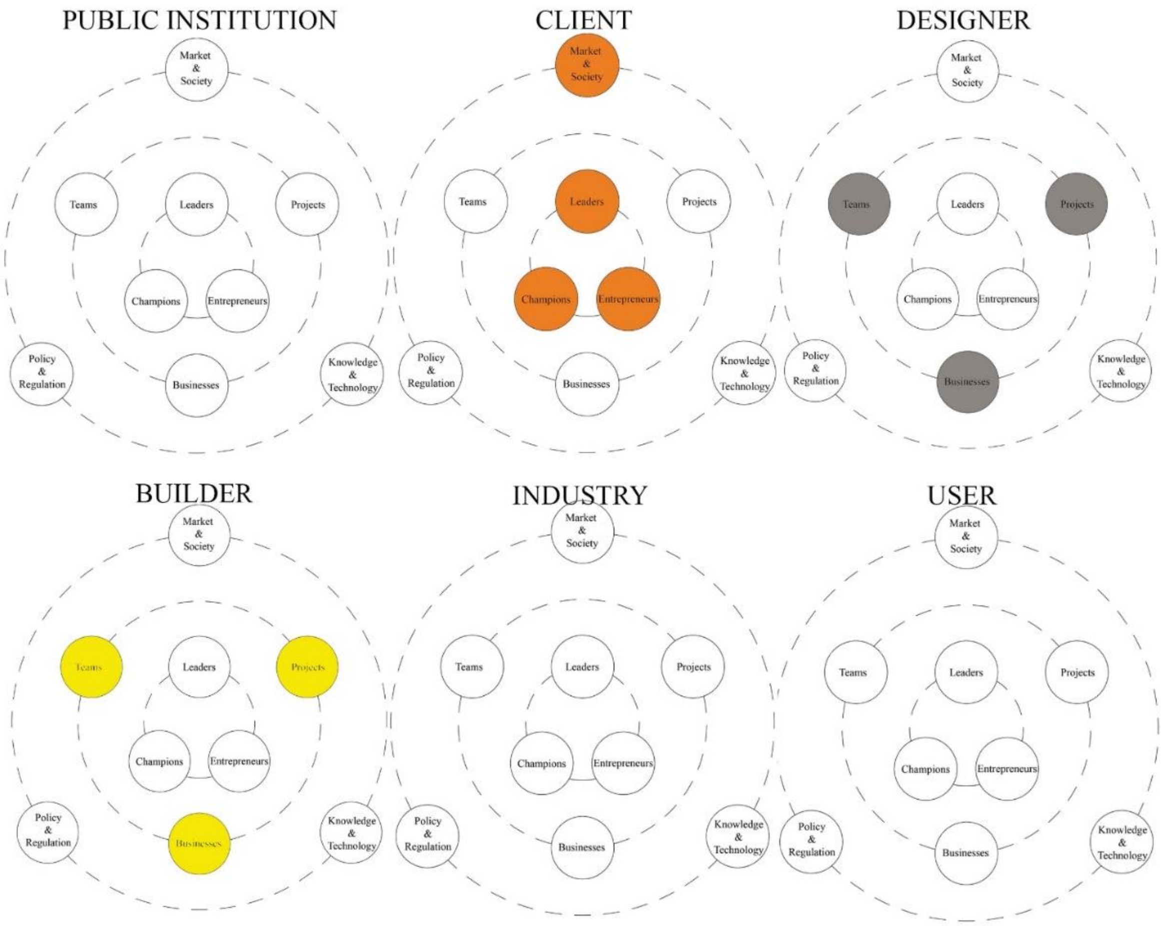
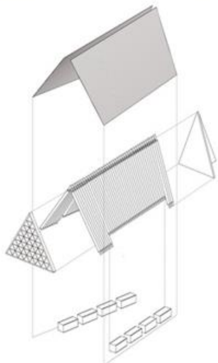


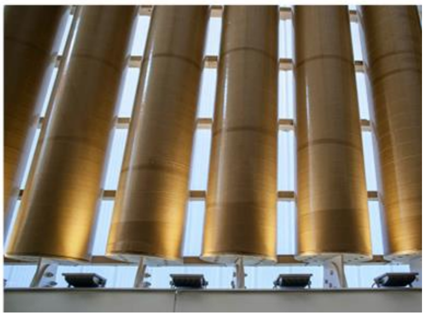
Figure 29: The image above shows the roles of actors on the project. Client, designer and builder played roles respectively in the eco-ideation, eco-innovation and eco-institutionalization phase.

5.2.3 The Cardboard Cathedral, Christchurch, New Zealand – Building characteristics

The Cardboard Cathedral
Christchurch, New Zealand
Shigeru Ban
2011

Context Characteristics:	Urban
Concpet Characteristics:	Golden Ratio and Existing Cathedral Facades
Orientation:	Emisphere (Emisfero) Austral Axes (Asse) north (entrance) / south (apse) 43°31'48" S 172°37'13"E.
Dimension:	Site: 2500 square metres, Building: 750 square metres
Shape:	A shape, there is a gradual change in each angle of paper tubes, narrower toward the apse. The shape unintentionally recalls the traditiona Maori house.
Floor number:	One floor, 24 metres, 5 meters vertically
Access and circulation:	Main entrance is in the front facade. On each side, between each of the four shipping containers, are located 3 secondary entrances. Two more entrances are located in the back of the altar.
Structure:	A-Shape Steel Portals
Construction systems:	Locally sourced laminated veneer lumber (LVL) rafters is inserted inside each of the 98, 610-millimeter-diameter (2-foot-diameter) cardboard tubes comprising the A-frame.
Evironmanetal control systems:	Transparent/opaque relation: between each cardboard tube the is a gap of 2 inches (5,1 cm), in order to let the light pass through polycarbonate roof Automated vents at the top and bottom of the opposing ends provide cross ventilation when required Heating pump for underfloor heating Maximisation of local material
Water treatment:	Standard water collection through gutters, connected to sewerage.





Delivery process

The cardboard cathedral was built in 2011 as temporary building in response to reconstruction emergency in Christchurch, Nez Zealand after the big earthquake that hit the city in the same year. This building was commissioned by the Anglican Diocese of Christchurch with fundraising, community donors, and earthquake funds. The scope of the cardboard cathedral was, and still is, to host the activities of two congregations: the St. John congregation, and the Anglican Diocese of Christchurch, after their former buildings were destroyed by the earthquake. The designer for this building was Shigeru Ban Architects in conjunction with a local firm called Warren Mahoney Architects. Shigeru Ban was selected and directly contacted because he had already experience in emergency shelters in cardboard. In 1986 he had built projects such as: Paper Log Houses (Kobe, Japan, 1995), Paper church (Kobe, Japan, 1995-2005, disassembled), Paper Emergency Shelters for UNHCR (Byumba Refugee Camp, Rwanda, 1999), Tsunami Reconstruction Project (Kirinda, Sri Lanka, 2007), Hualin Temporary Elementary School (Chengdu, China, 2008), Paper Concert Hall (L'Aquila, Italy, 2011). As per other projects, Shigeru Ban worked pro-bono, and provided concept drawings, interior design, supervision of technical and construction aspects. Warren and Mahoney helped the Japanese firm with the papers and produced technical drawings. The construction of the building was carried out by Naylor Love as major contractor, in conjunction with other fifty subcontractor. The project manager was Stephen Lynch. The financing process was complex. Initially the Anglican Diocese hoped to use the insurance pay-out of the old Christchurch Cathedral (NZ$ 4,2 million - mainly from a Material Damage indemnity pay-out, also from Business Interruption contributions) and its annual maintenance grant of NZ$ 240,000 gave by the City Council to pay for the Transitional Cathedral. img15. Naylor Love logo on the cathedral construction site. However, The Great Christchurch Building Trust (GCBT), co-chaired by former MPs Jim Anderton and Philip Burdon, took the Anglican Church to the High Court, to determine whether an insurance pay-out for Christchurch Cathedral can be used for the transitional cathedral. Following the judge indicating it may not be legal to build a temporary cathedral using the insurance pay-out (confirmed as illegal in April 2013) in November 2012, the church began fund-rising to pay for the NZ$5 million project. Key part played the factor that many of the actors involved worked pro-bono (for free), including: Peter Marshall and Richard McGowan (Warren and Mahoney Architects), Bob Blythe and Johnny McFarlane (Beca - Project Manager), John Hare and Stuart Oliver (Holmes Consulting), Chris Allington (Materials Testing), Darin Miller (Holmes Fire), Sonoco (Cardboard Supplier), Andrew Ward (Cardboard design and manufacture), George Hotel (provided free accommodation for Shigeru Ban and Yoshie Narimatsu, AirNew Zealand (providing sponsorship to facilitate international travel. Overall, more than 17 suppliers and contractors will have donated an additional US$832,000 worth of time, labour and materials to its construction, and many others offered discount prices. Among the funders we find the Church, public donations and the Rata Foundation, formerly Canterbury

Community Trust. Rev. Craig Dixon was clear that the Transitional Cathedral "had to pay for itself", so it also hosts conferences, weddings, corporate functions, celebratory dinners, fashion shows, seminars, presentations and many other uses. On the inauguration date concerts were held with a ticket price of NZ$10. By January 2013 NZ$2 million had already been spent on the project. The expected budget was NZ$ 5,3 million, but eventually it increased until NZ$ 5,9 million (€3,8 millions).

Innovation types and impacts

The cardboard cathedral project is characterised by areas of radical innovation, as well as system and architectural innovation. The emergency circumstances established a radical context for the project development, which had to be developed in a site which was not the initial of the former cathedral, in a fast manner, and depending on fundraising and community and professional involvement. The contextual characteristics were therefore uncertain and radical in terms of project promotion and ideation. The concept of the building – the cardboard cathedral – as well as the resulting structure are characterised by radical innovation. For the context of New Zealand, the use of cardboard as structural material was a radical innovation, as it had never been used before this project, and it triggered new processes in technology and industrial production, as well as introduced new skills and knowledge in the building industry (for instance in the construction systems and sequences). The orientation, the architectural characteristics, the dimension and the shape of the building were all characterised by architectural innovation, as determined the manner in which the artefact was conceived. These characteristics were influenced and inspired by the relation with the site and shape of the former existing cathedral. System innovation characterised the design decisions in the environmental control system, the orientation, and the water and sewage systems. Despite all these components were standard, by influencing each other, they were optimised to perfume efficient in the building, and therefore work as a system.

Table 26: The table shows the types of innovation in the cardboard building project. The use of cardboard in emergency setting was a radical innovation for the New Zealand context.

	Incremental	Modular	Architectural	System	Radical
Context Characteristics					
Architectural Design					
Construction Systems					
Secondary Elements					
Environmental Control Systems					

Table 27: The table shows that client, builder and industry had to undertake competence destroying activities on the project.

Actor	Competence Creating	Competence Destroying
Public Insitittution		
Client		
Designer		
Builder		
Industry		
User		

The type of innovation on the project relied on competence creating activities by the parties involved, which applied their knowledge to develop this project. Shigeru Ban for example already had previous experiences in delivery cardboard projects in emergency context, as previously explained. The exception can be found in all the participants involved with the delivery of the cardboard building structure, as well as for the client. The Diocese had to perform the role of client in the building industry, which is normally out of their tasks, and competencies, so they had to familiarise with the roles and processes involved in building delivery. Moreover, the main contractors, the subcontractors and the suppliers, who delivered the cardboard structure had to learn new set of skills and knowledge to deliver such technology.

Sustainability results

The majority of decisions taken both on building design and in the delivery process were of social nature. The scope of the project itself was of social nature, as the former cathedral played an important role for the community. Due to this role the design characteristics of the temporary cardboard cathedral were defined in order to recall the aspect and the characteristics of the former building, in such way to re-establish a sense of belonging and familiarity for the community with the new building. Aspects related to costs and environmental aspects were also considered, and results were achieved by delivering a building within tight budget and utilise materials that can be recycled and re-use once the cathedral was going to be dismantled. In line with the social approach of the building design, the delivery process was characterised by many social results. One of the most crucial aspect to complete the building, was the decision of many actors involved on the project to work pro-bono, and therefore to provide a service for the community. Many decisions in the process were also of economic nature, as the building funds were entirely based on donation and therefore decisions were made to respect the condition of limited budget. Also, in regard to environmental results, decisions were made to optimize the micro-climatic conditions of the area, rather than using active strategies. This was also due to the restricted availability of funds on the project.

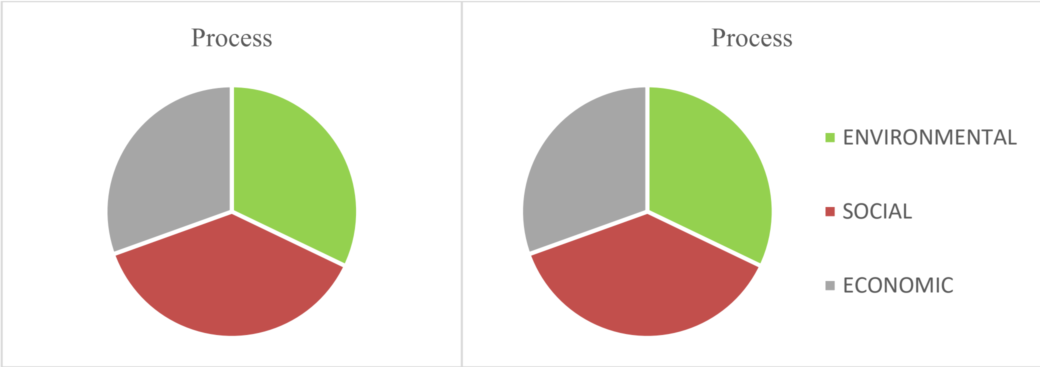


Figure 30: The pie charts above shows the nature of results both in the building design decisions and in the delivery process characteristics.

The actors and the eco-innovation and sustainability model

The actors who played a crucial role in the delivery of the cardboard cathedral were the client, the designer, and the community with their role of financing support. The co-ideation phase of the project was characterised by the role of the client – the St. John Anglican Diocese – which decided that they needed to provide to the community a temporary cathedral to host their religious functions, after the earthquake that destroyed the former building. They performed the role of leaders, entrepreneurs, and, in conjunction with the community who provided financing support, they also covered the role of champions. In performing this latter role, they assigned the design contract to Shigeru Ban, who, together with the builder (the main contractor) and the industry (the suppliers) were able to characterised the co-innovation phase, which was heavily impacted by the delivery of the cardboard structure of the building. These actors worked in teams on this project and established a very collaborative environment, characterised by remarkable social purpose. The social innovation here is to be found in the pro-bono nature of their activities that characterised the co-innovation phase. The co-institutionalization phase was characterised by the impact that the all the actors involved had on the market and society. Mostly, the scope of the project itself, as well as its delivery process was aimed, and it did achieved, great positive impact on the society, which could get the cathedral back in their community. The introduction of the cardboard technology as construction system also produced an impact on the area of knowledge and technology, by introducing new skills and abilities in the industry.

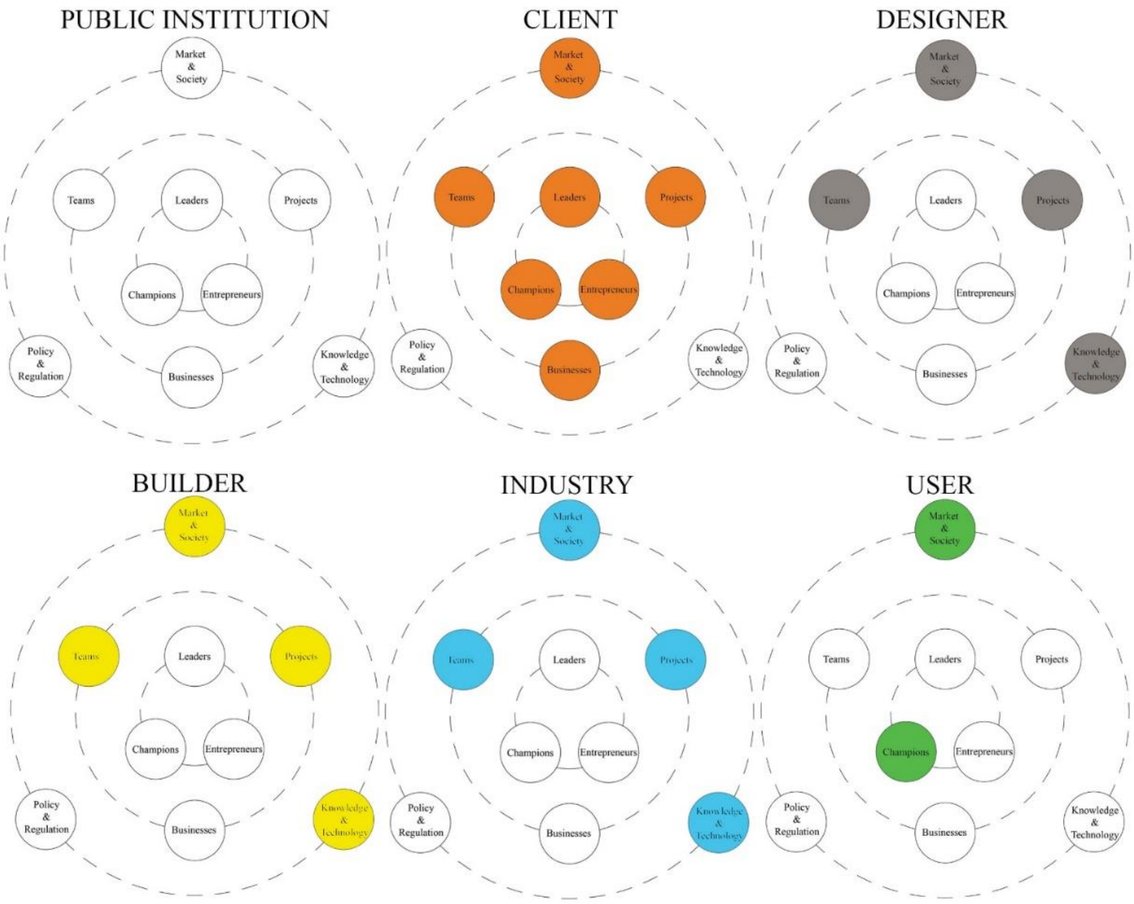


Figure 31: The image above shows the application of the eco-innovation and sustainable management model to the Cardboard cathedral project. The client had a predominant role in all the areas of innovation introduction, whereas designer, builder and industry were critical for the eco-innovation phase. The users, conceived here as the community played the role of champions who had an impact on the eco-institutionalization phase, by supporting financially a project for the community.

5.2.4 Cassia Coop Training Centre, Sumatra, Indonesia – Building characteristics

Context Characteristics:	Rural
Concpet Characteristics:	Courtyard building with light wooden construction on a base of heavy brick and concrete. The wooden construction gives a feeling of being within a cinnamon forest as where it is built.
Orientation:	North/South
Dimension:	484.0 sqm
Shape:	The building shape in plan is a rectangular geometry With a slope unattached roof, the whole building forms a prism in volumtric shape.
Floor number:	Single Storey
Access and circulation:	Main access on the lake-around road and flows for people(mainly), livestock, cars and tracks.
Structure:	Load bearing walls, wooden Y-shape pillars.
Construction systems:	Locally crafted brick to construct the load bearing wall,which mainly intended to divide the outdoor and indoor space. The trunk of the cinnamon tree is shaped into timber bar and joint with steel elements to form the Y-shape pillar to support the roof system.
Evironmanetal control systems:	Overheaded roof which means passive ventilation can easily go through the whole building site. provides a good solution to hot and humid local climate,
Water treatment:	Slope roof guides rainwater to flow into natural terrain which normally can absorb the water quickly,moreover in tropic climate, water evaporates soon. Standard wastewater treatment system.
Certification:	NONE

Resource: Cassia Co-op Training Centre<http://www.tyinarchitects.com/works/cassia-coop-training-centre/>
Cassia Coop Training Centre / TYIN Tegnestue Architects<http://www.archdaily.com/274835/casia-coop-training-centre-tyin-tegnestue-architects>

Delivery process

The Cassia Coop Training Centre is a project started in 2010 when the French business man Patrick Barthelemy engaged the TYIN Tegnestue Architects from Trondheim with the enquiry about the development of a training centre for cinnamon workers in Sumatra (Cifuentes, 2012). Sumatra produces 85% of global cinnamon used in the entire planet. Yet the human rights and the working conditions are reported to be very negative. Based on this data, the TYIN Architects after a year of planning made their move to Sumatra with the objective of design and build a sustainable school for the local labour of Sumatra, to work with Cassia Coop Co.Ltd as main client. The aim of this project was to deliver a competitive centre, characterised by work ethic and healthy working conditions. *McArdle and Vitusevych (2013) explained that: '…The project took roughly three months to construct using a large unskilled labour force, water buffalo which transported the timber to an on-site mill, and used only ten details in the whole construction. TYIN's basic and pragmatic approach to designing the training centre made it possible for this project to be realized by an untrained workforce'.* The centre displays the use of cinnamon timber, despite this used to be considered of low status and quality by the locals. Yet, the architects decided to use such material to display the opportunities that such material has when used as construction system and not only be considered a waste from the cinnamon production. Moreover, the centre operates by employing people from the local areas, and by setting an example for the rest of the community. *McArdle and Vitusevych (2013) explained that:'… the centre instilled the locals with a sense of sustainability in regards to the treatment of site. Allowing the Durian Trees to remain and influence the building, rather than removing for the sake of convenience, it has instilled a great value in the nature which they inhabit'.* The building was both build by local unskilled people, as well as it was designed to function based on the interaction and maintenance of such community. This was possible by combining the activities of architects, students, local community, unskilled labour, whom all worked in synergy for three months. The architect contributions was to design simple construction system and details that can be executed with local materials and unskilled labour. For instance, *McArdle and Vitusevych (2013) explained that: '…mass produced Y-Frame's were constructed and bolted to the concrete footings. This dissociation and separation of different building components with different material frequency has helped see the building through several earthquakes above five on the Richter Scale. A wide roof with deep eaves protects the underlying space from sun rays and provides sound shading for cool crosswinds and ventilation'.* Cifyentes (2012) explained that the construction survived several earthquakes reaching over five on the Richters scale, demonstrating the reliability of the materials and construction systems utilised. The budget from the building was 30 million of euros, and the capital was collected through found raising and private donors contributions.

Innovation types and impacts

The innovation types on the project are of many nature. For the context of Sumatra, the concept and the building scope are of radical innovation, as no training centre with such strong ethical approach were present on the area. The architectural characteristics as well as the construction systems and details were a radical innovation, as they were designed to allow the unskilled labour to assembly and maintain the building. Moreover, the waste of the cinnamon tree was here used for the first time as building material, and therefore opening new approaches to the use of such material. Architectural innovation can describe the shape, the architectural characteristics, the floor number and access, whereas the environmental control systems, the orientation, and the sewage and water treatment are characterised by system innovation, in attempting optimising the micro-climatic conditions of the area in conjunction to passive strategies to deliver a performing indoor quality of the space.

Table 28: the table shows the innovation type on the project. Radical innovation characterised the concept for the project, as well as the construction systems and details, which allowed great impact on the training of the local community and on the building industry development.

	Incremental	Modular	Architectural	System	Radical
Context Characteristics					
Architectural Design					
Construction Systems					
Secondary Elements					
Environmental Control Systems					

Table 29: Despite the project represented an intense learning experience for all the parties involved, the architect and the users were the actors who had to undertake the more intense competence destroying activities.

Actor	Competence Creating	Competence Destroying
Public Insititution		
Client		
Designer		
Builder		
Industry		
User		

The sustainable innovations in the building called for a number of competence destroying activities for the actors involved on the project. Despite the design activities to some extent always call for competence destroying activities – as every project is different from others – the architects had to learn the cinnamon delivery process, in order to understand the characteristics of the cinnamon tree and its waste. The greatest efforts was though done by the unskilled labour from the local community, who had to acquire building and maintenance skills to run their own training centre. The project represented therefore a learning process for all the parties involved.

Sustainability results

The majority of the decisions taken on the project - both in term of building design as well as process – led to achieve social and environmental results. The building scope and design characteristics allowed to achieve social sustainable results, such as the delivery of an ethical training centre for the cinnamon labour of Sumatra, the inclusion and the training in building activities of the unskilled labour, and the setting up of an example for the rest of the community. These results also represents an achievement in terms of economic sustainability, as the project contributed to market opening for the community who learned new skills and therefore could potentially enter into a new industry. Moreover, the building also achieved environmental sustainable results such as the re-use of waste and therefore starting an example of circular economy, as well as the optimisation of the micro-climatic conditions and the use of passive strategies, for example in the building ventilation. The design decision of reusing waste material as construction system impinged also on the process, which generated environmental results in terms if primary materials saving and trigger for innovative sustainable building process. The process was used to achieve the social inclusion of the community as social result, as well as to offering the opportunity to the community to learn new skills and enter as well in the building field, by both maintain the training centre, and set the example for other possible similar projects.

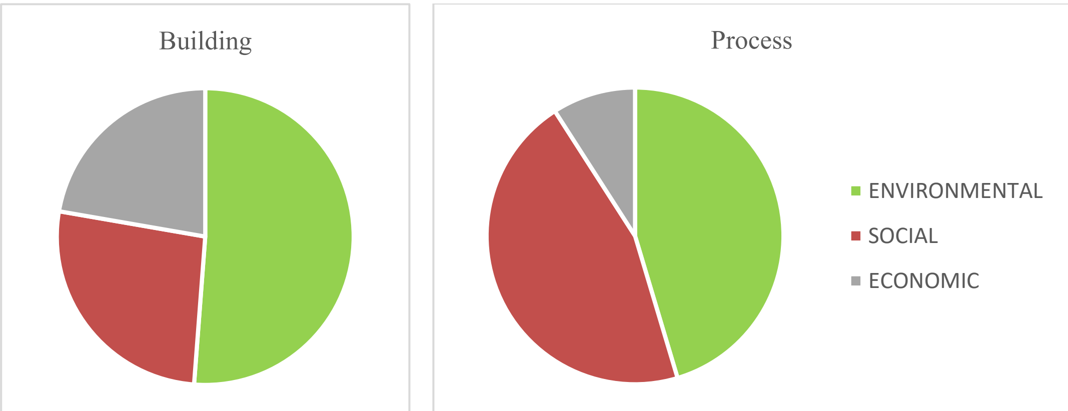


Figure 32: The pie charts above shows the predominance of social and environmental results on the project. The number of decisions made were aimed at producing a social impact with the inclusion of the community and by respecting the environment, promoting ethical approach to the work and production of cinnamon in Sumatra.

The actors and the eco-innovation and sustainability model

The actors involved on the project were the client, the designers and the local community. The co-ideation phase was led by both the client and the designers (both architects and architecture students). With the initiative of Patrick Barthelemy, who promoted the idea of the ethical training centre in Sumatra and its ability to involve the architects, he acted as leader and champion for this project. The architects, whom took the opportunity to organise a project and actualise this idea, acted as entrepreneurs during this phase. The co-innovation phase was characterised by the collaboration of designer and users., who all worked in inclusive teams with the opportunity given by the delivery of this project. This phase was characterised by the design that the architects delivered with the aim of including the community in the building and maintenance process of the building. The co-institutionalization phase was characterised by the impact on market and society by the client, designers, and users; as well as by the impact on knowledge and technology development achieved by the designers and the users. The impact on market and society was achieved thank to the aim of the project itself, as well as to the involvement of the larger community and the ability of the project to set up an example of best practice. The development of knowledge and technology was achieved by training the unskilled labour in building maintenance and technique; and by using construction systems and materials never utilised in the industry before.

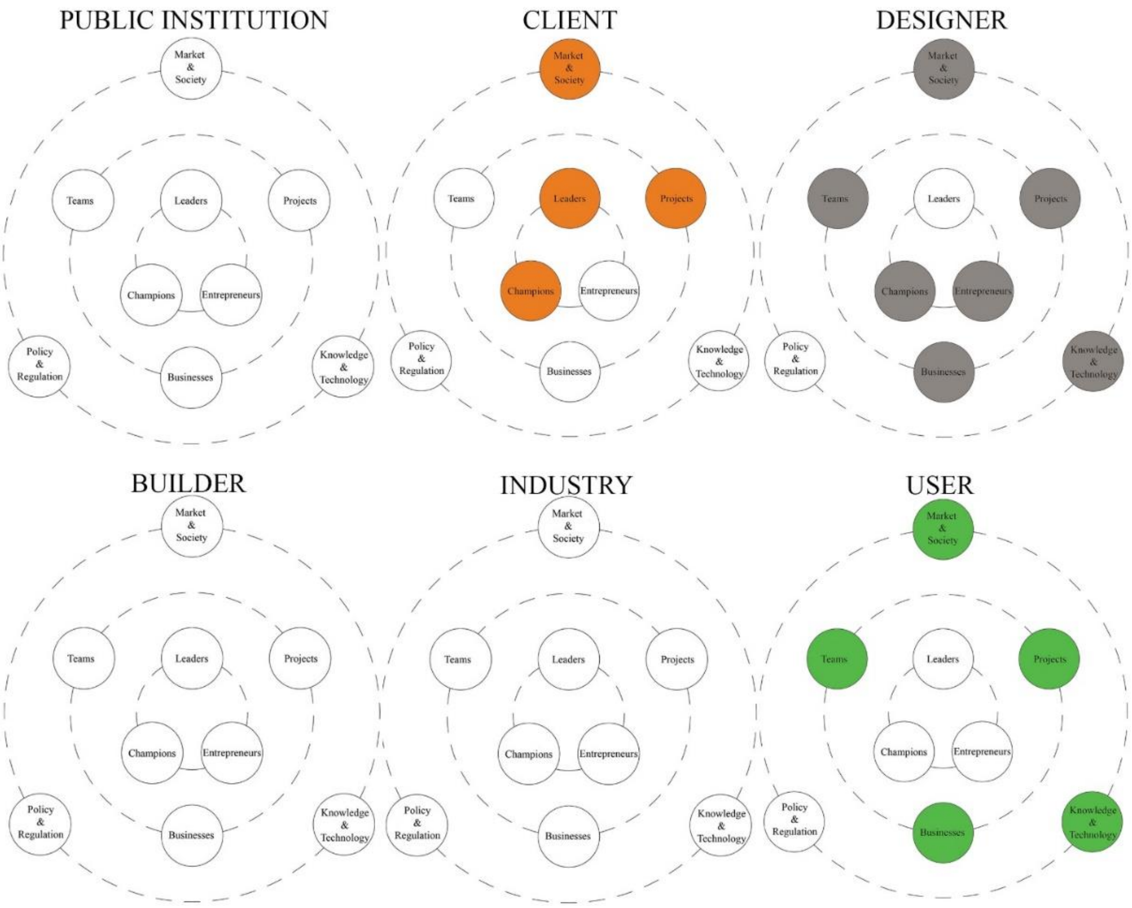
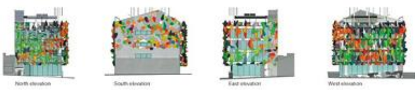


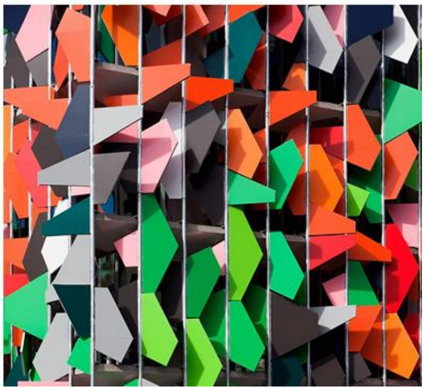
Figure 33: The image above shows the role of client, designers and users on the Cassia Coop project. These actors led the eco-ideation and eco-innovation phase, producing impact on market and society, as well as on the development of knowledge and technology.

5.2.5 Pixel Building, Melbourne, Victoria, Australia – Building characteristics

Pixel Building
Melbourne, Australia
Studio 505
2010

Context Characteristics:	Urban
Concpet Characteristics:	Pixel
Orientation:	North-South
Dimension:	1136 sqm
Shape:	Parallelepiped block
Floor number:	3 Storeys
Access and circulation:	Access from main entrance, free plan circulation inside the building. The building can be reach by different medium of transport
Structure:	Concrete slabs and concrete columns
Construction systems:	Glazed curtain wall with pixelcrete shading system
Evironmanetal control systems:	Rainwater harvesting, Photovoltaic panels with tracking system and wind turbine to produce electricity, a water-ammonia absorption pump is used to heat and cool the building, also thermally active floors works with radiant cooling, smart window system opens automatically allowing 100% fresh air circulation. A heat exchanger captures ebergy from the exhaust
Water treatment:	Innovative vacuum toilets system
Certification:	6 Stars over the 6 stars rating system scheme





Delivery process

The Pixel building was promoted and commissioned by the construction company Grocon in 2007, and completed in July 2010. The building cost was AUD$ 6 million. The building was designed by Studio 505, who were directly contracted by the client, in the basis of their abilities in delivering sustainable innovative projects. The brief for the project was to deliver a 6 Star Carbon Neutral, and with progressive development to allow the development and sale process during construction already. The building is located at the proximity of the Central Business District (CBD) of Melbourne, on the former CUB Brewery site. The scope of the Pixel building was to develop a prototype of commercial building that relies on sustainable innovation as key selling strategy. The building was delivered by Grocon Constructors Pty Ltd with the support of a number of consultants: VDM Pty Ltd (structural engineering), Umow Lai & Associated (building services and ESD engineering), Aurecon (fire engineering services), and Marshall Day Acoustic (Acoustic engineering). The building was financed by Grocon Ltd Pty along with five-years lease for the office. This five-years lease for the office was struck at a net annual rent of $400 per sqm. The building was delivered with design and build system, and the worksite organization and project management was all conducted internally by Grocon Ltd Pty. A number of technologies and materials were tested due to their degree of innovation, such as the ‘pixelcrete’ (a unique type of concrete developed ad-hoc for this project, after 12 months of research by RMIT University facilities), the structure, the vacuum toilets, and the grey water and embodied carbon analysis carried out by the Commonwealth Scientific and Industrial Organization (CSIRO). The building components were produced both Nationally and Internationally. Over the use of the building a number of intervention were required in terms of maintenance, such as for the light fitting, the vacuum toilets, and the tracking system for the photovoltaic panels.

Innovation types and impacts

The type of innovation on the Pixel building are of different types. The concept of relying on environmental sustainability strategy as competitive advantage for selling purposes was a radical innovation strategy for the Australian context at the time of the building development. Other radical innovations in the project were found in the construction system and in the development and use the ‘Pixelcrete’ developed ad-hoc in this occasion, as well as in the use of the vacuum toilets. The building location, shape, dimension fall into the category of architectural innovation. A number of design decision were also characterised by incremental innovation, such as in the case of access and circulation, foundation systems, and fire and communication systems, which follow the building code’s indications. System innovation was found in the lighting systems, which was powered by the photovoltaic panels on the roof; in the window and lighting systems.

Table 30: The image above shows the types of innovation in the Pixel building. The building achieved 6 stars score by applying radical innovation in the field of environmental innovation.

	Incremental	Modular	Architectural	System	Radical
Context Characteristics					
Architectural Design					
Construction Systems					
Secondary Elements					
Environmental Control Systems					

Table 31: Competence destroying activities were undertaken by the users who had to learn how to experience the building.

Actor	Competence Creating	Competence Destroying
Public Insititution		
Client		
Designer		
Builder		
Industry		
User		

The introduction of such innovation required competence creating activities by the parties involved. The client, who was also the developer and the main contractor undertook activities which were all within the scope of their business. Competence destroying activities were though required to the users, who had to familiarise with radical innovative components and therefore learning new knowledge in order to run the building.

Sustainability results

The results achieved in the building were mostly related to the commercial nature of the project and therefore of economic nature. As previously explained many design decisions were aimed at utilising environmental sustainability as selling strategy for the building. Such decisions led to competitive advantage and profit to the client, which was able to generate a return from such operation. Social results were also achieved in the design in terms of improvement of the indoor environmental quality, compared to other similar buildings in the same area. A negative results was found in the management of the building, due to the difficulties of the users in utilising the technological innovations introduced in the building. Pixel has achieved 100 points within the Greenstar rating system, with 75 points the benchmark for 6 Star Greenstar. It gained an extra five points for innovation, equating to world leadership. These five innovation points were points for carbon neutrality, such as a vacuum toilet system, the anaerobic digestion system and reduced car parking.

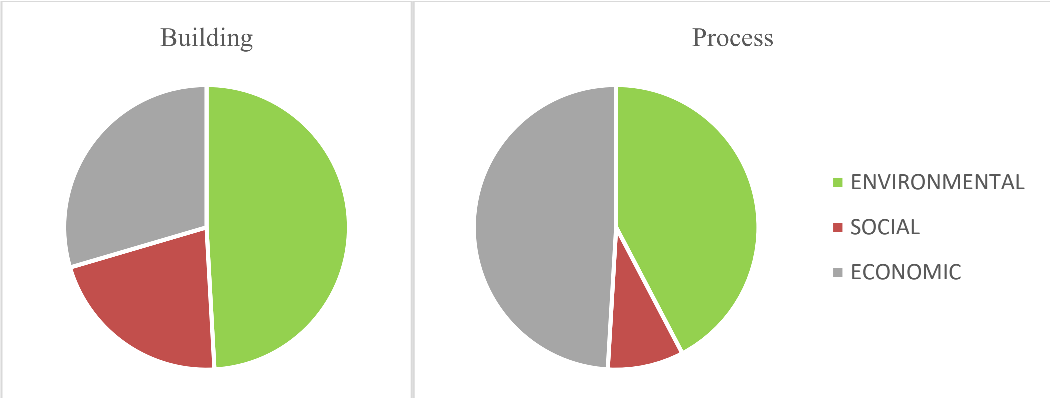


Figure 34: The pie charts above shows the results achieved on the project. As it was aimed during the programming phase, the project achieved positive economic and environmental results, despite some difficulties in some management aspects.

The actors and the eco-innovation and sustainability model

The Pixel building was characterised by the roles of the builder, who was also the client and promoter, as well as by the designer. The co-innovation phase was characterised by the dominant role of Grocon Ltd Pty, which acted as leader, champion and entrepreneur, since the company promoted the idea for the building, defined the strategy, and set up the delivery process for the project. The company also selected the team on the project and the delivery process. The co-innovation phase was also characterised by the role of Grocon Ltd Pty working in team on the project in conjunction with the architects and the consultants. The project itself was organized as a strategic development aimed at obtaining an economic profit for the company. The impact that such decisions had on the co-institutionalization phase was the production and introduction in the industry new knowledge and technology, for example in the case of the toilet system, the anaerobic digestion system and reduced car parking. Moreover, the project, by leveraging on the introduction of environmental sustainable innovation, attempted to communicate the value of sustainability to the market and society.

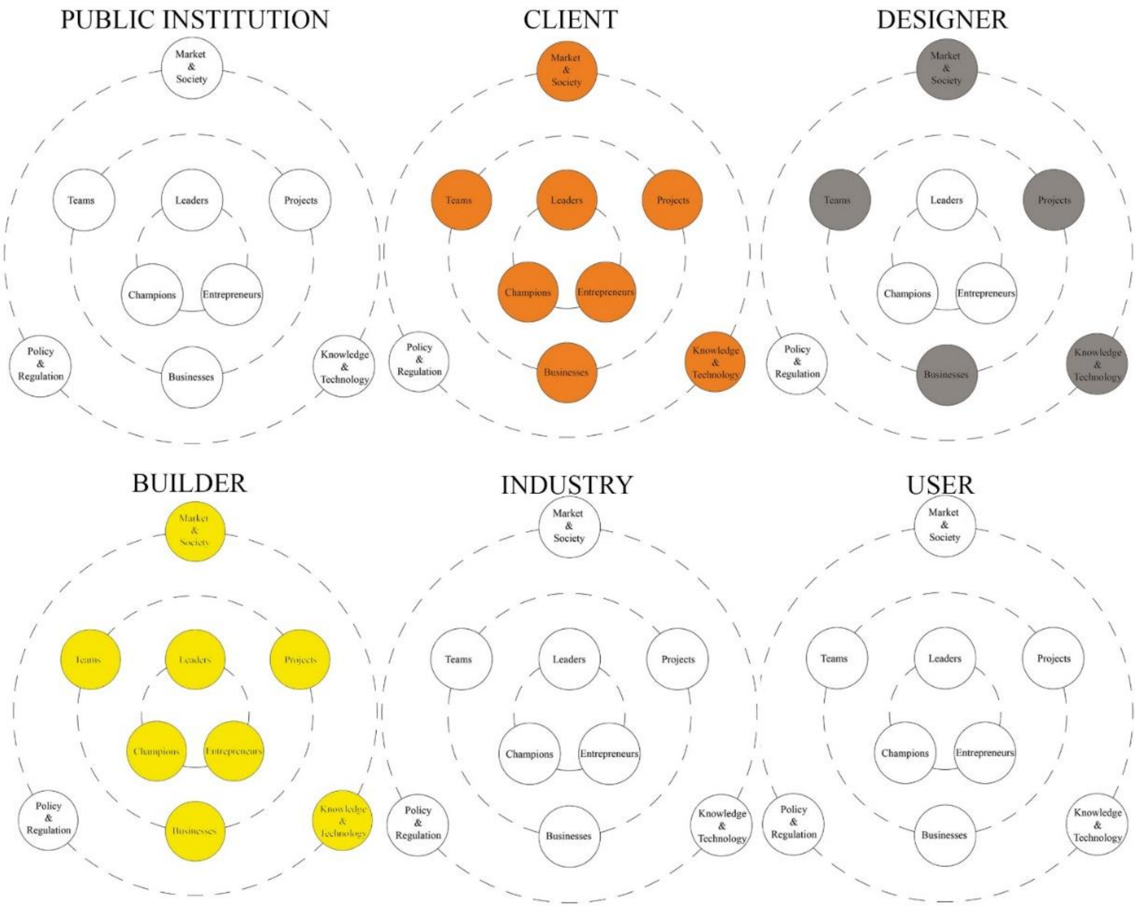


Figure 35: The image above shows the roles of actors within the eco-innovation and sustainable model. The company Grocon Ltd Pty covered a dominant role in all the three phases, namely eco-ideation, eco-innovation and eco-institutionalization

5.2.6 Children's Land Primary School, Gaza Strip, Palestine

Terra dei Bambini - Earth Bag School
Um Al Nasser, Gaza Strip
MCArchitects and Arcò Architettura e cooperazione
2011

Context Characteristics:	Rural - Desert
Concpet Characteristics:	Reinterpreting the Bedouin tent
Orientation:	North-WSouth
Dimension:	400 sqm
Shape:	Court building shape
Floor number:	1 Floor
Access and circulation:	Access from main opening and internal circulation through the court yard
Structure:	Bag of sand as load-bearing walls
Construction systems:	Earthbags and timber frame. The roof is a steel frame construction, covered by a material that can be folded.
Evironmanetal control systems:	The roof is a folding system that can change according to solar incidence, as well as it is intagrated by photovoltaic panels
Water treatment:	An ad-hoc water depuration system has been built for the building in the courtyard. From the roof the rainwater is collected into the central courtyard
Note:	A bombing attack destroyed the building in 2014

Delivery process

The Children's Land Primary School in Um Al Nasser, Palestine was a project developed in 2011 by Arcò Architectures in conjunction with Mario Cucinella Architects, as the result of a call for a 'Bedouin Tent' by the NGO Vento di Terra. The call was to provide a primary school that could remind of the traditional Bedouin culture of the 'tent' as the gathering place for the kid of the Bedouin, expelled from Ber Sheva in 1984. The architects decided to use bioclimatic criteria and the use of local material as main design criteria. The building was therefore built using earthbags, wetland, and photovoltaic panels, and with the help of local unskilled labour. This decision allowed the local community to learn and develop new skills. The school management is also carried out by a local team of people who were trained by teams from the NGO Vento di Terra. The construction was organized with critical path and it lasted only few weeks. Moreover, the NGO also organized and trained the local community to develop inclusive education programs. The project was part of the program 'Peace Architecture for Education in Gaza' and funded by the Italian Ministry of Foreign Affairs, Italian Episcopal Conference (CEI), Milano Municipality, L.U.S.H., and it is supported by the Vento di Terra NGO's network. The total cost for the project was 180.000 euro. As it was reported by many media, Unfortunately the school complex was destroyed during an invasion occurred in 2014.

Innovation types and impacts

The innovation types in the building spanned from incremental to radical. This latter is found in the concept, in the scope of the building itself, and in the technological systems introduced in the building such as the water purification system. The site itself is a radical setting for the construction of a public building, as the Gaza Strip is reported to be lacking of any programming or urban organization. Modular innovation characterises the timber floor system and the vertical internal partitions. Architectural innovation described the building typology, the geometry, the shape and the layout, whereas system innovation can be found in the relation between orientation, optimization of the microclimatic conditions, and the indoor environmental control strategies, such the use of natural lighting and natural ventilation. Despite, the use of earthbags can be considered an innovative building techniques for many context, in the area other examples of building with such materials already existed, and some of the project participant were already skilled to deliver such technique. For this reason, the construction system in the building can be consider either architectural innovation (if considered per se), or system innovation, as such technique contributed to the performance of the indoor environmental quality. Incremental innovation was found in the foundation systems, which followed the standard practice.

Table 32: The table the distribution of type of innovation on the building. On this project the types of innovation spanned from incremental to radical innovation.

	Incremental	Modular	Architectural	System	Radical
Context Characteristics					
Architectural Design					
Construction Systems					
Secondary Elements					
Environmental Control Systems					

Table 33: The project called for competence destroying activities for all the parties involved in the project.

Actor	Competence Creating	Competence Destroying
Public Insititution		
Client		
Designer		
Builder		
Industry		
User		

The innovation in the building required a certain degree of competence destroying activities for a number of actors involved. For instance, the NGO Vento di Terra and the local community had to learn new competencies to deliver the building project. To some extent, also some of the financing actors involved undertook roles that differs from their core scope activities, such as in the case of Ministero degli affari esteri; Cooperazione italiana; Comune di Milano; Comune di Sesto San Giovanni; L.U.S.H. Italia; NGO Vento di Terra. All the actors involved in the building construction undertook some risk during the delivery due to the high risk related to the war conflict in the area, and therefore had to acquire skills in relation to potential safety issues.

Sustainability results

The results achieved were predominately social and environmental. Economic results were also achieved in terms of cost saving and in the market opening and knowledge acquisitions for the local community, who, through the construction, could learn new competitive skills. The building set an example for environmental architecture for the Palestinian building industry. This result was achieved thanks to the use of low cost, low tech materials, and ease of constructability, and therefore replicable in other project in a similar context. The environmental approach in the building helped reduce the GHG emission and optimise the energy resources in the area. This result was achieved thanks to the fact that the building was for a part hypogeum, and therefore the class benefitted from the thermal inertia of the soil, which contributed to the temperature control. Also, the natural ventilation contributed to the indoor thermal performance of the space, as well as the double roof system allowed the convective motion and exchange between different air temperature. Water collection and storage was also an environmental achievement on the project., as well as the use of photovoltaic panels in the optimisation of energy resources. Beside the social nature of the project aim, the building help facilitate the introduction of innovative teaching methods, achieving the increase of literacy for the local kids. The building also aimed at providing a safe place for the kids, and women of the community. The teaching method also was focused on promoting ‘peace education’. The building also offered the space for setting up a counselling desk in support of education and mothers, as well as the organization of workshop by the Palestinian Medical Relief, in order to counter the proliferation of intestinal infection that affects the majority of Um al Nasser children in preschool. Unfortunately, these results did not last for long. As previously mentioned, the building was destroyed in 2014, destroying as well the meaning, the efforts and the positive results that the building had achieved after its construction.

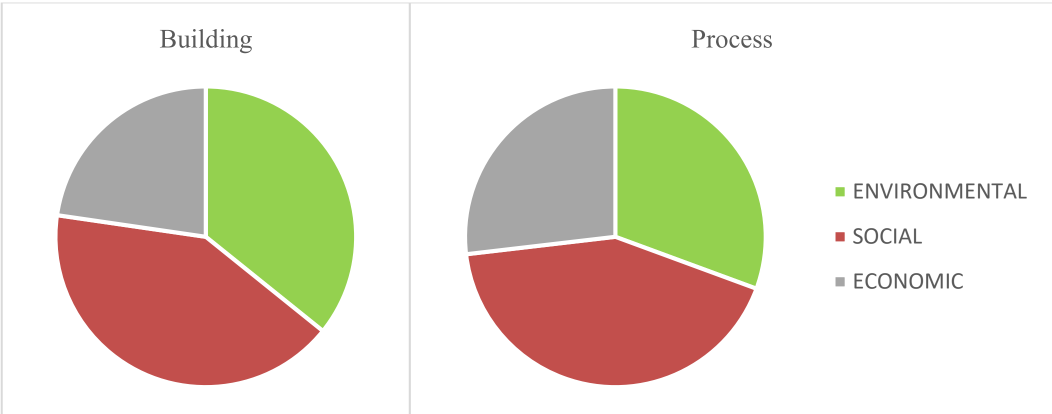


Figure 36: The pie charts above show the nature of the results achieved on the project. The Children’s land project was predominantly a social and environmental endeavour, which could, at least for a while, produce positive results in this instance.

The actors and the eco-innovation and sustainability model

The actors involved on this project were public institutions (such as the Italian Minister for Foreign Affairs, and other Local Italian Town Government), private entities (donors), the NGO Vento di Terra, The designers, and the local community. The co-ideation phase was characterised by the role of the public institution, which enabled the delivery of such project by setting up the ‘Peace Architecture for Education in Gaza’ program, and therefore acted as leader. The NGO Vento di Terra also acted as leader, champion ad entrepreneur, since they ideated, promoted and created the links to enable the project. The co-innovation phase was characterised by the teams of the architects and the local community who worked together on the design and delivery of the project. By doing so, they had an impact on the co-institutionalization phase, which was characterised by the generation of results on the market and society, by the development of the knowledge and technology, as well as, thanks to the role of the client and the public institution, the attempt to establish a benchmark for the delivery procedure of future projects in the area.

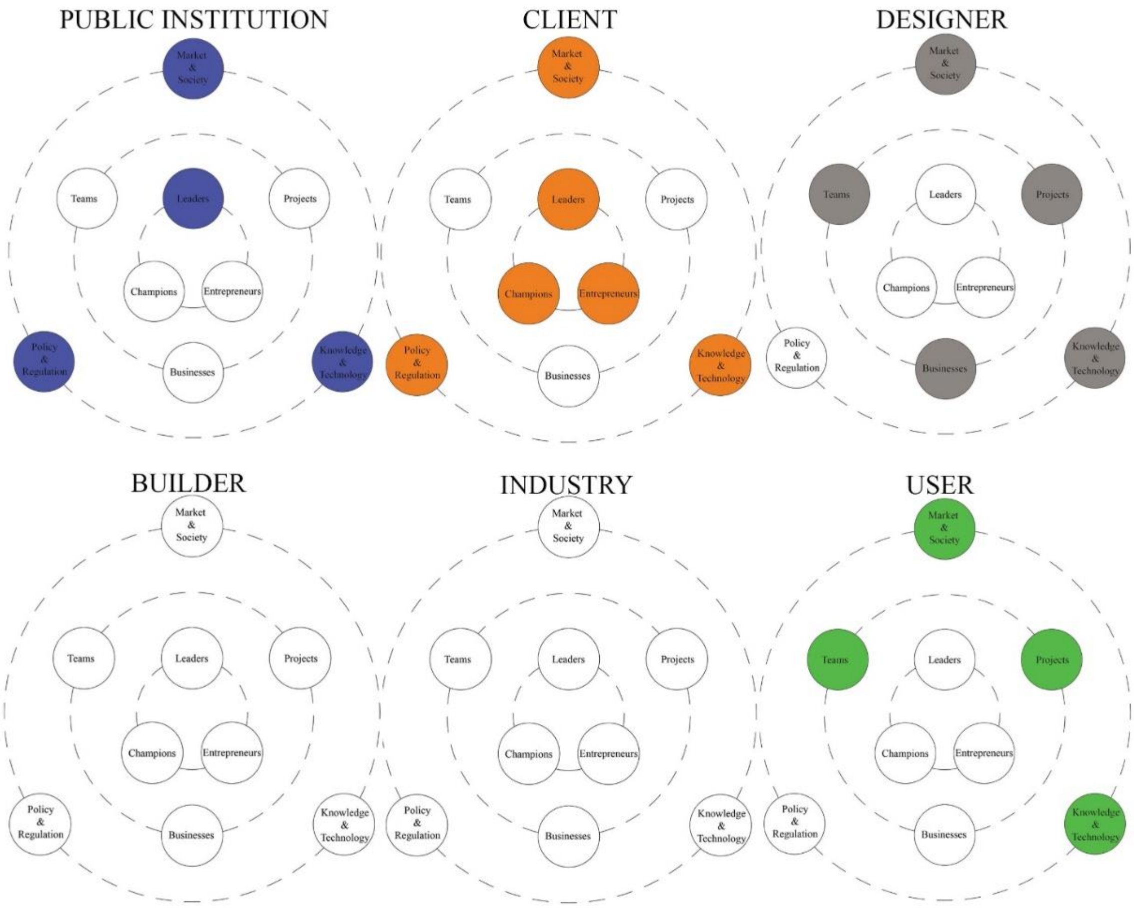
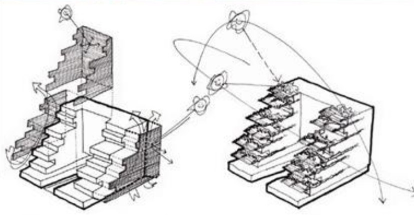


Figure 37: The image above shows the role of the actors involved on the project. The eco-ideation phase was characterised by the role of public institution and client. The eco-innovation phase was characterised by the roles the designers in conjunction with the local community; and the eco-institutionalization phase was characterised by impacts on market and society, knowledge and technology, and policy and regulation.

5.2.7 Sieeb Building, Beijing, China – Building characteristics

SIEEB
Beijing, China
MCArchitects
2006



Context Characteristics: Urban

Concpet Characteristics: Sun path as shape optimisation

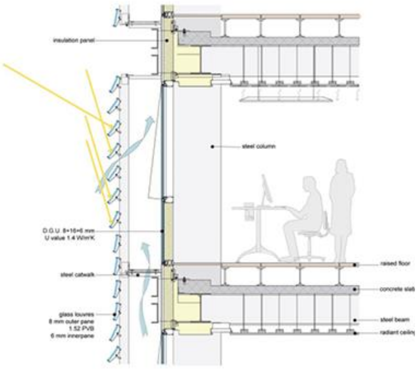
Orientation: North-South with courtyard opening to the South

Dimension: 20.000 msq

Shape: C Shape with sequence of roof gardens

Floor number: 10 Floors

Access and circulation: The circulation is designed to connect the internal courtayrd to the back part of the North facede of the building and therefore giving permeability to the ground floor of the building. The main access is from North side of the building



Structure: Steel structure

Construction system: Different systems of ventilated façades are used for the internal “skin” . The building’s east and west external sides are clad with a “double skin” of a simple curtain wall with a design of opaque/transparent modules and a screen-printed ex¬ternal façade. The east and west façades include special complements like inside and outside light shelf elements and interior blinds to control reflection and optimize the spread of daylight. The sunbreaker structure is made of reflecting glass blades that are inclined at different angles to control the sunrays and light’s penetration in the offices spaces

Environmental control systems: The building has a number os environmental control strategies both artificial and natural. In summer, the building relies on solar protection, green surfaces, photovoltaic system, open space ventilation, and rainwater collection. In winter, the building relies on solar support, high insulation wrap, winter winds protection thanks to its shape, and rainwater collection. Moreover the buiding has a system of energy co-generation

Delivery process

As MCArchitects (2018) explained: *'...Born out from a joint venture between the Italian and Chinese Governments, SIEEB was built on the campus of Tsinghua University, it occupies an area of 20,000 m2 and hosts the Sino-Italian centre of education, training and research for the protection of environment and energy conservation. The building is designed as a 'showcase' for the potential for reducing CO2 emissions in China. The design integrates passive and active strategies to control the external environment in order to optimise internal environmental conditions. The building is U shaped in plan around a central courtyard and on the ground floor public areas look onto a landscaped garden. It is closed and well insulated on the northern side that faces the cold winter winds and open and transparent towards the south. Offices and laboratories on the upper floors have terraced gardens shaded by photovoltaic panels that produce energy for the building'.* The building client and land owner were the IMET and MOST groups, and the Tsingua University. The project was entirely delivered by Italian companied, such as the designer MCArchitects, the building company Impregilo s.pa., the project and construction manager PMC Italia, as well as many other consultants and subcontractors. The project was entirely financed by the Chinese Government and the total cost was 20,500,000 euro. The building was developed and delivered in two year time. The construction systems on the project were mostly pre-fabricated in order to increase the control through design and optimised logistics already during the programming phase of the building. Inhabitat (2018) explained that the building was…'Designed to maximize passive solar capabilities and fitted with state-of-the-art active solar elements, the SIEEB is a dynamic energy-efficient oasis that optimizes its urban location with ecological considerations. Architect Mario Cucinella and the Milan Polytechnic conceptualized the structure to educate and showcase possibilities for energy-efficient building, particularly in regard to CO2 emissions'. Scope of the building was therefore both to achieve high results in terms of environmental sustainability, as well as to serve as benchmark for the local industry, and to set an example of best practice.

Innovation types and impacts

Despite none of the design decisions taken on the project fall into the category of radical innovation, the building is characterised by many architectural and system innovations. Some aspects of the project, such as the building location, the foundation systems and the internal partitions can be considered incremental and modular innovation, as they adhere to standard practice or introduce change in modular parts of the building. The overall bioclimatic design approach confer to the a number of design decision the possibility to be catharized both as architectural and system innovation. For instance, once could consider the building orientation, the volume, the shape and the layout as characteristic which are definitive of the architecture of the product (Henderson and Clark, 1990). Yet, in the specific case of the bioclimatic design approach, such characteristics also contribute to the overall environmental control strategy for the building, and therefore become a system with other technological innovations introduced on the project. Most of the innovations introduced on the project were of system nature. The four different façades that were design to optimise the microclimatic conditions of the site, the water collection, the monitoring system, as well as the passive ESD strategy, are all aspects that collaborated to increase the indoor environmental quality of the building.

Table 34: The table shows the innovation types in the SIEEB project. The most relevant outcome is the number of architectural and system innovation that characterised the nature of the bioclimatic design of the building.

	Incremental	Modular	Architectural	System	Radical
Context Characteristics					
Architectural Design					
Construction Systems					
Secondary Elements					
Environmental Control Systems					

Table 35: The Public Institution who promoted and developed the project undertook competence destroying activities.

Actor	Competence Creating	Competence Destroying
Public Insititution		
Client		
Designer		
Builder		
Industry		
User		

These innovations called for competence creating activities for most of the actors involved. The way in which the building was procured allowed the designers, the consultants, the contractor and the subcontractors to develop the design and the delivery by relying on their existing knowledge. This was due to the type of design (prefabrication), which allowed to exercise control over the final results, without meeting the challenges of dealing with the local industry, which mostly provided the labour on the project. The competence destroying activities existing on the project were undertaken by the Italian and Chinese Government, which joint into a venture to the delivery of the project, exploring activities not necessarily defining the core of their mandates.

Sustainability results

The building is designed as a 'showcase' for the potential for reducing CO2 emissions in China, and therefore achieved to become a benchmark and an example for the industry, as its design integrates passive and active strategies to control the external environment in order to optimise internal environmental conditions. MCArchitects (2018) reported that The envelope components made of extruded aluminium, as well as the control systems and the other technologies are the expression of the most up-to-date Italian production. This aspect allowed to the companies to obtain a competitive and qualitative advantage by displaying their innovations on this project, and therefore producing an economic advantage. Also environmental results were achieved such as the resource use minimization, including construction materials and water; the minimization of environmental impact in both the construction and in-use stages; the use of intelligent control during operation and maintenance; the improvement of air quality; the use of environmentally sound and durable materials; and the water recycling and re-use. In 2007 the project was awarder with the The Chicago Athenaeum Award by the Museum of Architecture and Design, Chicago, USA.

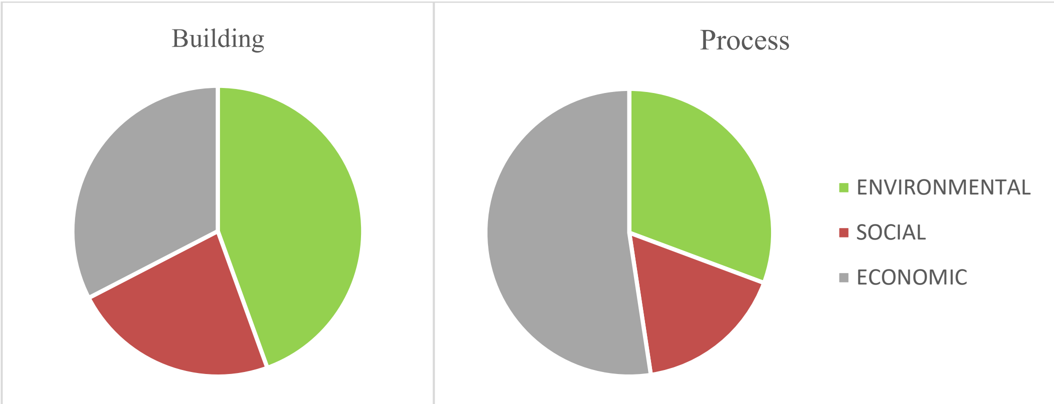


Figure 38: The pie charts above show the number of economic, social and environmental results on the project. The building became a model for environmental design in the industry, as well as generated economic advantages of different nature of all the actors involved in its delivery. It also achieved social results since it was aimed at raising awareness about the environment.

The actors and the eco-innovation and sustainability model

The actors involved on the project were the client, the promoter, the designer and consultants, and the main contractor and subcontractor. The project was delivered with a standard form of project and construction management. Regarding the introduction of innovation, it was critical the role of the public institution (the Italian and the Chinese Government) during the co-ideation phase, since they acted as leaders in promoting such project endeavour. They also acted as entrepreneurs as they had seen the opportunity to display and promote the Italian excellence and to transfer such technologies into the Chinese context. The client was involved in this phase as champion who was able to form links and organize the setting for the project development. The co-innovation phase was mostly dominated by the designers, the consultants and the builder. The industry was involved in the delivery, only after the definition of the type of innovation to introduce on the project. The co-institutionalization phase was characterised by the impact that the innovations in the building had on the market and society – by setting an example of best practice in terms of bioclimatic design – and on the development of knowledge and technology – by showcasing and transferring the knowledge in the Chinese industry regarding a number of technological system imported by the Italian designers, consultants and builders.

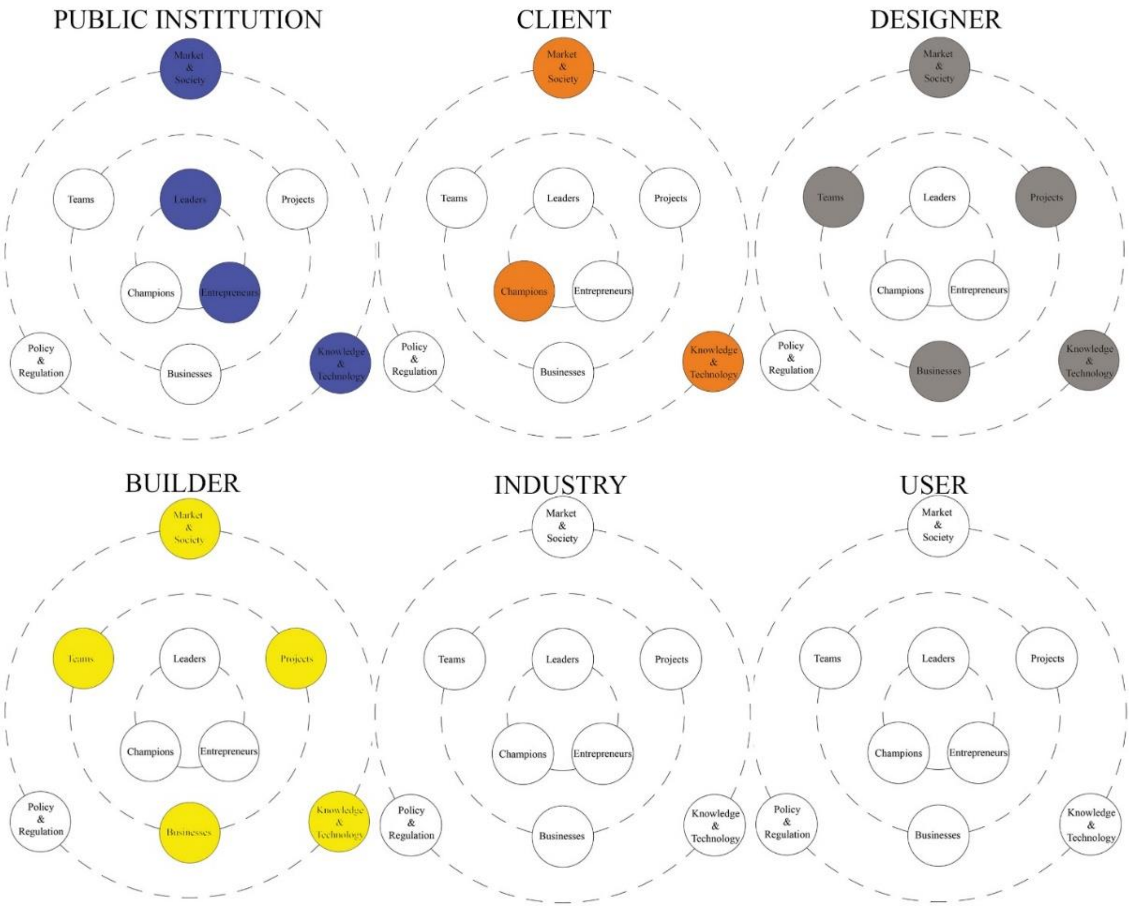
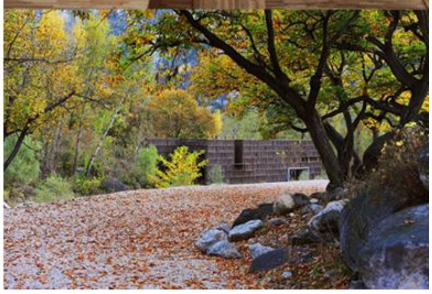


Figure 39: The image above shows actors and roles on the project. The eco-ideation phase was characterised by the roles of public institution and client. The eco-innovation phase was led by the designers, the consultants, and the builders. The eco-institutionalization phase was characterised by impact on the market and society, as well as on the development of knowledge and technologies.

5.2.8 The Liyuan Library, Beijing, Chin

WATTLE SCHOOL
Bejing, China
Li Xiadong
2015



Context Characteristics:	Rural - Wisdom Valley in the Huairou District of Beijing
Concpet Characteristics:	Integration with landscape
Orientation:	East-West
Dimension:	175 sqm
Shape:	Parallelepiped made in wattle sticks
Floor number:	2 Storeys
Access and circulation:	The location is only accessible via a winding mountain road. The building has a main entrance.
Structure:	Concrete foundation with steel structure and stone retaining walls
Construction systems:	The envelope of the building is built with the use of locally sourced wattle sticks. Opening are steel frame windows
Evironmanetal control systems:	The building relies entirely on natural and passive environmental control system. The building relies on natural light thanks to the large glass envelope surface, which uses wattle sticks as brise soleil; as well as passive ventilation thanks to openings and roof shape

Delivery process

The Liyuan Library – also called the wattle school – is a 175 sqm building located few hour drive from Beijing, in the area of the Jiaojiehe village. The project was an initiative of the architect Li Xiaodong, who with his atelier aimed at design and deliver a building that could represent an escape place and a meditation and relax retreat, where people could enjoy books and reading, far from the city. The land owner, who also was the client, was a committee of the Jiaojiehe village. This committee also became the final owner, whereas the building manager was Pan Xi. The building was built by Wang Hongli construction team, and the construction lasted from March 2011 to October 2011. The final cost was RMB 1050,000 and it was supported by the donations of the Luke Him Sau Trust and Pan Xi. The building is a celebration of the harmony and the beauty of its souring and it is meant to blend into the context. To achieve this effect, the architect explored the material availability on site and soon figured out that the dry wooden sticks were the most available. These sticks are the ones that local families of the village collect themselves for the house fire. Therefore, with the idea of creating a comfortable and relaxing place, Li Xiaodong decided to use the wooden sticks as main cladding material for its project. The building is a timber frame, entirely glazed internally. As Testa (2018) explained: *'... The irregular wooden sticks creating a filter between inside and out were harvested from nearby woodland. Recalling the firewood collected by the locals and stacked against their houses, they are here held together on a burnished steel frame. The entrance to the reading room is below the natural ground level and reached by a terrace over water that runs right up to the rock on which the whole building stands. Inside, a series of different levels mark out the different functional areas on a seamless ground plan. Light-coloured wooden slats clad the floors and wooden lattice structures line walls and ceiling. On the walls, these transom and mullion frames serve as bookshelves and windows giving views onto the natural landscape. Defused light filters inside through the irregularly textured façade shielding the glazing'.* These building characteristic allowed to include the local community during the building construction and the its maintenance. The local community collaborated in gathering the sticks that were used as cladding in the building. Moreover, the maintenance of such façade cladding is done by the locals, who look after the building by replacing the sticks in order to ensure its status.

Innovation types and impacts

The building context characteristics and concept represents a radical innovation. The aim of the project differed heavily from the type of construction that were developed in the Beijing at the same time of its construction (Testa, 2018). The idea of a meditation space, far from the city and its commercial development represented at that time a unique approach. Another radical innovation on the project was the use of sticks as external cladding façade. The use of such material represented a unique technology never used in the industry before, which could represent also an example for the local people on how to use stick for another market, as they were usually utilised only for house fireplaces. The architectural characteristics, the access and circulation, the shape of the building represented an architectural innovation, as they described the manner in which the artefact was composed. The environmental control systems, as well as the construction systems were developed as standard practice and therefore they represented incremental innovation.

Table 36: The table shows the innovation types on the project. Radical innovation can be found in the concept and in the unique construction system developed ad-hoc on the project.

	Incremental	Modular	Architectural	System	Radical
Context Characteristics					■
Architectural Design					■
Construction Systems	■				
Secondary Elements					■
Environmental Control Systems	■				

Table 37: Designers and Users had to undertake competence destroying activities, as showed in the table below.

Actor	Competence Creating	Competence Destroying
Public Insititution	■	
Client	■	
Designer		■
Builder	■	
Industry	■	
User		■

The innovations in this project called for competence destroying activities by the local community, who had to learn to become part of both building delivery and maintenance of the such library. To some extent also the designer had to undertake the role of project promoter and therefore acting outside the core scope of its business. The design and delivery of the project required instead competence creating activities by both the designer and the builder, who applied and evolved their existing knowledge.

Sustainability results

Beside the economic results in terms of cost saving of the materials, and tourism increase in the area, the majority of the results obtained on this project were social and environmental. This latter aspect was emphasised by the relation of the building with the surrounding, and the decision to rely on the use of local available materials, which conferred the unique aspect to the building. Moreover, this decision triggered positive results in terms of community inclusion both during the delivery and the life of the building. The building also received an award by the Royal Architecture Institute of Canada (RAIC), which gave to the project the inaugural **Moriyama International Prize**, named after esteemed Canadian architect Raymond Moriyama. The prize, which comes with a monetary value of CAD$100,000, has been established to recognise buildings that are judged to be "*transformative, inspired as well as inspiring, and emblematic of the human values of respect and inclusiveness*." Li Xiaodong started working with the community before funding was in place in the hope that a well-designed library would not only improve life in the village but also boost the local economy by attracting tourists to the scenic area. According to the RAIC, the conversations with users, research and selected site visits complemented the jury's review of the documentation provided by the architects. The formal and spatial qualities, its response to site, climate and culture, its craftsmanship, environmental design and its record of experience in use determined the positive outcome of the project on various domains.

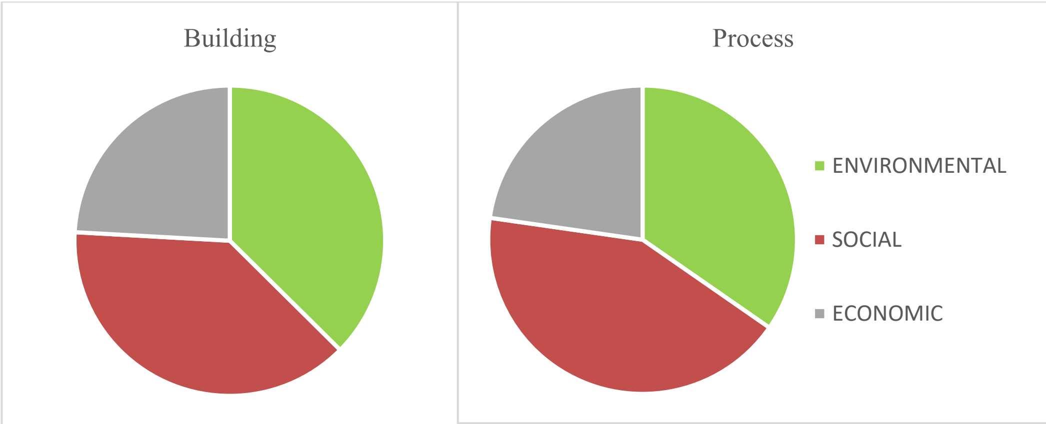


Figure 40: The pie charts above shows the type of results in the building and in the process. The project was characterised predominately by the social and the environmental domain.

The actors and the eco-innovation and sustainability model

The crucial actors on the project were the architects and the local community, who made possible the delivery of the library. The eco-ideation phase was characterised by the activities carried out by the designer. The architect acted as leader, entrepreneur and champion. He promoted the idea for the project, sought the opportunities of development, and convinced the local community and a private trust to both collaborate and fund the project. The eco-innovation phase was characterised by a number of teams who collaborated in the technical development and delivery of the project, such as the architect, the local community and the builder. All these three actors worked with a common aim and at the same time they obtained individual profit and advantages, of nature. The eco-institutionalization phase was characterised by the impact on the market and society as well as by the development of knowledge and technology. These results were determined by the scope of the project and its social impact; by the use of local wooden stick as cladding material and the inclusive effect that such decision determined on the community; as well as the development of a new technology by utilising in an innovative way a traditional material.

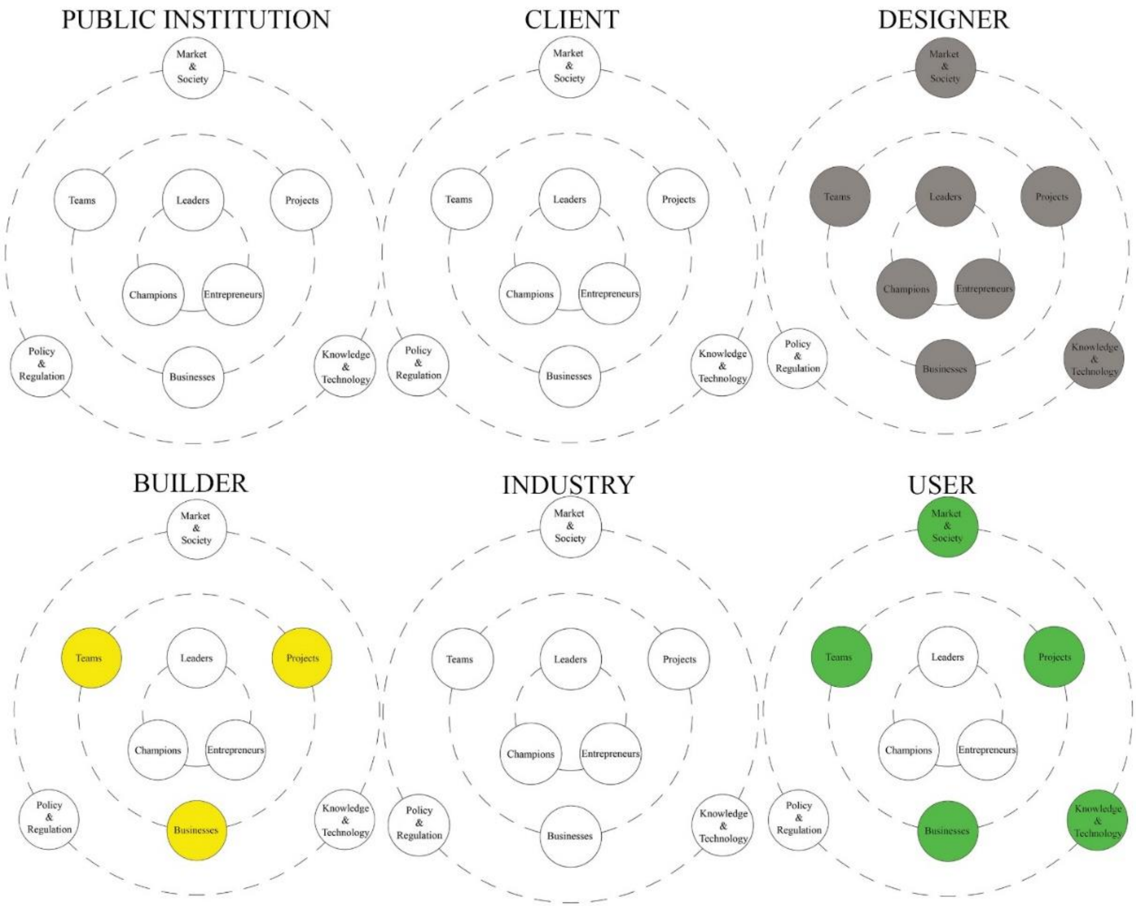


Figure 41: The image above shows the eco-innovation and sustainability model applied to the Liyuan library case study. The major roles on the project were undertake by the designer, the builder and the local community.

5.3 The South American context

The institution of the World Economic Forum (2018) has stated that:…' Latin America and the Caribbean, a region composed mostly of middle-income countries, is at a crossroads. In the context of the current economic slowdown, the region must take urgent steps to avoid falling further behind the industrialized countries and the most dynamic parts of the developing world in terms of growth and productivity, while also preserving the significant social gains it achieved during the commodity price super-cycle, which has now come to an end'. Moreover, the World Economic Forum, also called for efforts by the Latin American Governments in guiding a transition toward a sustainable industry with knowledge-intensive sectors, social inclusion, environment protection, and knowledge generation. Urban development is suggested as one of the crucial area in which sustainable results need to be sought, such as targeting low-energy buildings, transport management, solid waste and water treatment.

Chile

Serpell and Kort (2011) explained that there is a lack of sustainability policies in Chile. The existing legislation focuses mainly on the construction process, waste, noise reduction, and on thermal roof insulation. Serpell and Kort (2011) reported that such legislation cover 80/90% of the new construction. Another difficulty that characterise the lack of legislation is that the legislation activity is spread among different governmental institutions, which work with self-regulations. For instance, the most relevant regulation in regard to environmental sustainability is the Clean Production Agreement (APL). Moreover, Serpeel and Kort (2011) also explained that:…'The lack of environmental awareness and knowledge in Chile in general and in the construction industry in particular; - The lack of government support, especially regarding the small and medium-size design companies; - The lack of the application of integral designs; - The lack of assistance in relation to environmental norms and rules provided by government agencies; - The scarce environmental information availability'. The Sustainable Governance Indicators (2015) reported that the social key challenges that Chile need to address for a sustainable future are: the ongoing modernization process; the ambitious reform agenda moving slowly; constitutional constrains; lack of state capacities and instruments sufficient to ensure that policymaking takes a medium- and long-term perspective, especially in the case of social, economic and ethnic issues; inequality and poverty; economic pressure on the middle class; need for education reform; and entrenched political elite that prevent cultural change.

Peru

Ella (2015) in the report on Evidence and Lessons from Latin America explained that most of the countries in such regional area lack of sustainability development regulations. The main catalyst for sustainability introduction are voluntary certification rating systems. Among many, the most utilised in Latin America is the Leadership in Energy and Environmental Design (LEED)

Certification System, administered by the World Green Building Council. Peru joined such program in 2011. Another framework that support sustainable development is The United Nations Framework Convention on Climate Change (UNFCCC) developed the Nationally Appropriate Mitigation Actions (NAMAs) in 2007. The NAMAs database facilitates green project financing, capacity building, and/ or technology transfer in developing countries by helping decision-makers identify feasible opportunities and, subsequently, linking those opportunities to technical support and funding (Ella, 2015). Peru is currently in the NAMA conceptualisation phase for the widespread deployment of energy-efficient lighting in its residential, industrial, and public buildings. In general, specific financing mechanisms remain unclear. As the Organisation for Economic and Co-operation and Development (2018) explains that the social context in Peru is characterised by socio-economic inequalities compounded by gender, cultural, and geographical discriminations. These aspects impact negatively the health, the education and the work system in the country. Young women from poor and rural areas struggle to have access to basic health and information. The result of this condition is high rate of risk exposure to alcohol, tobacco, and drug abuse, as well as diseases related to sexual and reproductive health. Moreover, the risk of perpetuated violence is also high. This condition might be due to the low quality of education system in the country. Another repercussion of such low educational lever influence the challenges that young Peruvian face in entering the national labour market. Due to these reasons, the migration from rural to urban areas across national borders is very high. OECD (2018) reported that 76,400 young Peruvian left the country (representing the 54% of total migration from the country that year), and that between 1994 and 2008 the total number of young emigrants was about 500,000.

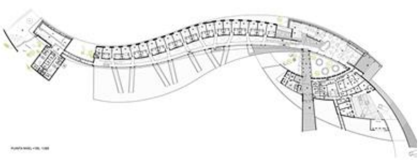
Uruguay

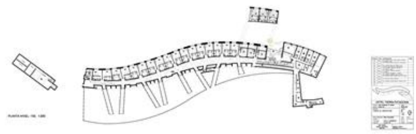
The World Bank (2018) reported that:'… Uruguay has been developing rapidly, particularly in the agriculture sector which accounted for 8 percent of national GDP, 11 percent of national employment, and 93 percent of export earnings in 2013. However, in this same year, the agriculture sector produced 80.2 percent of national GHG emissions. The Government of Uruguay has committed to "sustainable intensification," particularly within the agriculture sector to drive economic growth and manage natural resources while also reducing GHG emissions'. During the Eleventh Session of the Open Working Group on SDGs, the Government of Uruguay set six topics to propose a possible path to sustainable development in the country. The topics were: poverty eradication; sustainable agriculture; health and population dynamics; education and life-long learning; gender equality and women's empowerment; and water and sanitation. Despite, the Government of Uruguay has demonstrated a strong interested in the environmental sustainable development, the policy adoption in the application of such concept to the building industry is still slow. Yet, a number of voluntary certifications systems are playing a significant role in the industry, such as the

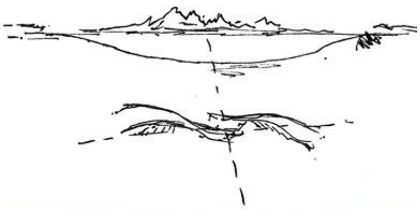
LEED program by the Uruguay Green Building Council, the TripAdvisor Green Leaders, and the Energy Start Challenge for Industry.

5.3.1 Hotel Patagonia, Torres del Paine, Chile – Building characteristics

HOTEL PATAGONIA
Lago Saramiento, Chile
Cazù Zegres
2011







Context Characteristics: The building is located in the proximity of the lake Saramiento, at the end of the mountain and sourrounded by nature

Concpet Characteristics: The hotel's image looks like an ancient fossil of a prehistoric animal, stranded on the shore of the lake

Orientation: North-South/East-West

Dimension: 4,900 sqm

Shape: The building shape emerges from the wind, natural element which is characteristic of the zone. The form seeks to join the metaphysical landscape of the place.

Floor number: 2 floors

Access and circulation: The space is structured from the interior routes, which are the way of inhabiting this extension. In the bedroom`s area the path is made with bridges suspended over the void.

Structure: Reinforced concrete

Construction systems: The hotel is anchored to the ground with stone embankments and entirely coated with wood paneling of washed lenga, in order to get the silver color which is common of wood corroded by water

Evironmanetal control systems: Building shape and materials, and radiant floor heating. Passive ventilation system and Led lighting system

Water treatment: Water storage system

Delivery process

The Hotel Patagonia is a resort built in Patagonia in 2011. The building was commissioned by Katari s.a. and designed by the local architect Cazù Zegres. Katari s.a was also the land owner, promoter, and building manager for the completed project. The general contractor was Salfa Corp and the project area 4,900 square meters. The major challenge for this project was to maintain an environmental approach that could deliver a building in harmony with the natural context of Patagonia. The building is located in a remote area at the entrance of the Chile's Torres del Paine National Park. As Cazù Zegers explained:'…*The building shape emerges from the wind, natural element which is characteristic of the zone. The form seeks to join the metaphysical landscape of the place. The hotel's image looks like an ancient fossil of a prehistoric animal, stranded on the shore of the lake. The hotel is anchored to the ground with stone embankments and entirely coated with wood paneling of washed lenga, in order to get the silver color which is common of wood corroded by water'*. The building is built with local materials, as well as the designer has attempted to rely on passive ventilation and lighting systems to control the indoor environmental quality. During the construction phase, extensive engineering and coordination work was required due to the tough low temperature and remote location. For instance, massive fires were lighted up to allow concrete to dry properly despite the temperature. Also the logistic was very complex due to the remote location, and therefore extensive work was carried out by the main contractor and the engineers to coordinate the construction phase and deliver the building. The technologies utilized were both in situ and prefabricated, and the main suppliers were local companies such as Arteknia, Atika, Ventanas Chile, Impa, Intertrade, GAF, Finning Chile, Aquasol, Maigas. Today the building is successfully in use and it became a landmark for the visitor of Patagonia, and in particular for the Torres del Paine National Park. The project has won so far eight awards from different institutions.

Innovation types and impacts

The context in which the project was developed can be defined as radical, as it is located in a remote and rural context, in which there were no other buildings in the proximity. The design approach, which shaped the architectural characteristics, the dimension, and the access and circulation, determined the radical innovation in the building. In the Chilean context, as Zegers (2013) explained, it was important to establish a design approach that could value the Chilean context by celebrating its nature and bioclimatic richness, conversely to the existing trend of commercial developments. In the case of the Hotel Patagonia, the dimension, the building height, and the shape were established to define an harmonic shape that could dialogue with the context. The building access as well, and its orientation were determined as well to emphasize the relation with the morphology of the surrounding land. Architectural innovation is present in the construction systems selected, the local materials utilised, and the type of internal partitions, and doors and windows. System innovation characterises the passive approach to environmental control, which is actualised on the building with natural lighting and ventilation.

Table 38: The table shows that radical innovation on the building was fund in the architectural characteristics, in the access an in the context characteristics.

	Incremental	Modular	Architectural	System	Radical
Context Characteristics					
Architectural Design					
Construction Systems					
Secondary Elements					
Environmental Control Systems					

Table 39: The table shows that designer and builder had to undertake competence destroying activities to deliver the building.

Actor	Competence Creating	Competence Destroying
Public Insititution		
Client		
Designer		
Builder		
Industry		
User		

This project called for competence destroying activities for the architect, the engineering consultant, and the builder. Even if the design process call for high degree of innovativeness on each project for the Architect Zegers, this was the first large project in a rural context and therefore a number of challenges ha to be faced and required the acquisition of new skills. This was due to the remote context that required the acquisition of new skills by the engineers and the builder to be able to deliver in such context.

Sustainability results

The building design characteristics led to a number of social and environmental results. In particular, by designing a project that was aimed at achieving harmony and celebration of the natural context, the architect achieved the objective of focusing on sustainability as key commercial strategy for the project. This was achieved by using large windows that could frame the landscape, as well as by the shape of the building volume itself that allowed the elegant immersion in the context. These decisions also generated an awareness toward the importance and the beauty of the Chilean nature and bioclimatic diversity. The process also generated results in the ability of delivering a project in a very complex construction place. This allowed the actors involved to achieve also economic results such as the competitive advantage and the knowledge acquisition. The building functioning and management allowed achieving the environmental results such as the use of sustainability concepts and environmental respect towards the landscape. This aspect also became the key of building use, which utilise its strategy as comparative advantage as accommodation promotion. Among many, the project received the Wallpaper Design Award, 2013 and the T+L Design Awards, 2013.

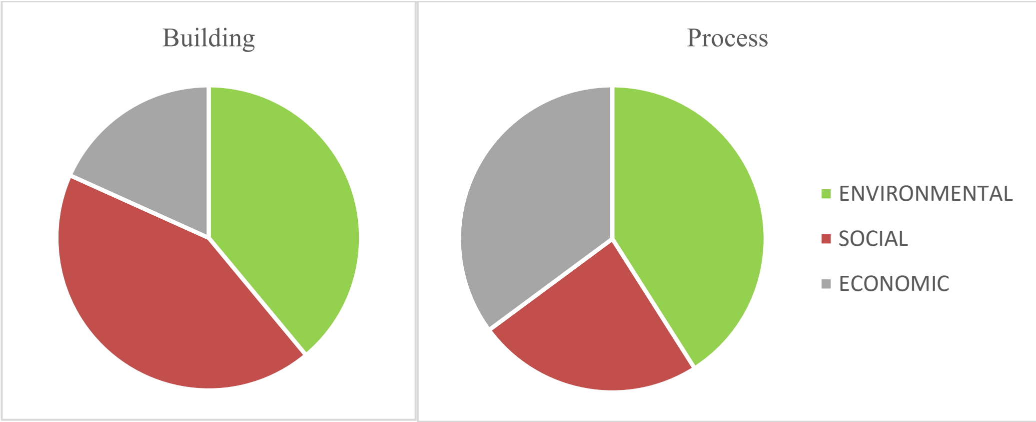


Figure 42: The pie charts show the results achieved on the project, which mostly were environmental and social. Economic advantage was also achieved for the client in the successful endeavour of their business.

The actors and the eco-innovation and sustainability model

The actors involved in the project were the client, the designer the builder and the industry. The co-ideation was led by the role of client Katari s.a., which acted as leader, champion and entrepreneur. The client, who already owned other hotels, understood that leveraging sustainability and the beauty of the landscape could have been a successful strategy. To this end they contacted the architect Zegers to ensure the delivery of their business idea. The co-innovation phase was characterized by the teams formed by the architect, the builder and the industrial partners, who all worked in conjunction to overcome the challenges set the remote location of the project. The role of the public institution was to allow the construction of the project at very proximity of the UNESCO natural park of the Torres del Paine. The co-institutionalization phase di not had any formal impacts, due to the private nature of project. Yet, the building help emphasize the awareness of sustainable tourism and landscape role for the Chilean country.

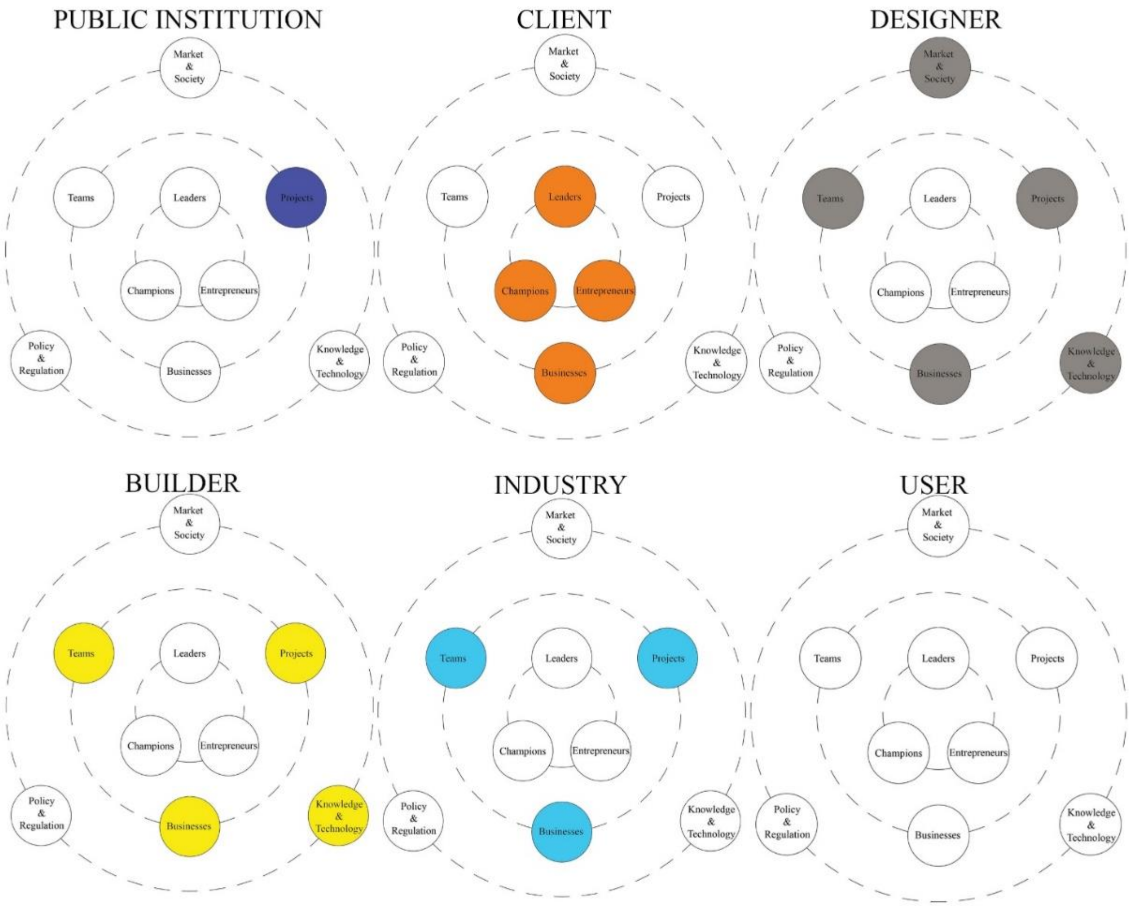


Figure 43: The image above shows the dominant role for the client in the eco-ideation phase, as well as the collaboration of designer, builder and industry in the eco-innovation phase.

5.3.2 Rainbow Desert, Ventanilla, Perù

RAINBOW IN THE DESERT
Ventanilla, Perù
51 - 1 Arquitectos
2013

Context Characteristics:	Rural - Desert
Concpet Characteristics:	Rainbow in the desert
Orientation:	North-South
Dimension:	54 sqm
Shape:	Rectangular layout, parallelepiped volume with sloping roof
Floor number:	1 Floor
Access and circulation:	Pedestrian access through a ramp to facilitate circulation of kids or disable people
Structure:	Reinforced concrete
Construction systems:	Oriented strand boards (wood) and corrugated metal sheet
Evironmanetal control systems:	Cross ventilation for air circulation. Materials with high thermal resistance and thick walls protect it from overheating. Windows strategically placed to generate natural ventilation and good air circulation, and to allow the view to the garden, in which the kid's cultivations are placed.
Water treatment:	To overcome the lack of water in the desert, an alternative and resourceful techniques for soil generation and irrigation with the agronomist Luis Camacho, who also chose a variety of crops that require little water.

Delivery process

The rainbow desert is a building for a kitchen where children from 3-5 years can learn to grow food and cook it by themselves with the help of the volunteers (Teachers and children´s families), in the desert of Ventanilla, Perù. It was promoted by the Peruvian Chef Gaston Acurio, and the Ministry of Social Inclusion of Teachers and the toiling chores of parents from Early Childhood Education Center No.129, with the aim of promoting awareness about growing own healthy food for the kids in the desert. The land owner was the local government as the building is located in the courtyard of an existing public school. The project, completed in 2013, was designed by 51-1 Arcquitecos, with a team led by architects Cesar Becerra, Fernando Puente Arnao & Manuel de Rivero, and by the structural advisor Emilio Rueda. The project was built by Freddy Ramos of Casco in conjunction with a number of local subcontractors. Crucial role was the one of the agronomist Luis Chamaco, who ideated a unique system to irrigate plants in a desert context. To do so, he designed a technique for soil generation in conduction with the use of a variety of crop that require little water. The building, which is today run by the local community and the school teachers, is a simple box with a double sloping roof, entirely cladded with colorful metal sheeting that gives the 'rainbow' aspects to the building, thanks to its color palette. As the 51-1 Arquitectos (2013) explained: *'The lack of rain in the Peruvian coast makes for extreme living conditions in the slums: in villa Pachacutec, children live in the sand without shade and disconnected from all vegetation, while their parents work all day in the city 2 hours away'.*

Innovation types and impacts

The building displays radical innovation in the concept and in the innovative use of soil generation ideated by Luis Chamaco, as well as the water system. The concept of the kitchen in the desert was very innovative, as well as the aim of growing plants and vegetables in the desert. The shape and the construction systems can be defined as architectural innovation, as they are definitive characteristics of the building, such as the colorful cladding system. Door and windows, foundation system, and internal partitions were standard and therefore fall into the category of incremental innovation. The orientation and the environmental control system are system innovation as they collaborate in delivery the performance of the indoor quality.

Table 40: The table shows the types of innovation in the project. Radical innovation was found on the concept, in the context characteristics and in the generation of the soil generation system.

	Incremental	Modular	Architectural	System	Radical
Context Characteristics					■
Architectural Design			■		
Construction Systems			■		
Secondary Elements	■				
Environmental Control Systems				■	

Table 41: The table shows that the client and the users had to undertake competence destroying activities.

Actor	Competence Creating	Competence Destroying
Public Insitittution	X	
Client		X
Designer	X	
Builder	X	
Industry	X	
User		X

In this project, competence destroying activities were undertaken by the client, who acted outside its core business as chef, as well as the kids, the teachers and the local community, whom had to acquire new skills for the building maintenance and use, especially for the soil generation system.

Sustainability results

The results obtained in the building and in the process were predominantly of social nature. The colours used in the building helped the definition of placemaking to communicate the value of the kitchen of the school for the kids. The indoor quality was achieved thanks to the construction systems utilised as well as the natural ventilation. The process of the building was carried out by a building company and the local suppliers, yet the participation of the community was significant, as school teachers, families and volunteers took part in the delivery and use of the building. Also, the maintenance process was characterized by social inclusion. This project allowed the education of children about healthy food in extreme areas.

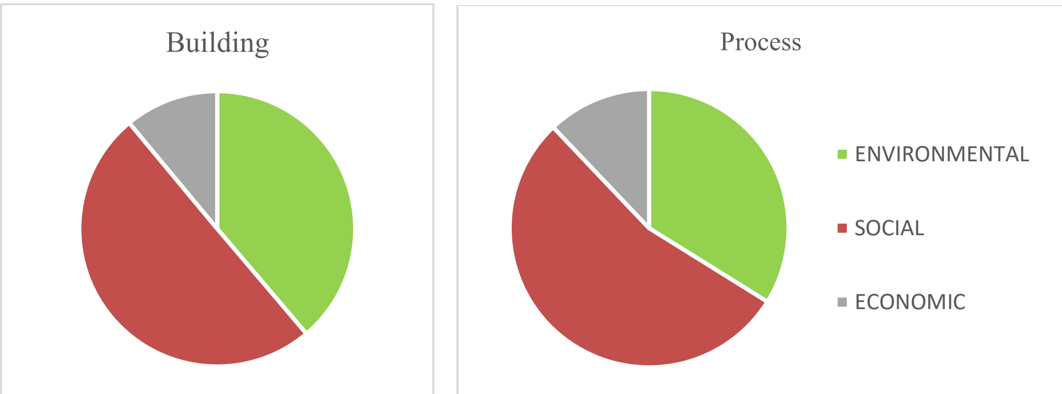


Figure 44: The pie charts above shows the results of the project, which mostly was of social nature.

The actors and the eco-innovation and sustainability model

The project was developed by the collaboration of all the entities analysed from the public institution to the users. In particular, the co-ideation phase was led by the role of the Peruvian Chef Gaston Acurio, who as a client, acted as leader in the project ideation, and sought the opportunities and the links necessary to actualised such initiative, and therefore acted also as entrepreneur and champion. The co-innovation phase was characterised by the team work of the architects, the builder, the industrial partners, the agronomist, and the users. Expect for these latter, the other firms worked in a collaborative environment, yet maintained private advantages for their own businesses. The co-initialization phase was characterised by the positive impact on market and society, as well on knowledge and technology.

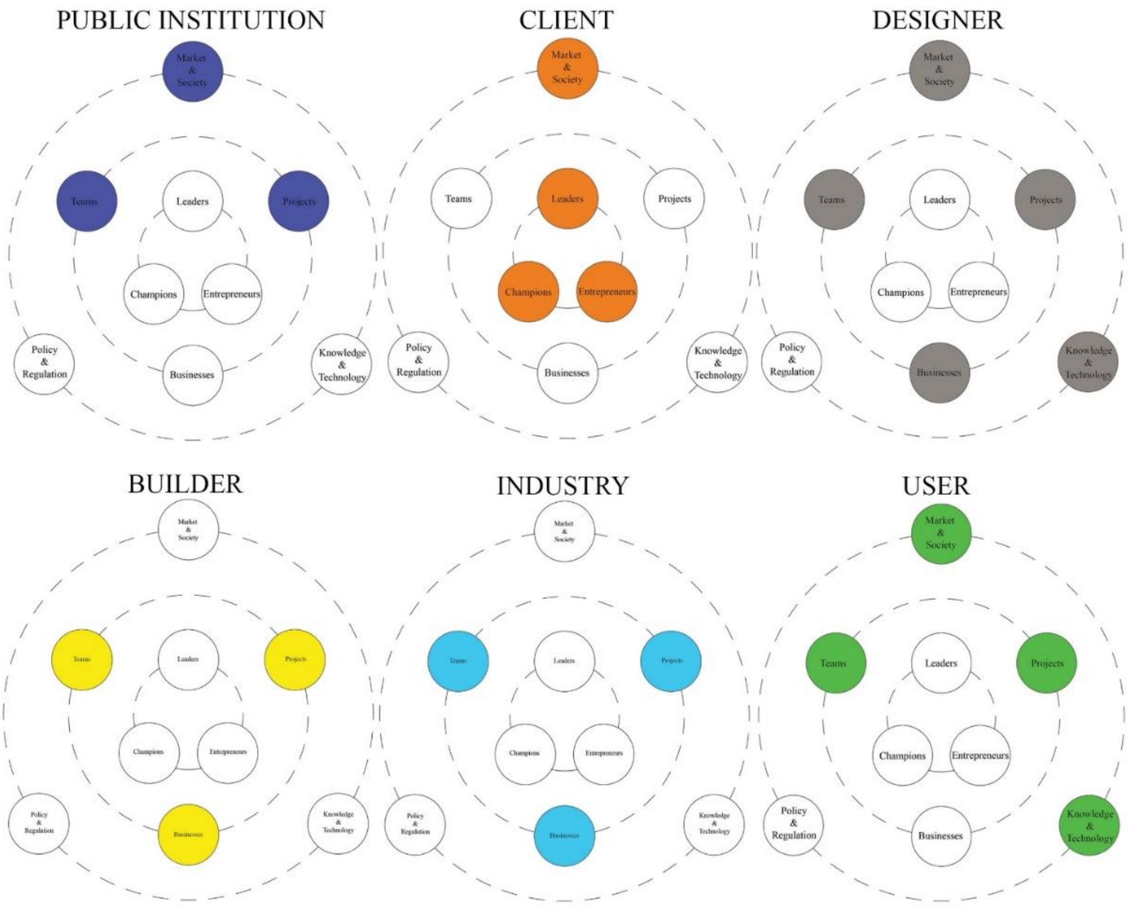


Figure 45: The image above shows the application of the eco-innovation and sustainability management model. The eco-ideation was characterised by the client, whereas the eco-innovation phase was characterised by collaborative environment between all the actors involved.

5.3.3 Earthship School, Jaureguiberry, Urugay – Building characteristics

EARTHSHIP SCHOOL
Jaureguiberry, Uruguay
Earthship Biotecture
2016

Context Characteristics:	Rural
Concpet Characteristics:	Re-use and re-cycle
Orientation:	The building is North oriented to maximise solar exposition, being placed in the Southern emisphere
Dimension:	270 sqm
Shape:	Rectangular and symmetric layout
Floor number:	1 Floor
Access and circulation:	Single corridor gives acess to the whole building. Circulation works in a linear manner
Structure:	Concrete slab and tires
Construction systems:	The school was built by volunteers who learnt in loco how to work with the construction system, developed by Earthship Biotecture. The materials used to build the school comprehend 2200 tires, 14000 cans, 5,000 plastic bottles and glass, 2,000 square meters of cardboard, concrete, earth and metal foil
Evironmanetal control systems:	The building has 12 solar thermal panels to produce its own energy, as well a system of reuse of rain water
Water treatment:	Treatment of gray and black water

Delivery process

The project was promoted by the Architect Micheal Reynold in conjunction with Martin Esposito to develop the first sustainable school in Latin America. This initiative was endorsed by the NGO Tagma, supported by ANEP - CEIP, Canelones stewardship and by public and private companies. This NGO carried out for more than one year meetings, workshops, festivals, visits to the building site, etc. to raise the awareness about the project. The aim of such project was to deliver a building with the responsible use of local natural resources and with the social inclusion of the project participants with the community. The school was a 270 sqm completed in 2016, built in seven weeks by 60% of recycled materials . such as and 40% of traditional local materials. As Reynold (2016) explained the earth ship system: '…*makes the most of the energy of the sun, water, wind, and earth. To do this, the surroundings are sensitive to the orientations, opening to the north to make the most of light and solar energy through a wide glass corridor that acts as a distributor of the three classrooms and two wings of the school, projecting to the exterior a simple and forceful facade dominated by glass and wood*'. Crucial aspect for the project deliver was the social participation, which also aimed at transferring knowledge about the system and encourage future similar endeavour. The people involved on the project were more than 150, between local community, students from many countries and volunteers. Unesco (2018) explained that the building consists of the creation of the first sustainable public school in Latin America, based on a self-sustaining building as well as a complementary program aimed at fostering community participation and education for sustainability. Moreover, Unesco (2018) highlighted that the building process was another educational process itself. This was due to the course on biotecture that was organized and carried out for all the project participants, who committed themselves in help the construction and to share the knowledge of such experience.

Innovation types and impacts

The project is characterized by radical innovation, in the concept, in the structural and construction systems, as well as in the sewage connection and water system. The idea for a building delivered with recycled and reuse materials was unique and radical for the context of Uruguay. Yet, Michael Reynolds previously built a high number of earthship project around the world, so from his perspective we could evaluate the same concept a radical innovation, as he had to apply only small changes to readapt his design to a new context. The building orientation, in conjunction with the passive approach of the environmental control systems represented system innovation on the project, as they collaborate to improve the performance of the indoor quality. The door and windows, access and circulation, and internal partitions can be considered both modular innovation and to some extent system innovation, as they as well contributed to the environmental control system. The greatest innovation of the building is its delivery process. Michael Reynolds set up a system, in which he delivers the concept and the construction drawings to the client and the volunteers and then let the community and the unskilled people the projects. He overcame the limitation about material availability by heavily relying in recycled materials donated by the community.

Table 42: The table shows the types of innovation on the project. Radical innovation is found in the concept, construction and structural systems, as well as in the water treatment.

	Incremental	Modular	Architectural	System	Radical
Context Characteristics					
Architectural Design					
Construction Systems					
Secondary Elements					
Environmental Control Systems					

Table 43: The table below shows that all the actors involved in the project had to undertake competence destroying activities.

Actor	Competence Creating	Competence Destroying
Public Insititution		
Client		
Designer		
Builder		
Industry		
User		

In doing so, he reduced the competence destroying activities that he had to do on every project. According to this type of scheme, the competence destroying activities on earthship projects are conducted mostly by the client, the volunteers, and the community. This is due to the responsibilities that they takes in dealing with building permits, design adaptation, material collection, and building processes.

Sustainability results

The project, both in terms of building and process, achieved many positive environmental results. The earthship school in Uruguay achieved the objective of generating its own usable water, electricity, and food, thanks to the wise use of rainwater, sunlight, thermal mass of the soil used as structural walls, and the reuse of recycled materials. The delivery process also achieved environmental results, such as the reduction of primary resources, and by relying on low technologies and unskilled labour. This aspect also represents the explanation of the social results. The project achieved the training of unskilled labour, developing social inclusion, sense of identity, and economic results such as knowledge acquisition and market opening. The project also represented a source of positive results for the NGO Tagma such as the competitive advantage obtained by developing the process, and therefore the ability of demonstrating their abilities in building knowledge, raising awareness, training key community actors and constructing self-sustainable buildings that could encourage and represent this new culture in Uruguay. In 2017, the project won the Latin American Green Award in the category of Urban Management.

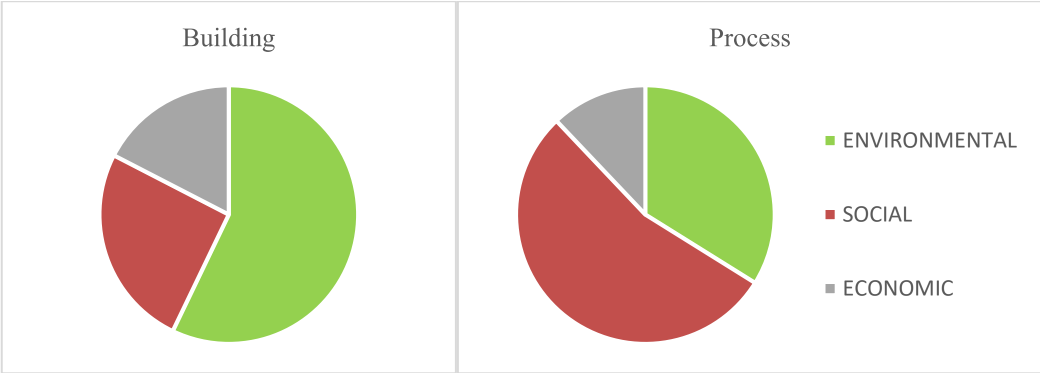


Figure 46: The pie charts above show the nature of results on the project. Social and environmental results are the main objectives achieved.

The actors and the eco-innovation and sustainability model

The social nature of the project involved largely the community during its delivery project. The designer and the client also had dominant role during the delivery. Specifically, the co-ideation phase was characterised by the role of the NGO Tagma that acted as leader by promoting the idea, as well as by the support of Michael Reynold who understood the opportunity for an earth ship, acting as entrepreneur, as well as who was able to set up the necessary link to start the project. The co-innovation phase was characterised the team of Michael Reynolds who trained and collaborated with the volunteers, and the local community both to deliver the building and to share knowledge about the construction idea and system. The co-institutionalization phase was characterised by social impact on the market and society, as well as the diffusion and transfer of the knowledge and the specific technology of the earthship.

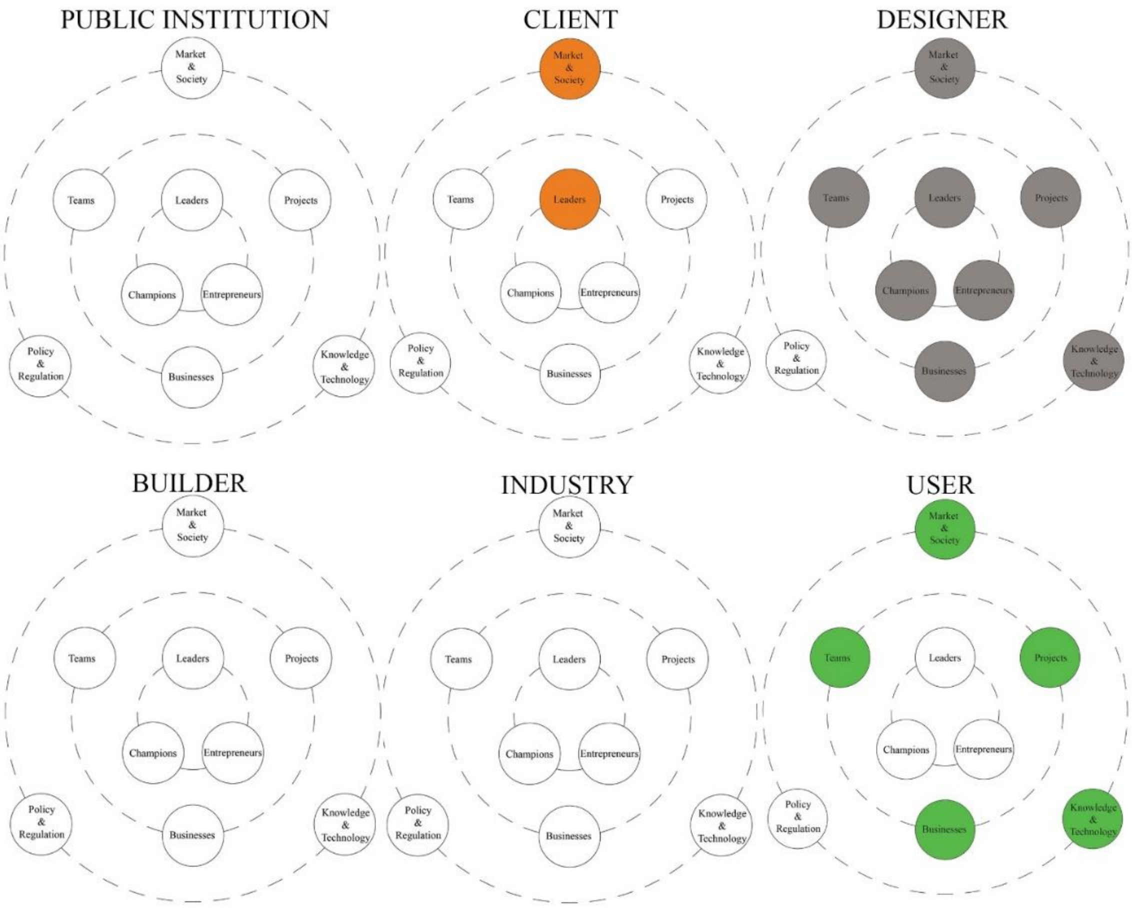


Figure 47: The image above shows the role of the actors involved on the project. The client acted as leader, and the architect led the eco-ideation and the eco-innovation phase. The users as well participated to the eco-innovation phase, as well as impacted the market and society and the development of knowledge and technology.

5.4 The African context

The United Nations (2018) explained that:…' African countries have committed to implement the African Union Agenda 2063, which is both a vision and a plan to build a more prosperous Africa in 50 years. The 2030 Agenda for Sustainable Development acknowledges the importance of the AU Agenda 2063 and considers it an integral part of it. Africa has made significant progress on the Millennium Development Goals, including enrolling more children in primary school, particularly girls, increasing the representation of women in national parliaments, and reducing child and maternal deaths and the proportion of people infected with HIV. Building on this progress, several countries are already taking steps to translate the ambitions articulated in the 2030 Agenda into tangible outcomes for their people; they are beginning with integrating the SDGs into their national visions and plans'. Moreover, the Sustainable Development Knowledge Platform by the United Nations (2018) explained that African countries are committed to the development of resilient infrastructure through financial, technological and technical support from foreign direct investments for those countries in great need, in accordance with each country national development programs. Yet, poverty, war, death have strongly limited the ability of many countries to embrace the international sustainability initiatives.

Burkina Faso

The United Nation Environment Program (2018) reported that Burkina Faso's economy is mainly based on mining, agriculture, livestock and fishery. 85 % of the population depends on natural resources and it is estimated to contribute to 31.5% of the GDP. The country joined the Program for Environmental Initiatives, in which the natural resources are of crucial role for the country's sustainable development. Such program supports the productivity growth with strategic planning and programs, which promote green economies and he investment in environmental sustainability. Moreover, such program has .worked as a catalyst for supporting Government to mobilise financial support from a range of partners, including funds for chemical mainstreaming from the Montreal Protocol and the Swedish International Development Cooperation Agency; the World Bank's rural development programme includes poverty-environment elements, the EU's Environment Development Fund 2014-2020 includes poverty-environment as one of its thematic areas and poverty-environment has been mainstreamed into the UNDAF.

Gansone (2013) explained that the construction industry in Burkina Faso is experiencing over 7.5% growth per year since 2001, particularly in dams, roads, commercial and residential buildings. Burkina Faso invested so far 150 million euro in the field of construction and engineering. Projects are mainly funded by Government, non-government organizations, and foreign aids. The sector is dominated by both the presence of foreign owned companies and local formal and informal companies. These latter play a crucial role in the sector covering most of the bricklaying, plumbing, and painting trades. The industry is otherwise dominated by a single large state company.

Nigeria

Nwokoro (2011) explained that the Federal Government of Nigeria has released various laws and Regulations to safeguard the Nigerian environment, such as: Federal Environmental Protection Agency Act of 1988 (FEPA Act), National Policy on the Environment (NPE) 1989 and Environmental Impact Assessment Act of 1992 (EIA Act).The Federal Ministry of Environment has published several guidelines for the administration of the FEPA and EIA Acts and procedures for evaluating environmental impact assessment reports (EIA Reports). The sustainability approach taken here is to the prevent environmental damages, and punish any potentially harmful activities. Moreover, another aim is to engage individuals and communities at risk of potential environmental damage in constructive conversations. Nwokoro (2011) that difficulties exists in the translation of provisions of the Act into an effective tool for managing the environment. This is because most Nigerian legislations crumble at the implementation stage. Although, some of these programs have produced positive results, the Nigerian construction industry is characterised by lack of skilled labour, material unavailability, power shortage and unethical practice. The construction industry contributed less than 16% to its economy.

Rwanda

National Sustainable Development Strategies and Other Planning Frameworks report on Rwanda were originally created in 2007. The original report consisted of details on the Vision 2020, and Poverty Reduction Strategy Paper which was implemented 2002-2007. The updated report 10 includes details include the Economic Development and Poverty Reduction Strategy Paper for 2008-2012. The report also includes details of the UNDAF for 2002-2006 and the “One UN” Pilot Programme which covers the 2008-2012 time periods. The approach that the government has for the Rwanda Vision 2020 is to promote gender equality, protection of the environment, sustainable resource management, and science and technology development. The Swedish Business and Invest Council (2017) explained that Rwanda’s construction industry is still relatively small, compared to the other surrounding countries. Yet, the GDP in the country have grown of 8% since 2000 mostly driven by the construction sector. This was possible thanks to the government investment in infrastructure, as well as the foreign investment in other urbanisation. Rwanda’s construction industry is expected to grow by 9% CAGR until 2021, which is the second fastest growth rate in whole Sub-Saharan Africa.

Burundi

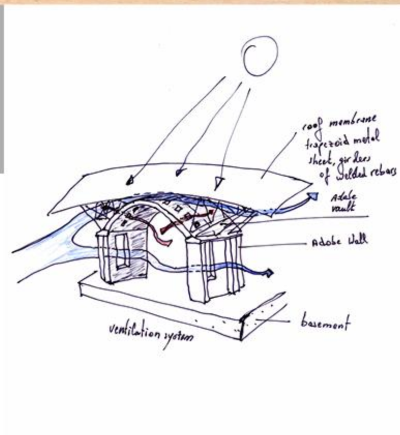
Although Burundi has experienced conflict since 1972, the latest violence started in 1993 with the coup and assassination of Melchior Ndadaye, the first democratically elected president. This unleashed ethnic massacres in Burundi between Hutus and Tutsis (United Nation, 2015). In the report 'Mapping of Sustainable Development Strategies in Countries Emerging from Conflict: Africa', the United Nation explained that the National Sustainable Development Strategies and Other Planning Frameworks report for Burundi was prepared in August 2007 and updated in February 2009. The report includes current Poverty Reduction Strategy Paper (PRSP) 2007-2010 and the Government Five Year Programme 2007-2010. It also includes expired planning framework for the UNDAF and UNDP CPAP which were implemented during 2005- 8 2007. As of March 2009, no updated frameworks were available for both the UNDAF and UNDP'. Moreover, the Ministry of Planning and Communal Development/Forecasting Unit United Nations Development Programme in Burundi released the report called Vision Burundi 2025 in 2011. In the report, it is highlighted that one of the weakness of Burundi is still the lack of infrastructure, the energy shortage, poor conditions of telecommunications and transport system. Another significant problem in Burundi is the destruction of the natural resources due to bush fires, trees cutting and mismanagement of lands and wetlands, mines and quarries, and air pollution. The Burundi Vision 2015 is aimed at implementing mechanism to protect the environment and limiting such problems, as well as at developing technologies, renewable energies to help reduce the use of wood as main source of household energy.

Ghana

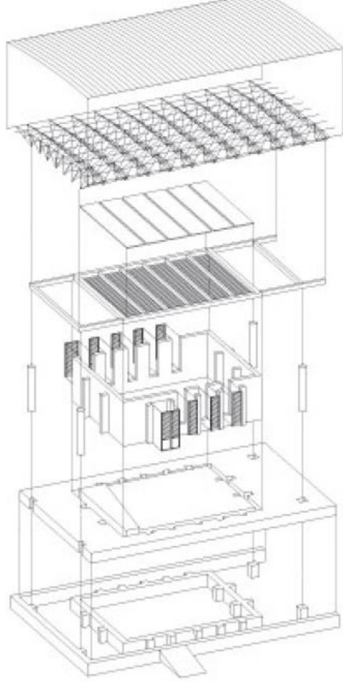
Ahmed, Hatira and Valva (2014) explained that the Ghanaian construction industry is complex and can be classified in four groups of operations: projects worth up to $75,000 (D4K4); projects ranging from $75,000-250,000 (D3K4); projects worth $250,000-500,000 (D2K2); and projects over $500,000 (D1K1) (Frimpong and Kwasi 2013, 121). The majority of the companies in Ghana fall under D4K4 and D3K4 classification. Djokoto, Dadzie, Ohemeng-Ababio (2014) explained that a number of barriers exist in the development of gthe construction industry in the country, such as: lack of demand, lack of strategy to promote sustainable construction, higher final cost, lack of public awareness and lack of Government support. The others are lack of cooperation, risk of investment, lack of Building Codes and Regulation, higher investment cost and lack of a measurement tool. Therefore, key barriers identified are related to lack of knowledge of green technologies, lack of green awareness and expertise and lack of government support. Ahmed, Hatira and Valva (2014) also explained that the Chartered Institute of Building in Ghana estimates that there are over 1,600 building contractors working in Ghana since October 2012, providing a means for social development, yet the industry is characterized by unprofessional practice. These conditions makes The unsustainable building construction processes coupled with the constant degradation of the environment continue to take their toll on Ghana's development (Djokoto et al. 2014, 135). Yet, the Ghana Green Building Council is an independent association registered with the Registrar General's Department in Accra (Ghana) was funded with the aim of transforming the built environment in Ghana towards sustainability through the way our communities are planned, designed, constructed, maintained and operated (GBC Handbook 2011, 11). Ahmed, Hatira and Valva (2014) also reported that the GHGBC is responsible for implementing the rating system in Ghana. The GHGBC does not have its own building rating system today. There is, however, a building rating system in South Africa called the GS SA-v1 Building Rating System, which was adapted from the GS-v1 Building Rating Tool in Australia.

5.4.1 Primary School of Gando, Burkina Faso – Building characteristics

Gando Primary School
Gando, Burkina Faso
Kere Architecture
2001



Context Characteristics:	Rural
Concpet Characteristics:	participatory design - local materials - community engagement - passive systems - self-sufficiency
Orientation:	it varies according to site conditions - openeings and ventilation holes position changes accordingly
Dimension:	520 sqm
Shape:	Parallelepiped
Floor number:	1 Floor
Access and circulation:	The main acess is from the porch, and blocks connected one to the other through a covered path (porch)
Structure:	Locally produced bricks masonry walls reinforced with vertical rebars
Construction systems:	Bricks masonry (20 cm thick - flemish bond)
Evironmanetal control systems:	Environmental control systems are based on natutal systems.Placing the main roof under a 7 meters spanning roof allowed to control the heat gain, protecting the space from direct sun radiation, as well as the shape of the roof and opening allow the natural ventilation of the rooms and also contribute to maintain the internal temperature comfortable.
Award:	Aga Khan Award for Architecture 2004 Global Award for Sustainable Architecture 2009



Delivery process

The Primary School in Gando, Burkina Faso was designed and built in 2001 by Diebedò Francis Kerè, who is an architect based in Berlin at the firm KereArchitecture, Germany and originally from Burkina Faso himself. The premises of this project have to be found in the personal experience of the architect, who as a child used to travel nearly 40 kilometers to attend a school with poor environmental conditions. This experience moved him to study architecture and later on to decide to invest his knowledge in promoting the construction of a primary school in his village. He therefore set up a fund raising foundation called Shulbausteine fuer Gando (Brick for Gando), and collected CFA Francs 22,750,000 (US$ 29,830). Francis Kerè designed the building and organized the construction himself, in conjunction with his father Weyneida Kerè, bringing together people and setting up teams of people who came together to join the project. Kerè explained that: *'...Traditionally, members of a whole village community work together to build and repair homes in rural Burkina Faso. In keeping with this cultural practice, low-tech and sustainable techniques were developed and improved so that the Gando villagers could participate in the process. Children gathered stones for the school foundation and women brought water for the brick manufacturing. In this way, traditional building techniques were utilized alongside modern engineering methods in order to produce the best quality building solution while simplifying construction and maintenance for the workers'.* After the building completion, the school became a landmark for the community and received in 2004 the Aga Khan Award for Architecture. The collective knowledge developed in the construction of the school empowered the participant on the project with new skills and inspired the local community to build new cultural and educational projects, such as a primary school extension, teachers' housing, as well as to start fund raising programs for the future construction of a secondary school, school library, women's center and ateliers.

Innovation types and impacts

The primary school of Gando displays radical innovation in the environmental control systems. The building was one of the first of relying on passive systems. The layout of the building is organized with classrooms placement under the roof shadow to control the heat gain. The ventilation and the lighting system are passive and faciliatetd by a suspended ceiling, which protect the space from sunlight. The floor number, the orientation, and the access and circulation can be considered on the verge between the definition of architectural and system innovation. They are definitive characteristics of the architectural artifact, yet the contribute to the environmental performance of the project in terms of environmental control. The structure and construction systems are local materials and they can be described as modular innovation. The door and windows are open elements in steel lamella and they follow the standard practice of openness utilized in the area.

Table 44: The table shows that radical innovation was found in the environmental control systems. These latter were supported by the system innovation in the building orientation, access and circulation, and roof typology and design.

	Incremental	Modular	Architectural	System	Radical
Context Characteristics					■
Architectural Design				■	
Construction Systems		■			
Secondary Elements				■	
Environmental Control Systems					■

Table 45: The table shows that the designer and users had to undertake intensive competence destroying activities on this project.

Actor	Competence Creating	Competence Destroying
Public Insititution	■	
Client	■	
Designer		■
Builder	■	
Industry	■	
User		■

The project called for large degree of competence destroying activities since the initiative, the ideation and process organization was carried out by the Francis Kerè architect and therefore, learning new knowledge beyond the scope of his business. Moreover, the community that was involved in the project construction and supply materials acquired new skills and therefore undertook competence destroying activities as well.

Sustainability results

Varanda (2004), in the technical report for the Aga Khan Award explained that:'… The school performs very well both in terms of spatial organization – having the classrooms separated by patios has the further advantage of sound insulation – and climatic comfort, where the results obtained are indeed remarkable. The mark it sets in the overall landscape is strong but consistent….The tenants seem satisfied with the space and climatic conditions. The concrete-block roof combs, added later but not yet rendered, may create problems where they join the rest of the wall'. Moreover Varanda (2004) explained that:'…*The school was originally intended to serve only the children of Gando, but use by children of the neighbouring villages is increasing. It has been reported that even the Peul, nomadic herders traditionally reluctant to let their children go to school, have let their children attend. This appears as an additional reason for the community's pride. One of the teachers affirmed that he has a better success rate here than in the schools he was in before; possibly because children are more comfortable, they are more attentive'*. The report, which later led to the delivery of the AGA Khan Award to the Primary School of Gando, explained that the building achieved great environmental result, whereas the delivery process developed great social inclusion and understanding the importance both the scope of the building and the importance to contribute to maintain such space for the kids. The building and the process were actualized despite a limited budget and therefore achieved results of cost saving, as well as knowledge acquisition for the community, and competitive and comparative advantage for the firm Francis Kerè Architecture.

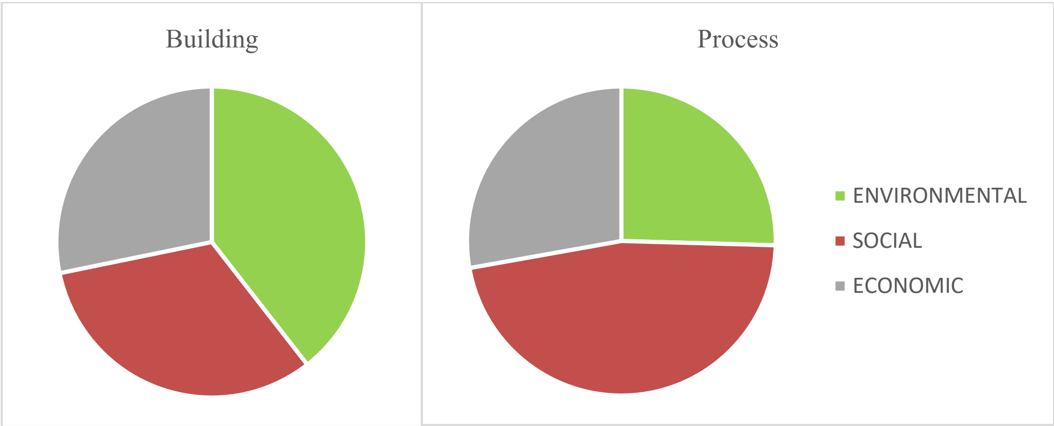


Figure 48: The pie charts above shows the predominance of environmental results in the building design, and the social results in the delivery process.

The actors and the eco-innovation and sustainability model

The co-innovation phase of this project was fully lead by the architect who acted as leader, entrepreneur and champion. He covered these roles by formulating the idea of the project, setting up and organizing the funds raising, as well as designing the building, and creating links with the local community to then set up the building construction.

The co-innovation phase was characterized by teams formed with the local community of people who together joined efforts in occasion of the building construction stage. The business firm involved in the project was Kerearchitecture, which core is to, beside obtaining a profit, fostering social innovation by promoting, designing and developing projects with such aim. The project itself represented an occasion to test sustainable innovation on the technological level. The construction system and the environmental control systems were designed to introduce new technologies in the socio-technical context.

At the co-institutionalization stage, the project has produced knowledge diffusion and technological introduction in the context by design. This is due to the ability of the building design characteristics, such as the use of low tech construction systems, environmental sustainable design (ESD) strategies and contemporary engineering systems, which were simplified to allow the local community to look after the building during its life span. This type of design allowed the architect to empower the local community of new skills, knowledge and inspire the ideation of future social project for the community. This latter seemed to have assimilated the importance of educational buildings as a critical milestone for their community and society.

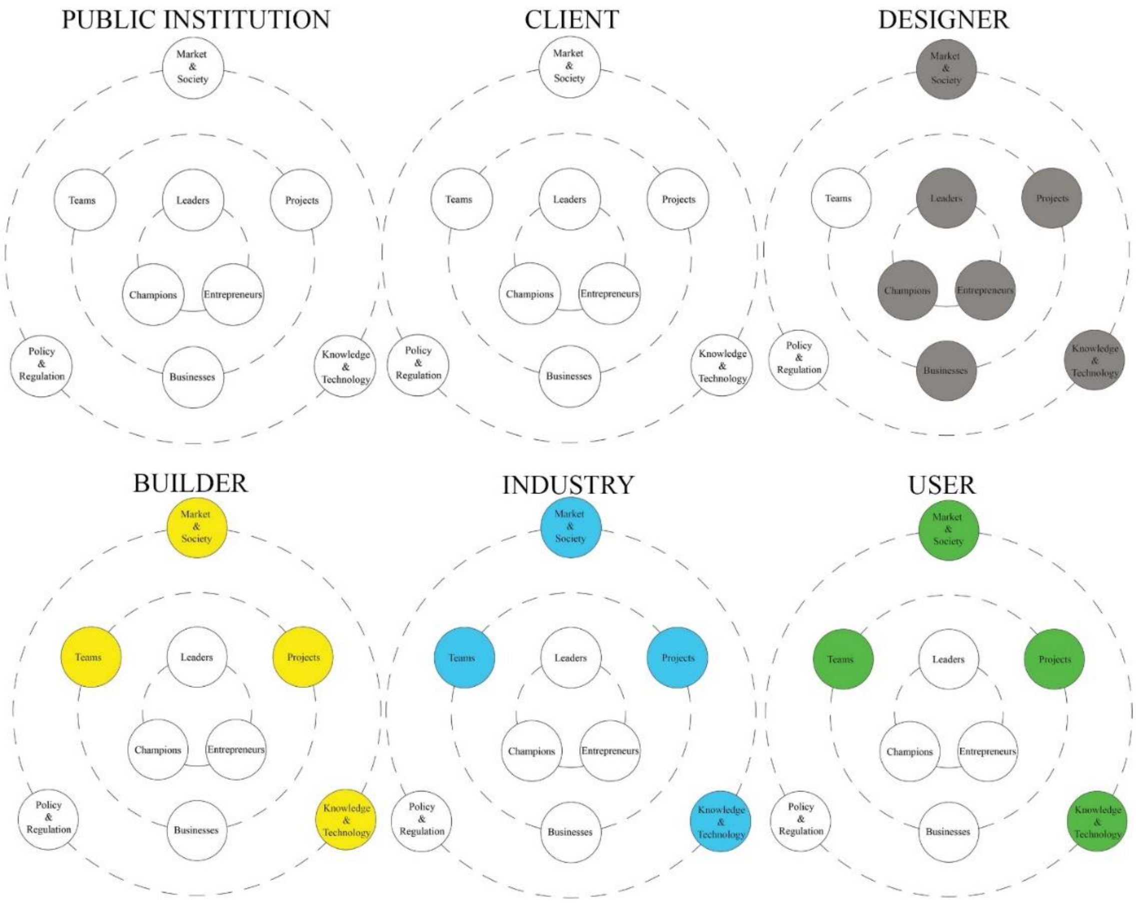
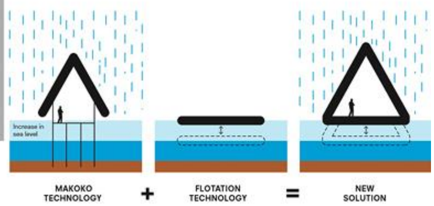
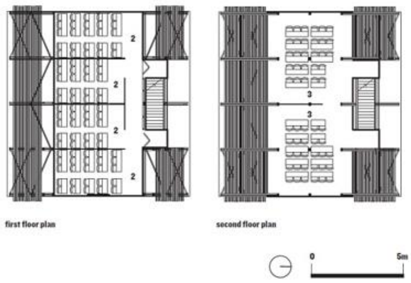


Figure 49: The image above shows the role of actors in the process. The eco-ideation process is was led by the architect, whereas the eco-innovation phase was characterised by the collaboration of the designer, builder, industry and user. This process produced positive impact on market and society, as well as in the development of knowledge and technology.

5.4.2 Makoko Floating School, Nigeria – Building characteristics

Makoko Floating School
Lagos, Nigeria
NLE' Architects
2013





Context Characteristics: Rural

Concpet Characteristics: Re-adapt the idea of the stilt house, a typical construction of the city of Lagos, to build a school that can accommodate 100 children in the district of Makoko

Orientation: Variable due to the floating movement

Dimension: 220 msq

Shape: Triangular frame on a rectangular layout

Floor number: 3 Floors

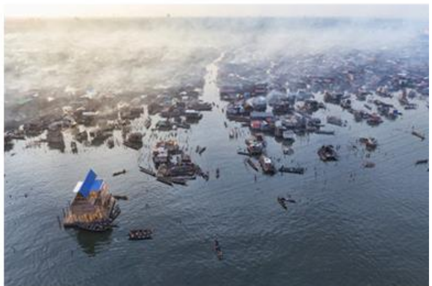
Access and circulation: Access is to open plan circulation system with vertical distribution

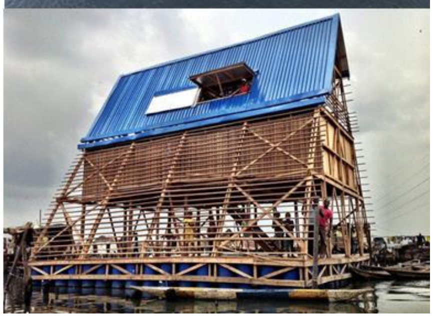
Structure: 16 wooden modules, each containing 16 plastic reused barrels, as well as bamboo of local origin

Construction systems: Timber construction on floating plastic barrels

Evironmanetal control systems: Natural lighting, natural ventilation, rainwater storage and depuration, and solar panels

Water treatment: Waste reduction and sewage treatment





Delivery process

The Makoko Floating School is an innovative prototype building built in 2012 by NLE' Architecture for the African water community of Makoko, Nigeria. The building is aimed at addressing social and environmental issues that the local community is currently facing, such as the lack of educational buildings, as well as poor environmental conditions of the built environment. The building/watercraft addresses social issues by providing a space for the kids of Makoko to access to the school system. It also addresses environmental issues by integrating solar panels installed onto the roof of the building, compost/urine diversion toilet adapted to the local practices has been incorporated into the building. The resulting compost will be recycled for vegetation and planting on the structure. The idea for this building came from the a visit the founder of NLE' Architect did to the Mokoko local community that expressed the need for a new school. The architect decided that through their knowledge, his firm would have contributed to help the community. Initially, the firm self-founded the projects, and later support was given also by Heinrich Boll Stinthung Foundation, and by the United Nations Development Programme/Federal Ministry of Environment Africa Adaptation Programme (AAP) in 2012, who supported with funds the construction of the building, and officially became stake holders in the project. The project has been carried out with the collaboration of community members, leaders and building experts from inception. NLÉ organized regular meetings with Makoko/Iwaya Waterfront Community representatives. This participated design system included dialogues, design workshops, progress updates and management issues, as well as constant updates on project development. Despite an initial successful start for the prototype, Makoko Floating School structure collapsed due to deterioration resulting from a lack of proper maintenance and collective management. This fact triggered a debate on the project, which started with doubts from the government and medias regarding the legality of the structure. It was neither a house nor a boat but a new typology that seemed to straddle land-water policy gaps and state-federal territorial boundaries. In April 2015, the Lagos State Ministry of Physical Planning and Urban development announced its consideration for incorporating the internationally acclaimed prototype structure 'Makoko Floating School' in a regeneration plan for Makoko Waterfront community. As reported by NLE'Architecture (2016), the structure was officially handed over to Makoko/Iwaya waterfront community in August 2015. Despite a detail handover manual was delivered, maintenance issues emerged due to the difficulties in establishing the ownership of the floating school between 9 community leaders of the different ethnic groups involved in the process. This difficulties in the management lead to the decommission of the structure and the later collapse. Yet, the architects have been working to improve the structure which has been exhibited at the Biennale of Architecture in Venice in 2016, and that has been nominated and awarded by many International institutions. The porotype experience as well as its international recognition has pushed the government to engage with its community and developed a conceptual plan and proposal presented to the State Executive Council (EXCO) for consideration and approval.

Innovation types and impacts

The context of the project and the type of structure (a floating building) represented radical innovation on the project. In the context of the slum of Makoko, other floating school did not exists prior to the this project. The architectural characteristics such as the shape, the roof, and the frame system contribute all to the environmental control of the building and therefore they represent system innovation. The construction details, developed ad-hoc for the project, as well as the construction system, and the materials contribute to the definition to the architectural composition of the building. No incremental innovation is found on the project, as the typology itself is highly innovative for its context.

Table 46: The table shows the innovation type on the project. The project was characterised by high degree of radical innovation, as well as architectural innovation.

	Incremental	Modular	Architectural	System	Radical
Context Characteristics					
Architectural Design					
Construction Systems					
Secondary Elements					
Environmental Control Systems					

Table 47: The table shows that most of the actors involved had to undertake competence destroying activities due to the radical nature of the innovation on the project. The suppliers were mostly international and therefore had a lower involvement in the impact that the innovation generated on the building.

Actor	Competence Creating	Competence Destroying
Public Insititution		
Client		
Designer		
Builder		
Industry		
User		

All the actors involved on the project, except for the suppliers who were mostly international, had to undertake competence destroying activities. This is because of the high degree of radical innovation of the project scope and its design feature.

Sustainability results

The building design achieved high performance in the environmental efficiency and energy generation. The cost were limited and yet the designed was able to define design choices that could satisfy the aim of delivering a floating school for the slum of Makoko. The delivery process and the life of the building achieved economic results, as well as environmental and social results. The social results achieved where the social inclusion and the knowledge diffusion between the community. The environmental results were achieved by the use of recycled materials, and the economic results were achieved as the process produced competitive and comparative advantage for the architecture firm, and knowledge acquisition and market opening for the community. The floating school design won the 2013 AR+D award for emerging architecture and was shortlisted for the London Design Museum's 2014 Design of the Year award. It also received a nomination for the 2015 International Award for Public Art.

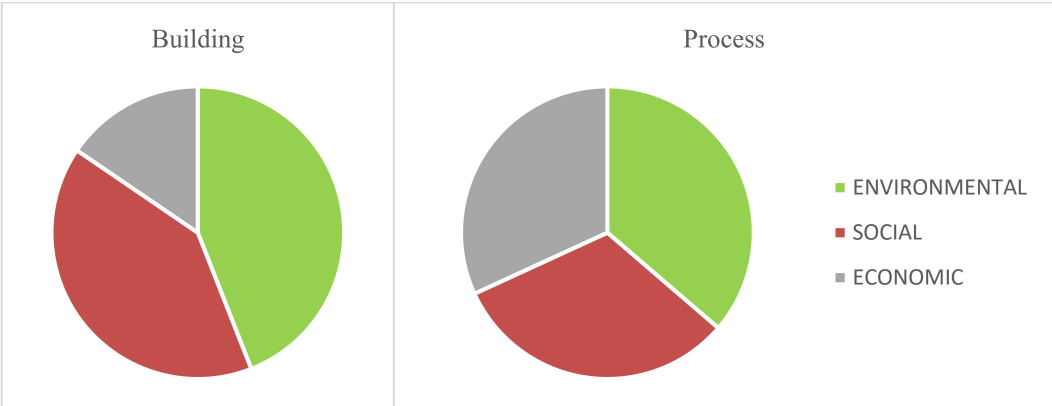


Figure 50: The pie charts above shows the nature of the results on the project. Both building and process achieved environmental, social and economic results.

The actors and the eco-innovation and sustainability model

The co-ideation phase of this project was largely influenced by the role of the architect, as leader and entrepreneur, who initiated the idea of developing the floating school, and started self-financing initiative. In conjunction with the architect, also the Heinrich Boll Stinthung Foundation, the United Nations Development Programme/Federal Ministry of Environment Africa Adaptation Programme cover the role of champions on the project, becoming actively stakeholder, just after the project ideation. The co-innovation stage of this project was largely characterized by teams from the local community, international consultants, industrial parties and design firms that all jointed together to undertake a design and delivery participatory process. The project was the occasion to define and test design solutions and technologies to achieved the environmental and social objectives defined for the floating building. The co-institutionalization stage of this project firstly found resistance from the local government, and overall public opinion (as expressed it in the media) in accepting the sustainable innovations that the floating school embedded both in terms of environmental control features, and in its social aim. After a first phase of reluctance, the Government understood the potential of the project and decided to define a plan to strengthen the engagement with the local community. To a certain extent the designer was therefore able, through its design, to produce an impact on the society. Yet, under a knowledge management and technology point of view, the project did not seem to influence the local industry, or community as much. This could be due to the fact that some of the material were not local, and that the engineering solutions have been developed by International experts. This fact might have generated a gap with the existing knowledge in the community that lead to the inability to properly manage the floating school. Difficulties in the decision making within the local community might also have negatively impinged on the finale state of the prototype. The work the designer had though an influence internationally and it raised the attention from the society toward the social and environmental state of the water community people in Africa.

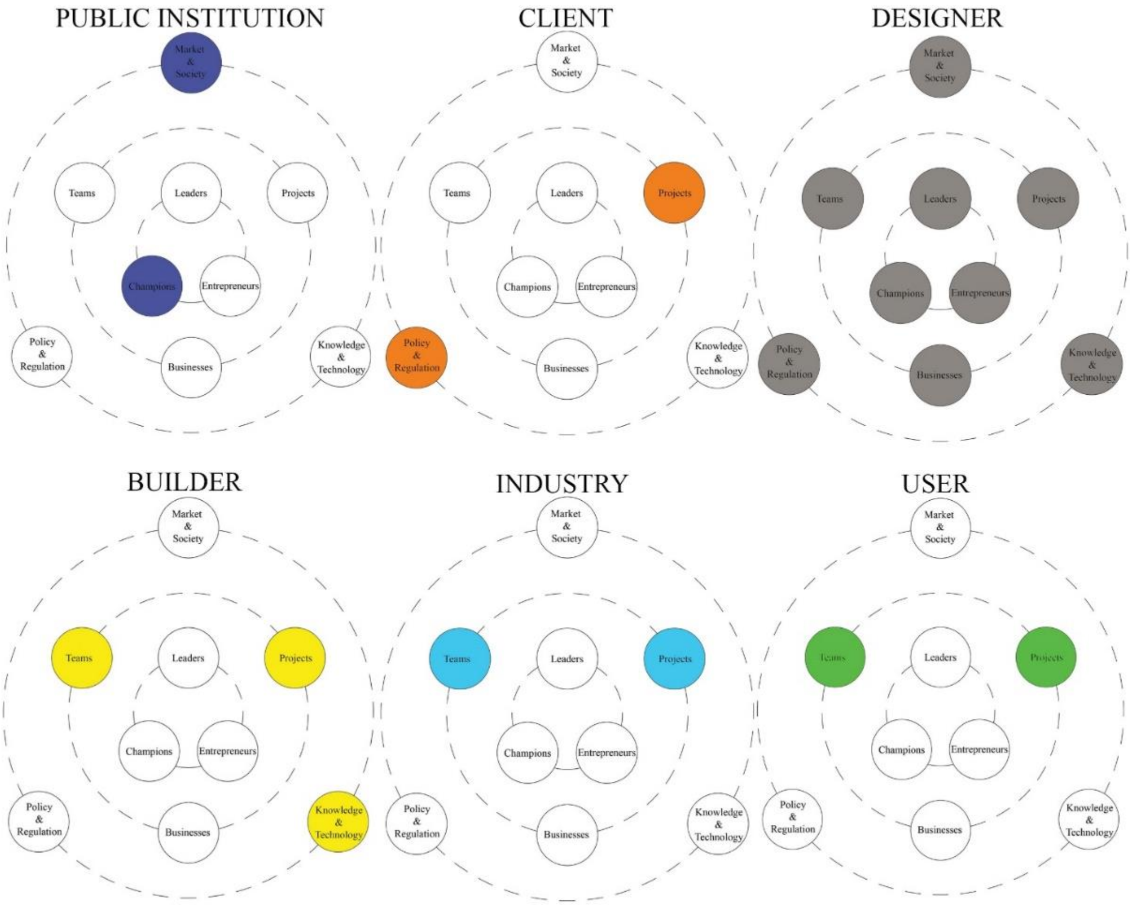


Figure 51: The image above shows the actors involvement on the project. The eco-ideation phase was characterised by the roles of public institution and the designer. The eco-innovation phase was characterised by the client, designer, builder, industry and user. The project had an impact on all the domain of the eco-institutionalization phase.

5.4.3 ECDC Centres, Rwanda (Various locations) – Building characteristics

ECDC
Various Location in rural Rwanda
ASAStudio
2013-2016

Context Characteristics:	Rural
Concpet Characteristics:	participatory design - local materials - community engagement - passive systems - self-sufficiency
Orientation:	it varies according to site conditions - openeings and ventilation holes position changes accordingly
Dimension:	500 sqm
Shape:	2 models have been developed: S shape / circular shape
Floor number:	1 Floor
Access and circulation:	The main acess is from the porch, and blocks connected one to the other through a covered path (porch)
Structure:	Locally produced bricks masonry walls reinforced with vertical rebars
Construction systems:	Bricks masonry (20 cm thick - flemish bond)
Evironmanetal control systems:	Rain water harvesting from roofs to underground water tank. Water is used for cleaning, irrigation, cooking. bricks masonry to control heat. Clay tiles without ceiling for ventilation and to protect from irradiation). One prototype of ECD is provided with solar pales devices (greatlakes energy supplier) with socket connected to charge phones or as portable lamps. Permanent ventialtion through holes in the masonry (removing 1 header brick here and there).
Water treatment:	composting toilets: each cubicle has 2 pits each of them is used for 6 months while the other is resting (and transforming waste in compost). After 6 months the compost is removed manually and the pit is switched again. Urine is separated and collected in a tank and used as fertilizer as well. Storm water is addressed towards soak pits as well as the underground tank overflow

Delivery process

Between 2013 and 2016, the ASA Architecture has developed a number of Early Childhood and Family Centre in various location in Rwanda, for the client Unicef Rwanda. The building dimensions were about 500smq each and the cost was approximately 200$/sqm for a total of about &100.000. Asa Architecture (2018) explained that:*'…Working with UNICEF Rwanda has offered the opportunity to develop and refine ideas on how to build Early Childhood Development centres, and test them at national level in 15 districts, within very remote rural communities. It has been a unique opportunity to gather access to the different realities of the country, and particularly to test the replicability and adaptability of the design to varying topographic constraints, scarce and limited material resources, and with a wide range of expertise provided by the implementing partners. Workshops have been organized to understand the most important themes in local community life, which have become the principal design items.'* Moreover, ASA Architecture continued explaining that: '…*The conceptual approach to the design rests on two pillars: it highlights the role of a central space as catalyst for community gathering, in a contemporary reinterpretation of the traditional "urugo" settlement pattern; and it conceives a modular structure, where components can adapt to different terrains and situations, but originate always similar facilities, organized around the central space. Two main typologies are being tested throughout the ongoing construction: a circular plan and a S- shaped plan. Ideally the outcome of different aggregation of the modules, they are the result of the adaptation to varying topographies and plots. All have required adjustments and changes during the construction process, in an effort to source locally available materials and transport them to difficult and remote site locations, together with the challenge of reacting to different climatic and geological conditions, such as soil types and heavy rainfall'.* These projects were promoted by both Unicef Rwanda and the Government of Rwanda that has recently started a program to develop the education sector in the country. Stassi (2017) explained that UNICEF Rwanda engages with a local partner (ADRA or PLAN International or IMBUTO foundation). ADRA has building capacity and builds directly; PLAN collaborates with a contractor (Betex) - direct award. IMBUTO asked the support of the district authorities to find a contractor to build the ECD: in this case a public tender is published. The builders selected for the projects were different depending on the site: ADRA, Betex were the main ones. The contractor provided only technical experts and the manpower is found on site from local community. The construction of each centre lasted approximately between 8-12 months. Stassi (2017) explained that the component production was entirely local, as the clay components were produced in the villages near to the sites, and the cement and metal came from Kigali. Some problems were identifies such as leaking roof, cement pavement cracks, roof tiles leaking, bad quality supply in general: metal profiles bending because of fake nominal thickness. ASA studio had a 2 years LTA contract with UNICEF Rwanda for architectural and engineering services and related construction administration services. The maintenance plan was not defined as the centres were delivered to the community to run and manage them. Yet, after few years, some centre are highly effective and in use, whereas other have been abandoned and looted of some of the building materials and components. Stassi (2018) stated that this heterogeneous repose to the centre depended largely by the cultural approach and interest that individual from the communities expressed, in regard to the centres.

Innovation types and impacts

Radical innovation can be found in the architectural holistic approach and in the environmental control. The approach to the architectural characteristics is to deliver a design that could be participatory, local, engaging, self-sufficiency, and environmentally passive. This latter concept set the premises for delivering radical innovation by designing rain water harvesting system, natural lighting, solar panels, and holes in masonry and opening to facilitate natural ventilation, as well as introducing fire extinguishers. The other project characteristics such as dimensions, shape, internal partitions, door and windows and circulation can be considered architectural innovation as they contribute to the composition of the final artefact. The use of local materials and the construction system can be considered as incremental innovation, as the architects selected a building strategy that could be managed by the local community already familiar with the processes, and therefore increase their sense of belonging and participation.

Table 48: The table shows the type on innovation on the EDCD buildings. Radical innovation is found in the holistic architectural design approach and in the environmental control systems.

	Incremental	Modular	Architectural	System	Radical
Context Characteristics		■			
Architectural Design			■		
Construction Systems	■				
Secondary Elements		■			
Environmental Control Systems					■

Table 49: The table shows that competence destroying activities were undertaken by the public institution, which was also the client, and by the users.

Actor	Competence Creating	Competence Destroying
Public Insititution		■
Client		■
Designer	■	
Builder	■	
Industry	■	
User		■

The activities on the project were competence destroying for some extent for the local community that had to learn and acquire some building skills to deliver the project. Also for the client and the promoter, the Rwanda Government these projects were a new endeavor and therefore had to acquire new knowledge to assist and ensure the delivery of the program.

Sustainability results

The building project achieved both environmental and social results through its design. The buildings were designed within budget and therefore it allowed cost invariance, avoiding any loss. The buildings achieved to provide space for the kids of the community satisfying their initial scope, and therefore providing protection, sense of gathering, participation, inclusion and giving the opportunity of receiving a first education to the kids. Positive results were also achieved in the environmental domain, since the buildings were self-sufficient in terms of energy generation, and allowed controlled indoor environmental quality to facilitate the education activities for the kids. The building delivery process and the building life and management also achieved economic, social, and environmental results. Despite not all the centres were used accordingly to their scope, and in some cases economic loss were created by the lack of maintenance and by the fact that some components were stolen (such as solar panels), the delivery and the use of such buildings represented a inclusive endeavour for the community and the possibility to create a cultural change for the kids through education and early childhood assistance. Also, the use of local materials and labour allowed the achievement of an environmental approach to construction which optimised the local resources and attempt to generate knowledge diffusion and skills acquisition.

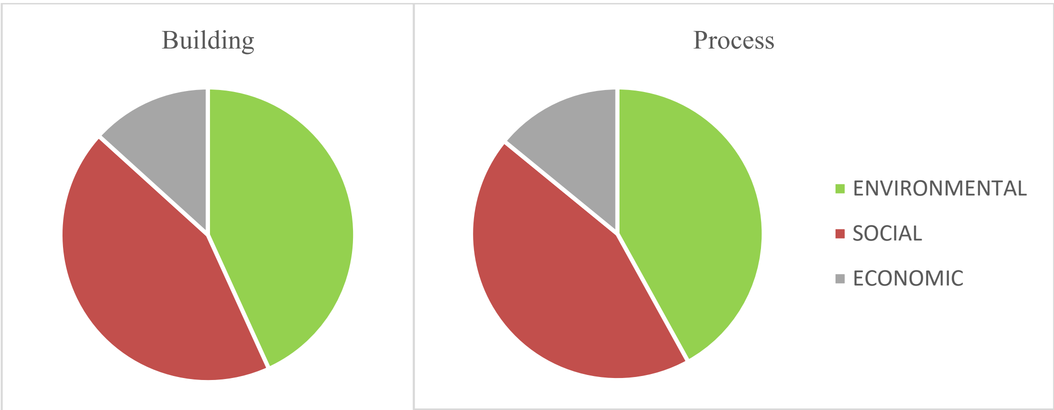


Figure 52: The pie charts above shows the distribution of type of results both in the building and in the delivery process. The social and environmental results seem to be the predominant.

The actors and the eco-innovation and sustainability model

The actors involved on the project were the public institution, the client, the designer, the builder, and the local community, as final users. The co-ideation was characterised by both the public institution (the Rwanda Government) and the client (Unicef Rwarda). The former acted as leader in defining ad promoting a new program for the schooling diffusion in the Rwanda territory. The client acted as champion and entrepreneur by establishing links and creating the opportunities to actualise the pub institution program. The co-innovation phase was largely run by the role of the architects (ASA Architect) who were able to define a specific design that could influence positively not only the final artefact itself, but also the delivery process. For this reason, the co-innovation phase was also characterised by teams of builders, and local community, who jointed efforts to deliver the projects. During this phase, the architect, the builder and the local community participant worked collaboratively and yet obtain a private return for their business. The local community acquired new skills that could re-use in other building activities and therefore they acquired new skills that potentially could open new working market for the individual participants. The co-institutionalization phase was impacted on the market and society level as well as on the knowledge and technology diffusion, thanks to the decision made by all the actors involved.

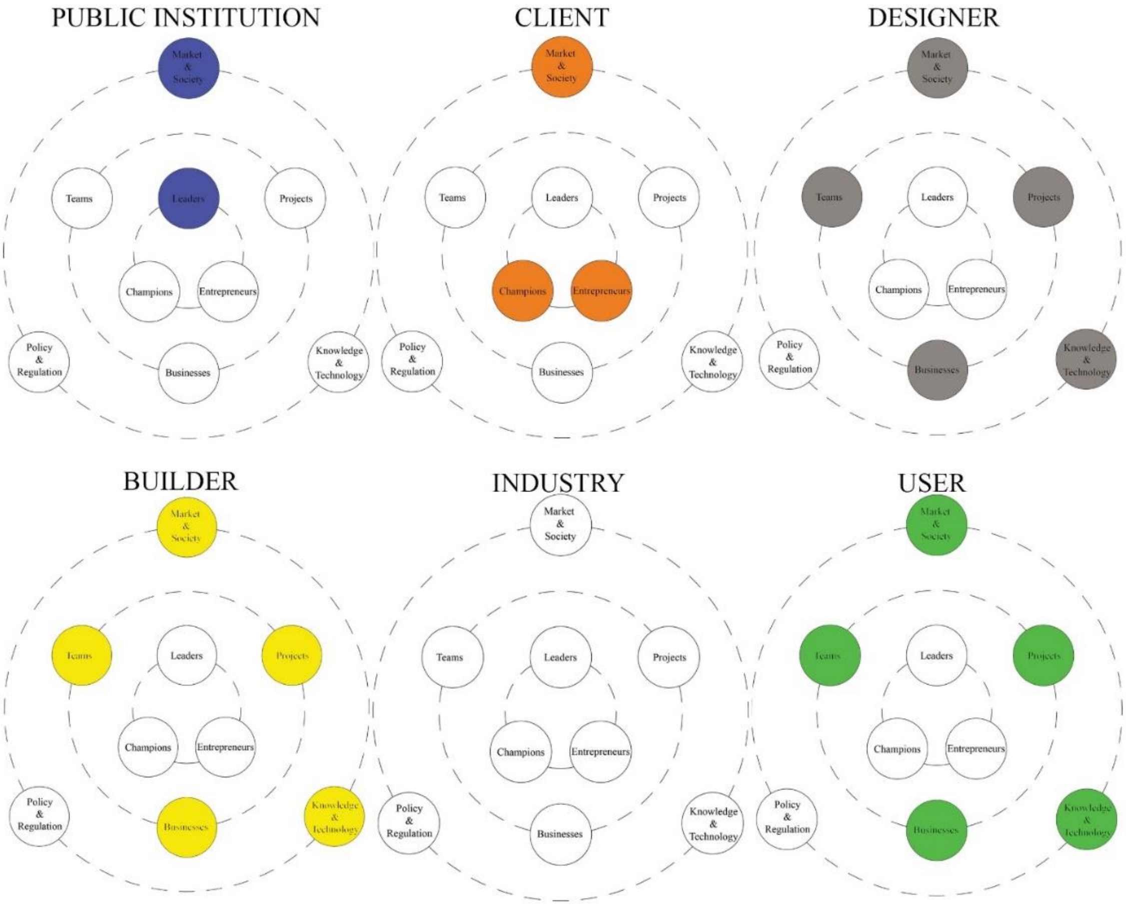


Figure 53: The eco-innovation and sustainability model shows the role of the various actors on the project. The public institution and the client acted as leader, champions, and entrepreneur during the eco-ideation phase, whereas the designer, the builder and the community were central to the eco-innovation phase. The results of the project had an impact on the eco-institutionalization phase both on the market and society domain, and on the knowledge and technology development.

5.4.4 Library of Muyinga, Muyinga, Burundi – Building characteristics

Library of Muyinga
Muyinga, Burundi
BC Architects
2012

Context Characteristics:	Rural
Concpet Characteristics:	Vernacular culture of construction in Burundi
Orientation:	South-West
Dimension:	140 sqm
Shape:	2 models have been developed: S shape / circular shape
Floor number:	2 Floors
Access and circulation:	The library is organized along a covered longitudinal circulation space. There are two different accesses on two different levels.
Structure:	Brick mansory and a lightweight concrete skeleton structure inside the CEB columns.
Construction systems:	Bricks masonry locally produced
Evironmanetal control systems:	On the longitudinal end there are blinders control access, also a high interior with continuous cross-ventilation. Transparent doors between the columns create the interaction between inside space and porch. The façade is perforated according to the rhythm of the Compressed Earth Blocks (CEB) masonry. Three façades of four are windowed with a great transparent/opaque relation that facilitate the natural internal ventilation. All the materials used for the construction was local, with a low energy producti
Water treatment:	None

Delivery process

The library of Muyinga in Buruindi was designed by BC Architects and completed in 2012. The scope of the project was to deliver a building for the deaf children of Muyinga. BC Arcitects (2018) explained that in the Burundian culture the story telling and the oral knowledge dissemination is central to the culture. For this reason, the deaf children often feel isolated and have difficulties in feeling part of the community. The project for the library of Muyinga was therefore aimed at provide an inclusive environment for this group of kids, who could develop a sense of belonging and worthiness, as well as develop the ability to then be integrated into a future school-based workshop to help them enter into the broader society. The project for this building was promoted and commissioned by the NGO Odedim and financed by Satimo Vzw, Rotary Aalst, Zonta Brugge and the Province of West-Flanders. The Odedim NGO contacted directly BC Architecture on the basis of their previous experience and research studies in the African context. The group designed and managed the construction process, which was organized as a collaborative environment. The construction process was organized and supported by the work of the local community, international and local students, as well as professionals and volunteers. The total cost for the building was 40.000 euros. The project building was organized as a 'hallway porch' to remind of the Burundian traditional house typology and therefore enhance the sense of safety and belonging for the kids. The BC Architect group utilise a scale 'open structure' previously tested on a case study in Katamga, Congo. The work was characterised by extensive research on the local area to seek and study available materials. In the construction were used local materials reducing the supply chain distances. The construction site was organized as critical path, and the maximum number of people on site was 60. The total site duration was four months. The internal space is organized with a massive amok built by a fisherman, who designed and delivered this object specifically for the kids so that they could lie down in the library while reading and engage playfully with the space.

Innovation types and impacts

Radical innovation in the building can be found in the fishnet utilized a horizontal partition in the building. Such idea changes the use of space and introduce new materials and activities in the library. The context characteristics, the concept, the architectural characteristics, the shape and the structure can be described as architectural innovation as they contribute to the definition of the definitive characteristics of the final artefact. System innovation can be found both in the environmental control systems, and in the selection of local materials and construction systems. These latter contributed, not only to the appearance of building and its aesthetic, but also the trigger of shorter supply chain, and inclusive construction process to involve the community. The environmental control systems are based on passive strategy to optimize the microclimatic conditions of the site.

Table 50: The table shows the types of innovation on the building. Radical innovation can be find on this project in the horizontal internal partition, since the horizontal floor is done with a fishnet amok designed and delivered by a local fisherman.

	Incremental	Modular	Architectural	System	Radical
Context Characteristics					
Architectural Design					
Construction Systems					
Secondary Elements					
Environmental Control Systems					

Table 51: The table shows that need for competence destroying activities for designer, builder, and users.

Actor	Competence Creating	Competence Destroying
Public Insititution		
Client		
Designer		
Builder		
Industry		
User		

These innovations called for competence destroying activities for the local community who had to learn new process to build the library, as well as experiment new forms of utilizing the building due to the innovative indoor setting defined by the presence of the fishnet amok. Despite, the BC Architects already had previous experience on similar projects, the new context and the involvement of new people trigger competence destroying activities in coordinating and organizing the work om site and during the materials production. Competence destroying activities was also required to the volunteers and the international and local students who participated to the construction of the project.

Sustainability results

The building design produced economic, environmental and social results. Firstly, the project was completed within budget, therefore avoiding any economic loss. Secondly, the project achieved to deliver a building that relies on natural ventilation, lighting and shelter from rainwater, creating an healthy and pleasant indoor quality for the kids. Thirdly, The building also achieved to be used by a high number of kids who engaged playfully with the building thanks to the interior design and choices. The building delivery process, as well as its use and maintenance achieved positive results in all the domains. This was possible because the delivery of the process was organized with a strong social inclusion between the community, the schools, the interns and the young architects. They all obtained both social and economic advantages, in developing a sense of community, inclusion and mutual care, as well as in acquiring new sets of skills that could open markets and represent qualitative advantages for all. This approach continued also in the use and maintenance of the building. BC Architects (2017) explained that different institutions contributed to the initiative with summer schools, workshops, and various activities, LUCA Architecture

University of Brussels sends a number students with the VLIR-UOS Scholarship every year to help with the activities in the building, as well as the Zevenkerken High School organised two weeks trips to Burundi for their students. Moreover BC Architect (2017) explained that: '…*Whatever the group, everyone joins in small on-site prototyping workshops on diverse topics such as CEB production, adobe production, earth analysis, bamboo weaving, sisal weaving, foundation solutions, furniture design, and so on, in an atmosphere of mutual contact and respect with local craftsmen, whereby knowledge of all involved is shared. These workshops bring an understanding of the direct social, cultural, ecological and economical effects of certain actions in a globalizing world: small scale actions do matter'*. The environmental results on the process are characterised by the strategic decision of organising a short supply chain, with the aim of achieving the stimulation of the local economy. This was achieved by choosing hand labour over machine labour when organizing earthworks; hiring only local labourers, a local foreman and local architect, and avoiding the interference of a contractor from Bujumbura or Rwanda.

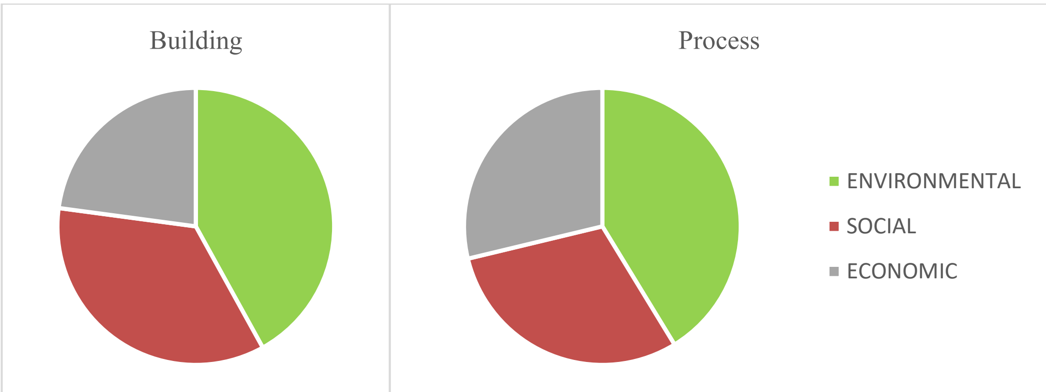


Figure 54: The pie charts above show the nature of the results on the project. Both in the building and in the process, the project achieved results in the three main domains of environmental, social, and economic sustainability.

The actors and the eco-innovation and sustainability model

The project delivery was characterised by high degree of collaboration between all the actors involved, from the public institution to the users. The co-ideation phase was characterised by the role of the Public institution and the client, who acted as leader, champion and entrepreneur in promoting the idea for such project, with the aim of creating an impact on the community. The co-innovation phase was highly inclusive and it was organized with teams of client represent ants, architects, local communities, national and international students and volunteers. The teams worked on the project and exchanged knowledge, enriching the individual business and individuals, and creating an environment characterised by high degree of knowledge transfer and diffusion. The co-institutionalization phase was characterised by positive impact on the market and society, as well as on the knowledge and technology development and dissemination.

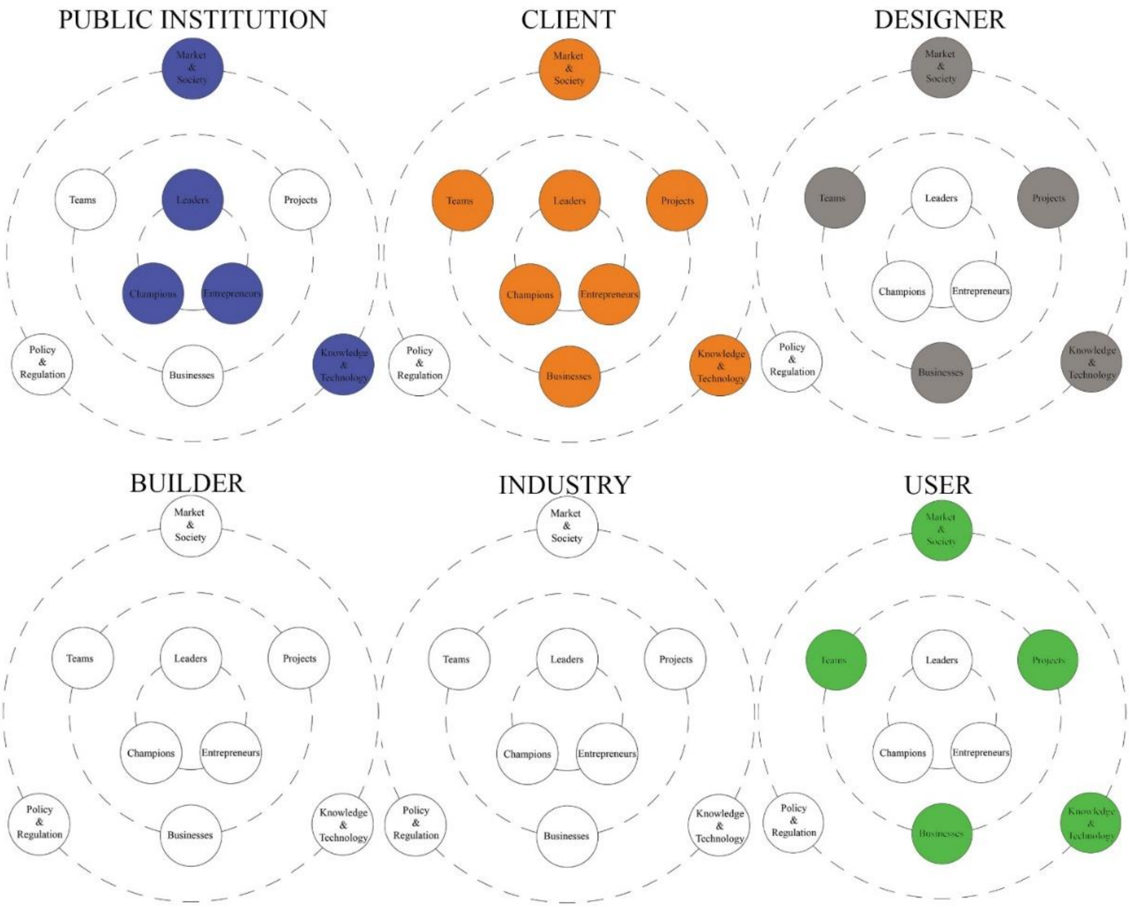


Figure 55: The image above shows the roles of the actors involved on the project. The eco-ideation process was ideated by the public institution and the client. The eco-innovation phase was characterised by highly collaborative environment between the client, the designers, and the users, as well as all the volunteers involved on the building construction. The eco-institutionalization phase was impacted in the area of market and society, and on the one of knowledge and technology development.

5.4.5 One Airport Square, Accra, Ghana – Building characteristics

One Airport Square
Accra, Ghana
MCArchitects
2015

Context Characteristics:	Urban
Concpet Characteristics:	The main approach to the project starts from the idea that the building is an opportunity to create public space, an area similar to a European square, a meeting place for people
Orientation:	Variable
Dimension:	17000 msq
Shape:	Irregular shape following the land shape
Floor number:	10 Floors
Access and circulation:	A main square is created as meeting area. The paved surfaces link the street with the upper level of the square, where we find the main entrance to the offices and commercial area
Structure:	The structural mechanics is a unique and organic collaboration between all its variable elements in reinforced concrete. This is a complex framework with a high degree of hyperstaticity where each element in any load condition works as a unit to balance the system of forces
Construction systems:	The enclosure is made up of a system of cantilever projecting slabs that protect the building from solar radiation, from a sun-protected glass façade protected from the sun, and from a diagonal structural weave in reinforced concrete that in an organic way surrounds the building
Evironmanetal control systems:	Natural lighting and ventilation system
Water treatment:	Reuse of gray water for flushing toilets
Certification:	4-Stars (Design Stage) by the Green Building Council of South Africa (GBCSA).

Delivery process

The One airport Square is a large development for a multi-functional commercial and office space building designed by MC Architects in 2015 in Accra, Ghana. The project was promoted by Laurus Development and Partners, and financed by the private investors Actis and Myma Belo Osagie of Boston Investments Limited. The builder was Micheletti Ltd, and total cost for the project was $62.5 million. The Stanbic Bank Ghana Limited and The Standard Bank of South Africa Limited partially financed it with a $31.2m medium-term loan facility. The construction lasted from 2012 to 2015. Molinari (2018) explained that: '… *The project arises from a few very practical considerations. The movement of the sun in Ghana is vertical, with different latitudes, different angles, and therefore different relationships with buildings. The average temperature is around 23 Celsius while the level of humidity varies depending on the season. In the summer it can reach saturation points of 90%. These simple considerations alone have led us to envision a building with horizontal overhangs to allow for constant shading of the glass walls of the building. The reduction of solar warming led to a drastic drop in energy demand for cooling, and to the possibility of using transparent glass. The other aspect is the structure of the building, which serves also as the façade. The façade was conceived of as a series of disassembled elements, handmade and imperfect, and was built with the essential support of parametric tools for optimizing building materials'.* The construction was organized and supervised by Politecnica Ingerneria and Architectura. The production of the component was organized with 'kit' of building parts. The "kit of parts" of the formwork has been designed by Politecnica Ingegneria e Architettura and manufactured offsite using customized machines in order to be economically viable both in terms of capital costs and efficiency. The components were produced in Italy, shipped to Accra and assembled onsite. This hybrid prefabrication system has reduced work time and enhanced safety while saving money and time. Moreover, due to the particular shape of the structural elements, a process of on-site industrialization was set up. A number of teste were carried out by different companies such as Politecnica Ingegneria e Architettura, Chapman – BDSP, and local MEP engineering, and AECOM. The project was carried out with integrated design system, and the drawings were produced by relying on BIM and parametric design.

Innovation types and impacts

Radical innovation was found in the building in the concept, the architectural characteristics, the structure and the construction system and details. The aesthetic and architectural elements of the project are inspired by local traditional art and therefore revise in a unique way the aesthetic approach of office buildings compared to the existing context. The structure of the building represent the most complex aspect of the building. The design complexity lies mainly in the analysis of the static support between the various parts of the structure. From an operative point of view, the structural mechanics is a unique and organic collaboration between all its variable elements in reinforced concrete. One cannot imagine a separation between the components providing resistance to vertical and horizontal loads, as well as the contribution of membrane stiffness. This is a complex framework with a high degree of hyperstaticity where each element in any load condition works as a unit to balance the system of forces. The enclosure is made up of a system of cantilever projecting slabs that protect the building from solar radiation, from a sun-protected glass façade protected from the sun, and from a diagonal structural weave in reinforced concrete that in an organic way surrounds the building. The 3D modelling of the grid's intersections and angles with the floor slabs (always different for each node) is an example of the complex framework generated by the balance of the structural flows of the whole organism. The building is characterized by an on-site concrete exoskeleton that resembles a sort of self-supporting basket, explains Fabio Camorani, Politecnica director of structural engineering and site management. The angle of the inclined pillars within each slab there are struts and tie rods of large diameter and anchorage nodes. The environmental control systems represent system innovation types, as they are delivered by applying specific technologies to control lighting and ventilation, and yet collaborating together to increase the performance of the indoor quality of the environment. Internal partitions and circulation can be consider incremental innovation, as they relies on standard system, modified for the project.

Table 52: The image table shows that radical innovation on the building was found in the structural element, construction systems, and construction details.

	Incremental	Modular	Architectural	System	Radical
Context Characteristics					
Architectural Design					
Construction Systems					
Secondary Elements					
Environmental Control Systems					

Table 53: The table shows that the local builders had to undertake competence destroying activities.

Actor	Competence Creating	Competence Destroying
Public Insititution		
Client		
Designer		
Builder		
Industry		
User		

These innovation did not call for any competence destroying activities, as most of the workforce was international with previous experience in delivering these projects. To a certain extent competence destroying activities were undertaken by the local labour who worked on the project, facing new technologies and complex construction systems.

Sustainability results

The project was characterised by a predominance of economic results both on the project and on the process. This was due to its commercial nature, which represented an investment for the developers involved. The architect was able in its design to achieve environmental results by promoting passive strategies and innovative aesthetic approach in order to achieve the uniqueness required by the client as competitive and comparative advantage. MC Architects (2017) also explained that:'...*One Airport Square is the first building in Ghana to have been awarded 4-Stars (Design Stage) by the Green Building Council of South Africa (GBCSA). The project was designed based on a detailed analysis of the site, the topographical and optimal orientation to become a point of reference and example for the new generation of office buildings in West Africa. At this latitude, the sun's path makes it particularly exposed to solar radiation fronts east and west. This, combined with medium to high temperatures present during the entire course of the year, made it necessary to adopt strategies to reduce the need to cool the building'*.

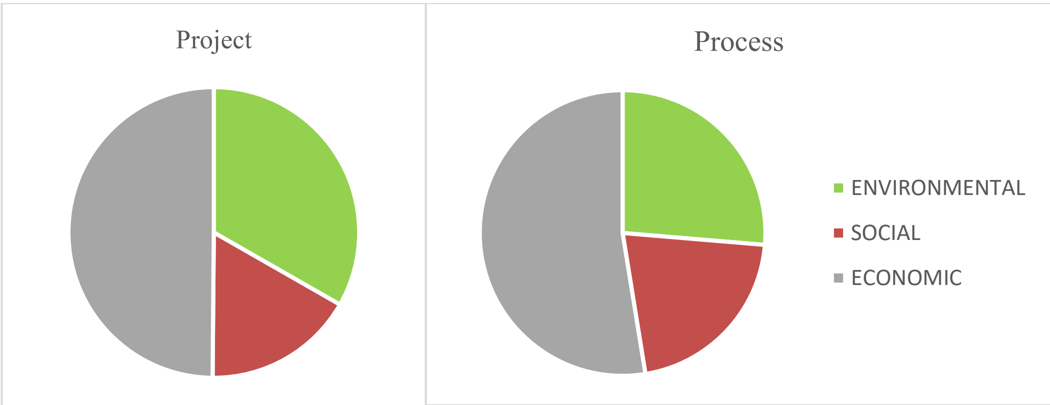


Figure 56: The project was characterised by the predominance of economic results due to the nature of the commercial investment of the project.

The actors and the eco-innovation and sustainability model

The co-ideation phase of the One Airport Square project was characterised by the role of the client who acted as leader, entrepreneur and champion. The operation was mostly an entrepreneurship endeavour, developed as a commercial investment. The client also created the links to develop the project by contracting MC Architects and all the other consultants and contractors involved on the project. The co-innovation phase was characterised by the work conducted by all the consultants, engineering, designer firms, as well as by the mail contractors and by the local labour. The teams worked on the project and achieved their individual profit for the businesses. The impact that the project produced on the co-institutionalization phase was related to setting an example of environmental sustainable building, and therefore developing knowledge and technology.

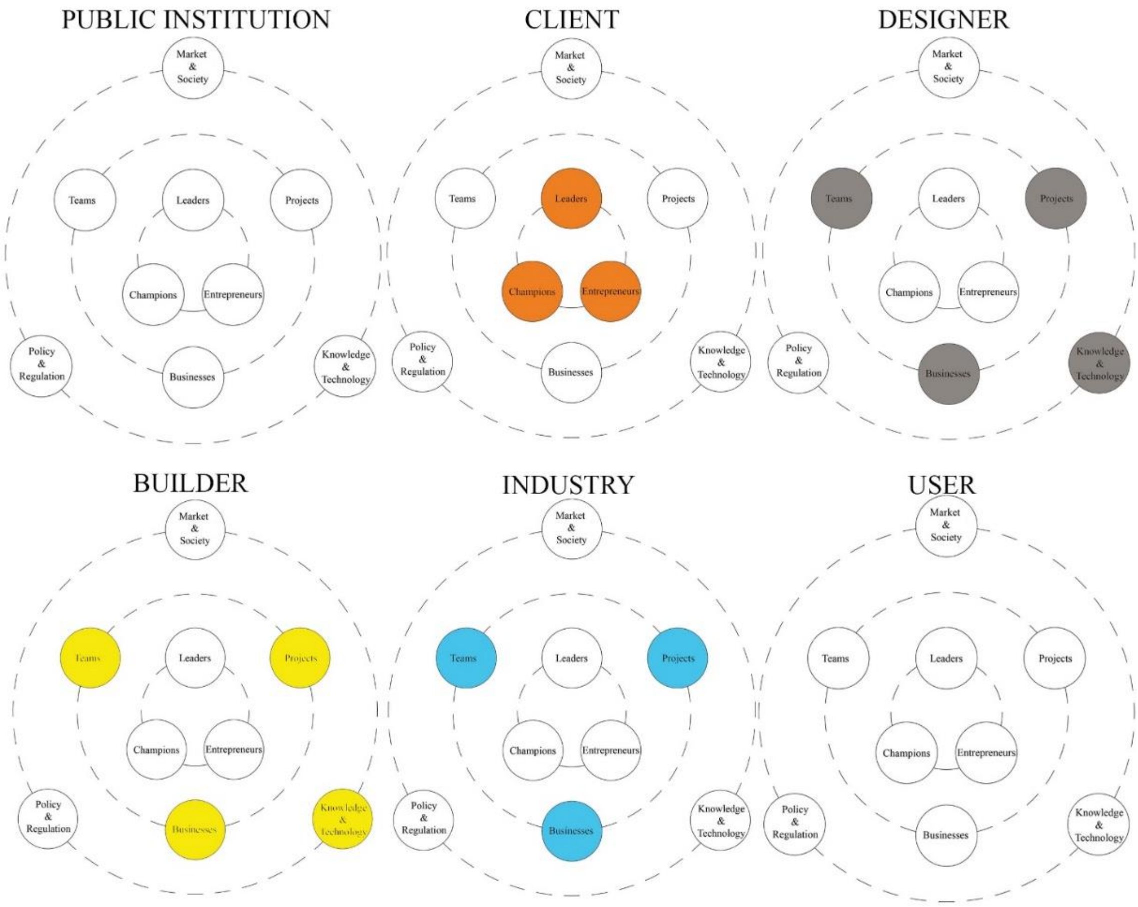


Figure 57: The image shows the actors involvement on the project. The client acted as leader, promoter and mostly entrepreneur during the eco-innovation phase. The eco-innovation phase was characterised by the designer, builders, and industry. The impact on the eco-institutionalization phase was the development of knowledge and technology.

5.5 The North American context

United States of America and Canada

Despite on June 1st, the United Stated of America announced the cease of their participation to the 2015 Paris Agreement on Climate Change Mitigation, which will be only formally actualised in 2020, the country has develop a number or National and regional program and policies to support sustainable development. For instance, the AIA (2014) explained that in 2009, the City of Berkeley published its Climate Action Plan, seeking to reduce its Greenhouse Gas emissions by 2020. As well as the case of California, many other states developed policies an regulations to support climate change action and sustainable development. In the context of the building industry, three assessments methods are the ones more utilised in the country: LEED, Green Globes, and Living Building Challenge. As Kibert (2016) explained, the Living Building Challenge was originated in 2005 by the Cascadia Green Building Council in the Northwest United States and Canada. Previous to the Living Building Challenge, in 1998 the US Green Building Council launched the Leadership in Energy and Environmental Design (LEED) building assessment system for new construction. As Kibert (2016) explained, the various LEED building rating address a number of types such as: building design and construction; interior design and construction; building operation and maintenance; neighbourhood development, and homes. Since it was released, the LEED system became very popular in the industry, and in 2010 over one billion square feet of commercial construction projects had been LEED certified. The majority of LEED-certified projects are for new construction, both in the public and private sector (Kibert, 2016). The Construction Sector Council (2011) explained that:'*…in recent years, the Canadian government has implemented a variety of initiatives in response to climate change and environmental concerns. For example, the Federal Sustainable Development Act (FSDA), enacted in 2008, includes targets and initiatives for sustainable development, as well as implementation strategies. Under the FSDA, a new office within Environment Canada will be established and a federal sustainable development strategy will be developed every three years.18 In addition, the Government of Canada's Economic Action Plan will provide $1 billion over a period of five years to the Green Infrastructure Fund (GIF).19 The GIF supports the development of sustainable energy generation and transmission infrastructure, as well as building upgrades that include modern transmission lines and wastewater infrastructure. Sustainable office buildings constitute a significant component of the federal government's approach to reducing its environmental impact, particularly due to the large volume of buildings that the government itself operates across the country. Since April 2005, the Government of Canada has mandated that all new government office buildings meet the LEED Gold level of certification.20 A nation-wide set of basic building standards and codes – referred to as the National Building Code of Canada (NBC) – are recommended by the Institute for Research in Construction. Because the NBC is a model code, it has no legal status until it is adopted by a* *region/jurisdiction. As such, provincial and territorial approaches vary significantly. Some provinces, for example, primarily use the 1995 NBCs, while others enforce the updated 2005 code'.* As in many other countries, a number of voluntary assessment methods are utilised in the Canadian industry, such as: Leadership in Energy and Environmental Design (LEED), ENERGY STAR, Built Green, Built Green, BOMA BESt, GreenHouse, Novoclimat, R-2000.

5.5.1 Ballard Library, Seattle, WA, USA – Building characteristics

Ballard Libray
Seattle, WA, USA
Bohlin Cywinski Jackson
2005

Context Characteristics:	Urban
Concpet Characteristics:	Ballard neighborhood is deeply rooted in Scandinavian tradition and culture, and the nearby working waterfront lends a strong maritime tradition.Remember a boat shape
Orientation:	North/South
Dimension:	15000.0 msq
Shape:	Basically a box; is based on a grid of columns that are the structure of the building. The roof is not a perfect geometrical curve, but rather a series of straight line segments that remember a boat
Floor number:	One floor
Access and circulation:	It is easily accessible by public transit, bicycles, and pedestrians
Structure:	Structure designed as a large open space surrounded by a curtain wall of clear glass.Three-dimensional network of the load-bearing part of a building with structure formed by linear elements like beams and pillars
Construction systems:	Tapered steel columns support a lilting roof, center components with its edges softened by wood purlins. Vegetated roof system.
Evironmanetal control systems:	Vegetated roof system. The plants provide insulation. Solar photovoltaic panels. Recycled-glass backfill, concrete forms made from milk cartons. Refrigerating and Air-Conditioning
Water treatment:	When possible, water comes from an on-site 38,500-gallon rainwater collection tank; the "sod" roof is a European system that absorbs water to be used later by planting material; interior water use reduced by metered faucets; no-flush urinals and efficient mechanical equipment

Delivery process

The Ballard Library in Seattle is a project designed by Bohlin Cywinski Jackson in 2005. The project aim was to develop the first major building in the Ballard Municipality, for a library and a civic centre, as well as to communicate the value of sustainability and care for the environment to entire community. The project was developed in Seattle, and it was developed in a previously developed land. The project was a public assembly type and total cost for the project, excluding the land was $6,500,000.00. The project promoter and client was the State Public Library. The land owner was the U.S. Bank. The builder was PCL Construction, and the building manager was David Kunselman. The project was developed with innovate financial strategy: bank that was originally part of the project pulled out during the design development phase. The financing percentage was organized as $196.4 million for all libraries, 6% were for Ballard Library. The AIA (2006) explained that:-*'... One innovative financing strategy was developed when a bank that was originally part of the project pulled out during the design development phase. The loss of that portion of funding caused the design team to consider replacing below-ground parking with surface parking in order to reduce costs. Instead, the team identified an option that created a dense building on the western edge of the site, allowing a 60-foot-wide parcel to be sold for mixed-use development. The funds from the sale of this property would be earmarked to pay for below-grade parking. The portion of the site was maintained as layout space during construction while being marketed for sale. The sale was delayed until construction was complete to maximize the sale price. Knockouts in the east wall of the structured parking further leveraged the neighbouring property's value by allowing an option to share a common drive, permitting a full 60 feet of storefront space on both faces of the through lot. The eventual sale netted $1,500,000, exceeding the cost of structured parking ($1,044,702), and provided a denser, more pedestrian-friendly neighbourhood'.* Moreover, The public nature of this building called for a public design process. The collaborative effort included the architect, the Seattle Public Library, the Neighborhood Service Center, and representatives from various user groups. The community was represented by people who continually distributed information between their groups and the design team. This group effort allowed the voices of thousands of potential users to be heard. The construction lasted from 2004 to 2005, whereas the design process started in 2000. The materials production was both local and International, as the building featured a number solar panels imported from Germany. Major building components were recyclable or reusable, as well as the glulam roof structure was erected with bolted connections, allowing for easy disassembly; the aluminum curtainwall that could be re-use and reconfigured for reuse in smaller projects. Moreover, the wood and galvanized metal siding was fastened with screws, allowing for disassembly and reuse. The project was developed with project management and general contracting for the construction company. The most significant maintenance works were done in 2013 and 2016.

Innovation types and impacts

One of the defining characteristic of the building is its aim of communicating its environmental suitable approach. This aim can be found in the definition of a number of building characteristics that contribute in achieving a great environmental performance for the building, and therefore acting as system innovation. These characterises are building orientation, shape, layout, environmental control systems such as the use of photovoltaic panels, glass type, green roof, and reused and recycled materials, and water cycle system. Moreover, as the AIA (2006) explained*:…' The Library and Neighbourhood Service Centre are two separate entities with different energy and conditioning needs. Mechanical units serving the two uses individually were isolated and located to simplify and reduce the length of duct runs. Simplified layouts reduce the amount of energy required to move air and reduce the loss of energy between the source and the use point. Taking care to reduce heat sinks (common in concrete construction) led to innovations in the structure of the building. Precast concrete planks, supported by cast-in-place concrete columns and beams, are covered by rigid insulation and a floating slab. Conditioned interior space is completely isolated from the garage below. Data and electrical runs are located in the floating slab, allowing for flexibility in the future. The design team worked with the Seattle City Light's Green Power Program to install rooftop solar panels, and, in the curtainwall, glazing with photovoltaic film. The photovoltaic glazing is one of the first such installations in the nation. The power generated by both systems is fed back into the power grid, and Seattle City Light continues to monitor the performance. The photovoltaic glazing also shades the lobby of the Neighbourhood Service Centre, eliminating the need for other shading devices, and minimizing the need for mechanical cooling. Meters at the base of these windows allow patrons to study the path of the sun and its effects on individual panes of glass in the curved wall of photovoltaics; In this way, the building features a high-tech sundial. Energy-efficient light fixtures were used throughout the project. Photocells and occupancy sensors ensure that electric lighting is not used when it's not needed'*. Moreover, the access and circulation around the building call for alternative system of transport encouraging the environmental control also in the proximity of the building project. The context characteristics, the concept, the floor eight and number represents architectural innovation that characterised the nature of type of final artefact.

Table 54: The table shows the predominance of system innovation in the project.

	Incremental	Modular	Architectural	System	Radical
Context Characteristics					
Architectural Design					
Construction Systems					
Secondary Elements					
Environmental Control Systems					

Table 55: The table shows that all the actors involved had to undertake competence destroying activities due to integrated design delivery system, which called for the participation of all the actors involved throughout the entire building delivery process.

Actor	Competence Creating	Competence Destroying
Public Insitition		
Client		
Designer		
Builder		
Industry		
User		

The introduction of such innovative features required extensive integrated design effort by the team, which had to carry out many competence destroying activities in the manner in which the design thinking process was done, in conjunction with the high number of people from the community participating to such process. Also, the people for the community had to undertake competence destroying activities by participating to a design activities and understanding the process of transforming the users' needs into architectural solutions.

Sustainability results

The project was selected as one of the top ten AIA (The American Institute of Architects) Green Projects for 2006. The results achieved on the project both on the building and on the process were both predominantly environmental. Economic and social results were also achieved. For instance the AIA (2006) reported that the building has 1,028 visitors per week, uses 411,00 gallons of water per year, demonstrating to be more effective than other standard buildings that serve the same scope. Libby (2006) also explained that over-18,000-square-foot green roof and 17 photovoltaic solar panels that generate 4.8 kilowatts of power. Despite Libby (2006) reported that lots of work were required in running and maintaining the building, overall the library works environmentally more efficiently than the previous existing building, which was replaced. Moreover, it was reported that the building was positively received by the local community, who could participate to the design process and therefore developed a sense of satisfaction, empowerment, and belonging.

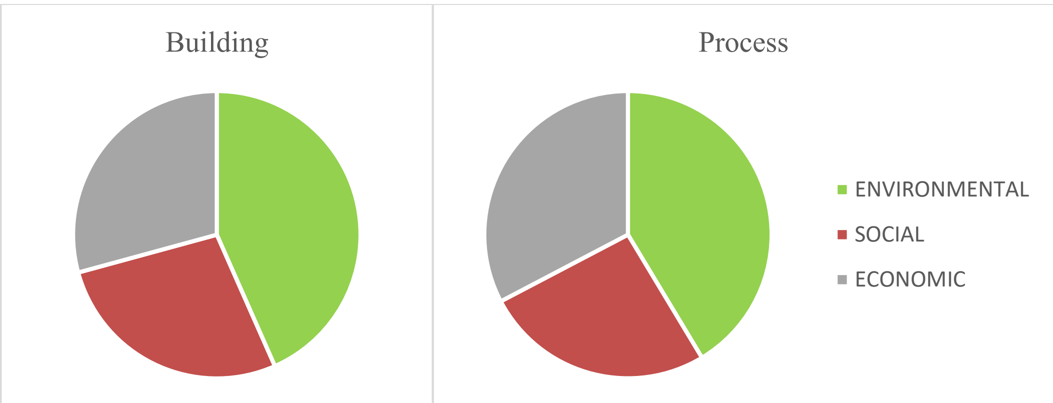


Figure 58: The pie charts above shows the predominance of environmental results on the project both in the building and in the process.

The actors and the eco-innovation and sustainability model

The delivery of this project was characterised by integrated design and participated decision making process, involving client, industry, designers, users, and community. The co-ideation phase was characterised by the client who acted as leader, champion and entrepreneur, by expressing the need for the new library, searching for the innovative financing systems, and engaging people and creating the links to actualize the project delivery. The co-innovation phase in which the technical innovation was designed and delivered in the building was characterised by the presence of designers, users, community, builders and suppliers, who all worked in teams collaboratively on the project. They all worked in team with the common aim and at the same time they were able to achieve individual profit or benefit in return. The co-institutionalization phase was characterised by the impact that the project had both on the market and society – for instance in the sense of participation and belonging developed during the project delivery – as well as on the knowledge and technology development, for example in the introduction of a number of technologies aimed at increasing the environmental performance in the building.

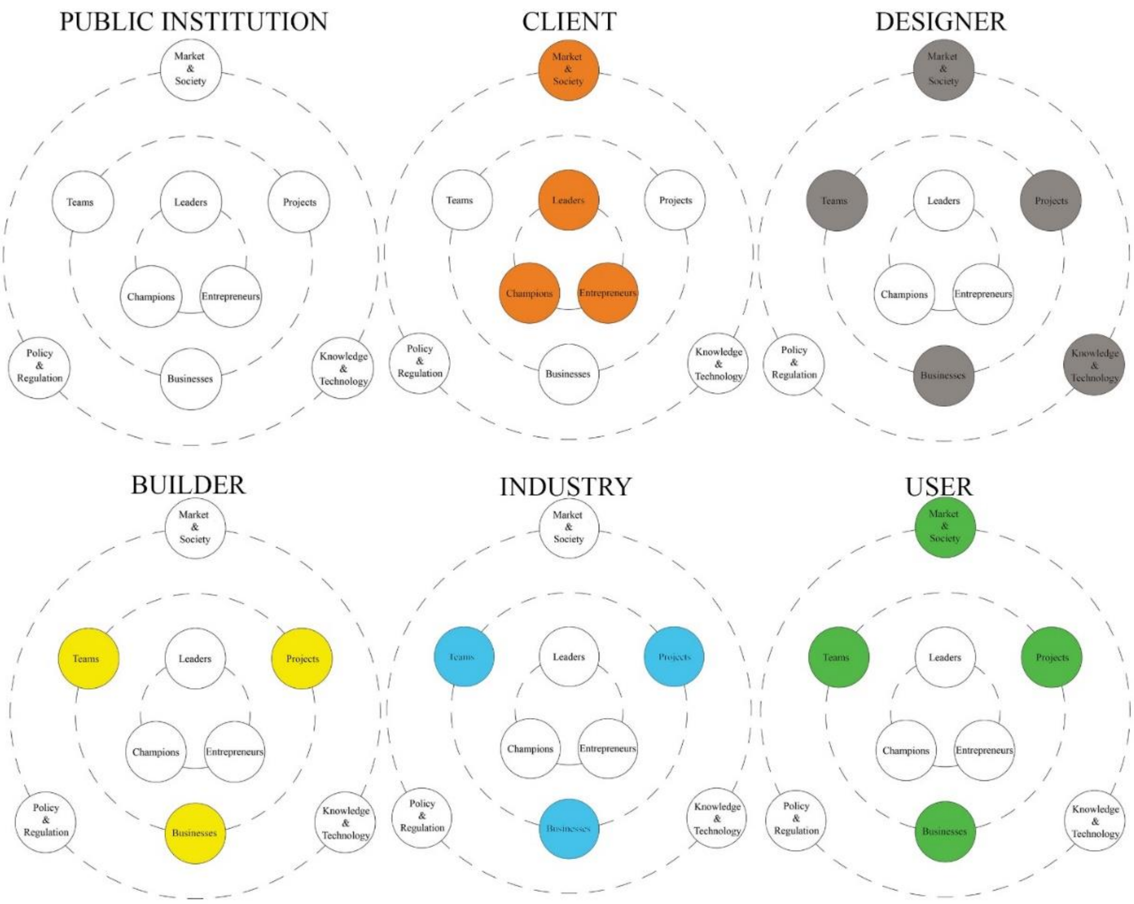
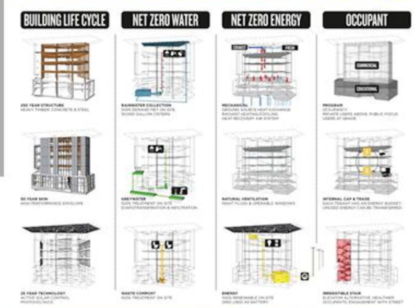


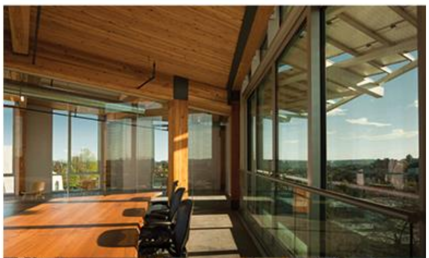
Figure 59: The image above shows the eco-innovation and sustainability project to describe the role of actors involved in the introduction of innovation on the project. The eco-ideation phase was led by the client, whereas the eco-innovation phase was characterised by the participated design process of designers, industrial partners and local community. Such phase generated positive impact on market and society and on knowledge and technology development.

5.5.2 Bullit Centre, Seattle, WA, USA – Building characteristics

Bullit Center
Seattle, WA, USA
Miller Hull Partnership
2012



Context Characteristics:	Urban
Concpet Characteristics:	Building a NET zero energy building
Orientation:	North/West
Dimension:	50000 msq
Shape:	Trapezoidal block
Floor number:	6 Floors
Access and circulation:	The building can be reached by different medium of transport
Structure:	Heavy timber, concrete anc steel
Construction systems:	High perfomance facade with both opaque and glazing surfaces
Evironmanetal control systems:	Photovoltaic panels, ground source heat exchange, radiant heating and cooling, heat recovery air system, natural ventilation through operable window, waste compost treatment of site, renewable grid used as a battery, internal cap and trade on user's energy budget
Water treatment:	Water collection and 50 gallons collection tank, grey gray water treatment



Delivery process

The AIA (2015) explains that:…'The Bullitt Center is a prototype high performance urban office building, conceived of as a replicable model of a commercially-viable structure with essentially no environmental footprint. Conceived of by the environmentally-minded Bullitt Foundation–this self-sustaining six-story 52,000sf office building is the first commercial structure to pursue the rigorous requirements of the Living Building Challenge, and is designed as a 'living' organism using only as much water and energy as it takes in'. The project was promote by KBA Construction on the land of the Seattle Department of Transportation. The client was the Bullit Foundation and the project was designed by Miller Hull Partnership, and built by Schuchart Construction. The aim of the project was to achieve the Net Zero Energy Building, and therefore the site selection was aimed at enhancing this strategy for the building design and development. The project achieved completion in April 2013. The building design achieve formal moves secondary to systems optimization, finds architectural expression of interdependencies mimics nature with an organic and natural synthesis. As the AIA (2015) explained:…'To optimize energy output required by a six-story building on a tight site in overcast Seattle, parametric modelling software facilitated testing of various geometric solutions for the highest photovoltaic array power production. Daylighting analysis drove massing and configuration of the curtain wall and skylights. Integrated sustainable features are visible throughout the structure and site, enabling the building to tell its own story. The building is designed like a living organism, windows and exterior shades automatically adjust through the course of the day giving the building a dynamic, ever-changing character'. The clear set goals of achieving net zero energy called for collaborative process and integrated teams of architects, engineers, contractors, client, and members from the regional and local community. The integrated design delivery process was assisted by the use of a number of design tools, such as the ones used for energy modelling which was used to set the parameters for the design process, as well as the integration of renewables and photovoltaic panels. Moreover, AIA (2015) explained that:'…The prototype Bullitt Center models obtainable high-performance goals and is inherently about sharing lessons learned to inspire similar buildings and others to progress beyond its example. Occupied for over a year, the building is continuously monitored and analyzed, with real-time building systems and information about the building design, construction, and operations available for review via an online dashboard, in published reports, and through numerous project team public presentations in a range of business, sustainable design, and civic-oriented venues'. The building was reported by the National Institute of Building Science (2016) to have achieved more than ten awards and the Living Building Challenge Certification.

Innovation types and impacts

The Living Building Challenged to get Net Zero Energy for the building was the major driver to introduce innovations in the project, both in design and delivery process. This goal also influenced the types of innovation introduced in the building characteristics. The concept itself was not driven by metaphor or aesthetic but by the performance metrics. The same logic was followed by the site selection, circulation and the access and circulation, structural type, construction systems, door and windows, materials, and construction details. Crucial role to the achievement of the net zero energy building definition is played by the environmental control systems and the water connection and treatment. All these building characteristics are designed to achieved environmental performance and therefore fall into the category of system innovation. Yet, the collaboration of all the building elements from the site selection to the construction details also allowed the adherence also to the definition of radical innovation.

Table 56: The table shows that the building is characterised by mostly system innovations

	Incremental	Modular	Architectural	System	Radical
Context Characteristics				■	
Architectural Design				■	
Construction Systems				■	
Secondary Elements				■	
Environmental Control Systems				■	

Table 57: The table shows that all the actors involved had to undertake competence destroying activities due to integrated design delivery system, which called for the participation of all the actors involved throughout the entire building delivery process.

Actor	Competence Creating	Competence Destroying
Public Insititution		■
Client		■
Designer		■
Builder		■
Industry		■
User		■

The integrated design delivery process to some extent called for competence destroying activities due to the collaborations between all the parties involved.

Sustainability results

The majority of results achieved by the project, both in building and process are of environmental nature. Yet, also economic and social results were achieved by levering on social inclusion strategy and communication of sustainability value as a commercial strategy. As AIA (2015) reported:…'*thousands of visitors—students, general public, design community, government officials, and foreign leaders—come to see how an urban building reduces its impact and restores its surroundings. Given its form, principles, and aesthetics, the building attracts socially-responsible tenants and has become a popular event venue.*

Realization of the building required close cooperation with local government, which proactively identified code barriers to sustainable buildings and modified zoning to enable its landmark sustainable strategies and support other projects to follow'. The environmental results achieved were many. The most important results was the achievement of the net zero energy certification. Among the results, the AIA (2015) reported to have achieved 75% of occupants using public transit, cycling or walking; 48% or reduction of regulated potable water; 80% rainwater collection; 82% of daylighting at levels that allows artificial lights to be off during day hours; 100% of outdoor view; 62% of openable windows; 835 of predicted percent reduction from National Median EUI for Building Type; and 0.40 watts/sf lighting power density. As reported by the National Institute of Building Science (2016), also economic results were achieved on the project levering on the choice of building elements on the basis of life-cycle costs, considering that economic sustainability can be achieved by a buildings is a building that lasts. Moreover, the National Institute of Building Science (2016) also explained that*:… 'The Center's photovoltaic array, funded by U.S. Treasury grants to offset the cost of the PV and waste treatment systems, mitigates the need for development of new, gas-fired power plants in Washington State. The Bullitt Foundation chose not to calculate simple paybacks for premiums to obtain Living Building status because those payback models illogically do not incorporate all external costs paid by society. Program goals included developing a market rate, leasable commercial building able to compete with area Class A office space. Rents are comparable to those for newly constructed, LEED-certified buildings in the area, and it eventually expects a positive return on investment. A rigorous analysis of the cost of the Center compared to the total cost of a baseline building forced to recognize its externalities will be published in conjunction with obtaining Living Building status'.* Moreover, the National Institute of Buildig (2016) explained that:'… *integrated design delivery process ensured all participants understood and bought into the sustainability goals, and were clear of their role and responsibility in achieving the overall desired results'.* As reported by the National Institute of Building Science (2016), in 2015 the building was awarded by the Living Building Challenge Certification by the International Living Future Institute. Moreover, the building was a warded with a list of prizes such as: Honor Award: 2014 Sustainable Building Industry Council Beyond Green Awards, Category A: High-Performance Building; Architizer A+ Awards, Finalist & Special Mention—Architecture + Sustainability, 2014; World Architecture News, Sustainable Building of the Year Award, 2013; Green Dot Award, Excellence in Green Services Award, 2013; Wood Design & Building North American Wood Design Awards, Citation, 2013 U.S.; Woodworks, Wood Design Awards, Best Multi-Story Wood Design, 2013; ENR | National, Best Project of the Year, 2013; ENR | Northwest, Best Green Project of the Year Award, 2013; AIA Northwest & Pacific Region, Special Jury Recognition, 2013; Metal Architecture Magazine, Sustainable Metal Building of the Year, 2013; Architizer.com A+ Awards, Finalist & Special Mention, Architecture + Sustainability, 2013; Forest Service Council, Design and Build with FSC Wood

Award, 2012; Seattle Business Magazine Washington Green 50, Special Project Citation, 2012; AIA Seattle, What Makes it Green? Award, 2012; and EcoStructure Magazine, Evergreen Award on the Boards category, 2011.

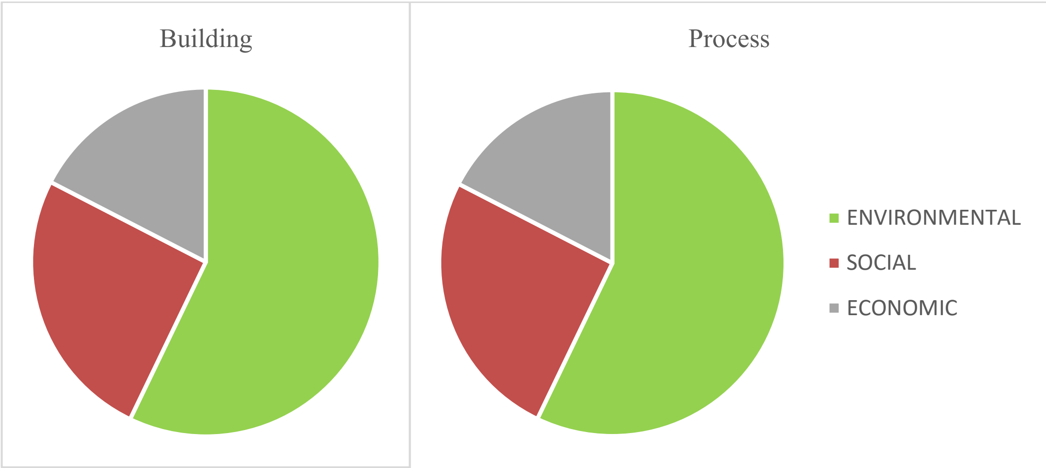


Figure 60: The pie charts above shows the prevalence of environmental results on the project.

The actors and the eco-innovation and sustainability model

The project deliver was characterised by the integrated design delivery process, which called for the collaboration of the promoter, client, designer, consultants, contractors, users, and regional and local community. The co-ideation phase was characterised by the promoter and the client, who acted as leader, entrepreneur, and champions. The developer KBA Construction acted as leader by ideating the idea for this project and sought for the entrepreneurial opportunity of development, and then in connection with Bullet foundation as client decided to act as champions to develop the links required to develop the project. The co-innovation phase was characterised by high degree of collaboration of all the actors involved, who all worked on the project aiming at obtaining common goals that could satisfy also individual businesses. The co-institutional phase was impacted on the knowledge and technological level, as well as market and society.

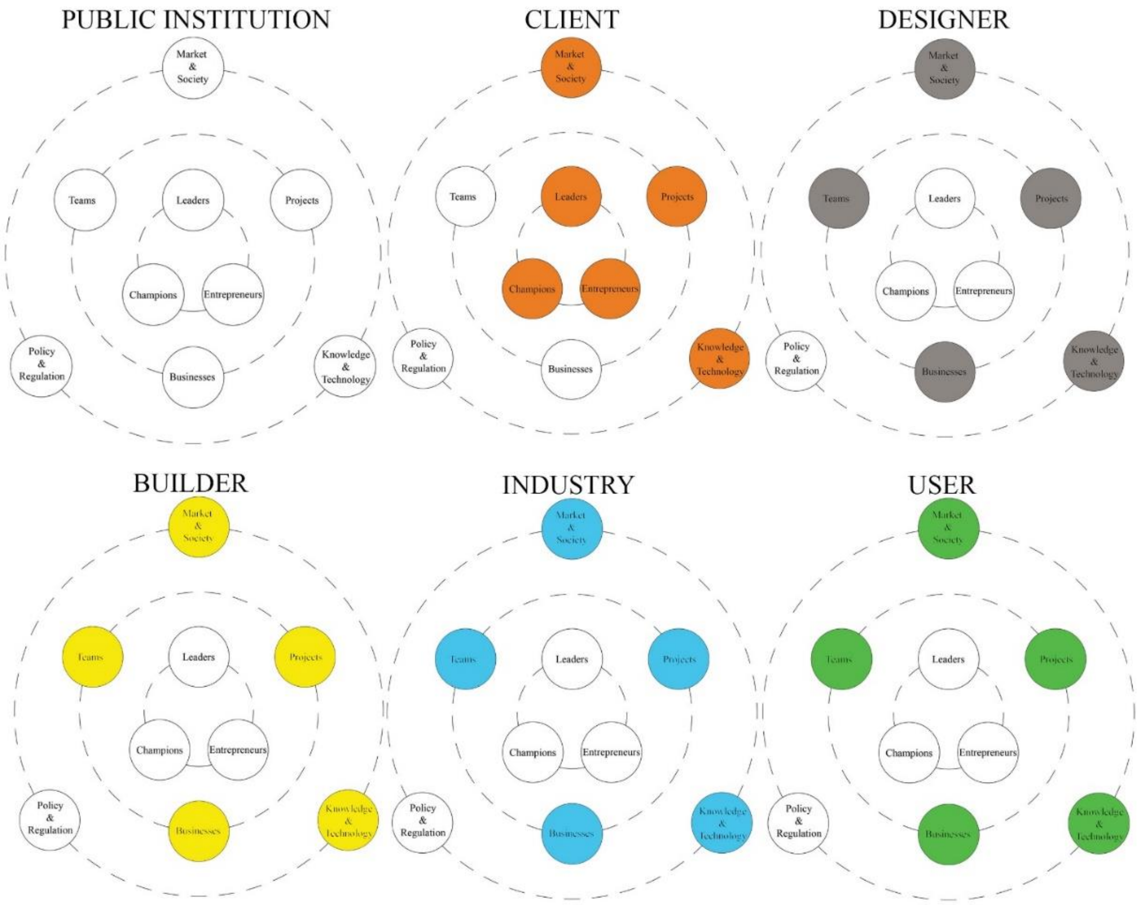


Figure 61: The image above shows the roles of actors in the eco-ideation, eco-innovation, and eco-institutionalisation phase.

5.5.3 West Branch Berkley, Berkley, CA, USA – Building characteristics

West Branch Berkley Library
Berkley, CA, USA
Harley Ellis Devereaux
2013

Context Characteristics:	Urban
Concpet Characteristics:	Building’s zero net energy design
Orientation:	North/South
Dimension:	500 msq
Shape:	Parallelepiped with communication strategy to explain climatic conditions and social mission of the project
Floor number:	One floor with double height to allow future vertical extensions
Access and circulation:	Located in close proximity to public transportation, with adequate space for bike parking, no auto parking was provided on site. Rather the building encourages patrons to bike or walk, while it enhances the streetscape and the pedestrian experience
Structure:	Wood-framed building, 97.1% FSC certified. Renewable resource
Construction systems:	Fiber cement panels with a fiber-cement panel rain screen façade above a concrete base provides and a high performance envelope and an elegantly organized façade that befits a civic structure.
Evironmanetal control systems:	Natural lighting through skylight, natural ventilation No conventional air handling system is needed, with heating and cooling provided by a radiant floor and pre-tempering radiators at the north windows. Energy production with solar and photovoltaic panels
Water treatment:	All roof runoff is collected in Flow-Through Planters integrated into the base of the building. Potable water use is reduced by 58.2% from the LEED baseline through low flow plumbing fixtures.
Certification:	LEED Platinum certified in 2016

Delivery process

The project was promoted by the city of Berkley, designed by Harley Ellis Devereaux, and built by Kitchel CEM - West Bay Builders. The project aim was to extend the existing and undersized West Branch Library. Critical step to achieve this goal was to engage the community and build consensus and therefore many workshops were carried out by the architects and the community. The idea for the building was to develop a Zero Net Energy building to comply with the Climate Action Plan published in 2009 by the City of Berkley. To do so, the architects suggested to introduce passive and active strategies for a high performance building envelope, daylighting and natural ventilation. The AIA (2014) explained that the building was designed with natural ventilation, daylighting, and photovoltaics led to an innovative wind chimney that provides cross ventilation while protecting the library interior from street noise. At the same time, the wind chimney increases the façade height, reinforcing the civic presence of the library along University Avenue. The production of the project was 31.2% Regional Materials Content, sourced within 500 miles of site. 90.53% of construction waste diverted from landfill, Waste comingled and tracked using GreenHalo. The AIA (2014) explained that*:…'To reduce building loads, early modeling, including Daysim, Radiance, Skycalc, and computational fluid dynamics, was used to determine optimal roof configuration and building height to maximize natural ventilation, daylighting, and energy production. These studies led to the building's most innovative feature: the wind chimney, designed to use the steady ocean breezes to draw natural ventilation through the building'*. The building life and its maintenance was carried out with a roof-top weather station coordinates the systems, switching modes from natural ventilation to full cooling for comfort control. There is no additional HVAC system in the facility. The project was a public project and the total cost was $7,900,000.00. As AIA (2014) explained despite the limited budget of the public bid project, the design team achieved zero net energy performance, with spacious, daylit interiors, building the first certified Living Building Challenge ZNE public library in California. The Library was LEED Platinum certified in 2016.

Innovation types and impacts

The innovation types on the project are mostly system and architectural type. The Net Zero Energy pushed for design decisions that could collaborate to achieve this result. In doing so the environmental control systems, the water treatment, the building orientation, the materials used, and the construction systems, and the doors and windows types, the access and circulation were all aimed at achieving the zero energy goal. These aspects can be defined as a series of independent innovations that collaborate together to enhance the performance of the building, therefore they can be considered system innovation. The architectural characteristics, such as the layout, the shape, the entrance aesthetic and dimension represents architectural innovation, as they define the visible features that determine the artefact.

Table 58: The table shows the predominance of system innovation on the project. Also architectural characteristics characterised the project characteristics.

	Incremental	Modular	Architectural	System	Radical
Context Characteristics					
Architectural Design					
Construction Systems					
Secondary Elements					
Environmental Control Systems					

Table 59: The table shows that designer and users had to undertake competence destroying activities on the project.

Actor	Competence Creating	Competence Destroying
Public Insititution		
Client		
Designer		
Builder		
Industry		
User		

The activities undertaken to develop the building called for competence destroying activities both for the architects and the community who took part to initial design workshops.

Sustainability results

The results achieved on the project, both in the building and in the process are of environmental, social, and economic nature. The AIA (2014) explained that the building achieved the following environmental results: 50% of percent of occupants using public transit, cycling or walking; 97% of daylighting at levels that allow lights to be off during daylight hours; 95% views to the outdoors, 18% 15 feet of an operable window. Moreover, 76% Percent Reduction from National Median EUI for and Building Type, and 1.70 watts/sf of lighting power density. These data, as well as the achievement of the Net Zero Energy Building achievement showed that the building both in the design decision as well as in the procurement methods, construction systems, and management achieved a significant number of environmental results. Also, economic results were achieved, as it is explained by the AIA (2014), which explained that:'*…The Zero Net Energy design reduces energy consumption and reduces utility bill costs to the mininum monthly charge. PG&E current rates are $0.14/kwh, therefore the annual savings to the owner would be $15,624.98 less $432, equaling $15,192.98. This translates to a payback period of approximately 31 years, if rates remain the same. However, a more realistic economic representation is derived by comparing similar-sized libraries completed in the City of Berkeley and California during the same time period. With this method, the cost differential is minimal. Compared to the new South branch library, which is not a zero net energy project, the West branch cost $10/sf. more. On a 9,399-square-foot building, this amounts to a premium of $93,990. PG&E provided a onetime Savings-by-Design incentive of $13,420. Using the predicted energy consumption* *of the South branch, the true payback period would be ($93,990-$13,240)/$5,894 = 13.7 years'.*

Social results were also achieved such as the adaptability of the building in its design, and the relation with the urban context achieved with the entrance design. Moreover, the process achieved the inclusion of the community increasing the sense of belonging, as well as this process allowed to educate the users and the owner about the value of the environmental and the correct behaviour in the building to help reduce the GHG emissions.

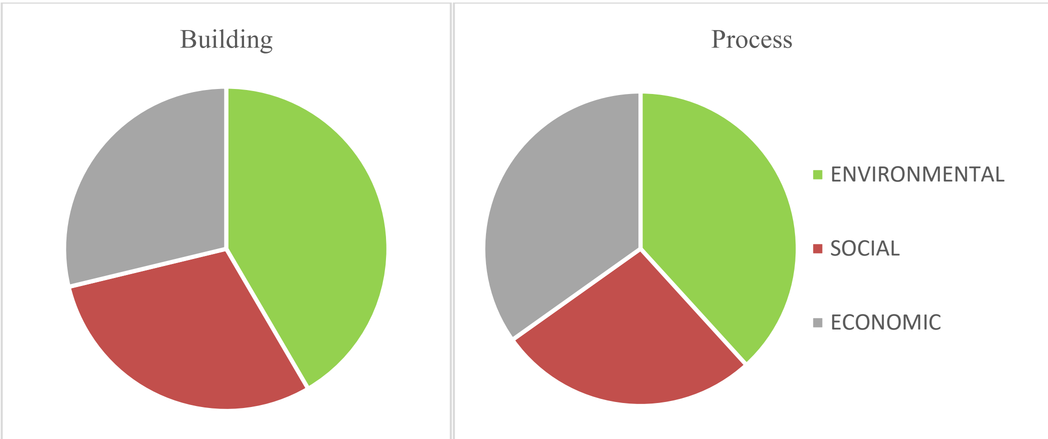


Figure 62: The pie charts above shows the social, environmental and economic results on both project and process.

The actors and the eco-innovation and sustainability model

The co-ideation for the project was characterised by the role of the public institution and the client. The public institution acted as a leader in this phase, as they set the programs such as Climate Action Plan, seeking to reduce Greenhouse Gas emissions, by 2020. The client, within this scheme, acted as entrepreneur and champion in setting the premises to deliver the project for the West Berkley Library. The co-innovation phase was organized as a highly collaborative phase, in which the architect worked in conjunction with the community to develop the initial design scheme. This phase was also characterised by the role of builder, industry, and consultants who worked in a collaborative environment on the project, at the same time obtaining individual profit for their business. This collaborative work led to an impact on the co-institutionalization phase, by generating positive results on market and society, as well as in the knowledge and technology.

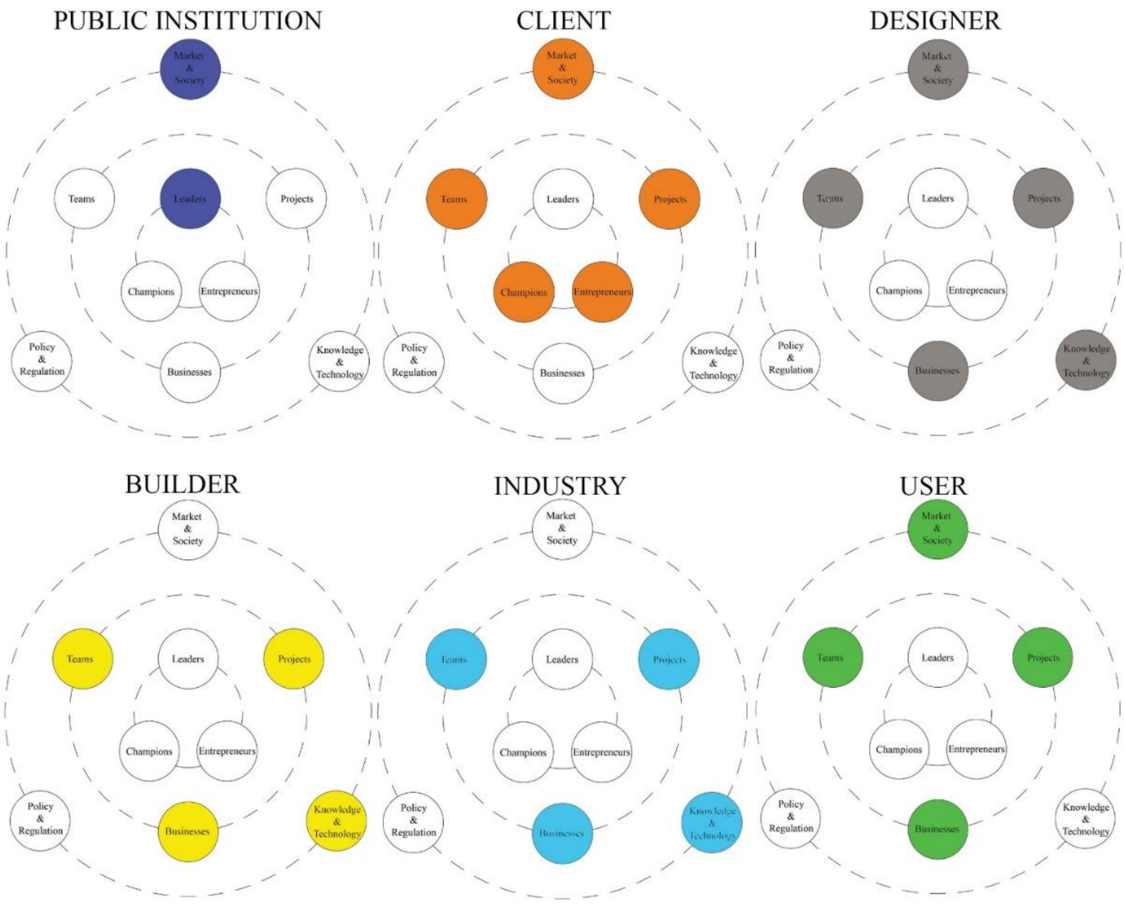
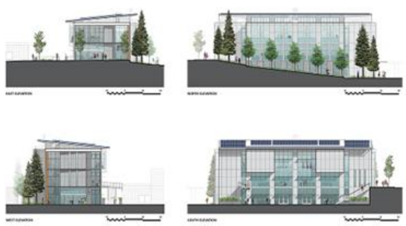


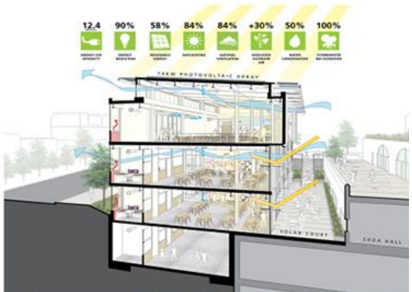
Figure 63: The image above shows the eco-innovation and sustainability model for the West Berkley project, the eco-ideation phase was characterised by the role of public institution and client. The eco-innovation phase was characterised by the collaborative work environment carried out by the designer, the builder, the industry and the user. The project had an impact on the eco-institutionalization phase on the market and society and the knowledge and technology.

5.5.4 Jacob Institute of Innovation, UC Berkley, CA, USA – Building characteristics

The Jacob Institute of Innovation
UC Berkley, CA, USA
Leddy Maytum Stacy Architects
2015



Context Characteristics:	Urban
Concpet Characteristics:	"Beacon of innovation" expressing the sustainable values of the Institute and the University
Orientation:	East/West
Dimension:	2232 sqm
Shape:	Aggregation of parallelepiped shapes
Floor number:	3 Floors
Access and circulation:	The building is accessible by pedestrian path and public trasport. Inside the building, the compact floorplan minimizes circulation and service space while optimizing flexible teaching spaces
Structure:	Steel frame
Construction systems:	A highly insulated envelope, with exterior insulation, rain screen cladding and integrated sun-shading on three exposures, manages external building loads
Evironmanetal control systems:	Space heating is provided by hydronic radiators, augmented by tempered mechanical ventilation air. Cooling is provided by natural ventilation and ceiling fans, augmented by "bump cooling" delivered by the mechanical system. The building is naturally ventilated, augmented by code-required mechanical ventilation in internal areas and the basement. 30% with more air than ASHRAE standards is provided to enhance indoor air quality when windows are closed.
Water treatment:	Ultra-low flow fixtures reduce building water consumption by 50% from baseline, storm water management with excess filtered stormwater is delivered to the city storm sewer



Delivery process

The Jacob Institute for Innovation is a project for an educational space for the UC Berkley, introducing design innovation in the center of the university campus, to allow students to reflect and be responsive to societal challenges. The designer of the building was Leddy Maytum Stacy Architects, and the project was completed in 2015. The main contractor was Hathaway Dinwiddie. The project was conceived by the College of Engineering as an interdisciplinary hub for students and teachers from across the university who work at the intersection of design and technology. To address such aim, the architects designed a high-density, low carbon, living and learning space. In particular the project reutilised 11,000 SF site, expresses the value of suitability, and it is designed to exceed the AIA 2030 Commitment target to sue less than 90% energy than the National average of the existing university buildings. The building is designed by relying on three main strategies: building orientation to optimize the micro climatic conditions of the site; the use of compact mass with an efficient skin-to-floor area ratio; and high performance envelope with insulation, rain screen cladding and sun-shading on three exposures. As the AIA (2016) explained:…'17% of all building materials are recycled, including 50% fly ash content in foundation concrete and floor slabs, carpet, and steel. Aluminum was required to have 50% recycled content. 12% of all materials were regionally harvested and manufactured to reduce embodied energy and carbon footprint associated with shipping. 75% of all wood products are FSC-certified. Rapidly renewable materials include rubber flooring and base, linoleum flooring, and agrifiber door cores'. The materials used were selected to ensure healthy environment and 1,595 tons (97%) of site and construction debris was recycled and diverted from landfills. Recycling and composting stations throughout the building promote ongoing waste management. As the AIA (2016) explained the delivery process was based on design dialogue, energy modelling, renewable energy during construction, energy performance, and post-occupancy evaluation. The design team worked with the College of Engineer and University representatives during workshops to explore sustainability, comfort and maintenance option already during the pre-design phase. During the design phase students and faculty representatives were included into discussion in which key project milestones were presented and explained. A specific document called Building Performance Narrative was prepared during the pre-design stage to inform all the participants on the design goals and strategies. Post-occupancy evaluation was carried out to explore the users' experience in the building, providing satisfactory results. The total building cost was $25 million.

Innovation types and impacts

The building project is characterised by many system innovations. The aesthetic approach envisioned the building as 'beacon of innovation' and therefore the approach was to address and communicate the value of environmental sustainability that the project was aimed at. Such environmental sustainability was achieved by a number of technologies used in the environmental control systems. For instance, A cantilevered 74kW photovoltaic array, celebrated as a signature architectural element, provides 58% of the building's energy requirement; the building is naturally ventilated, augmented by code-required mechanical ventilation in internal areas and the basement. 30% more outdoor air than ASHRAE standards is provided to enhance indoor air quality when windows are closed. Moreover, the he narrow building floorplate presents a shaded façade to the south for optimum daylight harvesting. Large north-facing windows and interior glazing help to reduce internal glare. 100% of instructional spaces above the basement and 85% of all regularly occupied spaces are day-lit. These building characteristics, as well as the building orientation, contribute to the overall building performance and therefore can be considered system innovation. Even if the shape of the building contributed to the efficiency of the floor plate, the volumetric shape, the layout and the typology can be considered architectural innovation as they define the overall building organization.

Table 60: The table shows the predominance of system innovation on the project. Also architectural characteristics characterised the project characteristics.

<table>
<tr><th></th><th>Incremental</th><th>Modular</th><th>Architectural</th><th>System</th><th>Radical</th></tr>
<tr><td>Context Characteristics</td><td></td><td></td><td></td><td style="background:#00B0F0"></td><td></td></tr>
<tr><td>Architectural Design</td><td></td><td></td><td style="background:#00B0F0"></td><td></td><td></td></tr>
<tr><td>Construction Systems</td><td></td><td></td><td></td><td style="background:#00B0F0"></td><td></td></tr>
<tr><td>Secondary Elements</td><td></td><td></td><td></td><td style="background:#00B0F0"></td><td></td></tr>
<tr><td>Environmental Control Systems</td><td></td><td></td><td></td><td style="background:#00B0F0"></td><td></td></tr>
</table>

Table 61: The only figure who had to undertake competence destroying activities on the project was the architect.

<table>
<tr><th>Actor</th><th>Competence Creating</th><th>Competence Destroying</th></tr>
<tr><td>Public Insititution</td><td style="background:#FFC000"></td><td></td></tr>
<tr><td>Client</td><td style="background:#FFC000"></td><td></td></tr>
<tr><td>Designer</td><td></td><td style="background:#CC0099"></td></tr>
<tr><td>Builder</td><td style="background:#FFC000"></td><td></td></tr>
<tr><td>Industry</td><td style="background:#FFC000"></td><td></td></tr>
<tr><td>User</td><td style="background:#FFC000"></td><td></td></tr>
</table>

The activities undertaken to deliver such innovations were competence creating for most of the actors involved, except for the architects (designers) who had to develop innovative design for this unique project.

Sustainability results

The building was nominated as one of the top ten building by The American Institute of Architecture (AIA) in 2014. The building achieved a number of positive environmental results, such as: the percent of occupants using public transit, cycling or walking was 99%; the 85% of daylighting was achieved at levels that allow lights to be off during daylight hours; the building had 85% of views to the Outdoor, and 85% was also operable window. Located in a semi-arid climate that experiences periodic droughts, the project reduces total potable water use by 50% and treats 100% of roof drainage on the small, constricted site. Moreover, the building achieved total pEUI of 29 kBtu/sf/yr, Net pEUI: 12 kBtu/sf/yr, which represented 90% reduction from National Median EUI for Building Type. The building was developed within budget, and it produced both profit and competitive advantage for the companies involved in its delivery. The delivery process also was characterised by social inclusion, and participation, which allowed creating a sense of belonging, participation and the desire to look after the life time of the building.

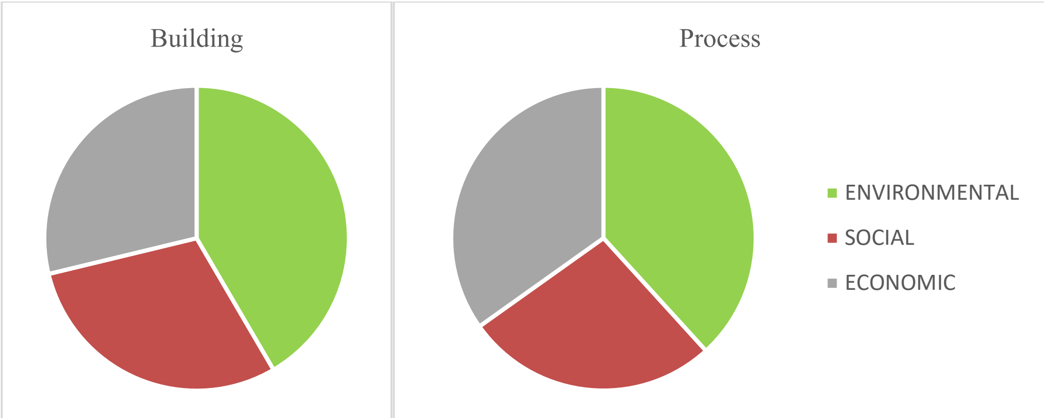


Figure 64: The pie charts above shows the social, environmental and economic results on both project and process.

The actors and the eco-innovation and sustainability model

The eco-innovation and sustainability model on this project shows the role of the participants on the project in the introduction of innovation. The eco-ideation phase was characterised by the role of the public institution – acted as leader - which called for the GHG Emission within the Climate Action Plan published in 2009, as well as the client who promoted and structured the premises for the project to be actualised. The eco-innovation phase was a very collaborative phase in which the designer, the client, the users, the builder, and the industry carried out the project design and delivery collaborated in teams to achieve the aim of a sustainable project. During this phase all the innovations in the building were design and developed and each participant though collective work could achieve also individual benefit for their business. The impact that such project had on the eco-institutionalization phase was on the market and society – as the building was aimed at producing a space to accommodate studies for future societal challenges – as well as on the development of knowledge and technology.

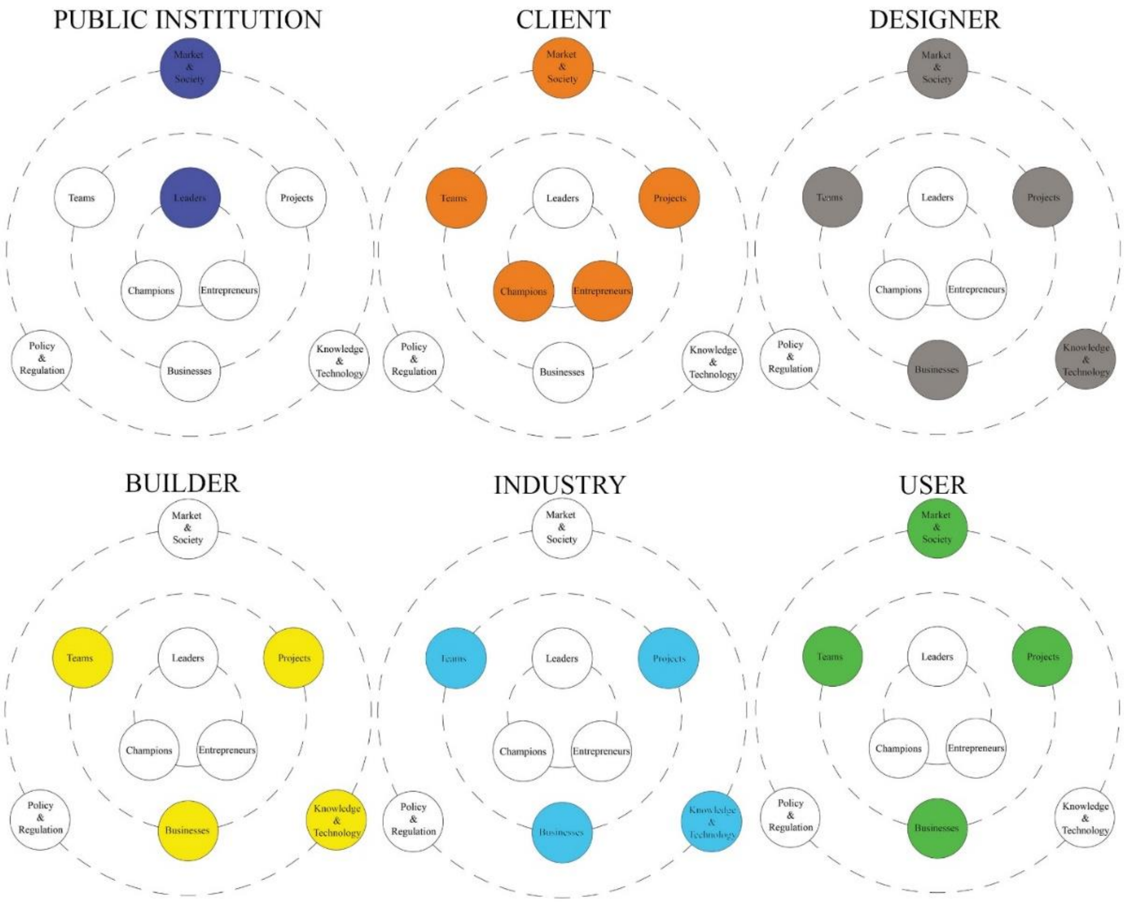
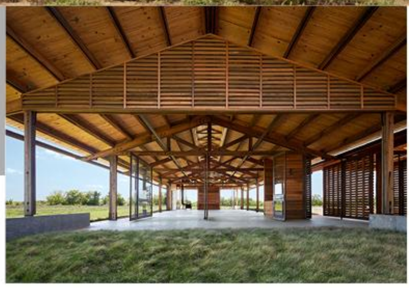


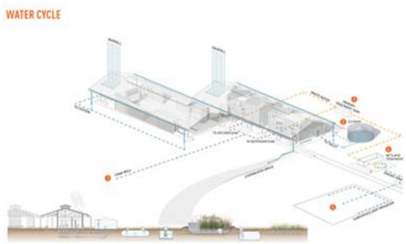
Figure 65: The eco-innovation phase was characterised by the collaborative work environment carried out by the designer, the builder, the industry and the user. The project had an impact on the eco-institutionalization phase on the market and society and the knowledge and technology.

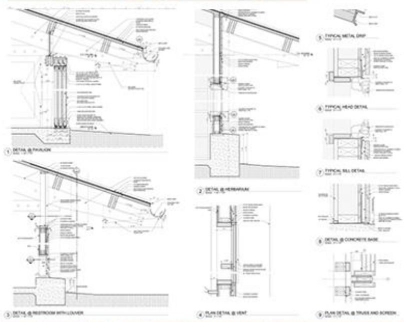
5.5.5 Dixon Water Foundation Pavilion, Decatour, TX, USA – Building characteristics

Dixon Water Foundation Pavilion
Decatur, TX, USA
Lake|Flato Architects
2014



Context Characteristics:	Rural
Concpet Characteristics:	Vernacular regionalism. In particular the building is aimed at promoting healthy watersheds through sustainable land management, ensuring the preservation of our water resources
Orientation:	North/South - East/West
Dimension:	500 msq
Shape:	Two similarly scaled buildings connected by a shady porch
Floor number:	One floor
Access and circulation:	The building can be openale in all its side and and therefore it allows the full acees and permeability
Structure:	Timber structure in live oak
Construction systems:	Timber frame and shading, as well as some insertion of steel frame
Evironmanetal control systems:	100% of wastewater is treated onsite and returned to the natural water cycle. At least 100% of the energy used is produced by solar panels and testing has confirmed that indoor air quality is almost indistinguishable from surrounding outdoor fresh air. The structure captures cool breezes in summer and blocks cold winter winds
Water treatment:	13000 gallons water storage tank Use of acquifer below the building to potable water Greywater for the sink and blackwater to the toilet Wetlands cleans the water circulation After cleaning, clean water back into the acquifer
Certification:	First Living Building Project in Texas





Delivery process

The Dixon Water Pavilion is an educational centre aimed at promoting the healthy watersheds through sustainable land management, promoted by the Dixon Water Foundation. The AIA (2016) explained that:'*...The client's initial goals were clear: design a comfortable meeting and education facility to shelter those that come to learn how the Dixon Water Foundation uses livestock as a tool to restore our native prairies and create healthier watersheds'.* The building was designed by Lake Flato Architects and built by local contractors and manufacturer such as: ASSA ABLOY, Big Ass Fans, DuPont, Elkay, Nucor, Owens Corning, PPG IdeaScapes, Think Wood, Zurn, Gerdau Corsa, Sierra Pine, Helios, RAM Windows, Independence Tubing, Southern Diversified, Atlas Tube, Majestic Steel USA, Hanson Aggregates, Fronius, Interceramic, American Clay, Gemini, American Gypsum, Roy O' Martin, Urban Woods, Southern Star, GRACE, Nicholson Metal Fabricators, Headwaters, Silicon Energy, Corian® Design Hide. Consultants were also involved such as TLC Engineering for Architecture, Datum Engineers, and Biohabitats. The design approach of the Lake Flato Architects was to A building that embraced the simplicity and serenity of the North Texas prairie. To this end, the Josey Pavilion was designed to have no active heating or cooling and adapt according to the weather conditions on any particular day. Gapped wooden doors open to allow maximum ventilation through the central gathering space and along porches that are oriented to capture the cooling summer breezes from the southeast. Glass pivot doors on the east and west of the education center can be adjusted to allow the southeast corner to be entirely open, maximizing the impact of these cooling breezes. All 186 materials used on the project were red list free, locally sourced and manufactured, and harvested sustainability. The project started with the expression of the aim of Betty and Clint Josey, the Dixon Water Foundation staff, who explained their vision and goals for the project. At this stage the client did not have in mind the idea of undertaking the Living Building Challenge, rather they wanted to demonstrate how livestock can be a part of a healthy ecosystem. It was only after Lake Flato presented the option of the Living Building opportunity that the client embraced the strategy as a medium to emphasize their aims. The project was developed as integrated design delivery system, in conjunction with teams of engineers who run CFD modelling to study air flow and daylight. The building use and maintenance is also still monitored by the architects who run post-occupancy measurements to constantly ensure the efficient performance of the building. The pavilion is set in the rural area of Decatur, Texas. The total cost for the project, excluding the land was $1,800,000.00.

Innovation types and impacts

The building was characterised by a number of system innovations, which collaborated to achieve the Living Building Challenge and to increase the environmental performance of the building. the construction details, the architectural characteristics that shaped a building with a roof that cover a large openable porch which represents the full surface of the building, contributed to increase the performance of the building. Specifically, this allowed the 100% daylight and passive ventilation when required. Therefore these characteristics worked in collaboration with the environmental control systems, which were envisioned as passive strategy for the project, which the collaboration of photovoltaic panels. The concept and the water system in the building represented a radical innovation, since they represented the expression and the communication of the unique aim of the project and therefore they also contribute to the aesthetic definition of the project. The water cycle system became in fact part of the experience in the building and therefore created a unique space in which it is possible to experience and learn aspects about the water usage. Other building characteristics such as the access and circulation, the dimension, and the shape are aimed at expressing the vernacular regional style, as explained Lake Flato (2016) and therefore they can be considered architectural innovations as they contribute shaping the array of the final artefact.

Table 62: The table shows the innovation types on the building. Radical and system innovation are the predominant on the project.

	Incremental	Modular	Architectural	System	Radical
Context Characteristics					
Architectural Design					
Construction Systems					
Secondary Elements					
Environmental Control Systems					

Table 63: The table shows that competence destroying activities were undertaken by client and designer (architects).

Actor	Competence Creating	Competence Destroying
Public Insititution		
Client		
Designer		
Builder		
Industry		
User		

The delivery of these innovations called for competence destroying activities for the client and the designers, who had to acquire news skills to carried put the integrated delivery process and establish a dialogue that could translate the unique clients' vision into the delivery of the final building design.

Sustainability results

The project has achieved results which are predominately influenced by the environmental sustainability aims of the building. the project achieved the AIA Top Ten Project Award for 2016, and it is awaiting for the Living Building Certification. The sustainability results achieved on the building were the 100% of daylight and view to the outdoor, as well as the complete operability of the windows elements. Moreover, as it is explained by the AIA (2016): …*'the main* *energy reduction strategy of replacing mechanical systems with passive systems resulted in a savings of the 334,194 kBtu of energy which prevents 72 tons of carbon emissions. It takes 180 hectares of grassland one year to sequester that same amount of carbon…*The final component of the energy strategy is the 4kW solar array, which offsets more that 150% of the project's energy use'. Moreover, the AIA (2016) also reported that:..' *The Josey Pavilion acts as a demonstration tool for how to mitigate the negative effects of waste and storm water. Rainwater is collected from the roof and stored in a 13,000-gallon cistern. This water is used for sewage conveyance and occasional irrigation needs. The constructed wetland cleanses and returns all of the water used in the pavilion back to the aquifer. Thus the groundwater pumped into the pavilion's sinks eventually becomes groundwater again. In this way, as guests interact with the project's water systems, they are connected with a small-scale water cycle that parallels how rain is collected in a watershed, used by plants and people, processed by wetlands— nature's kidneys — and returned to aquifers belowground'.* Social results were also achieved on the project, such as the frequent use for conference venue – for instance the 2014 Holistic Management International Conference – the use for international meetings on motivating, connecting, and supporting farmers, ranchers, and land stewards, in developing life of farm and ranch community. Moreover, the AIA (2016) reported that:…' *the local ranchers hold monthly meetings at the education center and find comfort and familiarity in the simple execution of the pavilion's vernacular form with large overhangs and deep and inviting porches. Civic and school students frequently travel by bus to visit the education center for field days learning about watershed health, wildlife, and native plants. Kids on the Land, a program sponsored by the foundation, uses an integrated Science, Technology, Engineering, and Mathematics approach to teach children about the region where they live. The program uses the Josey Pavilion to help connect children to the land and encourage them to live a more sustainable future'.* The project represented a knowledge acquisition process for both the client and the designers. Moreover, it also allowed the companies involved to achieve an economic advantage in the profit they made after the collaboration. The project also was develop within budget, demonstrating that the introduction of technological innovation such as photovoltaic array and a constructed wetland did not exceed $150,000, which equated to about 8% of the final construction costs.

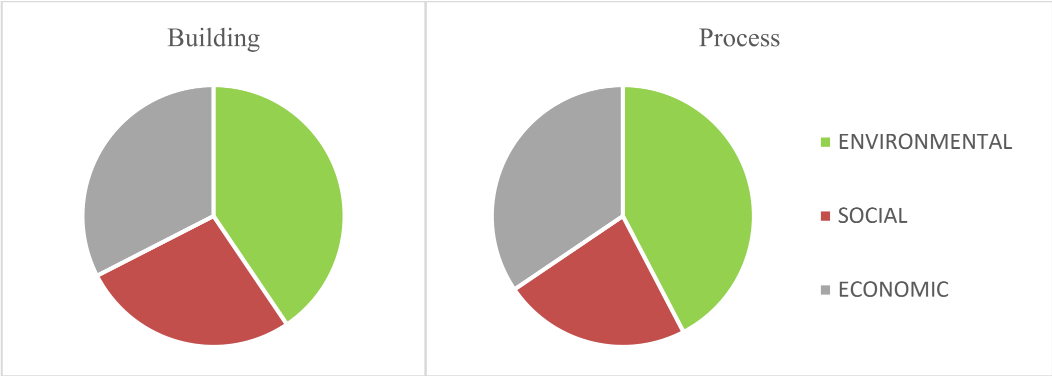


Figure 66: The pie charts above show the nature of the results on the project. The environmental results are the one predominant on the project.

The actors and the eco-innovation and sustainability model

The co-ideation phase for the project was characterised both by the role of the client and the one of the architects. Despite the initial leadership position of the client in ideating the desire for this project, the architects acted also as entrepreneurs understanding the opportunity to propose the Living Building Challenge to the client, who agreed and proceeded in the role of champions to actualise the activities required to start the design and delivery of the building. The co-innovation phase was characterised by the integrated design delivery process which called for the participation of the consultants, industry and builders into the project, working as a unique team to achieve the common aim of the Living Building objective. Yet, such activities contributed to the individual development of the business of each participant on the project. The co-institutionalisation phase was impacted by the creating of positive social results in the area of market and society, as well as in the knowledge and technology development for all the participants.

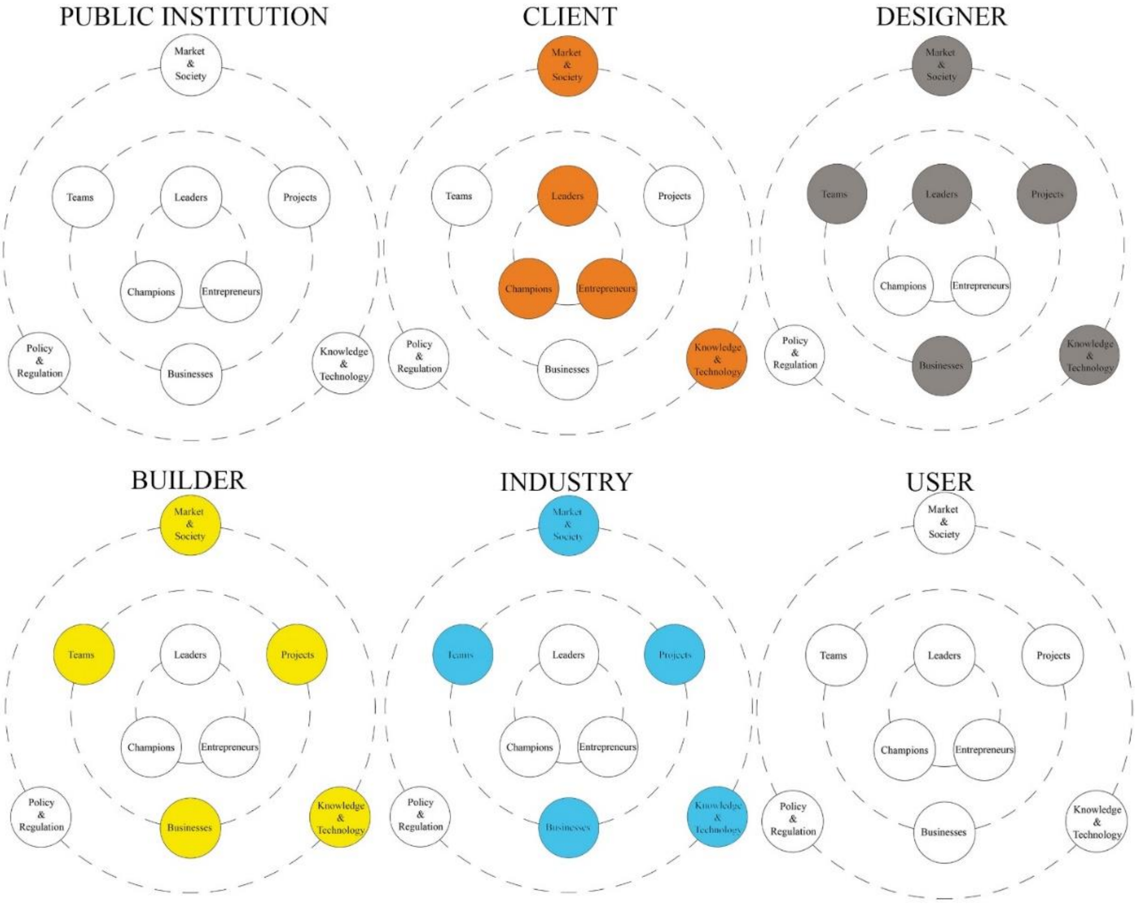


Figure 67: The image above explains the role of the actors involved on the project. The eco-ideation phase was led by the client and the designer, whereas the eco-innovation phase was characterised by collaboration between designer, industry and builder. The eco-institutionalisation phase was impacted on the market and society domain, as well as on the knowledge and technological development.

5.5.6 Newbern Library, Auburn, AL, USA – Building characteristics

Newbern Library
Auburn, AL, USA
Rural Studio
2013 - 2015

Context Characteristics:	Rural
Concpet Characteristics:	Library as social center, providing such resources as after-school programming, computer access, and the first public internet point in the community. The reuse of building materials and the retaining of the original facade contributed to define the aesthetic approach of the project
Orientation:	North/South - East/West
Dimension:	148 msq
Shape:	Parallelepiped shape with a cubic extension of the back of the existing building
Floor number:	1 Floor
Access and circulation:	Linear circulation and access to the courtyard
Structure:	Masonry shell and glass storefront were preserved and refurbished. A simple metal canopy extends from the front facade and shelters the entrance
Construction systems:	In the rear of the building, the team added a 700-square-foot (65-square-metre) cubic addition clad in cypress, which contrasts with the white brickwork. Inside, the team installed bookshelves made of birch plywood, which were milled using computer numerical control (CNC) techniques and assembled on site. Birch was also used for the patterned ceiling panels
Evironmanetal control systems:	Fan assisted natural ventilation with openable windows, and natural lighting with addition of spotlights
Water treatment:	Standard existing system

Delivery process

The Newbern Library is an adaptive reuse project of the local bank building built in 1906, and completed in 2015. The building is located in the rural town of Newbern in Alabama, USA with less than 200 residents. The project was carried out by the fifth-year students from the architecture students at Auburn University's Rural Studio – a programme founded in 1993 by Samuel Mockbee to create architecture for disadvantaged residents in rural areas, by the university students. The project was originated by the request of the local community to Rural Studio to develop a new library for the town. The design for the building was a simple renovation, organized as an extension of the existing flat-roofed building. In doing so, the students had to face the mail challenge of preserving and refurbishing the existing masonry shell and the glass storefront. The extension was done in the rear of the building and it was of 65 sqm, using a cladding in cypress as contrast with the white brickwork. The interior was redesigned by the installation of a bookshelf system in birch plywood, using computer numerical control (CNC). Within the bookshelf a number of alcoves accommodate computers, windows eats, storage, private study space and access to bathroom and outdoor. Moreover, the studio preserved many elements of the existing building such as the vault bank and the pine flooring system. Also, the bricks from the original structure were re-used for the lower part of the walls and paving. Other material were donated by the local and regional suppliers. The entire delivery process was undertaken by four students from the fifth-year architecture program from the Auburn University, whom designed and built the library. The students were Ashley Clar, Morgan Acino, Stephen Durham and Will Gregory. Whitley (2015) explained that:…' *As this group of students worked on the library, they met with librarians who offered insight into how the building's design would influence its work. Representatives from other West Alabama towns helped the students understand the role of a public library in a community. In a rural community like Newbern, a library can be even more of a social centre than it might be elsewhere'*. The entire delivery took 975 days. The students removed by hand 8,200 bricks, and $63,000 worth of material was donated to the project, as well as more than 7,000 books for the library, explained Whitley (2015).

Innovation types and impacts

The project did not show any radical innovation. The architectural characteristics were maintained as closer as they were in the existing building, the only exception was the extension. This latter can be defined as an architectural innovation, whereas the other aspects such as the materials used, the construction systems, and access and circulations, internal partitions and environmental control systems were all modular innovations. The overall approach was to re-use as much as possible the existing materials without modifying dramatically the existing structure of the building, and therefore the project was articulated as a series of modular and specific intervention to regenerate the overall volume.

Table 64: The table shows the innovation types on the project. The building shows predominance of modular innovation.

	Incremental	Modular	Architectural	System	Radical
Context Characteristics					
Architectural Design					
Construction Systems					
Secondary Elements					
Environmental Control Systems					

Table 65: The table shows that competence destroying activities were undertaken by the students who worked both as designers and builders.

Actor	Competence Creating	Competence Destroying
Public Insititution		
Client		
Designer		
Builder		
Industry		
User		

Great activities of competence destroying was undertaken by the four students who designed and built the project, who had to learn and acquire skills and knowledge throughout the entire delivery process.

Sustainability results

The project achieved great economic and social results. As Ashley Clark, Morgan Acino, Stephen Durham and Will Gregory (2015) explained the project became the social centre for the town of Newbern, providing resources such as after-school programming, computer access, and the first public internet point in the community. Moreover, both the building design and the process produced economic results in terms of cost saving, as well as knowledge acquisition for the participants, and wise use of the donated materials for the construction phase.

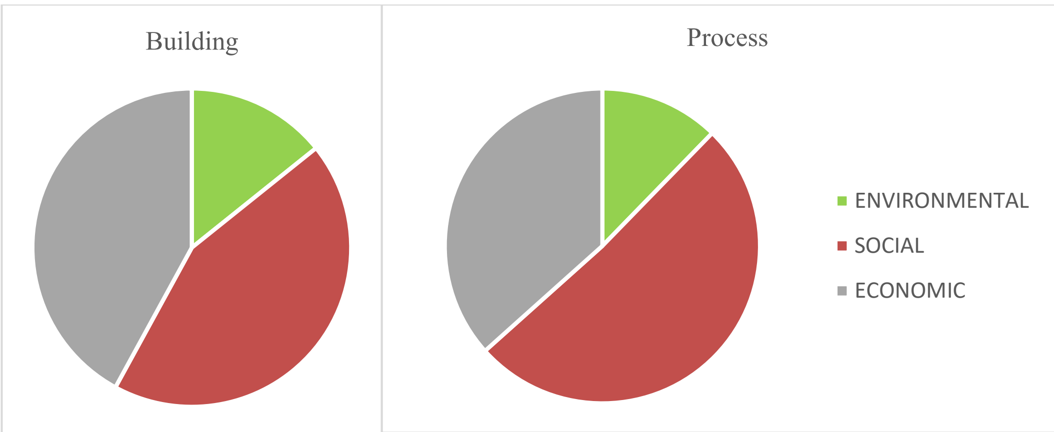


Figure 68: The pie charts above shows the predominance of economic and social results in both building and process.

The actors and the eco-innovation and sustainability model

The co-ideation phase was characterised by the role of the community – the users – who requested the help of Rural Studio's students for the design and delivery of a library for the small town of Newbern. The students also took part in this phase by creating the links necessary for the project developments with the donors and the suppliers who supported the project. The co-innovation phase was characterised by the role of the students – acting as designers and builders – who worked on the project as a team to achieved the aim expressed by the community. This was possible also thanks to the donations by the local suppliers. The building had a positive impact on the market and society in the co-institutionalisation phase.

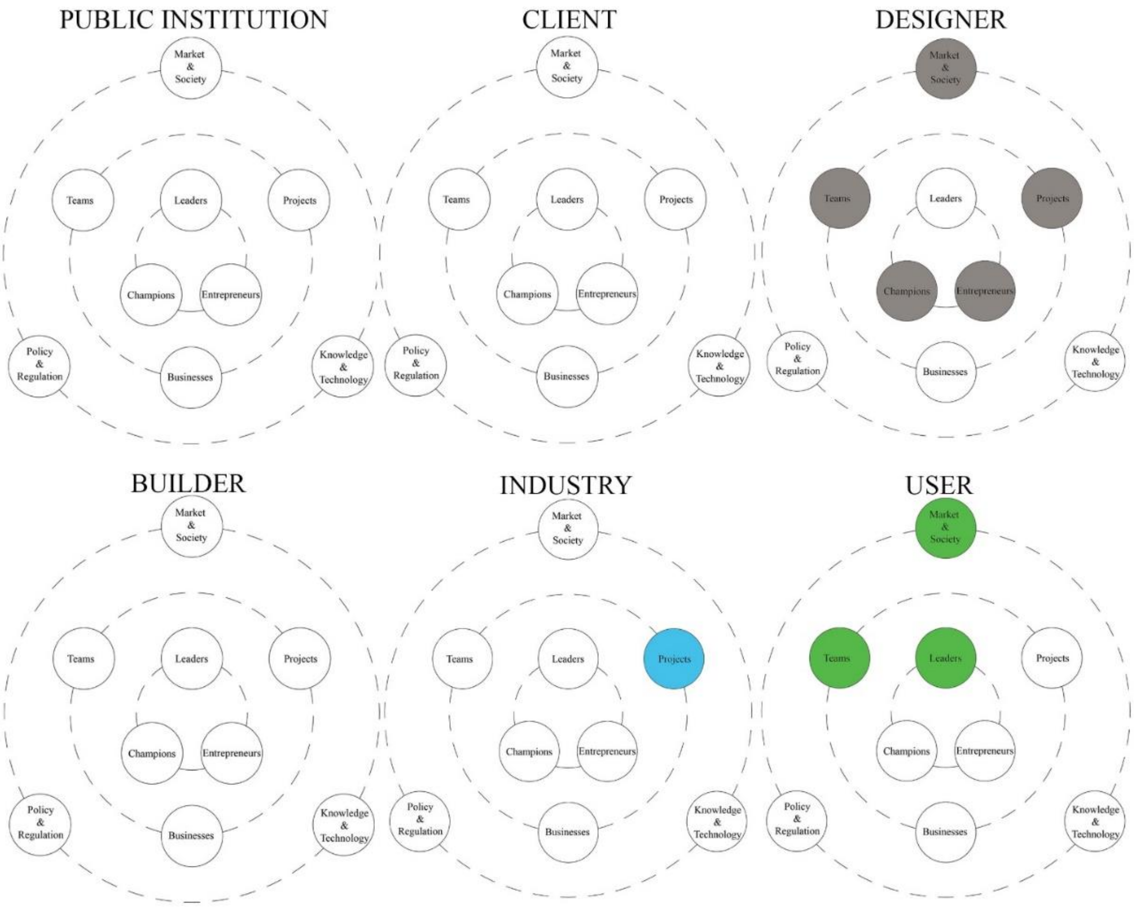


Figure 69: The image above shows the role of actors in the project, the eco-ideation phase was characterised by the role of the designers and the users. The eco-innovation phase was characterised by predominantly the role of the designer with a contribution of the local industry, in terms of suppliers. The impact on the eco-institutionalization phase was on the market and society domain.

5.5.7 Albion Public Library, Toronto, Canada – Building characteristics

Albion Public Library
Toronto, Canada
Perkins+Will
2017

Context Characteristics:	Urban
Concpet Characteristics:	Reminiscent of a walled garden, the dynamic façade gives the illusion of a front porch trellis – its privacy veil injecting colour into the street
Orientation:	North/South - East/west
Dimension:	2694 msq
Shape:	Block with façade that give the illusion of a front porch trellis – its privacy veil injecting colour into the street
Floor number:	One double height floor
Access and circulation:	The building is accessible with different medium of transport. Moreover, the adjunted site was transformed into lush public plaza with a landscaped parking lot and space for a market square. A community garden allows for food production and a habitat for butterflies and pollinators. All exterior lighting is directed down to provide safe, well-lit pedestrian routes and mitigate light pollution
Structure:	Steel frame and concrete
Construction systems:	50MM Square glazed terracotta extrusion hung from the steel frame
Evironmanetal control systems:	Daylight harvesting and a photovoltaic array located on portions of the sloping roof will target 5 percent renewable energy that will be sold back to the grid
Water treatment:	Storm water management strategies include a number of elements which contribute to the quality, quantity, balance and control of water leaving the site and entering municipal systems
Certification:	COTE top ten AIA Award 2018

Delivery process

The Albion Public Library was commissioned by the Albion Public Library in 2017. The building was designed by Perkins+Will and built by Acquicon Construction Ltd. The Albion Library is located in the Rexdale neighbourhood to the north-west of the city, where the population is predominantly immigrants, minorities, and low-income residents. The aim of the project was to deliver a library building to a community in need for a new social gathering space. The project was carried out during a series of workshops with the community, during which the initial design proposal shifted radically from the first ideas that the architects proposed. As the architects (2018) explained:… *'The result is a library that features a theatre for community empowerment inside and out…Reminiscent of a walled garden, the dynamic façade gives the illusion of a front porch trellis – its privacy veil injecting colour into the street. Punctuated by courtyard gardens and interior pavilions, Albion Library's footprint is a pure square. The perimeter is defined by a screen of polychrome terracotta tiles in bright, unexpected colours. Contrasting the monotone asphalt that surrounds the site, the form offers a respite from the busy arterial context of Albion Road'.* The project relies on passive approach to control the quality of the indoor environment, as well as on the renewable energy generation from the array of photovoltaic panels on the roof. The project design and development lasted about two years. The building uses prefabricated materials all from local suppliers. The project was delivered with project and construction management system led by Acquicon Construction Ltd. The structure was designed and tested by WSP and Blackwell Engineering, and the MEP services were designed by Hidi Rae (mechanical and plumbing services), Mulvey Bananni (electric services). The total project cost was $11.8 million. The project was awarded with the COTE top ten AIA Award in 2018.

Innovation types and impacts

The innovation types on the building are modular, architectural and system innovation. The context characteristics are not innovative as, other libraries exist in the city, yet the local area required a specific gathering place. The structural system is also modular innovation, and to some extent also standard. The building characteristics such as the concept, shape, floor number and height, access and circulation, internal partitions and construction system pertain to the definition of architectural innovation as they are elements which collaborate to determine the composition of the final building and its aesthetic. The orientation, the environmental control systems and the water treatment collaborate together to increase the performance of the building and therefore can be considered system innovation.

Table 66: The table shows the innovation types on the building. In this project most innovation types were architectural, and system.

	Incremental	Modular	Architectural	System	Radical
Context Characteristics					
Architectural Design					

Construction Systems					
Secondary Elements					
Environmental Control Systems					

Actor	Competence Creating	Competence Destroying
Public Insititution		
Client		
Designer		
Builder		
Industry		
User		

The designer had to undertake competence destroying activities as the design process was heavily informed by the workshop with the community, and therefore the architects had to negotiate the initial design idea with the needs of the clients.

Sustainability results

Both building and process achieved a number of environmental and economic results. The social results are explained by Perkins+Will (2018) stating that:… *'the Urban Living Room resembles an extension of the home, providing an adaptable space for cultural events, concerts and readings, from spoken word to hip-hop battles. The library's Innovation Studio Lab contributes to cultural production and houses a myriad of STEM programming, empowering youth to enhance their technical skills in coding, circuit building and 3D Printing'*. Moreover, they explained that: …*'The Albion District Library is one of the most well used of all the Toronto Public Libraries and serves a diverse neighbourhood population'*. The project therefore achieved its aim of providing a space for social inclusion and community gathering. The COTE top ten AIA Award 2018 also explained that:'…*This project has a predicted energy use reduction of 40 percent over the national average for this building type and climate while providing thermally comfortable, well daylit, and joyful spaces for the occupants. This library is a praiseworthy example of design excellence'*. The project was designed and delivered within budget, generating knowledge acquisition for the participants, as well as competitive advantage for these actors.

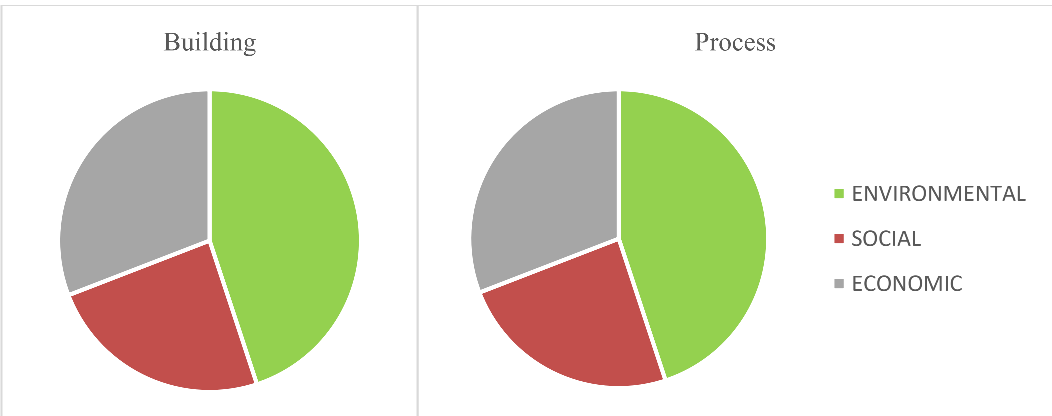


Figure 70: The pie charts above shows the predominance of environmental results on the project.

The actors and the eco-innovation and sustainability model

The co-ideation phase of the project was characterised by the public institution that acted as leader, champion and entrepreneur in ideating the project and in setting the premises for the delivery process. The co-innovation phase was characterised by intensive collaborative work between the architects (designer) and users. Moreover, in this phase also the builder, the consultants, and the industry world collaboratively on the project, and at the same time obtaining individual profit for their business. The innovation introduction achieved results on the co-institutionalisation phase by producing positive impacts on the market and society domain, as well as on the development of knowledge and technology.

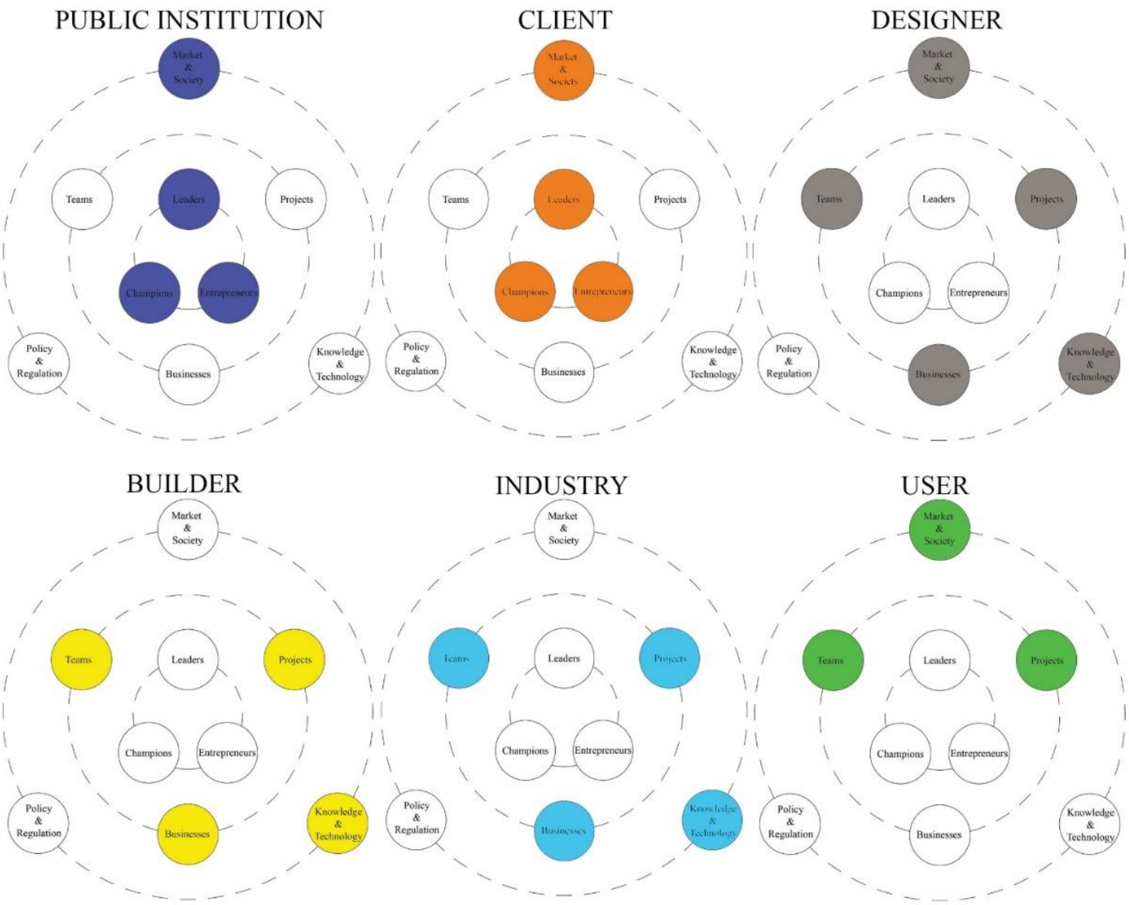


Figure 71: The image above shows the role of the actors involved on the project. Public Institution and client run the eco-ideation phase, whereas the eco-innovation phase was dominated by high degree of collaboration between designers, builder, industry and user. The eco-institutionalisation phase was impacted on the market and society domain and the one of knowledge and technology.

In this chapter the results of the case study analysis was presented, by providing an overview of the case studies, both in terms of project characteristics and process. For each case study the context of development was presented in terms of legislation and construction industry characteristics. Moreover, for each case study the results of the analysis of type of innovation, sustainability results, and actors involvement was presented. In the next chapter, these data will be discussed and pattern of innovation will be highlighted.

Chapter 6

Patterns of Sustainable Innovation

In this chapter, the author presents the findings emerged from the building case studies analysis carried out in the previous chapter. Such findings will attempt to answer the research questions defined for this work, and they will be presented by discussing: 1) the patters of types of innovation and impacts encountered on the projects explored; 2) the management levels and the roles in introducing sustainable innovation; and 3) the patterns of sustainable results and their relevance, in both buildings and processes. Moreover, the chapter will highlight 4) the links between all the design variables both in building characteristics and process, attempting to shed light on important connections that can be considered in the strategic planning of sustainable innovation introduction; as well as a 5) final consideration will conclude the chapter discussing the role of context, the internationalisation of practice and the role of building development strategy.

6.1 Types of Innovation and impacts

The analysis showed that different types of innovation called for different degrees of competence destroying activities, and therefore impinged on the ability of the actors involved to absorb the risk associated with the change required by innovation. Incremental and modular innovations are characterised by more confined changes within the overall building system, and therefore their related impacts and the competence destroying activities in the delivery process are limited. Whereas, in the case of architectural, system and radical innovation it is possible to highlight a more holistic impact on the buildings, and therefore the degree of potential impacts and competences destroying activities are higher, and involved more actors in the participation of the delivery. The need for sustainable buildings in the industry calls for this latter approaches, and therefore for design solutions able to generate impacts on multiple levels. A first findings can be defined as that architectural, system, and radical innovations are the more efficient, because of their holistic and complex nature, in providing the opportunities to delivery sustainable buildings under an economic, social, and environmental point of view. Moreover, in line with Winch (1998) radical innovation is also associated with the concept of progress and disruptive phenomena. The analysis has also shed light on the labile distinction between different types of innovations. For instance, when architectural innovation is found in all the building characteristics, by definition this became a system innovation, as all the links of the buildings become a synergy that increase the performance of the building. Also, when system innovation occurs in every category of the building characteristics the impacts generated are similar to the ones of radical innovation. This latter could be considered the case of the North American buildings analysed, which aimed at achieving the completion of the Living Building Challenge, and in which all the building characterises create a system aimed at delivering an artefact designed ad-hoc to achieve energy efficiency.

6.1.1 Types of Innovation

The analysis carried out shows a predominance of incremental innovation in the context characteristics; architectural innovation in the architectural design; system and architectural innovation in construction systems and secondary systems, and system innovation in the environmental control systems (Table 67).

Table 67: The table shows the total of innovation types identified in all the case studies analysed

	Incremental	Modular	Architectural	System	Radical
Context Characteristics	10	2	4	6	8
Architectural Design	0	1	17	7	5
Construction Systems	5	6	4	9	6
Secondary Elements	4	6	9	9	2
Environmental Control Systems	1	1	0	23	5

According to Nigra and Dimitrijevic (2018) and to the analysis conducted in this work, in the context of buildings, the category of incremental innovation can be identified in any building project, as every building is unique (Turin, 1980) to a certain degree. Therefore small changes always have to occur to adjust to new conditions even if they are based on current knowledge and standard practice (Slaughter, 1998). This type of innovation is unlikely to generate competence destroying activities, as the actors involved in the introduction of such type of innovation can rely on their existing knowledge and therefore to competence creating activities. Incremental innovation based on previous experience always occurs, even if standard design solutions are utilised, for example, by simply locating a building in a new site, different conditions have to be considered both in the design and in the construction process. Incremental innovation is recognized as slower changes, generally based on existing solutions improvement (Norman and Verganti, 2014). The analysis showed that incremental innovation often occurred in the building foundation type, in the secondary elements, such as doors, fixtures, horizontal and vertical partitions, or sometimes in the use of traditional construction systems. This work has therefore found that incremental innovation can be associated with the minimal changes required in standard practice.

Modular innovation is also a common type of design change, which generally can be identified as a limited innovative solution in specific project areas or components, for example, in a new type of door, or windows, or internal partitions, both vertical and horizontal. Also, in this case of innovation, as in the case of the incremental one, the activities required can be mostly considered competence creating. In the analysis this type of innovation described most of the secondary elements of the building projects analysed. The only exception was found in the horizontal partition of the Muyinga Library in Burundi, in which the secondary element (the ceiling system made of a fish net) was instead defined as a radical innovation. This is in line with the definition of Slaughter (1998), which defined modular innovation as a significant change in a component but not in the links between parties of the product.

As Henderson and Clark (1990) explained, the essence of an architectural innovation is the reconfiguration of an established system to link together existing components in a new way. Moreover, the Oxford Reference (2018) underlined that architectural innovation is a type of change that creates an improvement in the ways in which components, at least some of which may not in themselves be innovative, are put together; as well as Slaughter (1998) specified that architectural innovation is characterised by small changes within components but major changes in the links. In line with these definitions, the analysis conducted demonstrated that architectural innovation can be found in the relations between different building components or spaces, for example, in an innovative volumetric arrangement, or in the organisation of access and circulation, the shape, the volumetric arrangement, the layout, or the relation between opaque an transparent elements in a building. Many of the buildings analysed relied on architectural innovation to achieve sustainable social results, such as in the case of the Culloden Battlefield Visitor centre, in which the access and circulation determined the uniqueness of the experience of the users defining the most innovative aspect of the project.

System innovations, generally recognized as context-dependent (Hellström, 2003), seemed to be targeting mostly environmental aspects by creating a system of innovative design solutions in different part of the building (windows, doors, heating systems, ventilation systems, water collection systems) that contributed to the reduction of usage of natural resources and CO_2 emissions. The system type of innovation seemed to be strategic and long-term, producing slower and long-lasting effects. For instance, in the case of the South Lanarkshire Low Carbon Teaching Building, in which environmental control features are visible - as a design choice – the ability of teaching sustainability aspects to the students by observing and understanding their own building is enhanced. Other system innovations noticed in the case studies were developed through specification of building materials, construction systems, doors and windows, and through architectural design. For instance, local materials – especially timber – were used on the above projects and stimulated local economies in terms of production and manufacturing. This finding conforms and expand the definitions by Slaughter (1998) that has defined system innovation as the integration of multiple independent innovations that must work together to perform new functions, or to improve the facility performance as a whole. As suggested by Lindgren (2016) this type of innovation – which the author defines as 'systemic' – is relevant and particular important for the evolution of practice. This is due to the need to approach, control and direct the complexity of the nature of the building industry and its product in order to foster sustainable change.

As Slaughter (2018) explained, radical innovation is considered a breakthrough in science or technology that would allow to change the entire nature of the industry. Moreover, Henderson and Clark (1990) explained that Radical innovation is concerned with new core design concepts development embodied in components that are linked together in a new architecture and with disruptive effects on products and practice. The analysis showed that radical innovation can potentially be found in any area of the building characteristics. The case of the Floating School of Makoko for example is characterised by radical innovation in the context characteristics, as the building relates to this latter by 'floating'. The case of the Ch2 Office Building in Melbourne shows radical innovation in its architectural characteristics, whereas the Library of Muyinga in the secondary elements. Most of the projects analysed though characterised by radical innovations in the area of environmental control systems, such as in the case of The Edge Office Building, in Amsterdam.

6.1.2 Impacts of Innovation

The analysis carried out in the previous chapter has also highlighted a relation between type of innovation and degree of competence destroying activities required for the delivery of such innovations.

Table 68: The table shows the total of competence creating or competence destroying activities detected in all the case studies analysed.

Actor	Competence Creating	Competence Destroying
Public Insititution	22	8
Client	19	11
Designer	10	20
Builder	16	14
Industry	22	8
User	11	19

As Shilling (2010) and Becattini (2013) explained innovation can generate or require either competence enhancing or creating and competence destroying activities throughout their delivery. This latter case is the one in which innovation is generated by knowledge that is out of the core business of activities of a certain individual or firm, whereas the competence enhancing activities are the ones that can generate innovation by relying on the existing knowledge within the core business of individual or firms.

The analysis conducted on the case studies showed that anytime a change occurred, competence destroying activities were generated. For instance, whenever radical innovation was delivered, competence destroying activities occurred, for most of the actors involved in the delivery of such projects, and therefore the more radical is the innovation and the more are the actors involved in competence destroying activities. Examples of this are projects such as the CH2 Office Building in Australia, the Children's Land in Palestine, the Earthship School in Uruguay, the Ballard Library and the Bullit Centre in USA. In all these projects characterised by radical innovation, the process was carried out with great actors involvement and participated processes. The analysis of the case studies shows that in collaborative environments, such as in the case of integrated design and delivery processes, the risk of generating radical innovation and therefore the emergence of competence destroying activities is shared between all the parties involved. In the cases in which individuals or firms acted as champions and promoter of introducing the innovation, the competence destroying activities seem not to be shared by all the participants, but only by the ones that are involved in the specific innovative characteristics. An example of this instance is the Primary School of Gando, in Burkina Faso, in which the architect Francis Kerè took the responsibilities of the entire project delivery, and therefore acted beyond the scope of his core business, and therefore had to acquire new knowledge. The analysis has also demonstrated that, due to the creative based nature of their profession, the architects (and designers in general) always have to undertake competence destroying activities. The analysis has also showed that that every time an actor act outside the scope of its traditional role, competence destroying activities are generated. This aspect is used in some of the project analysed as development strategy, such as in the case studies in which the building process was organised in such way to function as training for the unskilled labour or the local community, such as in the Libray of Muyinga, in Burundi, the Gando School, in Burkina Faso, or the Cassia Coop Training Centre in Indonesia. To trigger change on this level, either architectural or system innovation had to be introduced in the construction systems and in the material used. This is a crucial aspect, as introducing innovation in the construction phase triggers change and competence destroying activities for the builders and industry participants. These actors are the most risk-averse category in the building industry, as traditionally they build their competitiveness on previous experiences (Gann 2000). Understanding the areas of potential risk and competence destroying activities in relation to innovation introduction could help reduce the risk of failure, and increase the capability of absorbing innovation by those actors. Another strategies to produce change that emerged from the analysis is the strategic use of system and radical innovation to generate competence destroying activities for the users. This strategy is used in the case studies of projects in which it was crucial to empower the users in the environmental control systems of the building, such as in The Edge Office Building in The Netherlands, or in the Dixon Water Pavilion in USA. The analysis has also showed that the more incremental the innovation is and the less likely is the emergence of competence destroying activities and the generation of change.

6.2 Management levels and roles in sustainable innovation introduction

The use of co-innovation and sustainability management model allowed to shed light on roles and dynamics that facilitated the innovation introduction in the case studies analysed. The model helped understand the roles that beyond the traditional positions can be covered by any of the actors involved in building delivery process, and therefore help highlight the responsibilities and opportunism that exist in the delivery of sustainable innovation in buildings.

The case study analysed demonstrated that the role of individuals in the co-ideation phase can be covered by any institutions or individuals without necessarily any specific skill sets, or financial capacity. At least for the role of leader, any figure could initiate a sustainable idea promotion. This level of management is generally covered by public institutions, or clients. Yet, some projects have showed that also designers, builders or users can be part of this level. When this level of management develop very structured frameworks, the co-innovation is organised in a more traditional way; whereas when the co-ideation phase is less defined, more extensive collaborative work appear to happen in the co-innovation level. The more responsibility are taken in the co-ideation phase and the more likely is to obtain impacts on the area of the market and society in the co-institutionalisation phase. Moreover, it is also possible - as it has been showed in the case of the CH2 Building in Melbourne, Australia – that decisions taken in the co-ideation phase could be strategically determined to create an impact on the area of policy and legislation in the co-institutionalisation phase.

The co-innovation phase is the core level of the generation of the sustainable technical innovation introduction. This phase is characterised by the role of skilled teams or individuals, whom yet need to collaborate in inclusive environments with also non-skilled or third parties, to generate wider impacts on the co-institutionalisation phase. Although, a predominance of figures such as the public institution, or the client is noted in the analysis undertaken, it is significant to point out that the more actors are involved across levels, and the wider are the impacts on the co-institutionalization phase.

The co-institutionalisation level is largely influenced by the array of the previous two levels. The more structured the co-ideation phase is and the more likely is the production of policy and regulations and market and society impact generation in the co-institutionalisation phase. The more intensive is the work in the co-innovation phase and the more likely is the production of knowledge and technology development in the co-institutionalization phase.

6.2.1 The role of the Institution – Enabling/disabling innovation introduction through legislation framework

The institution only appears on less than 30% of the case studies analysed, and is present in the co-ideation phase and in the co-institutionalisation phase, but never in the co-innovation phase. Two exceptions are the case of the Alder Hey Children's Hospital in Liverpool, UK, and in the case of the CH2 Office Building in Melbourne Australia. In the first case, the institution was actively involved in the co-innovation phase with the presence of the NHS Client in the definition of the requirements for the hospital expressed in the brief, which influenced the design decision and construction process determined during the co-innovation phase, which was carried out with round tables and workshops with representants also from the public institution. In the CH2 Office building in Melbourne, Australia, the role of the institution was also crucial for the co-innovation phase, as this latter was strategically utilised to establish and test the effectiveness of the six star rating system in Australia, by developing a project that could display all the top sustainable technical design choices and innovations. In most of the other cases analysed, the institution played mostly the role of either promoter or the legislating role that set the framework within sustainable initiatives can be developed. Moreover, it is observed that in all the case studies analysed, the strategic role of the institution – both in enabling sustainable projects through framework or in having a more active involvement - generates an impact on the co-institutionalisation phase. In all the case studies in which the role of the institution was to set the legislative ground to enable sustainable initiatives the impact achieved was in the area of market and society. In the case in which the public institution had a more active role during in the co-innovation phase, their impact was also on the area of knowledge and technology development. Although the ability of the institution of establishing legislation frameworks is traditionally recognized as the main enabler for innovation introduction, in some cases – such as in the Primary School of Gando, in Burkina Faso and the Cassia Coop Training Centre, in Indonesia – the lack of legislative framework allowed the ideation of individual initiatives to promote, organise and deliver innovative sustainable projects.

6.2.2 The role of Client – An open position

The client role appears to be one of the most crucial and yet open position in the introduction of sustainable innovation. Traditionally, clients have been described as either public or private entities, as well as they have been conceived as separated entities from the other actors involved in project delivery. Yet, from the case study analysis, it emerged that the role of client can be undertaken by any entities or individual, including the ones that are already playing other roles, in the same project. It is not unusual that a builder also acts as client – for instance as in the example of the Pixel Office Building in Melbourne, Australia - or a designer, as in the case of the Primary School of Gando, in Burkina Faso. Moreover, often client and users are found to be the same entities or individuals. This is a two-fold significant finding. Firstly, the role of client can be undertaken by any institution or individual, and therefore potentially anyone could be a leader in the co-ideation phase of sustainable endeavour. This is also because the financing investment does not necessarily have to be carried out by the client per se, as for instance, the analysis has demonstrated that financing processes can be supported by private-public formulas, independent NGO's, donors, or others. Secondly, when the same entity or individual covers more than one role on the project delivery, beside the one of client, the decisional power on the project and the aims are reinforced and ease of sustainable innovation introduction seems to be facilitate. Moreover, the role of client is always fund in the co-ideation phase. Clients can play the sole role of the leader, or also the one of champion and entrepreneur. Whenever the client occupies the role of leader, an effect on the co-institutionalisation is generated in the area of market and society; whereas whenever the client also cover a role in the co-innovation phase, an impact on the knowledge and technology development are is generated.

6.2.3 The role of Designer – A cross level position

The role of designer (both as architect or consultant) is a cross level position within the co-innovation and sustainability model. Yet, the predominant level in which a designer figures is the co-innovation level. This means that designers are the ones who are in the crucial position to ideate and introduce innovation into projects. Moreover, depending on the type of innovation and the design decisions made accordingly, designers are in the position to vehiculate the type of impact that such innovations will have on the co-institutionalisation phase. For example, in project such as the Muyinga Library in Burundi, the designers decided to use a particular construction system that could generate a positive impact on the social inclusion of the community in the construction process and therefore generating an impact on the area of market and society in the co-institutionalisation phase. In the case of The Edge building in Amsterdam, the designers introduced technological innovation in relation to the environmental control system of the building, which generated an impact on the knowledge and technological development within the co-institutionalisation phase. From the analysis conducted, it also emerged a relation between the role of the public institution and the one of the designer. The more the institution is present in the co-ideation phase by setting directions, frameworks and policies, and the less is the designer. This aspect is particularly evident in the case studies set in UK, in which the institution has organized a strong body of policies regarding sustainability in the industry, whereas in places such as Makoko, Nigeria, the designer had to perform significant role in all the management level. Moreover, in context in which the public institution set strong legislation and policies, it is less likely to witness the emergence of radical innovation.

6.2.4 The role of the Builder – From absence to participation

Although the role of the builder often appears in the co-innovation level, the builder seldom appears in the co-ideation level. One exception was the case of the Pixel Office Building in Melbourne, Australia, in which the builder was also the promoter, client and developer of the project. In this specific case the builder had a decision making role in ideating the introduction of sustainable innovation. The meaning of this is that in most of the projects analysed, the builder is never part of the ideation process, in which individuals take decision making responsibilities and commitment toward the sustainable innovation introduction, but rather acts as passive participant in the actualisation process of such innovations, after the main aims have been already determined. In some projects, such as the in the Primary School of Gando, or in the Muyinga Library, the construction process is used as a medium to train the local community to learn new skills, and therefore the role of builders is almost absent, as unskilled labour is taking that role. In other projects, the builder operates in a traditional manner, regardless by the degree of innovation, the builder only comes on the project during the building process, in which client and designer have already defined the major directions for innovation introduction. For instance, in the case of the Culloden Battlefield Visitor Centre, or the South Lanarkshire Low Carbon College, the institution, the client and the designers played a central role in defining framework and strategies of sustainable innovation. A more active role, is undertaken by the builder in the case studies in which the procurement method is integrated design delivery, such as in mostly the North American case studies analysed. Such procurement method allows to involve the role of the builder also in part of the co-ideation phase, and in the design process, and therefore in the decision making process regarding the sustainable innovation ideation and actualisation. In this last circumstance, the role of the builder is also able to produce an impact on the co-institutionalisation phase, for example in the area of knowledge and technology development. Conversely, when the builder only works in projects in the co-innovation phase, operating in a traditional manner, the role of the builder on the co-institutionalisation phase seems to be absent.

6.2.5 The role of the Industry – The external collaborator

The industry (suppliers and manufacturer) never appears in the co-ideation phase of the case studies analysed. Similarly to the builder, the industry only appears in the co-innovation phase, in which they contribute as external collaborator that supply goods to the project delivery process. Only in the case of integrated design delivery process, the industry is involved to certain extent into the design and decision making process, and therefore have the possibility of producing an impact on the co-institutionalisation phase. In the other case studies analysed, the role of the industry tends to be minimized due to recycling or re-use design strategy. In the case study of the Earthship School in Uruguay for example, the involvement of the industry is absent, as all the materials used on the project are collected within the community; or in the case of the Children's Land School project in Palestine, where the materials were either donated or fund on site. In other cases, the industry is involved in projects as donors, as in the case of the Newbern Library in Auburn, Alabama, in which the local suppliers donated materials to complete the renovation of the old bank building for the community. In this case the industry participates to the building delivery process but they are not able to obtain a financial return for their business, other than obtaining comparative advantage in the promoting their companies in light of ethical behaviour. A last category of project was fund in the analysis, in which the industry is not involved at all due to the internationalisation process of the delivery systems. Projects such as the SIEEB in China, or the One Airport Square in Ghana are characterised by mostly international companies involvement, which have almost no contact with the local industry, expect for a minimal involvement of the local labour. All these different roles of the industry of the project show that the potential learning curve and participation in the introduction of sustainable innovation into building project is very high. Therefore a possible path to explore for the industry can be found in the definition of delivery processes that could include their participation earlier in both the co-ideation and co-innovation phase, as an active development strategy.

6.2.6 The role of the Users – The empowered position

In the majority of the case studies analysed, the users play a crucial role on many levels of the co-innovation and sustainability model. The exception is found in projects such as the Pixel Office Building or the 41 Exhibition Office Building, Melbourne, Australia, in which the developers and the clients promoted the project as a commercial endeavour, rather than an end user inclusive experience. The majority of the projects analysed witnessed a progressive active involvement of the users from the co-ideation level to the co-institutionalisation level. In particular, in all the project in which the user was involved in the co-ideation phase, a positive impact on the area of market of society was produced in the co-institutionalisation phase. The users are empowered in this way to actively determine the nature and type of impact that the project will generate. For instance, the case studies analysed show three strategies: the first one sees the users involved in the design phase – such as in the North American case studies – in which the users develop a sense of community and belonging by participating to the decision making process. The second strategy involved the users in the construction phase, like in the case of the Earthship School in Uruguay, or the ECDC Centres in Rwanda, and enabled the users to learn building skills and to put them in the position of looking after the maintenance and the life cycle of the building. The third strategy is showed in the case study of The Edge Building in Amsterdam, in which the user is empowered with the responsibility of the energy consumption control of the building. According to the type of user's involvement in the co-ideation and in the co-innovation phase it was therefore demonstrated that different types of empowerment can be achieved in the co-institutionalisation phase.

6.3 Sustainability results and strategic development opportunities

The analyses conducted shows that the distribution of economic, social and environmental results is different in buildings and processes even within the same project (Table 69). For instance, projects with 'green design' can be delivered through processes characterised by predominately social and economic aspects, rather than environmental. Vice versa, some design might not aim at great efficiency in the environmental control system, but they rely on short logistic or sustainable supply chains. This is significant to the understanding that building and process represents both potential development opportunities for the sustainability innovation introduction.

Table 69: The table shows the total of projects analysed according to the predominance of types of sustainability results achieved.

Type of Sustainability Results	Number of projects	
	Building	Process
Environmental	20	15
Social	7	7
Economic	3	8

6.3.1 Environmental Results

The environmental results are predominant in the case studies analysed. This might be due to the type of case study selected – most of which have been awarded with environmental certification achievements - but also to the progressive emphasis that practice, academia and government have placed on the role of the building industry within a larger discourse about climate change. For instance – as previously mentioned - The World Green Building Council (2018) stated that crucial environmental achievements for the building industry are: greenhouse Gas emission reduction, use of renewable energies, reduction of potable water consumption in building, carbon emission reduction, saving on energy spending, job creation, increase of assets value over traditional buildings (about 7% more), workers in green environment increase their cognitive performance of 101%, workers in well-ventilated and employers who worked in offices with operable windows and well-ventilated areas sleep an average of 46 minutes more per night. These types of results are the one that shaped the main aims of most of the projects analysed. From the observation of the case study analysis is possible to notice at least three strategies to achieve these goals were used. The first strategy is the performance-based approach, the second one is the low tech local materials and sustainable supply chain, and the third is a user-based design. The case studies in North America seem to champion the first approach. They have participated or achieved the Living Building Challenge, which is a system, as previously explained, that put strong emphasis on the environmental approach in building. These projects are conceived as 'green machines' aimed at satisfying the environmental requirements starting from the design approach to the use and maintenance of the building. The Bullit Centre for example, as well as the Jacob Institute of Innovation, are conceived without relying on any metaphoric design concept, rather they are set from the very early stage in a way to optimise all the design decisions to obtain the maximum environmental performance, of both the building and its life cycle. The second approach is the one used, for example, in the Scottish Culloden Battlefield in Inverness, the South Lanarkshire, and the Robert Burns Birthplace Museum, in which the design solutions adopted as well as the delivery processes were aimed at using and displaying the opportunities of local materials, low impact supply chains, and local labour. For example, in these case studies large use of Douglas-fir was done to stimulate and trigger local productions and use of this local timber, generally not utilised in the construction industry before at its full potential (Nigra and Dimitrijevic, 2018). The third approach, based on the user-based design experience, is the one utilised in The Edge building that represents the use of top technological innovation to empower the user in managing and controlling the building environmental conditions and energy use. In this latter case, as in the one of the Pixel Office Building in Melbourne, the environmental sustainable features in the building are also utilised as commercial strategy to increase the value of the development operation in delivering such projects. In this latter category, the visible features, as well as the sense of empowerment of the users represents an essential marketing strategy that help communicate and sell the value of sustainability to the market. Yet, in the number of projects analysed the environmental results seem to be not as relevant as in the majority of the others. These are the case of the buildings analysed in developing countries, such as the Primary School of Gando, the Floating School of Makoko, or the One Airport Square in Ghana. In such projects, the results obtained are related either to the commercial scope of the project (i.e. One Airport Square project in Ghana), in which the results are predominantly of economic nature, or to the social nature of education buildings such as the schools of Makoko, Nigeria or in Burkina Faso. This might be due to the overall guidelines dictated by the institution or by the contextual conditions of specific countries, which need to respond to other perceived burning challenges rather than the environmental one. For instance, the need of ensuring access to education to the kids of Makoko, Nigeria, or to provide a shelter for health and education for the women and children of Muyinga in Burundi.

6.3.2 Economic results

The economic role of the building industry has been largely discussed (Ruddock 2009). Yet the strategies and the types of economic results that are achievable on projects might vary. These can span from knowledge acquisition, comparative and competitive advantage to market expansions. These results can be generated on projects and achieved by any actors involved. For instance, either by participating on a project experience or to open up a market, from the client to the users, these figures can all obtain different sort of economic advantage. Economic results might have an immediate or a longer time impact on the context and the participants. As previously explained, buildings are costly products (Turin, 1980) and so they are their development process. This mean that large capitals are required in a short time frame to produce the artefact, and therefore producing economic profit or benefit for the parties involved. Moreover, the analysis of the case studies has showed that projects have the potential to generate economic benefit for the participant also for longer time. Regardless the length of the potential economic impacts of projects, the case studies analysed showed at least three strategies to obtain such results. The first strategy is a traditional approach that sees the participation on projects by a number of actors who obtained punctual economic profit by delivering their tasks on specific projects, performing within established budget. The second strategy is characterised by the knowledge acquisition goal potential, meaning that the project is strategically used for the participant as an opportunity to acquire new skills. The third strategy is the one aimed at obtaining economic profit by leveraging on environmental sustainability features as selling strategies to increase the value of the project while being under delivery.

6.3.3 Social results

As previously mentioned in the chapter four, the social results that buildings generate are many – such as social inclusion, community cohesion, improvement of health and wellbeing, quality of education, resilience to change – and yet difficult to gauge, due to their qualitative and complex nature. Although, the social impacts might remarkably vary according to the context, it was possible to identify a number of strategies, in achieving at least the following results: cultural identity and diversity enhancement, social inclusion, health, safety, and well-being, community resilience, support to education and gender equality, social responsibilities empowerment, fear reduction and aspiration definition support. The strategies adopted in the case studies analysed were at least three. The first strategy was established in the building programming phase and it is actualised through the social definition of the scope of the project itself. For instance, in this strategy the social role of the project is defined by programming a shelter for education, health, gender equality, for example as in schools, hospital, or health centres. The second strategic approach seemed to target social inclusion by leveraging onto the delivery process, both through participated/integrated design, and/or participation during the construction process. The third strategy focused on the interaction with the user to promote social behaviour and individual empowerment such as in the case of The Edge, in The Netherlands, The Dixon Water Pavilion, in Texas and in the 41 Exhibition Street Office in Australia. The first approach is actualised by a number of projects which are aimed at achieving a social intent in their scope, such as most of the case studies developed in the African continent. Among these, the Primary School of Gando in Burkina Faso, the Makoko Floating School in Nigeria, the ECDC Centres in Rwanda, and the Library of Muyinga in Burundi have all a social nature as they are meant to respond to the need of improving education, health and safety in their context of development. This social intent is often translated into design strategies that envision shared spaces to facilitate the community cohesion, and high degree of accessibility. Yet, these approaches might fail to actually engage the community in the actual use and maintenance of the building. for instance, as ASA (2017) reported, some of the ECDC Centres in Rwanda have been abandoned and savaged of some of the building components, as result of the lack of care and use from the local communities. Although some of these projects might not have fully obtained the envisioned goals, other that relied on the same approach had positive impacts on the community and their ability to using, maintaining and engaging with the building facilities, such as the case of the Rainbow Desert project in Perù, the Cassia Coop Training Centre in Indonesia or the Liyuan Library near Beijing, China, in which the community takes active part in running and looking after the building facilities. The second approach leverage heavily on the concept of community involvement during the delivery of the project. Such concept is actualised by engaging future users, either in the design phase or in the construction processes. This latter option is used mostly in the case studies built in the developed countries, where the social aim is to engage the community and to help participant acquiring skills though the building processes. In all the project developed in Africa mentioned above, the involvement in the construction phase was used to empower the locals with new set of skills, as well as to hope creating a sense of community and belonging, which as we said only worked in some of those projects. This might be due to the transitory nature of worksites, in which people work and then leave with the acquired skills and experience, searching for new working opportunities somewhere else. Moreover, the community participation in the case of the African projects for example is not involved in the decision making phase, and therefore the community might not be ready for the change the building is aimed at producing in the society. In Rwanda for example some of the unused ECDC centres are abandoned due to the lack of participation of the community in understanding the value or supporting the early education program for their children. This sense of participation and belonging is enhanced when the users are involved in the design phase rather than in the construction process. This is the case of the case studies analysed in North America, in which the community was largely involved in the integrated design delivery process, and therefore they felt more part of decision making process, as well as empowered with the responsibilities of the decisions on the nature and characteristics of the buildings. All the process looked into health and wellbeing as well as in accessibility. The third strategy is characterised by empowering the users with the responsibility of the environmental control of the building. This approach - that can be fund for example in The Edge Office, The Dixon Water Pavilion, and in the 41 Exhibition Street Office – can produce cohesion, responsibility, behaviour adaptation to change, resilience, and space personalisation with a consequent increase of activities performances, as it was reported by Schneider Electric

(2017) for example in the increase of production and satisfaction as in The Edge building.

6.4 The links between building characteristics, delivery process, innovation and sustainability results

The methodological approach that consider sustainable buildings as complex projects allowed to highlight the links between building characteristics, process, innovation types, innovation impact, actors role and economic, social, and environmental results, as conceptually showed in Appendix C. This section will discuss such findings by exploring the relation between each design variable in the building characteristics – as per index provided in the European Standard UNI EN 16627:2015 (CEN, 2015) – innovation types, innovation impact, actors role and economic, social, and environmental results, that were generated by different design decisions taken on each project. Moreover, the section will discuss the traditional areas of delivery process, as described by Tombesi (2008) attempting to highlight the innovation opportunities and the possible results that can be achieved. In conclusion, this section will highlight the overall links that have been found in reading the patterns in all the case studies and that can provide a strategic guideline for sustainability introduction in projects.

6.4.1 Building characteristics:

The site/context

The context selection is generally defined during the building programming phase, and it has crucial important during the use of the building. The type of innovation introduced in this case was found to be either incremental, system or radical with either a competence enhancing or a competence destroying impact on the actors involved, depending on the type of innovation introduced. In the case of urban sites, the innovation type introduced was either incremental or system. This is due to the existing built context that represent the existing knowledge on which incremental decisions can be made, and when the site boundaries allowed environmental considerations that can enhance the performance of building, the innovation introduced was of system type. This was the instance the case of the North American buildings analysed, which targeted the Living Building Challenge, in which through optimisation of building orientation, the use of passive lighting and ventilation strategies, or the use of renewable resources, the project were aimed at working as performing systems. In the case of rural sites, innovation was, similarly for the urban case, of system type, but mostly it was radical. This was due to a number of logistic complexity to deliver projects in remote areas, as well as in the (in)ability to rely on local expertise, as it occurred in the case of the delivery of the Hotel Patagonia, in which radical construction systems were found to be needed. The site selection is also found to be a participated decision that can involve the presence of public institution, client, designers, or local community, and therefore in the eco-ideation phase (Bossink, 2009). In case of radical innovation introduction, these actors share the risk of absorbing the change. Such change may have significance for local communities in terms of identity, history, meaning, and resource availability, in terms of social results. Micro-climatic characteristics of the site can influence the environmental features of the building, as well as of the surrounding environment. Regarding the economic level, the land value may vary before and after project delivery, developing therefore economic benefits for local communities, both during building construction and its life-cycle.

Concept

The building design concept can address social, economic, and environmental meanings and objectives. This is due the aim of concepts to communicate values and design intent through visible features (Nigra, 2017). The analysis has showed at least three major approaches in terms of conceptual design approach. The first one relies on a metaphorical approach, in which architects (designers) relies on the use of theoretical concept to derive the overall architectural characteristics of the building. This is the example of the Culloden Battlefields Visitor Centre in Scotland, which concept was based on determining the main axes of the building by redesigning the movements of the Jacobites Clans within the battlefield and therefore by creating more engagement with the audience; the Rainbow in the desert in Perù, which concept was that even a colourful rainbow can be generated in the desert and therefore by giving the space to kids to grow their own food they could see the colours of flowers and vegetables, or by the One Airport Square in Ghana, which concept was to celebrate the geometric patterns found on the local fabrics and decorative motives. These types of projects have showed to be more likely to achieve social results, as they leverage on the visible feature to communicate and deliver specific messages and values to a larger number of people. A second approach was the one that relied on the vernacular or regionalism approach, such as in the case of the Robert Burns Birthplace Museum in Scotland, the Water Dixon Foundation Pavilion in Texas, The Hotel Patagonia in Chile, or the EDCD centers Rwanda. These projects relies on concept that place importance of the natural and cultural context and they aim at emphasizing the value and the opportunities of such context. Specifically these concepts relies on the continuity with the site characteristics, with the use of local technologies, construction systems and materials, or with the use of the traditional typological buildings. This approach is likely to produce social, environmental and economic results. This is due to the ability to contribute to determine or celebrate the *genius loci* of a place, respect its environment and attempt in stimulating local circular economies. The last approach is the one of the projects conceived as ‘green machines’, such as the case of the North American case studies analyzed, or the CH2 Office Building in Melbourne, Australia. The concept for these project is to design building that showcase its environmental role, and therefore they do not rely on metaphorical concepts or ideas, but rather they adopt a functional approach aimed at achieving the highest possible environmental performance without having the generate any design concept, that could instead interfere with such performance. As a consequence, this approach is the one that will have most of environmental impact. To some extent, this concept. For example in the CH2 Office Building in Melbourne is also aimed at showcasing as educational strategy all the environmental sustainable feature of the building to communicate their value. The concept generation idea is a process that traditionally is carried out in the eco-innovation phase by architects or designers. Yet, for example in the case of the CH2 Office building, this process can also occur during the eco-ideation phase, with the involvement of many other actors involved. Yet, the concept generation remains a crucial competence destroying activities for the designers because, despite the type of innovation in the concept, they always need to generate a unique one for each project, and therefore requires to designers to acquire new knowledge or skills.

Orientation

The building orientation, in the analysis conducted, plays a crucial role in the achievement of environmental results as, when possible, contribute to the achievement of the environmental performance of the building. This is because of the ability to optimise the micro climatic conditions of the site. The achievement of high performance environmental conditions also impact on the perception of the quality of the space and therefore generate a social improvement as well. In the projects analysed the orientation depended much on the specific site characterises such as available boundaries, wind directions, sun exposure, presence of trees or other natural elements. These conditions are easier to be utilised as design strategy in rural contexts, in which the natural elements are available as tools for design without other interference, whereas in the urban context the site specific characteristics might be less impacting the final design due to the existing built environment which could limit the sun incidence, or the wind pressure. The building orientation might also have social relevance as in the case of the Robert Burns Birthplace museum, in which the main axes of the building determine its relation with the existing monuments dedicated to Robert Burns in the same village.

Architectural Characteristics

The architectural characteristics, or aesthetic approach are found to be in line with the overall concept defined for the building, which set the principles for the design decisions during the project development. As per the category of ‘concept’, the architectural characteristics, or aesthetic approach represents a competence destroying activities for the designers. Yet, in the case of integrated design delivery process, such decisions might be taken in a collaborative environment in conjunction with local communities, users, and clients, expanding the scope of the eco-innovation phase (i.e. in the case of the Northern American case studies analysed). The discussion about architectural characteristics of sustainable innovation has been largely since many years. As Nigra (2017) explained, aesthetic is defined here as a set of principles governing the idea of sustainability, which finds its expression in visible features of architectural form, and therefore has the opportunity to have social impact. It is since the Bruntland Report (1987), when the concept of sustainable development was formally defined that the practice of architecture has started evolving and searching for new means, methods, and aesthetic approaches. It was not many years later that Guy and Farmer (2001) had already identified at least six approaches to sustainability in architecture, namely eco-technic, eco-centric, eco-aesthetic, eco-cultural, eco-medical, and eco-social, gauging the complexity of interpretation of the concept of sustainability in architecture. These approaches encompassed different technological solutions, sources of environmental knowledge, and images of space, which contributed to define the overall aesthetic approaches that each of those represented. Yet, ten years later Lee (2011), by editing the book: '*Aesthetic of Sustainable Architecture'*, collated the contribution of at least twenty five academics and architects, in which various approaches to the aesthetic of sustainability were defined and explained, underlining the fact that the debate on the aesthetic of architecture was still open, and more complex than before. Moreover, Hosey (2012) stretched those concepts both, by shedding light on the degree of controversy that exist in the debate around sustainable aesthetic in architecture, and by proposing a 'manifesto' of principles for a new conception of what he defines 'the shape of green'. Recently, the debate seemed to be more open than ever: the aesthetic and management matters related to sustainability are still subjected to enquiry and exploration, both in practice and in the scientific community (Hensel and Nilsson, 2016). Despite controversies and variety of approaches, aesthetic plays a crucial role in communicating the value of sustainability, and therefore maintains its important for the work of many designers and architects. Overall, the analysis showed that the case studies analysis fall into at least three of the categories defined by Guy and Farmer (2001), such as the eco-aesthetic (i.e. The Culloden Battlefield Visitor Centre), the eco-social (i.e.The Library of Muyinga, The Gando Primary School, or the Eartship School in Uruguay), and the eco-technic (i.e. The CH2 Office Building), as a derivation of the three conceptual design approaches previously discussed in the 'concept' section.

Dimension

The project analysed can be organized in the three categories: small buildings: below 1000 sqm, medium buildings: between 1000 and Big buildings: 10.000 sqm, and above 10.000 sqm. The decision on a project size is generally either determined by the client, or by the boundaries set by codes and site characteristics. The eco-ideation level and the programming phase are generally the ones that characterise the decision making process about dimensions. Discussions on dimensions can also be held during integrated design and participated processes including communities and individuals. The small size projects are the ones in which is more likely to have social inclusion during the construction, and also to be able to become more accessible for the community. This is due to the fact that the community will be able to feel included also in the life of the building and in its management. Smaller projects are also the ones in which radical innovation and competence destroying activities can often occur, since the dimension can help limit the risk. Yet, such dimensions might also represent a limit in the ability of becoming a breakthrough experience to change the industry and the practice, by not being able to produce economies of scale. Yet the importance of using projects as exemplar experience for the industry has been largely discussed both in practice and academia (Bossink, 2009; Bygballe and Ingemansson 2014; Slaughter 1998; Winch 1998), and for example the projects in Africa have the ability to be replicated once the community and the institutions understand their values, producing a greater impact. The medium size are the one realised with more traditional process and in which the architects generally takes the risks of all the sustainable introduction innovations. These projects can be of various nature and scope and generally they target spatial quality for social inclusion, identity definition, and value communication, such as for example the case of the Robert Burns Birthplace Museum in Scotland. Moreover, the medium size projects are also more likely to utilise passive strategies for environmental control. These projects are also the more risky in terms of balancing budget and innovations introduction, as generally project management bodies are not present. The big size projects are the ones that generally have commercial scope in their nature and in their development. These projects are more likely to produce economies of scale and to have a greater economic impact on the industry. This is because by triggering productions scaled which are big enough to economically allow the changes in manufacturing process, productions and logistics, such projects are able to represent a potential breakthrough in the industry and produce change. These types of projects tend to have less social inclusion and due to their dimensions often requires mechanical and artificial environmental control systems, rather than relying on passive strategies. Yet economies of scale are possible in these instance also regarding the renewable energy resources, which can produce over the required quantities and therefore re-distribute resources back to the community (i.e. solar panel or photovoltaic energy production). The complexity of such projects often shift the responsibility and the competence destroying activities from the designers to the management bodies. These latter tend to consider sustainability as an extra feature that could be included only when the economic budget allow for it, unless concepts of environmental sustainability are used as commercial strategies as in the case of The Edge Office Building in The Netherlands or the Pixel Office Building in Australia.

Shape

The results of the analysis shows that shape, geometry, building typology, volume, access and circulation, number of floor and the visual relations that the designs created internally and between indoor and outdoor space can contribute to the communication of the narrative and values that the buildings are aimed to communicate, as well enhance the environmental control strategies and performance. The decisions around these design variables are mostly responsibility of the designers, whom, as previously mention, often undertake competence destroying activities due to the inner nature of the creative design process. Such process can also be shared with the participation of clients and/or final end users, or with all the stakeholders involved in projects, and therefore making the eco-innovation phase open throughout participated procurement and design methods during the delivery of projects.

The layout geometry of a building has the potential to obtain great impacts in terms of economic, environmental and social results. The layout might address environmental control solutions such as the use of corridors and mitigating space for thermal behaviour, organizing control of sun incidence on the main spaces, and creating areas passages for wind flows to facilitate passive ventilation. Economic aspects can relate to the layout organization for example in relation to the cost of material of internal partition, as well as to the possibility of defining spaces of different value and business opportunities. For example all the office building analysed tend to minimize the internal partitions and to privilege open spaces solutions. Moreover, the layout can have great impact on the social level. In the case of the African schools for example, the layout of the projects tend to recreate the internal distribution of the local villages so to generate a sense of protection, familiarity and security. Layout would also dictate many aspects of the projects such as access and circulation, main space shapes and geometry and therefore influencing the very nature of buildings characteristics.

The volume, in the case studies analysed, often plays a central role in the achievement of environmental results. Yet, the volumetric arrangement of shapes can also represent a strategic opportunity to obtain social and economic results. The volume can either become the expression of the optimisation of the micro-climatic characteristics of the site (for example prevailing winds, or sun direction), or can be shaped in order to minimise the visual impact on the existing environment, such as in the case of the Hotel Patagonia. Simples shapes such as cubic blocks or parallelepiped were used in most of the building projects analysed, since these solutions allowed rationalisation of material use and therefore a more parsimony both in relation to costs and resources use. Volumetric complexity was used in the Alder Hey Children's hospital, in which an aggregation of volumes shaped the figure of a hand, allowing each finger to have natural light and ventilation from both side. In this case the volumetric organization was utilised to achieve also environmental goals as well as social impact on the patients, whom claimed that the visual relation with the outside park help them recovery.

Exception made for the 41 Exhibition Street Office Building, in Melbourne, none of the case study analysed exceed the 10/15 stories. The tallest building analysed are all office buildings, whereas the others with different scope, such as schools, museums, or community centres all limited number of floors. This might be due to different dimensions requirements as well as to the ability of becoming more accessible and inclusive when the accessibility to the space is more direct, and therefor with less floor.

Access and circulation are features that demonstrated to be crucial to achieve a number of social and environmental results. To achieve these latters, access and corridors can be used to vehiculate wind directions, creating buffer zones to mitigate thermal behaviours and sun incidence on served spaces, as well as can be shaped to provide chimney stuck effects and energy optimisation use. Mostly though, the case study analysed showed that access and circulation have the great potential of enhancing social inclusions, set or remove barriers, determine relations with existing context, as well as to create gathering spaces for individuals and communities. This can be true both for public buildings and for more private ones. For instance, the role of the atrium and the serving spaces (corridors) in The Edge Office Building is crucial to determine the identity of the company, to provide social space, and to increase the wellness of the workers positively influence their performance. Even more crucial is the role of corridors in the Culloden Battlefield Visitor Centre, in which corridors are designed in such way to produce a path to conduct the visitors through the historic reconstruction of the battle, specifically by moving within the building in the same manner in which the clans were moving in the battlefield. Also, in the West Branch Library in California the access and main building facade played an important role in reconnecting the building with the local community, literally opening up the doors to a larger audience.

Construction System

The role of construction systems, and in general of the construction process as development opportunity has been largely discussed (Gann 2000, Gann and Salter 2000; Ruddock 2009). Construction system, construction details, and technological solutions are the core opportunity for the development and introduction of technological development. Yet, all the activities and participants to the construction phase are the actors who are portrayed as the most risk-averse within all the buildings delivery processes (Nam and Tatum 1995, Tombesi). Along with the design decisions, building construction processes can also offer the opportunity to achieve positive economic results (Gann, 2000; Winch, 1998; Winch and Campagnac, 1995, Ruddock 2009). The use of certain building materials such as local timber for example can trigger new manufacturing processes, knowledge acquisition, and competitive benefits, contributing to the economic growth of local and/or national industries. In many case studies, such as the Scottish ones specifying local timber in buildings can be considered as an economic stimulus to encourage both growing, manufacturing and market openings. The use of other traditional materials generated positive results regarding the economy of scale by increasing the demand for those materials. Other examples are the ones used in Africa, such as in the case of raw earth used for its ease of construction and for the opportunity that this could give to locals to learn a self-sufficient technique. Among many reasons, this is due to the degree of competence destroying activities within the eco-innovation phase required to the introduction of innovation during the construction processes. The importance of construction systems, details and technological solutions on project can be found also in the social and environmental impact that they can generate. They offer opportunities to apply strategies related to embodied energy and energy use, thermal control, easy construction and streamlined logistics. Yet, in the projects analysed, the foundation system is the category in which the least change is pursued. Every project showed the use of standard and robust solutions that can be categorized as incremental innovation, and therefor can be delivered by relying on competence enhancing activities without creating any risky impact on any other part of the building or of the process. Prefabrication is also identified as a strategy to reduce risk, trigger economies of scale and optimise the supply chain and construction timing on site. Roofs and envelopes offer instead great opportunities for technological innovation, in which radical innovation can be introduced, and economies of scale in component production can be facilitated.

Internal partitions and door and windows

The internal partitions, as well as door and windows in a building can have a social relevance by contributing to the perception of the space by the users. The internal partition may contribute to the definition of environmental control systems in a building. The internal partitions, as well as doors and windows influence the cost of a building in terms of material selection, quantity and availability. These elements have found to be either incremental, modular, architectural innovation. Door and windows can also fall into the category of system innovation, whenever they contribute actively to achievement of the desired environmental performance of a building. The innovative role of these elements can potentially be very high, as they have the potential to leverage on economies of scale and to be re-used in other project. This is true whenever they are considered modular innovation within the overall building as product, as they maintain their specificity and individual specificity. The only radical innovation found within this building element category was the horizontal internal partition of the library of Muyinga in which a fish net was used as flooring system. This is the only example in which competence destroying activities were required for both the delivery and the use of the element, and yet it did produced positive impacts in terms of social response and environmental behaviour. All the other examples suggested that robust technical solutions, especially in the case of internal partitions, were preferred.

Environmental Control Systems

Environmental control systems such as water, lighting, heating and ventilation systems play a crucial role in the achievement of environmental performance of building projects. Yet the type of impact that such building characteristics can achieve is multi-fold. The environmental indoor characteristics of a building can impinge on the social ability to perform within such space, for example it was reported that in The Edge Office Building the productivity or the employees was increased thanks to the quality of the indoor space. Moreover, environmental control system can contribute to reduce the life cost of a building by producing strategies that can decrease the energy consumption and therefore its cost. The strategic use and definition of environmental control system are generally determined during the eco-innovation, and in some cases the eco-ideation phase, for example in the case studies of The Bullit Center or in The Ballard Library, which aimed at achieving the Living Building Challenge satisfaction already during the programming phase. To develop such strategies competence enhancing activities are required by the designers, engineers, and consultants, yet in some cases competence destroying activities are also required by the client and the users, for example in the building The Edge where the users had to learn a new manner to use the building. Environmental control systems by definition seem to define the boundaries of system innovation, as they literally are a series of punctual innovations that create synergies and contribute to the performance of the building. It was also observed, from the case studies analysed, that passive strategies were preferred in rural contexts (i.e. The Dixon Pavilion Water Foundation, The Gando School, or the Muyinga Library), where the micro-climatic characteristics were more favourable in terms of least influence from other built pre-existences, whereas in urban context, often hybrid solutions between passive and mechanical approaches were needed (i.e. The Ch2 Building, The Pixel Building, or the 41 Exhibition Office Building). Moreover, as previously mentioned very innovative solutions were proposed in the application of smart technologies to increase the environmental performance of building, as well as empowering the users in taking active actions toward the energy consumption reduction. The strategy of empowering the users with tools that can help them to take responsibility and understanding the consequence of their behaviour in terms of energy consumption was indicated by many designers as a future strategy to undertake. Within many certification agencies and systems the operability of some building components (such as windows openings) are indicated as a social strategy to achieve the same goal, yet it was found the an interface that can help the user to interact with the building in an easy way is required (i.e. The Water Dixon Pavilion or The Edge Office Building). Such strategy can achieved either with smart technologies, or with interior design solutions that highlight behavioural patterns and help understanding the importance of environmental decisions during the use of a space. As previously mention, The Edge Office Building offers examples for both strategies, by providing an app on the phones of the users to allow them varies the indoor micro-climatic conditions, as well as by providing them green-coloured plugs, directly feed by the photovoltaic panels, to indicate where to charge personal smart phones or laptops without imping on the overall building energy consumption. These solutions called for competence destroying activities by the users and therefore generated an impact on the eco-institutionalization phase on the social domain. Environmental control systems, and therefore system innovation, were found to be the core innovation type of strategies among the case studies analysed, and this might be due to the progressive call for climate change actions among most countries.

Water treatment and sewage connections

Although in many building project analysed strategies of water collection and storage and reduction of potable water in the building were utilised, the treatment of water is still a ground to explore. Only few examples, such as the Ecopolis Plaza in Madrid, Spain, or the Rainbow in the Desert in Ventanilla, Perù, relied on water filtering and treatment that allowed the use of grey water for further usages. With the only exception of The Netherland, in many countries water shortage still represent a crucial issue to overcome, and therefore strategies related to water collection, storage and treatment in those areas represent path for innovation and technological advancement. Similarly, sewage connections are an area of building characteristics that could be developed further. Among the project analysed, most of the case studies relied on incremental innovation, and therefore connected to existing technological solutions, whereas in the majority of developing countries analysed, the local sewage system was non-exiting.

6.4.2 Delivery process:

Building Opportunities Generation

This project delivery phase include the definition of stakeholders, resources definition, and reasons to start a building project endeavour. Aspects of this phase overlap with the eco-ideation level of the eco-innovation and sustainability management model by Bossink (2009). This phase was critical to determine the scope and the nature of the building projects analysed, as well as the behaviour and role of stakeholders involved. This phase of the delivery process is the strategic moment that need to be informed by the relation between innovation types, impacts, and sustainability results. During this moment, commissioning, financing and programming are crucial activities to establish and determine the strategic approach and the future results that a project can achieve. During this phase, it would be critical to share technical knowledge and inform the decision-makers on the potential of the project in terms of economic, social, and environmental results. As showed in a number of projects, such as the North American case study, this can be achieved through the implementation of integrated procurement processes, in which knowledge and participation can allow the understanding of the users need, as well as the technical implications. Other cases, such as the one of the Primary School of Gando in Burkina Faso, in which the architect covered all the roles within this phase by taking the responsibilities of defining all the building characteristics and delivery strategies. Increasing the technical knowledge in this phase can help the stakeholders and the decision makers to produce briefing documents that can already vehiculate the introduction of sustainable innovation, and strategically determine the guidelines for the following phase of the delivery process. For example in this phase, it could be possible to determine strategies of labour training through the use of specific construction system and therefore establish policies for work development, as in the case of the African case studies analysed (excepted for the One Airport Square in Ghana), or the possibility of communicating the social implication of environmental sustainability by determining the strategy of including users in the design of the building use, such as in the case of The Edge Office building.

Building Scope and Formulation

The building scope and formulation phase is the one that include activities of program design, space boundaries definition, performance design, and specification definition. Among all the case studies analysed, most of the sustainable innovation delivered was developed during this stage. In this phase designers, engineers and consultants work in collaborative environments to design and achieve the desired performance of the building. in accordance with the founding of Bossink (2009), the sustainable innovation introduction was mostly achieved in this phase and promoted by architects. Also, in the analysis conducted, in most of projects – excluded the ones in which the government had an active role in establishing the desired sustainable results to achived – the architects were the ones that initiated sustainable proposals, and attempt to define the project in such way to generates social, environmental, or economic impact. Also this phase could benefit by sharing knowledge about users expectations and long term strategies in terms of impact generations.

Project Definition and Control

This phase is characterised by the definition of project organization, organization structure, procurement type. This phase is generally characterised by project management activities. In the projects analysed, it was reported that projects management discipline is largely based on the achievement of objectives such as cost, time and risk optimisation. Yet, these aspects can sometimes limit the sustainability ambitions of projects, which might require a more long term view on the management of such aspects. In many of the conducted interviews, the call for a turn toward a more sustainability orientated approach from the project management practice emerged. This phase of the project delivery would benefit from the inclusion of more sustainability principle in the core aims of the management practice, as well as the inclusion of the management actors into eco-ideation and eco-innovation levels, by sharing active roles and responsibilities in the introduction of sustainable innovation. Yet, this phase resulted to be very important in allocating the responsibilities of the innovation introduction strategy. The understanding of the roles and the opportunity that each actor has in the introduction of sustainable innovation is critical to determine the strategic development of projects, as within this stage technological priorities and design delivery characteristics are set.

Building Production

This phase is described by Tombesi (2008) as the moment in which materials and construction systems are selected, designed and produced. This phase is critical for the involvement of the industry, in particular manufacturer and suppliers. This is a crucial moment for the introduction of innovation due to the risk that the industry has to undertake in participating to innovative projects (Slaughter, 1998). In order to reduce such risk, it would be important to warn the companies about the type of change that the innovation will call for. Each building components could trigger disruptive change for the manufacturer and/or suppliers, and therefore understanding the type of innovation could help understand if the companies would need to undertake competence enhancing or competence destroying activities. For instance, Nigra and Marfella (2014) explained that certain building components characteristics might have different disruptive impacts on the supply chain. Specifically, in building facades components, for example, characteristics such as colours and type of materials might not have radical disruptive impacts, whereas dimensions can call for the need of new machineries, different facilities and quantities that companies might not be ready to sustain. The understanding of the type of change is therefore crucial to attempt reducing the risk for the industrial partners. Moreover, this understanding could also help define ad-hoc development strategies for the industrial partners through the participation on innovation projects that could allow them to develop positive change, in particular by starting new productions and open new markets. In this phase new manufacturing systems can be tested and implemented, as well as materials can be selected, tested and used. This could trigger local economies, by triggering economies of scale, industrial improvement, and market opening.

Building Erection

This phase comprises of site organization, assembly process, and testing definition that are generally carried out and managed by main contractors or construction companies. These actors build their competitivity on their history and therefore positive past experiences are crucial to their success. Yet, they are, in conjunction with the industrial partners, the ones that takes the highest economic risk in the building delivery process. Similarly to the supplier and manufacturer, these actors would benefit by the understanding of the type of technological innovation on projects and therefor to the degree of competence destroying required. This phase of the delivery process is also characterised by many development opportunities, as indicated by the case study analysis. In particular, the construction process can produce new building techniques and therefore producing progress; can be used as training for unskilled labour, and can test innovations and technologies opening new markets.

Building Functioning

The building functioning is a phase that also seem to be critical to the introduction and use of sustainable innovation. The case studies analysed showed that building use, maintenance and adaptability ate key moments to actively practice the implementation of sustainability. In particular, two strategies were highlithed in the projects analysed. The first strategy relies on procurement methods and contracts to ensure the sustainability goals are maintained also after the handover of building projects. An example of this strategy is the one that the 'soft landing' type of contacts that some construction companies are contracted with. These type of contracts are defined in such way to ensure the transition between the construction stage to the operational stage, in order to ensure the efficient functioning of the building and its correct use. A second strategy, used for example in The Edge Office Building or in the Dixon Water Foundation Pavilion, is to use the interface, either spatial or virtual, between the building and users to monitor and encourage sustainable behaviour, especially in the field of environmental control. At this stage, the correct use, communication and understanding of sustainability principles is crucial to the ability of building successful experiences and set examples and benchmark to change the industry, the behaviours and ultimately our built environment.

6.5 The role of context, the internationalisation and the role of building development strategy, smart technology

The analysis showed that, although a recurrence seems to exist in the relation between building characteristics, process, innovation type and impact, actors, and sustainability results, a number of external aspects play significant roles in determining the characteristics of sustainable projects. The analysis has highlithed at least three of such aspects: the role of socio-political and technical context, the internationalisation dynamics of the architectural practice, and the emerging role of smart technologies.

In line with Campioli (1993) the socio-technical and economic context of the projects analysed seem to be critical to the ability of introducing change within the building industry and to the larger built environment. This is due to the impact on projects of existing technical conditions, normative framework and labour characteristics and availability. The understanding of these aspects are fundamental to define, program and establish development strategies. In particular, Campioli (1993) explains that the relation between projects and context are critical to test and introduce new materials on the market; manage primary resources; implementing recycling strategies; develop and introduce technical innovation; and enhance the importance of building use and maintenance. Moreover, Campioli (1993) explains that sustainable development strategies should be therefore developed accordingly. Yet, Cooper, Hughes and De Loambaerde (2008) explained that globalisation dynamics could interfere with this approach. The analysis of the case studies conducted showed that although, many of the analysed projects have been conceived as development opportunities, the findings showed that, in line with Campioli (1993), it is essential to strengthen the collaboration between designers and industry with the aim of sharing knowledge about the characteristics and development opportunity of the industry, and overcome the technical fragmentation typically portraited as characteristic of the building industry. Moreover, the case studies analysed showed that to achieve such goals, inclusive design activities and technical responsibilities sharing are necessary to include the socio-technical context in the preliminary phases of the project delivery. This is critical because the conditions of the context are important to understand in order to assess the type and impacts of innovations that sustainable project could introduce. The analysis of innovation and type conducted had therefore to always refer back to the contextual conditions, as the degree of innovation is always related to the existing conditions rather than a global development status. Despite the knowledge transfer between professionals within International contexts, the building industry remains a local matter. The development strategy will leverage on the opportunity that the industrial context offers, yet the development direction will be always dictated by the long term view envisioned on political level of our built environment.

The second aspect is the one of the globalisation of architecture and the process of semantic homologation that the neo-liberal approach has generated in the industry (Cooper, Hughes and De Loambaerde, 2008). Ruggiero (2010) explained that such approach was the one generated:'… *by the Guggenheim Museum in Bilbao and strengthened by the Disney Concert Hall in Los Angeles by Frank Gehry, in the last decade aimed at capturing the interest and the imagination of the public to trigger off processes of regeneration of individual districts if not whole cities have proliferated. Architects like Norman Foster, Peter Eisenman, Enric Miralles, Zaha Hadid, Daniel Libeskind, Renzo Piano, Will Alsop, Rem Koolhaas have created for private and public clients spectacular icons of urban architecture, arousing admiration and polemics in an equal measure'*. This approach generated remarkable modifications to the built environment and it aimed at triggering attention towards areas and cities that were not attractive before, imposing a commercial identity that was not related to the context. This was mostly established as an economic strategy that left behind considerations about social and environmental aspects, generating criticism and doubts about the architectural star system (Ruggiero, 2010). To some extent, this is the case of the SIEEB building in China and the One Airport Square in Ghana, in which despite the effort in achieving sustainable results, the buildings are aimed at delivering a 'Western' style, or in this specific instance 'Western' skills. In both case studies the involvement of designers, builders and suppliers is largely 'imported' from developed countries. On one hand this choice was to ensure the effective deliver of designs that were aimed at championing the environmental sustainability of buildings. Yet, on the other hand, this approach failed in engaging with the local industry and to produce a possible growth within the locals. It can be argued that these project could serve as setting benchmark and examples, but many other projects analysed in Africa has showed that the inclusion during the delivery process had economic and social impact also on a long term and therefore produced a more robust change in the industry, as strategic use of innovation for growth. This latter approach is explained by Ruggiero (2010) as:'*…the creation of eco-buildings with a modest environmental impact or which recall natural shapes, self-sufficient and even positive in energy consumption. A real cultural turn-a-bout ,using sophisticated technologies and their mutual interaction, has made respect for the climate and nature, the awareness of the fragility of natural environments the primary sources of inspiration for the architects in the creation of new urban icons. Natural materials and renewable energy, bio constructions and bio architecture in many cities , victims and at the same time responsible for the global climatic change ,* *are used both to improve the quality of life of the residents and to give life to the new architectonic icons and town planning of the eco-sustainable culture'.* Moreover, Cooper, Hughes and De Loambaerde (2010) explained that such concepts adhere to the idea of regionalism as societal-based groups that oppose to international neo-liberal approaches, changing the paradigm from the economic to the social domain.

The last aspect is the emerging role of smart technologies that are changing the way people live and also the way in which people interact with buildings and vice versa. The case studies analysis suggested that smart technologies are among the most radical strategies for reshaping the use of the built environment and at the same time they redefine the human behaviour. This findings is in line with the position of Visher (2005), who suggested that environmental control and users' perception of control influence, for example, workers on at least two levels: on the operational control and to the sense of empowerment. Both these aspects contribute to increase worker's spatial satisfactions and ultimately to increase their productivities, therefore generating, beside environmental efficiency, also social and economic results. As previously explained these approaches were found for example on the Dixon Water Foundation Pavilion, in Texas, in which the users had the operational control of determining the vertical cladding and partition configuration according to their perception of indoor quality; as well as in the case of The Edge Office Building, in The Netherland, in which smart technologies empowered the users with the control of the indoor environmental conditions. Moreover, through the use of smart technologies, tracking and mapping users' behaviour in a built environment can be crucial in order to understand the interaction between the living space and the users. This technique can be useful to achieve the aim of gather data and discover insights, while carrying on an evaluation of the building's functionalities (Germak, et.al. 2017). Adaptive technologies such as the use of sensors can help facilitate the interaction between human behaviour and environmental conditions. Smart technologies can therefore represent a strategy to enhance the adaptability of building and human behaviour, managing high number of data, complexity and multi-nature aspects and building characteristics. The use of smart technologies have therefore the potential to radically change the nature of the building in its use and life time, by generating radical impact on many levels. Yet, few examples of such use have been developed up to date and therefore it is still hard to predict the degree of impact that such project might be able to develop. The Edge Office Building in Amsterdam represented, for example, a starting point for the firm PLP Architecture, which is aiming at replicating the use of smart technologies as environmental control strategy in the Oakwood Timber Tower project in London. Among all the case studies analysed this project set the path for potential radical innovation in the design of sustainable buildings, which is definitely a future field of study and research to explore, as it might change radically the innovation introduction and use dynamics in the field.

The chapter has discussed the findings obtained after conducting the case studies analysis in the previous chapter. In this chapter, innovation type and impacts were discussed, as well as role and behaviour of actors, and sustainability results. Moreover, by exploring the building characteristics and the project delivery phases, the chapter has highlighted the opportunities and the links between the constituting elements of the building project conceived as complex systems. Moreover, in Appendix D all the links between these constituting elements were highlithed as a strategic matrix that can show the characteristics of sustainable innovation introduction dynamics. This matrix is important to shed light on the opportunity and potential risk factors of competence destroying activities for the actros involved into sustainable innovation introduction. Such matrix should also inform on the building characteristics and delivery process phase that can generate specific environmental social, or economic results. The chapter has also mentioned three crucial aspects that could influence the introduction of sustainable innovation and development strategies, namely: the role of context, the globalisation of architectural practice, and the role of smart technologies within the area of sustainability for the built environment.

Chapter 7

Conclusion

In this chapter, the author proposes concluding reflections about the identification of patterns of sustainable innovation and its introduction dynamics in the building industry, as well as their the importance in regard to future built environment. To do so, the chapter presents an overview of the role of sustainable innovation management in the industry, a reflection about the relation between economics and design organizing, and a proposal for future studies. Within these areas, the chapter in particular concludes by answering to the four research sub-question, specifically by discussing: 1) the importance of promoting diversity of innovation and the repartition of risks and impact of innovation; 2) the need for collaborative environments and integrated forms of procurements; 3) the different links between strategic development approaches and building characteristics; and 4) the possible links and relations between types and impacts of innovation, building design characteristics and sustainability results achieved, in such way to overcome the risk of uncertainty in the introduction of sustainable innovation.
Overall, the chapter offers insights and suggestions on the sustainable resource management that can contribute to the process of shaping our future built environment.

7.1 The role of sustainable innovation management in shaping the built environment

The challenges that our planet is facing today are complex, multi-fold and ever changing (United Nations Development Programme 2015). The field of architecture and building, in line with many others, is called to define new technical solutions, envision scenarios and propose innovative approaches. Although innovation is largely discussed as a medium of advancement and progress (Emmitt, 1997; Gann, 2000; Henderson and Clark, 1990; Lindgren, 2016; Slaughter, 1998; Winch, 1998; Gambatese and Hallowell, 2011), its nature (in terms of type) against specific development objectives remains an area of possible further exploration. This work, in line with Leach et al. (2012) has shed light on the importance of diversity of innovation, on the crucial roles and organization types that can foster the introduction of sustainable innovation in the industry. The work has explored also the links between building characteristics, delivery process organizations and possible sustainability results. This exploration is significant to demonstrate that certain sustainability results are possible and valuable without necessarily relying on disruptive solutions typical of radical innovation, and that a design management process aimed at achieving sustainability results can lead to better informed project development strategies based on the optimization of type of innovation and role organizations defined in relation to specific projects objectives. Such information is crucial for all the parties involved in building project developments, as the economics – conceived as all the activities to manage resources - and project organization characteristics play a crucial role in shaping the development of our built environment. The understanding of how to manage the resources on building projects (e.g. materials, labor, capital) is a responsibility that call for actions institutions, clients, designers, consultants, builders, industry participants, and users. The understanding of the nature of change and its impacts are therefore important to attempt proposing strategies in line with alternative and more sustainable economic models and approaches.

7.1.1 Opportunities and limitations of complexity as lenses for the analysis

This work has taken the ontological position of considering building projects as complex systems. As Allen (2008) explained, the built environment is a multi-layered and multi-nature system subjected to continuous evolution. The field of architecture and the building industry have been described already by many authors as complex systems, characterised by many levels of domains and meanings (e.g Bachman 2008, Turin 1981, Winch 1998). The call for sustainability has pushed the practice to enhance the emphasis in considering climatic changes, social fragility, and economic scarcity. These domains are intertwined, complex, and characterised by different nature. With the aim of gauging the importance of such complexities, this work developed a methodological approach to gauge the interconnection (links, feedback loops, and variables) between different parts of the complex system analysed, without losing the ability of understanding the specificity of the analytical areas taken into consideration (characteristics of the constituting elements). This approach contribute to strengthen the description that Bachman (2008) provided of the 'first encounter' of architecture with complexity, and in particular the one that sees buildings either as ecological dimension of complexity and the one that conceived it as organizational flow, in line with Groak (1992). Within this theoretical context, the work focused on the nature of sustainable innovations in building characteristics and delivery processes; the actors that enabled the introduction of such innovations; the economic, social and/or environmental results achieved by such design and organizational solutions and decisions; and the links between all these aspects. This proposed approach departed from existing disciplinary assessment methods commonly utilised in the field of sustainability, by trying to read simultaneously environmental, social, and economic aspects, as well as considering together qualitative and quantitative characteristics of the complexity of sustainable building projects and their development processes. Moreover, this approach considered both building projects and delivery process as a unique system able to generate sustainable development and advancement, and therefore enhances and highlights opportunities. The approach can be applied in as built circumstances, in order to revise and learn from design and management solutions taken; or also as a modelling systems of the cause-effect relations of the design and organizational decisions in a programming phase of projects developments. This latter application can offer support in testing design solutions and immediately provide a cross check of the possible environmental, social and economic impacts to be produced, empowering therefore designers with the ability of designing desired impacts already in the preliminary phase. In particular, such approach can offer an understanding of the nature of design change in relation to the potential results to achieve, and help highlighting paths of types of required innovation according to specific contextual characteristics and specific objectives. This methodological approach attempt to overcome the limitations of the studies highlighted by Wolfe (1994) and King and Anderson (1995) – such as the length of the data collection; the scattered nature of type of data; and the third reason is the plurality of units of analysis – by utilizing building projects as unit of the analysis as they are the convergence of plurality of information and socio technical levels. Yet, the application of such methods required the ability of reading and interpreting different source of information, as well as facing potential barriers and limitation in information diffusion by the parties involved in project deliveries. Despite many authors have discussed the lack of studies assessing types of innovation within the sustainability literature (Dickinson, Cooper, and McDermott 2005; Slaughter 2000; Sidwell et al. 2001; Ling 2003), the analysis conducted in this work has proven that the categories defined by Slaughter (1998) namely: incremental, modular, architectural, system and radical seem to offer an accurate description of both types of design change departing from standard solutions, and possible application to the building artefacts. It was in fact possible to understand the correlation between type of innovation and recurrence of such types in each type within categories of building characteristics. This understanding was particularly important in the relation to the a type of sustainability result achieved: social, economic and/or environmental. Highlighting these links is crucial to inform strategies of innovation introduction in relation to development objectives. Moreover, by relying on the concepts of 'competence destroying' and ' competence enhancing/creating' defined by Shilling (2010) it was possible to provide an indication of potential risk in undertaking the introduction of each type of innovation type analysed. This was a critical finding as it might be significant to warn all the actors involved in a project delivery about the need of developing new knowledge, skills or materials, or by relying on the existing ones within the core of everyone's activities. This understanding is crucial to the attempt of reducing the risk of uncertainty highlighted as one of the major barrier to sustainable innovation in the industry, as highlighted by many authors (e.g. Nam and Tatum 1995, Tombesi 2008, Slaughter 1998). Moreover, in order to suggest strategies to overcome barriers such the socio-technical fragmentation of the industry (e.g. Gann and Salter 2000, Winch 1998, Tombesi 2008, Turin 1981), the analytical approach used in this work relied on the eco-innovation and sustainable management model by Bossink (2009), which allowed to explore the individual behaviour beyond standard roles. The use of such model allowed to trigger considerations about the need for more integrated organizational form and the need for considering behavioural approaches. In particular, the model has allowed understanding that positive behaviours in fostering sustainable innovation introduction can be found within participants regardless the institutional roles that they are undertaking. This is an important finding as it suggests that the initiative to promote sustainable practice can be generated and nourished by any of the actors involved in the project deliveries, despite degree of technical knowledge or operational power. In line with Hakkinen and Belloni (2011), this work has also observed and linked types of sustainability results within the environmental, economic and social results. The ability of reading such results depend upon the information availability. This is due to the scattered and multi-nature characteristics that characterised such domains. The approach of this work was to collect and observe both qualitative and quantitative data, observing simultaneously the impacts generated. This approach in line with Edmonds (1999), Bertuglia and Staricco, (2000) and Dioguardi (2000) is aimed at observing the plurality of results and meaning that can be find within the output of building delivery processes. The more results are observed and the more accurate the description of sustainable building as complexity system will be. The ability of providing such description can provide the basis to develop models that can be describe and analysed with precise rules that could predict dynamics developments and links between social, economic and environmental impacts, as suggested by Gidado (1996). This understanding is critical to define sustainable development strategies suited to specific contexts, in such way to respect and enhance ad-hoc development opportunities. As suggested by (Edmonds, 1999; Bertuglia and Staricco, 2000; Dioguardi, 2000) in the case of other complex system, this system would require to be applied to a significant number of building projects, in order to observe the system behaviour according to difference variables and characteristics. Specifically, the methodology could provide the base for a statistical analysis of the recurrence of specific dynamics and characteristics that the innovation introduction can generate on the system, highlighting areas of possible development opportunities, warning of possible risks of system disruption, and helping decide how to allocate and manage resources in the building industry.

7.2 Economics and sustainability in design organization

The building industry, as many other industries, represents a remarkable part of the economic output of countries (Gann 2000, Ruddock 2009). This is because economic activities are those actions that describe how resources are managed within a certain domain. In particular, the Merriam-Webster Dictionary defined an economy (From Greek οίκος – "household" and νęμομαι – "manage") as a social domain that emphasizes the practices, discourses, and material expressions associated with the production, use, and management of resources. Moreover, economic agents can be individuals, businesses, organizations, or governments. The building industry is responsible for resources consumption, transformation, waste generation, and for the creation of long-lasting output characterised by plurality of meanings (Turin 1981), and therefore it is concerned with the practices, discourses, and material expressions associated with economies. The call for sustainability has sharpened the request of attention toward the wise use of resources of different nature, and therefore the industry had to develop tools, approaches and behaviours that could address such request (Helsen and Nilsson 2016). Within this context, the building industry is trapped within the tension between development models based on the idea of progress relying on unlimited resources (Schumpeter 1942; Solow 1956; Schmookler 1966; Freeman 1974; Scherer 1982; Ruddock and Ruddock 2009), and the alternatives ones that either suggest to consider resources limited (Georgescu-Roegen 1975; Daly 1993) or even far past the limits of possible exploitation (Martinez-Alier, Pascual, Vivien, & Zaccai, 2010). The findings of this work has showed that the sustainable building projects analysed seem to be the reflection of such theoretical models. For example, projects such as the Earthship school in Uruguay represents an economic design and organizational approach that attempt to re-use existing resources and unskilled labour, adhering to the idea of economic de-growth and reduction of material exploitation and output impacts. Another examples that considered instead resources as limited are the ones of the case studies of projects characterised by use of local materials, unskilled labour, and passive environmental control strategies. Often these case studies are the one analysed in the developing countries or within rural contexts, such as the Primary School of Gando, in Burkina Faso, the ECDC Centres in Rwanda, or the Library of Muyinga in Burundi, Africa. Yet, there are also cases in the developed countries in which an attempt of considering limited resources and wise management activities were undertaken, for example in the case of the Scottish buildings; the Culloden Battlefield Visitor Centre, the Robert Burns Birthplace Museums, or in the one of Guastalla Kindergarten in Italy. These projects relied on strategies that considered economic limitations, use of local materials and labour, environmental synergy and long term social impacts, attempting limiting the impacts on both resources consumption and output generation. A last category was the one of projects that instead kept pursuing the technological progress and at the same time acknowledging the need to address climate issues and resources awareness. An example of such category is The Edge Office Building in Amsterdam, The

Netherlands, in which technological progress and radical innovation were used to both maintain competitive economic returns for all the actors involved, and at the same time addressing behavioural changes in regard to environmental control systems by the users. This was achieved by the use of smart technologies, as an approach that in somehow seems to remains within the classical economic models that push for progress, but at the same time attempt to shift the paradigm from the consumption of physical resources to the one of knowledge, as suggested by Daly (2013). Specifically, Daly (2013) suggested that since knowledge growth has no limits, it can be – even though with some limitations - considered the ultimate resources that can support the idea of economic growth without limits. These examples show that buildings are the output of economic, design and organizational activities, which by definition (Merriam-Webster Dictionary) are a 'representation by means of signs'. Among a number of definitions, the Merriam-Webster Dictionary defines the verb 'to design' as…*'An underlying scheme that governs functioning, developing, or unfolding'.* It is therefore critical for the actors involved in the building sector to understand their role and responsibilities in defining characteristics of design and organization under the aegis of sustainability needs. This is because every design solution or organization is structured, the design and building activities will have an impact on the future of our built environment. It is therefore essential that the actors involved in the design and building practice understand the implication of managing innovation dynamics as they are the critical vehicle to progress and development. The understanding of such nature is critical to understand to which model we are contributing to with our design decisions and which opportunities we have to actually make a change. To do so the understanding of the relation between types of innovation, impacts, responsibilities and results is crucial to understand how to better manage our resources, and to shape our future built environment.

7.2.1 Design variables, roles, and links

This work has contributed to the understanding of how to better manage our resources, and to shape our future built environment, by shedding light on the role of innovation types, impacts, roles and responsibilities of actors involved on projects deliveries, sustainability results, and the links between all these aspects, by providing observation of patterns in thirty building case studies. These aspects are important to highlight opportunities and limitation in resources utilisation and therefore to the ability of defining informed strategic design directions and solutions. Ultimately, the understanding of design variables, roles and links can help the actors involved in project delivery to contribute to a larger discussion regarding economics models and sustainable future.

The understanding of the different nature of innovation can help stimulate design solution and organization structures that are able to target objectives which are specific to each unique project development and that therefore might require different level of change and impact in relation to their socio-technical context. The role of context is not only crucial to the way in which resources are put together in the building industry (Campioli 1993), but also in terms of possible output that can shape the economic, social and environmental characteristics and future direction of a country. This work has found out that, conversely to the position of Pries and Janszen (1994) whom explained that incremental innovation is the most relevant in occurrence in the building industry, incremental and modular innovation seem to be limited in sustainable projects only to specific areas of projects design and organizations (e.g. in the foundation systems, door, windows, fixtures), with the ability of producing slower changes in the industry (Norman and Verganti, 2014). In line with the definitions of Henderson and Clark (1990) and Slaughter (1998), this work has found that architectural innovation is a reconfiguration of an established system to link together existing components in a new way, providing opportunities to optimize established solutions to achieve efficiency through the improvement of the links between components, such as for example in access and circulation, the shape, the volumetric arrangement, the layout, or the relation between opaque an transparent elements in a building. the impact of such innovation are greater than the one founds in incremental and modular innovation, and might generate more significant changes within their socio-technical context. Yet, the type of innovation that seems to be more utilised in the context of sustainable buildings is system innovation. In line with Lindgren (2016), this work has found that despite system innovation has been traditionally considered as secondary to other types (e.g. radical innovation), a progressive need and attention for such type has been developed, both in practice and within the specific literature. This might be due to the ability of system innovation to generate synergies between parts and high degree of optimisation in resources consumption, use and output, and therefore to show optimal characteristics for enhancing the opportunities within the environmental domain. Radical innovation remains of significant and strategic importance in the industry of developed countries. Being the classic economic models still the dominant (Gavin 2011), radical innovation is still portrayed as the most effective vehicle to progress and development. Yet, as explained by Slaughter (1998) and Winch (1998), radical innovation trigger disruptive processes, impinging heavily on the existing contextual conditions both in terms of resource consumptions and output. Although these characteristics might sound contrasting the positions established by the call of sustainability, Daly (2013) highlithed potential limits and opportunities in shifting the paradigm and the vision of radical innovation and growth from the consumption of physical resources to the one of knowledge, as an alternative to maintain the ability of further unlimited economic growth.

This work has also highlighted the role and behavior of the actors involved in sustainable projects and discussed the opportunities that each role has in introducing sustainable innovation. Conversely to the majority of authors pointing out the socio-fragmentation in the building industry (e.g. Gann and Salter 2000; Nam and Tatum 1997; Bowley 1960; Slaughter 1998), this work has found out that collaborative environments and integrated forms of procurements are the ones that better enabled the introduction of sustainable innovation. Such approach helps overcome the differences in technical knowledge and skills among actors, and therefore to bridge gaps between different management levels. In particular the work has found out, that despite the role of institutions has been largely portrayed (e.g. Seaden and Manseau 2001) as one of the key contributor to innovation introduction, institution do not play always an active role in fostering innovation. A number of projects analyzed – for example the Makoko Floating School, or the Primary School of Gando - showed that not only the government was absent in the normative framework or policy regulation, but it also learned from such projects, which set the examples for the definition of ad-hoc development policies. This observation trigger the consideration that whenever the institution fail supporting progress and development, other actors can still undertake the role of champions, entrepreneurs and or leaders in enabling sustainable innovation. This work has in fact highlighted that the role of clients is instead one of the most critical to enable sustainable innovation, since it is an 'open position' that anyone can occupy. Conversely to Nam and Tatum (1997), whom explained that clients and owners play an active role in taking programming decisions, and defining technical matters, throughout the entire delivery process, this work highlighted that regardless the degree of technical skills or knowledge, any individual or institution can take the role of client. Yet, the success of such organizational position depends upon the degree of collaboration among all the actors involved, in such way to fill up the knowledge gaps that might exist throughout the process. This aspects might shift the degree of risk from the building companies and industrial partners, to the management level, that would require a high degree of competence and involvement throughout the entire delivery process, in line with the position of Nam and Tatum (1997). Another very important role is played by the designers (e.g. architects, consultants, engineers). As already identified by Bossink (2011) architects have been, since a number of years, playing an important role in triggering sustainable design solutions and striving for innovation. This work, in line with Nam and Tatum (1997) has also founded out that designers have a cross level position in the processes of delivering sustainable projects, and therefore can facilitate the communication among parties and knowledge sharing to fill the gaps between actors. This might be due to the multi-layered nature of their profession, which appeared to be often subjected to competence destroying activities, and the consequential need of creating and communicating new knowledge on every project. Although the role of the builders have been defined as the most risk-averse category within the industry, and many companies maintain a conservative behavior in the industry (Gann and Salter 2000; Slaughter 1998), this work has found that a number of building companies has started understanding the opportunities of participating in sustainable innovative building endeavors, by taking part already in the early part of the programming phase, or even by exploiting the commercial competitive return that sustainable projects can provide. Yet, industrial partners instead, such as suppliers and manufacturers seem to still act as external collaborators to project deliveries and their decision making processes. Despite the opportunity of setting strategic development path through testing innovation in building projects (Pries and Janszen 1995), the industrial partners seldom appeared in the early programming phases or within decision-making processes of the projects analyzed. This absence fails to establish a fruitful connection with the industry and to trigger, define and structure strategic development process for the industrial milieu. A last very significant role was identified in the one of the users. The involvement at different stages of the delivery projects seems to represent a key strategy to generate ling term impact on the social, economic and environmental level. Strategies such as decision making inclusion, construction participation, and/or empowerment in the environmental control processes represented successful approaches to attempt generate a change in the operational aspects of the built environment.

This work has also shed light on the links between design variables in building characteristics and delivery process and the types of results achieved. The understanding of these links is fundamental to help overcome the knowledge gaps typical of the industry (e.g. Gann and Salter 2000; Nam and Tatum 1997; Bowley 1960; Slaughter 1998), as well as to empower all the actors involved in projects delivery to attempt determining informed design strategies since the early stage of the delivery. Moreover, by knowing such links and relations could help overcome the risk of uncertainty when change is triggered within processes and competence destroying activities are required. Examples of such links were found in the relation between: 1) strategies of environmental performance-based approach, low tech local materials and sustainable supply chain, or a user-based design and environmental results (e.g. the ones defined by the United Nation Development Program 2017, The World Green Building Council 2016-2018, the International Association for Impact Assessment IAIA, 2018); 2) delivering tasks on specific projects within budget, knowledge acquisition goal potential, and/or achievement of economic profit and economic results (e.g the ones explained by Maneschi, 1998 and Ruddock 2009); and 3) building programming phase as social definition of the scope of the project itself, social inclusion by leveraging onto the delivery process, both through participated/integrated design, and/or participation during the construction process, and interaction with the user to promote social behaviour and individual empowerment, and social results (e.g. as explained by Dimitrijevic and Langford 2007, Lawther and Nigra 2013, Jones, 1988). The emergence of these links was possible by leveraging on the opportunities that design variables both in building and in process offered to introduce sustainable innovation. For example, building characteristics such as the context (e.g. micro climatic characteristics, orientation) can inform and allow environmental strategies from the early phase of building programming; architectural design (e.g. aesthetic approach, concept, shape, dimensions, floor number and height, access and circulation) can generate remarkable impacts on the social context; construction systems (e.g. structure, envelope, roof, foundation systems) can provide opportunities for economic and environmental development – and to some extent also social, and environmental control systems (e.g. water systems, lighting, heating, ventilation) can and have to generate impacts on the environmental context. Also, the delivery process can offer opportunities for social, economic and environmental development. For instance, the phase of building opportunity generation and building scope and formulation can address from the early stage of projects aim and nature of sustainable endeavours, as well as actors involvement; whereas project definition and control, building production, building erection, and building functioning can facilitate the integrated procurement methods that have been proved to facilitate sustainable innovation introduction. Moreover, these latter phases of the project delivery can present opportunities for social development, inclusion, economic advancement and environmental strategies introduction and results achievement, as explained table 1, in chapter six. Understanding such meanings and opportunities can enrich the design process and the organizational structures of projects. As previously explained the economics role of design and projects organization is the key to the contribution of shaping a future sustainable built environment, and the ability to read links between design variables, roles, and sustainability results is crucial to definition of informed sustainable innovative strategies, that could help overcome some of the barriers typical of the nature of the building industry.

7.3 Future studies

At least two streams of research should be further investigated. Firstly, in line with Edmonds (1999), Bertuglia and Staricco (2000), and Dioguardi (2000), more case studies would need to be explored with the aim of refining the observations about the behaviour of sustainable projects conceived as complex systems. This will be critical to collect more data, variables, roles behaviour, and external contextual aspects that might influence the ability of introducing sustainable innovation in building projects. Moreover, the observation of possible social, environmental and economic results will need to be further explored and mapped. Despite many tools can address the parameters to understand and describe the environmental and economic results (e.g. BREEAM, LEED, HQE, Life Cycle Cost Analysis, Value Engineering), the social results seem still to be difficult to gauge, and yet very important to shape our future built environment. With the increase of number of case studies, it would be possible to run statistical analysis to help describe the nature of components and links between variables, characteristics and results. Such analysis could contribute to the definition of a possible second stream of research, which should focus on the development of a tool that could inform possible risk and opportunities. Such tool could shed light and mathematically weight the links between design variables, type of impacts (and therefore risk), and possible achievable results, with the aim of generating general model that could assist future projects development in the management of sustainable innovation. Understanding these strategic opportunities and aspects can contribute to the development and management of our future sustainable built environment by informing designers, policy makers, industry participants, and management and consultancy entities. Yet, it remains crucial to explore further the direction of change (Leach et al. 2012) that any innovation can lead to. Leach et al. (2012) suggest that clear goals and principles driving development policies and innovation strategies need to address the kind of transformation we envision for our future, as well as consider the trade-offs that often lie beneath complex environmental, economic and societal contexts. Within this context, in a 'Mumfordian' way, architecture, on one hand can still be considered the reflection of the societal changes that we decide to address, and on the other hand it has the role of communicating the changes by providing appropriate responses to the emerging societal needs.

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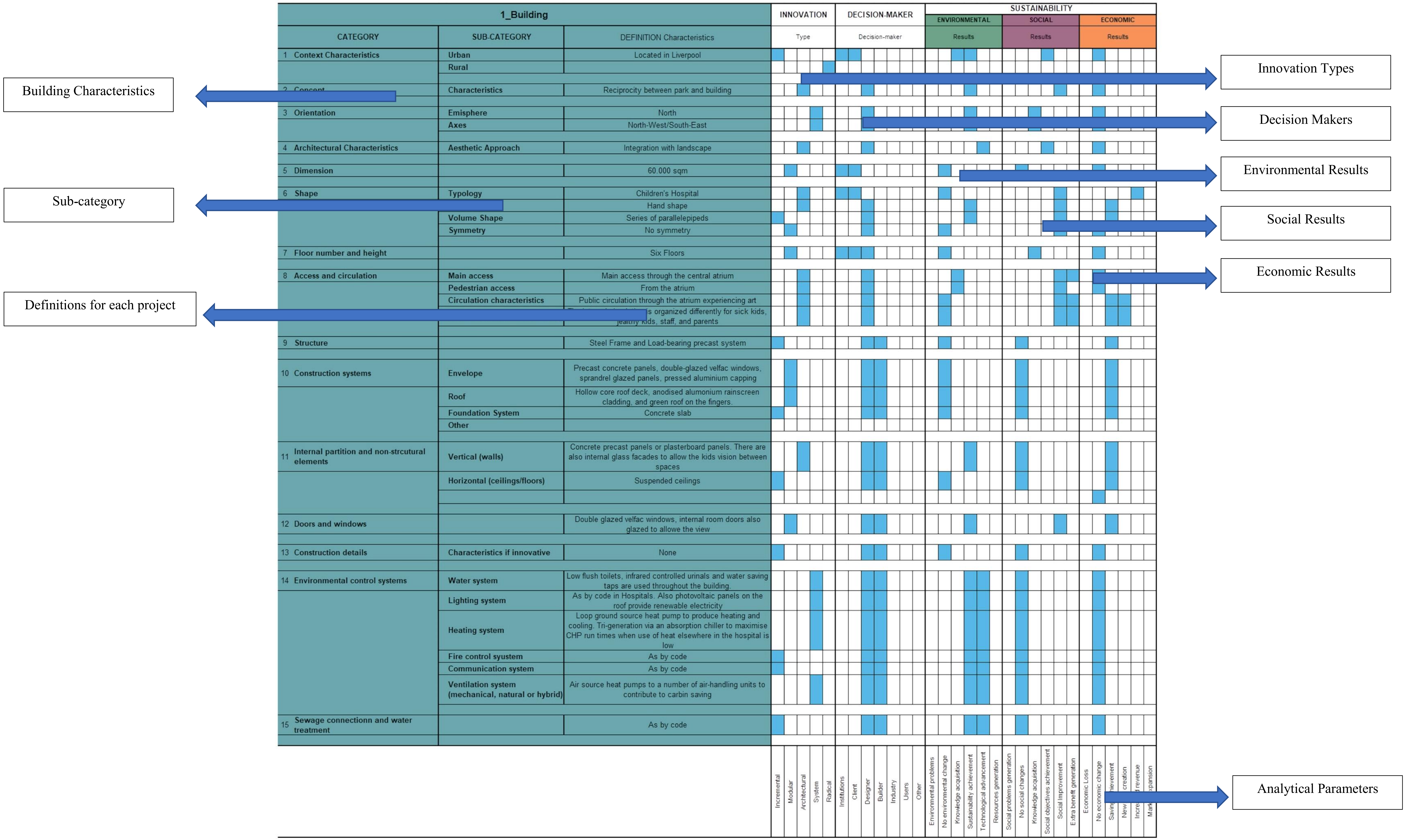
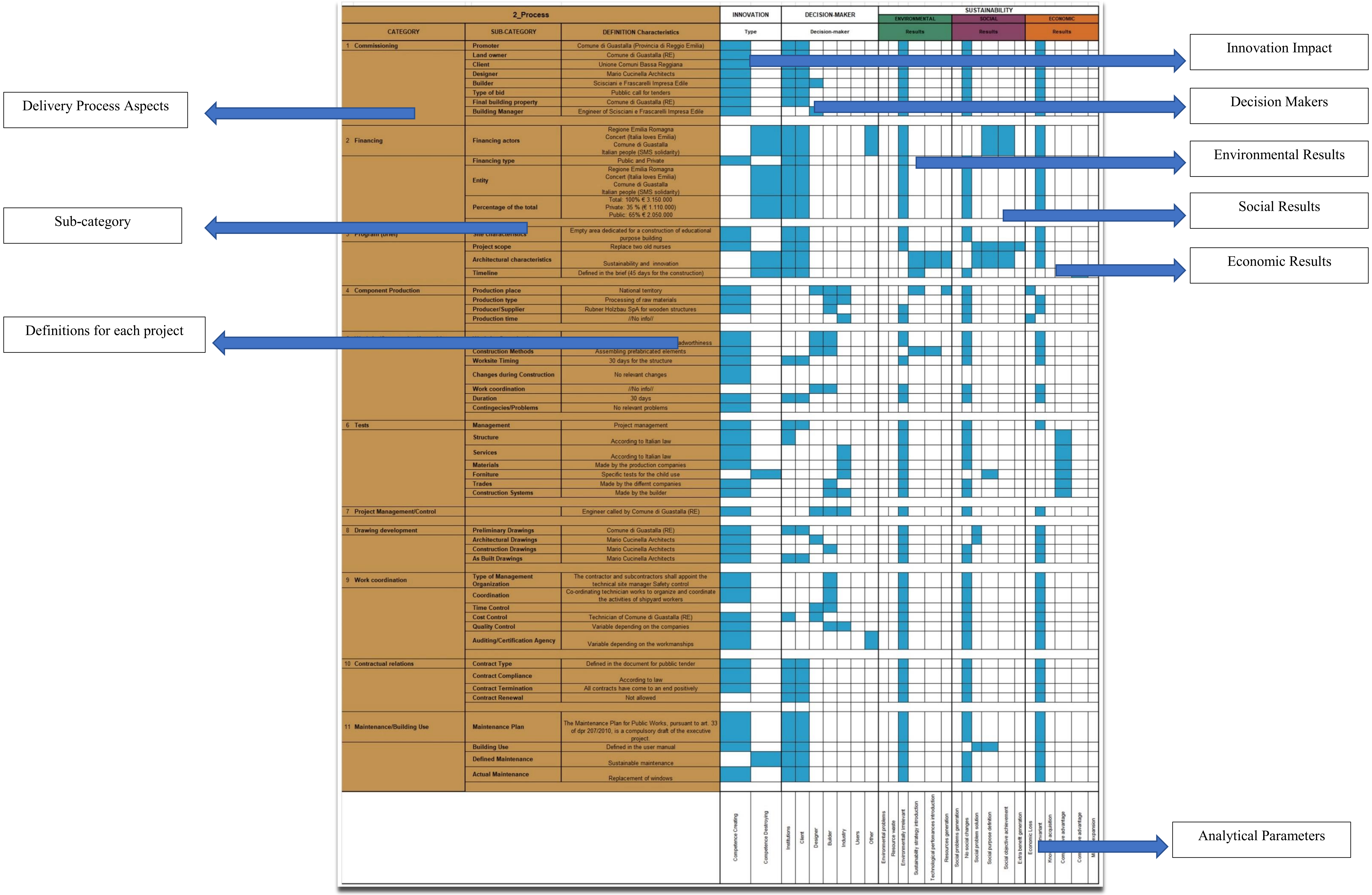
Appendix A

Working Frame Template – Building


Building Characteristics
Sub-category
Definitions for each project
Innovation Types
Decision Makers
Environmental Results
Social Results
Economic Results
Analytical Parameters
1_Building
INNOVATION
DECISION-MAKER
SUSTAINABILITY
ENVIRONMENTAL
SOCIAL
ECONOMIC
CATEGORY
SUB-CATEGORY
DEFINITION Characteristics
Type
Decision-maker
Results
1 Context Characteristics
Urban
Located in Liverpool
Rural
Characteristics
Reciprocity between park and building
3 Orientation
Emisphere
North
Axes
North-West/South-East
4 Architectural Characteristics
Aesthetic Approach
Integration with landscape
5 Dimension
60.000 sqm
6 Shape
Typology
Children's Hospital
Hand shape
Volume Shape
Series of parallelepipeds
Symmetry
No symmetry
7 Floor number and height
Six Floors
8 Access and circulation
Main access
Main access through the central atrium
Pedestrian access
From the atrium
Circulation characteristics
Public circulation through the atrium experiencing art
healthy kids, staff, and parents
9 Structure
Steel Frame and Load-bearing precast system
10 Construction systems
Envelope
Precast concrete panels, double-glazed velfac windows, sprandrel glazed panels, pressed aluminium capping
Roof
Hollow core roof deck, anodised alumonium rainscreen cladding, and green roof on the fingers.
Foundation System
Concrete slab
Other
11 Internal partition and non-strcutural elements
Vertical (walls)
Concrete precast panels or plasterboard panels. There are also internal glass facades to allow the kids vision between spaces
Horizontal (ceilings/floors)
Suspended ceilings
12 Doors and windows
Double glazed velfac windows, internal room doors also glazed to allowe the view
13 Construction details
Characteristics if innovative
None
14 Environmental control systems
Water system
Low flush toilets, infrared controlled urinals and water saving taps are used throughout the building.
Lighting system
As by code in Hospitals. Also photovoltaic panels on the roof provide renewable electricity
Heating system
Loop ground source heat pump to produce heating and cooling. Tri-generation via an absorption chiller to maximise CHP run times when use of heat elsewhere in the hospital is low
Fire control system
As by code
Communication system
As by code
Ventilation system (mechanical, natural or hybrid)
Air source heat pumps to a number of air-handling units to contribute to carbon saving
15 Sewage connectionn and water treatment
As by code
Incremental
Modular
Architectural
System
Radical
Institutions
Client
Designer
Builder
Industry
Users
Other
Environmental problems
No environmental change
Knowledge acquisition
Sustainability achievement
Technological advancement
Resources generation
Social problems generation
No social changes
Knowledge acquisition
Social objectives achievement
Social Improvement
Extra benefit generation
Economic Loss
No economic change

Appendix B

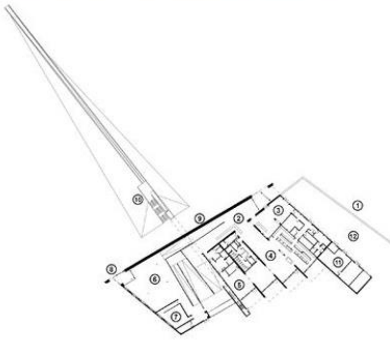
Working Frame Template – Process


Innovation Impact
Decision Makers
Environmental Results
Social Results
Economic Results
Delivery Process Aspects
Sub-category
Definitions for each project
Analytical Parameters
2_Process
CATEGORY
SUB-CATEGORY
DEFINITION Characteristics
INNOVATION
DECISION-MAKER
SUSTAINABILITY
ENVIRONMENTAL
SOCIAL
ECONOMIC

Appendix C
Case Studies' Working Frames

Culloden Battlefield Visitor Centre
Culloden Moor, Scotland, UK
Gareth Hoskins Architects
2007

Context Characteristics:	Rural
Concpet Characteristics:	Integration with landscape and Jacobites moves during battle
Orientation:	North-West/South-East
Dimension:	2400 sqm
Shape:	Double L plan layout. The volume follows the main orientations of the landscape
Floor number:	Single floor with accessible roof
Access and circulation:	Circulation is either external or internal to see the battlefield or the building as part of the visiting experience to recreate the movement of the battle of the Jabobite clans
Structure:	Steel frame on concrete slab
Construction systems:	Highly insulated timber walls and roofs. External walls are mainly clad with untreated Scottish Larch and Caithness Stone
Evironmanetal control systems:	Natural light and high efficiency lighting with automatic lighting controls Massive Insulation and a fully automated woodchip boiler system A passive ventilation system was developed, combining opening windows and low-level vents, with high-level ventilation via parapets and roof cowls.
Water treatment:	Low flush toilets, infrared controlled urinals and water saving taps are used throughout the building
Awards:	The Civic Trust & Commendation, RIAS Andrew Doolan Award Best Building in Scotland, World Architecture Festival, the Wood Awards, Inverness Architectural Association Award, Glasgow Institute of Architects Award, RIBA Awards Regional Awards, Scottish Design



1_Building			INNOVATION					DECISION-MAKER							SUSTAINABILITY ENVIRONMENTAL						SOCIAL						ECONOMIC					
CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	Type					Decision-maker							Results						Results						Results					
1 **Context Characteristics**	**Urban**		■			■		■	■								■					■						■				
	Rural	Rural	■			■																										
2 **Concept**	**Characteristics**	Integration with landscape and Jacobites battle strategy			■	■				■							■							■	■						■	
3 **Orientation**	**Emisphere**	North		■	■			■	■								■					■						■				
	Axes	North-West/South-East		■	■			■	■										■	■		■									■	
4 **Architectural Characteristics**	**Aesthetic Approach**	Integration with landscape			■					■								■	■					■	■					■		
5 **Dimension**		2400 sqm		■				■	■	■							■					■						■				
6 **Shape**	**Typology**	Visitor Centre		■	■			■	■								■						■					■				
	Geometry	Double 'L' Plan Layout	■	■	■			■	■	■							■							■	■					■		
	Volume Shape	Parallelepiped		■	■			■	■	■							■					■						■				
	Symmetry	No symmetry	■	■	■			■	■	■							■					■						■				
7 **Floor number and height**		Single floor with accessible roof			■			■	■								■							■				■				
8 **Access and circulation**	**Main access**	Main access to the building or to the green roof			■	■		■	■								■					■						■				
	Pedestrian access	Access from carpark			■	■		■	■								■					■						■				
	Circulation characteristics	Circulation is either external or internal to see the battlefield or the building as part of the visiting experience			■	■				■							■						■					■				
	Circulation within the building	The internal circulation is based on the Jacobites movement during the battle, which is here re-organized in the visit strcuture of the building			■	■				■							■						■	■	■			■				
9 **Structure**		Steel Frame and Concrete Slab	■							■								■	■				■		■			■				
10 **Construction systems**	**Envelope**	Highly insulated timber walls and roofs. External walls are mainly clad with untreated Scottish Larch from a nearby estate, other areas are clad with local Caithness Stone and field stones salvaged from the site.			■					■								■	■			■					■					
	Roof	Wave shaped form. The roof is a covered with a TPO membrane. More than 1000sqm are used as a public viewing terrace and are covered with an intensive green roof system.			■					■								■	■			■						■				
	Foundation System	Concrete slab	■							■							■					■						■				
	Other																															
11 **Internal partition and non-strcutural elements**	**Vertical (walls)**	Internal timber linings are made from untreated Scottish Larch with all other joinery made from oiled British Oak. Large internal and external floor areas are covered with local Caithness flagstones.		■						■							■							■	■			■				
	Horizontal (ceilings/floors)	Stone finishes with underfloor heating		■						■							■					■						■				
12 **Doors and windows**		Oiled British Oak Joineries		■						■							■					■						■				
13 **Construction details**	**Characteristics if innovative**	Apart from the poured concrete floors and foundations, the steel structure is bolted to assist its deconstruction and timber panels are demountable.			■	■		■	■	■								■						■						■		
14 **Environmental control systems**	**Water system**	Low flush toilets, infrared controlled urinals and water saving taps are used throughout the building.				■				■	■							■				■								■	■	

			Incremental	Modular	Architectural	System	Radical	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	Resource waste	Environmentally Irrelevant	Sustainability strategy introduction	Technological perfomances introduction	Resources generation	Social problems generation	No social changes	Social problem solution	Social purpose definition	Social objective achievement	Extra benefit generation	Economic Loss	Cost invariant	Knowledge acquisition	Comparative advantage	Competitive advantage	Market expansion
	Lighting system	At the restaurants, kitchen and education room, the curved roofs distribute north east clerestorey light evenly and extend to overhang the south east glazed terraces for shading and shelter. A long north facing clerestorey to the orientation and interpretation areas and aftermath gallery allows both glare free lighting and views out at key points. The large area of south facing glazing illuminating the Derby Council display is shaded by external louvres which are incorporated into the larch cladding. Public and staff areas are lit by high efficiency lighting with automatic lighting controls. Specialist lighting in the exhibition includes less efficient halogen lamps to minimise UV damage to artifacts on display, and provide excellent colour rendering. But these lights are dimmed to very low lux levels (less than 50 lux) – reducing energy consumption in line with the rest of the lighting strategy.				X				X	X							X				X								X	X	
	Heating system	Massive Insulation and a fully automated woodchip boiler system provides space heating and hot water generation. Woodchips are supplied by the Scottish School of Forestry – harvested from sustainably managed forest within a 10km radius of the building- and should save approximately 55% of the total CO2 output of the building.				X				X	X							X	X			X								X	X	
	Fire control syustem	As by code	X					X		X							X					X						X				
	Communication system	A sophisticated ethernet-based building management system monitors and controls energy use in the building. Building performance can be assessed and improved through separate sub-metering of hot and cold water, zoned electrical loads, and gas consumption (LPG).	X						X	X							X					X						X				
	Ventilation system (mechanical, natural or hybrid)	A passive ventilation system was developed, combining opening windows and low-level vents, with high-level ventilation via parapets and roof cowls. The system is generally wind-driven, orientated towards the battlefield/prevailing wind. Low speed plate fans, concealed within the roof cowls, provide increased airflow for extreme conditions e.g. high visitor numbers on a still summers day. Ventilation control is automated, with manual override by the user – to respond to unexpected changes in visitor numbers. There is minimal dependence on artificial cooling - only catering kitchen and WCs. Cooling is required only in the small exhibition AV room, and the manager's office – both are remote from the façade and contain much IT equipment. The visitor support curved roofs also assist the aim of maximizing natural ventilation via high level clerestories.				X				X								X	X			X						X		X		
15 **Sewage connectionn and water treatment**		Waste water is processed in a modern aerated water treatment plant. The tanks are entirely concealed below ground. The tanks are entirely concealed below ground. As the final outfall from the plant is delivered to the river Nairn, SEPA required discharge from the new centre within the water quality limits imposed on the original NTS visitor centre. This high standard helps to protect a number of Sites of Specific Scientific Interest (SSSIs) located downstream of the site.			X			X		X							X					X						X				

2_Process

CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	INNOVATION Type	DECISION-MAKER Decision-maker	SUSTAINABILITY ENVIRONMENTAL Results	SUSTAINABILITY SOCIAL Results	SUSTAINABILITY ECONOMIC Results
1 Commissioning	Promoter	National Trust of Scotland/Royal Fine Arts Commission/The Highland Council					
	Land owner	National Trust of Scotland - Heritate Listed					
	Client	National Trust of Scotland					
	Designer	Gareth Hoskins Architects					
	Builder	Morrison Construction Scotland - Highland					
	Type of bid	Commission aftrer competition					
	Final building property	National Trust of Scotland					
	Building Manager	National Trust of Scotland					
2 Financing	Financing actors	National Trust of Scotland					
	Financing type	Public					
	Entity	£9.4m					
	Percentage of the total	The contract sum for the building was £5m including £1m of external works. The contract sum for the exhibition was a further £1.5m, which was added to the main contract with Morrison Construction Ltd					
3 Program (brief)	Site characteristics	Heritage listed Culloden Battlefield					
	Project scope	The new building is three times the size of the existing facilities it replaces and is designed for up to 250,000 visitors a year, housing interpretation of the battle along with educational and conference facilities, a 240 cover café and restaurant, a shop and staff/ancillary accommodation.					
	Architectural characteristics	Sustainability and Landscape Identity and Memory					
	Timeline	4 years					
4 Component Production	Production place	Local Production in a 50 miles radius					
	Production type	Scottish Larch from a nearby estate, other areas are clad with local Caithness Stone and field stones salvaged from the site					
	Producer/Supplier	Main Contractor: McLaughlin and Harvey Timber Supplier: Forestry Commission (from Glentress Forest) Nor-Build Glazing: Charles Henshaw & Sons Ltd Roofing: SpectraROOF Heating/Insulation/Ventilation: Highland Wood Energy					
	Production time	MISSING INFO					
5 Worksite/Construction/Assembly	Worksite Organization	Standard					
	Construction Methods	Critical Path					
	Worksite Timing	2 or 3 years					
	Changes during Construction	Changes due to the contract type to optimize costs and skills					
	Work coordination	Construction Company					
	Duration	2 or 3 years					
	Contingecies/Problems	Leaking Roof for single layer roof					
6 Tests	Management	Not Required					
	Structure	Not Required					
	Services	Not Required					
	Materials	Not Required					
	Forniture	Not Required					
	Trades	Not Required					
	Construction Systems	Not Required					

			Competence Creating	Competence Destroying	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	Resource waste	Environmentally Irrelevant	Sustainability strategy introduction	Technological perfomances introduction	Resources generation	Social problems generation	No social changes	Social problem solution	Social purpose definition	Social objective achievement	Extra benefit generation	Economic Loss	Cost invariant	Knowledge acquisition	Comparative advantage	Competitive advantage	Market expansion
7 **Project Management/Control**							■	■	■					■					■						■				
8 **Drawing development**	**Preliminary Drawings**	Gareth Hoskins Architects	■		■	■								■						■					■				
	Architectural Drawings	Gareth Hoskins Architects	■				■							■						■					■				
	Construction Drawings	Builder	■					■						■					■						■				
	As Built Drawings	Builder	■		■	■								■					■						■				
9 **Work coordination**	**Type of Management Organization**	Project Management Jacobs Babtie	■					■						■					■						■				
	Coordination	Main contractor Morrison Construction Scotland	■					■						■					■						■				
	Time Control	Planning Supervisor Stewart Anderson Associates	■				■	■						■					■						■				
	Cost Control	Thomas and Adamson	■		■		■							■					■						■				
	Quality Control	None	■					■	■					■					■						■				
	Auditing/Certification Agency	None	■								■			■					■						■				
10 **Contractual relations**	**Contract Type**	The building was procured as a two stage design and build contract (amended JCT 1998 With Contractor's Design) with architect and structural engineer novated at second stage.		■	■	■								■					■						■				
	Contract Compliance	Change of contractor	■		■	■								■					■						■				
	Contract Termination	First contractor contract termination, the compaby was the same that built Glencoe Visitor Centre		■	■	■								■					■						■				
	Contract Renewal	New contract with a more commercial oriented construction company		■	■	■								■					■						■				
11 **Maintenance/Building Use**	**Maintenance Plan**	National Trust of Scotland	■		■	■								■					■						■				
	Building Use	National Trust of Scotland	■		■	■								■						■	■				■				
	Defined Maintenance	Standanrd Maintenance by the builder ad per building code	■		■	■								■					■						■				
	Actual Maintenance	Issues with the roof and extra maitenance		■	■	■								■					■						■				

South Lanarkshire Low Carbon Teaching Building
East Kilbride Scotland, UK
Austin-Smith:Lord
2014

Context Characteristics: Within campus in a semi-rural area

Concpet Characteristics: IBREEAM as environmental guidelines

Orientation: North-East/Sout-West

Dimension: above 500 sqm

Shape: L-Shaped

Floor number: Three floors

Access and circulation: Stairs and main corridor located to optimize solar exposure

Structure: Steel frame on concrete slab

Construction systems: Facing brickwork, cavity, breath membrane, plywood, recycled paper insultation, timber battens, gypsum duraline plasterboard

Evironmanetal control systems: Natural Ventilation via openeable windows in the North, East and West, combined with stack ventilation in the corridor and in the atrium
Assisted mechanical ventilation is also provided
Underfloor heating system with heat pump
LED lighting fittings
BMS system to control and monitor the rest of the building service

Water treatment: Dual flush toilets, flow restrictors on all taps, leak detection on all incoming water supplies
Rainwater harvesting collection

Awards: BREEAM ‘Outstanding’ rating for the design stage

1_Building			INNOVATION	DECISION-MAKER	SUSTAINABILITY		
					ENVIRONMENTAL	SOCIAL	ECONOMIC
CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	Type	Decision-maker	Results	Results	Results
1 **Context Characteristics**	**Urban**	Urban					
	Rural	In campus					
2 **Concept**	**Characteristics**	BREEAM as major generator of the work					
3 **Orientation**	**Emisphere**	North					
	Axes	North-East/Sout-West					
4 **Architectural Characteristics**	**Aesthetic Approach**	Secondary to the energy efficiency requirements					
5 **Dimension**		above 500 sqm					
6 **Shape**	**Typology**	Education					
	Geometry	L shape					
	Volume Shape	Parallelepiped					
	Symmetry	Non symmetric					
7 **Floor number and height**		Three floors					
8 **Access and circulation**	**Main access**	Main access from main entrance					
	Pedestrian access	Access from main road					
	Circulation characteristics	Stairs and main corridor located to optimize solar exposure					
	Circulation within the building	Stairs and main corridor located to optimize solar exposure					
9 **Structure**		Steel Frame					
10 **Construction systems**	**Envelope**	Facing brickwork, cavity, breath membrane, plywood, recycled paper insultation, timber battens, gypsum duraline plasterboard					
	Roof	Profiled metal roofing system, vapour control layer, plywood, timber stud beam, thermoflex timber insulation, Intello plus membrane, vapour barrier,					
	Foundation System	Concrete slab					
	Other						
11 **Internal partition and non-strcutural elements**	**Vertical (walls)**	Thirteen types of wall type with different layers of plasterboard, gypsum or brick finishes, and different ypes of insulation according to the needs					
	Horizontal (ceilings/floors)	Suspended ceiling syste, lay in mineral fibre ceiling tiles, ecophone gedina					
12 **Doors and windows**		Openable windows to have an total opening area of not less than 1/30th of the floor area of the room in which they are located. Windows to be fitted with a ventilator to provide a minimum of 4000sq.mm. free air flow. Actuated control system in the atrium.					
13 **Construction details**	**Characteristics if innovative**	Standard					

No.	Element	System	Description	Incremental	Modular	Architectural	System	Radical	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	Resource waste	Environmentally Irrelevant	Sustainability strategy introduction	Technological perfomances introduction	Resources generation	Social problems generation	No social changes	Social problem solution	Social purpose definition	Social objective achievement	Extra benefit generation	Economic Loss	Cost invariant	Knowledge acquisition	Comparative advantage	Competitive advantage	Market expansion
14	**Environmental control systems**	**Water system**	Dual flush toilets, flow restrictors on all taps, leak detention on all incoming water supplies,		■	■					■	■							■				■								■	■	
		Lighting system	LED lighting fittings			■					■	■							■				■								■	■	
		Heating system	Underfloor heating system with heat pump			■	■				■	■							■	■			■								■	■	
		Fire control system	SVP's to have intumescent collar where they pass through concrete separating floors. SVP stacks to be wrapped in 25mm insulation and ducts covered with two layers of plasterboard. Pipes and cables to have H/T intumescent mastic fire protection seal where passing through wall/floor construction from room to service duct. ROCKWOOL Cavity Barrier (Timber Frame) cavity closers around the perimeter of the curtain walling and windows and doors - see details ROCKWOOL FirePro SP60 cavity fire slab around the perimeter of the curtain walling at floor slab level, where vertical curtain walling runs full height up building.	■	■				■		■							■					■						■				
		Communication system	BMS system to control and monitor the rest of the building service	■	■					■	■							■					■						■				
		Ventilation system (mechanical, natural or hybrid)	Natural and Mechanical Ventilation. Natural Ventilation via openeable windows in the North, East and West, combined with stack ventilation in the corridor and in the atrium. Assisted mechanical ventilation is also provided.			■	■				■								■	■			■						■		■		
15	**Sewage connectionn and water treatment**		Rainwater harvesting collection.			■			■		■							■					■						■				

2_Process

CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	INNOVATION Type	DECISION-MAKER Decision-maker	SUSTAINABILITY ENVIRONMENTAL Results	SUSTAINABILITY SOCIAL Results	SUSTAINABILITY ECONOMIC Results
1 Commissioning	Promoter	South Lanarkshire College					
	Land owner	South Lanarkshire College					
	Client	South Lanarkshire College					
	Designer	Austin-Smith:Lord					
	Builder	CCG Specialist Building Services					
	Type of bid	Direct agreement					
	Final building property	South Lanarkshire College					
	Building Manager	South Lanarkshire College					
2 Financing	Financing actors	South Lanarkshire College					
	Financing type	£4.5 million					
	Entity						
	Percentage of the total						
3 Program (brief)	Site characteristics	Existing lot in campus					
	Project scope	College School					
	Architectural characteristics	Incorporation of micro climatic elements and construction aspects					
	Timeline	According to schedule					
4 Component Production	Production place	Local					
	Production type	Pre fab					
	Producer/Supplier	Local					
	Production time	According to schedule					
5 Worksite/Construction/Assembly	Worksite Organization	CCG Specialist Building Services					
	Construction Methods	CCG Specialist Building Services					
	Worksite Timing	CCG Specialist Building Services					
	Changes during Construction	CCG Specialist Building Services					
	Work coordination	CCG Specialist Building Services					
	Duration	According to schedule					
	Contingecies/Problems	None					
6 Tests	Management						
	Structure	Will Rudd Davidson					
	Services	CCG Specialist Building Services					
	Materials	CCG Specialist Building Services					
	Forniture	CCG Specialist Building Services					
	Trades	CCG Specialist Building Services					
	Construction Systems	CCG Specialist Building Services					
7 Project Management/Control		Gardiner and Theobald					
8 Drawing development	Preliminary Drawings	Austin-Smith:Lord					
	Architectural Drawings	Austin-Smith:Lord					
	Construction Drawings	Austin-Smith:Lord					
	As Built Drawings	Austin-Smith:Lord					
9 Work coordination	Type of Management Organization	Project Management					

			Competence Creating	Competence Destroying	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	Resource waste	Environmentally Irrelevant	Sustainability strategy introduction	Technological perfomances introduction	Resources generation	Social problems generation	No social changes	Social problem solution	Social purpose definition	Social objective achievement	Extra benefit generation	Economic Loss	Cost invariant	Knowledge acquisition	Comparative advantage	Competitive advantage	Market expansion
	Coordination	Gardiner and Theobald																											
	Time Control	Gardiner and Theobald																											
	Cost Control	Doig and Smith																											
	Quality Control	Gardiner and Theobald																											
	Auditing/Certification Agency	South Lanarkshire College																											
10 **Contractual relations**	**Contract Type**	Professional fees																											
	Contract Compliance	Yes																											
	Contract Termination	None																											
	Contract Renewal	None																											
11 **Maintenance/Building Use**	**Maintenance Plan**	South Lanarkshire College																											
	Building Use	South Lanarkshire College																											
	Defined Maintenance	South Lanarkshire College																											
	Actual Maintenance	South Lanarkshire College																											

Robert Burns Birthplace Museum
Alloway, Ayr, Scotland, UK
Simpson & Brown Architects
2010

Context Characteristics: Semi-Rural

Concpet Characteristics: Orientation of building axes in relation to other significant places of the life on Robert Burns in the close area of its birthplace and passive house strategies

Orientation: North-West/South-East

Dimension: 500 sqm

Shape: Rectangular symmetric plan

Floor number: Single floor

Access and circulation: The existing walkway bordering the main road and linking the Cottage Site at the north end of the village and the New Museum Site at the south end, has been enhanced, as well as access points to existing paths

Structure: Timber strcuture on concrete slab

Construction systems: South-East elevation is glazed, while the rest of the envelope is clad with untreated Scottish Douglas-fir horizontal boards

Evironmanetal control systems: This naturally tempered air enters the building via a basement plant room where additional cooling or warming is provided by the ground source heat pump system installed under the new car park on the North-east side of the site.
The air filling the gallery space circulates by natural convection, or 'chimney stack effect' assisted by fans when required.
Black box quality of the space has offered absolute control to lighting of the exhibition space

Water treatment: Standard

1_Building

CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	INNOVATION Type	DECISION-MAKER Decision-maker	SUSTAINABILITY ENVIRONMENTAL Results	SUSTAINABILITY SOCIAL Results	SUSTAINABILITY ECONOMIC Results
1 **Context Characteristics**	**Urban**						
	Rural	Semi -Rural					
2 **Concept**	**Characteristics**	Axes to connect the new building with other significant places of the life on Robert Burns in the close area of its birthplace					
3 **Orientation**	**Emisphere**	North					
	Axes	North-West/South-East					
4 **Architectural Characteristics**	**Aesthetic Approach**	Integration with landscape visually and by historic meaning					
5 **Dimension**		500 sqm					
6 **Shape**	**Typology**	Visitor Centre					
	Geometry	Rectangular plan					
	Volume Shape	Parallelepiped					
	Symmetry	Mostly symmetric					
7 **Floor number and height**		Single floor					
8 **Access and circulation**	**Main access**	Main access from main entrance					
	Pedestrian access	Access from cottage and Burn's significangt places					
	Circulation characteristics	. A new reception and ticket building has been introduced between the car park and the entrance to the site. The existing walkway bordering the main road and linking the Cottage Site at the north end of the village and the New Museum Site at the south end, has been enhanced with the addition of interpretative installations including a large-scale bronze mouse statue and weather vanes. New access points have been provided onto the path and it has been straightened and made more direct by the addition of a new timber arch footbridge over the old railway line – now part of the national cycle network – that used to cut off the Museum site from the walkway.					
	Circulation within the building	The internal circulation with the building follows the internal museum organization					
9 **Structure**		Timber structure sources locally					
10 **Construction systems**	**Envelope**	Predominately glazed South-east elevation, is clad with untreated Scottish Douglas-fir horizontal boards sourced and processed in Moray					
	Roof	Green roof. The plant sown on the roof is a succulent plant called sedum, which will help reduce the water run-offs from heavy precipitations and cool the atmosphere above the building during the summer, while requiring a minimum maintenance.					
	Foundation System	Concrete slab					
	Other						
11 **Internal partition and non-strcutural elements**	**Vertical (walls)**	The public spaces including the entrance court, the reception hall and the café are defined by a substantial green Douglas-fir structure developed in close collaboration with structural engineers, Buro Happold and Carpenter Oak and Woodland's workshop in Angus. The rest of the building is made of European redwood panels The external wall panels are filled with 250mm of recycled paper (cellulose) which not only gives excellent thermal insulation and reduces the energy consumption of the building but also enhances the hygroscopic quality of the structure, allowing the building envelope to release excess of moisture from within the rooms and the structure to the outside environment.					
	Horizontal (ceilings/floors)	Roof ceiling is clad with untreated Scottish Douglas-fir horizontal boards sourced and processed in Moray, but each square plan is crested by a sweeping curve of green roof. The intertwined relationship of both curves makes for an exciting silhouette.					

12	**Doors and windows**		window frames assembled by Transition Interiors in Kilmarnock
13	**Construction details**	**Characteristics if innovative**	Douglas-fir structure developed in close collaboration with structural engineers, Buro Happold and Carpenter Oak and Woodland's workshop in Angus. Interlocking system as joints
14	**Environmental control systems**	**Water system**	Standard
		Lighting system	Black box quality of the space has offered absolute control to the exhibition and lighting designers over the way the artefacts are presented to the visitors, in contrast to the black box, Main Gallery, the reception hall and the café are very much opened to the outside world and to each other, and take advantage of natural ventilation and natural lighting.
		Heating system	This naturally tempered air enters the building via a basement plant room where additional cooling or warming is provided by the ground source heat pump system installed under the new car park on the North-east side of the site.
		Fire control syustem	As by code
		Communication system	None
		Ventilation system (mechanical, natural or hybrid)	The air filling the gallery space circulates by natural convection, or 'chimney stack effect' assisted by fans when required. It is sucked in through an air intake structure located in the garden of the museum, and finds its way towards the building through a labyrinth of five large concrete pipes, each 30 m long, buried two meters below ground, and so benefiting from the constant temperature of the ground at this depth; this warms up the incoming air in winter and cools it down in summer. The air is then passed through another set of pipes, distributing it evenly in the plenum below the Main Gallery space. A portion of it is expelled through the high-level vent grilles below the roofline while the rest is being re-circulated to the plant room. The latter process allows for a better control of the humidity content and for a reduction in heating input
15	**Sewage connectionn and water treatment**		None

Item	Incremental	Modular	Architectural	System	Radical
12 Doors and windows		■	■		
13 Construction details			■	■	
14 Water system	■				
Lighting system			■		
Heating system				■	
Fire control syustem	■				
Communication system	■				
Ventilation system				■	
15 Sewage connectionn and water treatment	■				

Item	Institutions	Client	Designer	Builder	Industry	Users	Other
12 Doors and windows			■				
13 Construction details	■	■	■				
14 Water system			■	■			
Lighting system			■	■			
Heating system			■	■			
Fire control syustem	■		■				
Communication system		■	■				
Ventilation system			■				
15 Sewage connectionn and water treatment	■		■				

Item	Environmental problems	Resource waste	Environmentally Irrelevant	Sustainability strategy introduction	Technological perfomances introduction	Resources generation
12 Doors and windows			■			
13 Construction details				■		
14 Water system				■		
Lighting system				■		
Heating system				■	■	
Fire control syustem			■			
Communication system			■			
Ventilation system				■	■	
15 Sewage connectionn and water treatment			■			

Item	Social problems generation	No social changes	Social problem solution	Social purpose definition	Social objective achievement	Extra benefit generation
12 Doors and windows		■				
13 Construction details				■		
14 Water system		■				
Lighting system		■				
Heating system		■				
Fire control syustem		■				
Communication system		■				
Ventilation system		■				
15 Sewage connectionn and water treatment		■				

Item	Economic Loss	Cost invariant	Knowledge acquisition	Comparative advantage	Competitive advantage	Market expansion
12 Doors and windows		■				
13 Construction details				■		
14 Water system				■	■	
Lighting system				■	■	
Heating system				■	■	
Fire control syustem		■				
Communication system		■				
Ventilation system		■		■		
15 Sewage connectionn and water treatment		■				

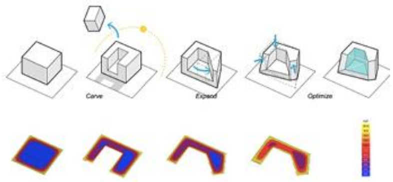
2_Process

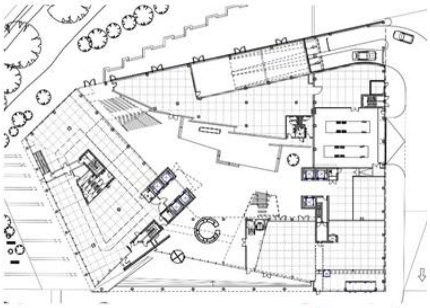
CATEGORY	SUB-CATEGORY	DEFINITION Characteristics
1 Commissioning	Promoter	National Trust of Scotland
	Land owner	National Trust of Scotland
	Client	National Trust of Scotland
	Designer	Simpson & Brown Architects
	Builder	Border Construction Otd of Carlise
	Type of bid	Public competition
	Final building property	National Trust of Scotland
	Building Manager	National Trust of Scotland
2 Financing	Financing actors	National Trust of Scotland
	Financing type	$ 17 milion
	Entity	
	Percentage of the total	
3 Program (brief)	Site characteristics	Burns National Heritage Park
	Project scope	To celebrate the place of birth of Robert Burns
	Architectural characteristics	Use of local materials and integration with the other building part of the Burns National Heritage Park
	Timeline	According to schedule
4 Component Production	Production place	Local - Kilmarnock and Angus
	Production type	Local- Milling and manufacturing
	Producer/Supplier	Local
	Production time	According to schedule
5 Worksite/Construction/Assembly	Worksite Organization	Border Construction Otd of Carlise
	Construction Methods	Critical path
	Worksite Timing	
	Changes during Construction	None
	Work coordination	None
	Duration	According to schedule
	Contingecies/Problems	None
6 Tests	Management	Capita Symonds
	Structure	Buro Happold
	Services	Border Construction Otd of Carlise
	Materials	Border Construction Otd of Carlise
	Forniture	Border Construction Otd of Carlise
	Trades	Border Construction Otd of Carlise
	Construction Systems	Border Construction Otd of Carlise
7 Project Management/Control		Capita Symonds
8 Drawing development	Preliminary Drawings	Simpson & Brown Architects
	Architectural Drawings	Simpson & Brown Architects
	Construction Drawings	Simpson & Brown Architects
	As Built Drawings	Simpson & Brown Architects
9 Work coordination	Type of Management Organization	Project Management
	Coordination	Capita Symonds
	Time Control	Capita Symonds and Morham & Brotchie of Edinburgh
	Cost Control	Morham & Brotchie of Edinburgh
	Quality Control	Capita Symonds

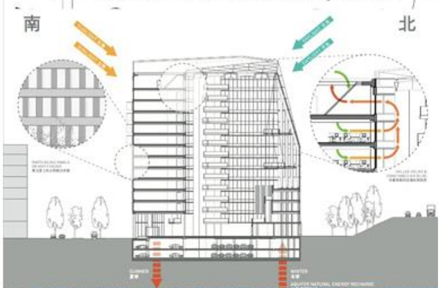
INNOVATION	DECISION-MAKER	SUSTAINABILITY: ENVIRONMENTAL	SUSTAINABILITY: SOCIAL	SUSTAINABILITY: ECONOMIC
	Decision-maker	Results	Results	Results

			Competence Creating	Competence Destroying	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	Resource waste	Environmentally Irrelevant	Sustainability strategy introduction	Technological perfomances introduction	Resources generation	Social problems generation	No social changes	Social problem solution	Social purpose definition	Social objective achievement	Extra benefit generation	Economic Loss	Cost invariant	Knowledge acquisition	Comparative advantage	Competitive advantage	Market expansion
	Auditing/Certification Agency	National Trust of Scotland																											
10 **Contractual relations**	**Contract Type**																												
	Contract Compliance	Yes																											
	Contract Termination	None																											
	Contract Renewal	None																											
11 **Maintenance/Building Use**	**Maintenance Plan**	Standard																											
	Building Use	National Trust of Scotland																											
	Defined Maintenance	Standard																											
	Actual Maintenance	Standard																											

The Edge
Amsterdam, The Netherlands
PLP Architects
2015







Context Characteristics: Urban

Concpet Characteristics: Orientation as volumetric shape generator

Orientation: North/South

Dimension: 40000.0 sqm

Shape: The building shape is the result of the orientation optimization from a bulky volume to an open shape toward the North side and work as environmental buffer and light diffusion enhancement

Floor number: 15 Storeys

Access and circulation: Different access and flows for bikes, electric cars,

Structure: Load bearing walls to the south, east and west

Construction systems: East and West load bearing walls have smaller openings to provide thermal mass and shading, and solid openable panels for ventilation. Louvers on the south facades are designed according to sun angles and provide additional shading for the office spaces, reducing solar heat gain. The North facades are highly transparent and use thicker glass to dampen noise from the motorway. The Atrium façade is totally transparent, allowing views and steady north light in.

Evironmanetal control systems: Smart technologies to control the environment and use
Chilled ceilings and conditioned air reuse
Solar Panels
Waste collection system
Smart lighting
Thermal energy storage (Two 129m deep wells reach down to an aquifer)

Water treatment: Rainwater collection and storage for flushing toilets and plants and garden watering

Certification: BREEAM - 'Outstanding' with a score of 98.36 %

1_Building			INNOVATION	DECISION-MAKER	SUSTAINABILITY ENVIRONMENTAL	 SOCIAL	 ECONOMIC
CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	Type	Decision-maker	Results	Results	Results
1 **Context Characteristics**	**Urban**	Located in Amsterdam					
	Rural						
2 **Concept**	**Characteristics**	Orientation as volumetric shape generator					
3 **Orientation**	**Emisphere**	North					
	Axes	Nothr-South					
4 **Architectural Characteristics**	**Aesthetic Approach**	Glass facade office building aesthetic					
5 **Dimension**		40000 sqm					
6 **Shape**	**Typology**	Office					
	Geometry	Bulky block					
	Volume Shape	Parallelepiped sectioned on the top					
	Symmetry	No symmetry					
7 **Floor number and height**		fifteen Floors					
8 **Access and circulation**	**Main access**	Main access through the central atrium					
	Pedestrian access	From the atrium					
	Circulation characteristics	Different access and flows for bikes, electric cars					
	Circulation within the building	The internal circulation is organized from main atium for pedestriam and from basement for anybody else					
9 **Structure**		Steel Frame and Load bearing walls to the south, east and west					
10 **Construction systems**	**Envelope**	Glass facades with dirrefetn types of class according to the orientation					
	Roof	A portion is glass and steel and another portion is covered with solar panels and water saving system					
	Foundation System	Concrete slab					
	Other						
11 **Internal partition and non-strcutural elements**	**Vertical (walls)**	Concrete precast panels or plasterboard panels. There are also internal glass facades to allow the kids vision between spaces					
	Horizontal (ceilings/floors)	Suspended ceilings					
12 **Doors and windows**		Internal glass door partitions, as well as doors and glazed facade					
13 **Construction details**	**Characteristics if innovative**	None					
14 **Environmental control systems**	**Water system**	Rainwater collection and storage for flushing toilets, and plants and garden watering					
	Lighting system	LED Ethernet-connected lighting system					
	Heating system	Chilled ceilings and conditioned air reuse and solar panels to warm up thermal energy storage (Two 129m deep wells reach down to an aquifer)					
	Fire control syustem	As by code					
	Communication system	Smart building management control system					

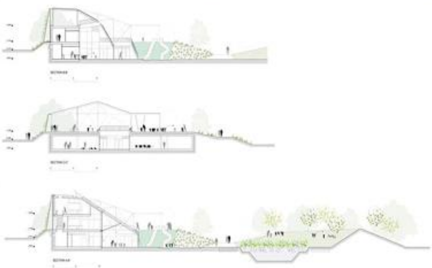
				Incremental	Modular	Architectural	System	Radical	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	No environmental change	Knowledge acquisition	Sustainability achievement	Technological advancement	Resources generation	Social problems generation	No social changes	Knowledge acquisition	Social objectives achievement	Social Improvement	Extra benefit generation	Economic Loss	No economic change	Saving achievement	New jobs creation	Increased revenue	Market expansion
		Ventilation system (mechanical, natural or hybrid)	Solid open palenls to allow natural ventilation																														
15	**Sewage connectionn and water treatment**		As by code																														

2_Process

CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	INNOVATION: Type	DECISION-MAKER: Decision-maker	SUSTAINABILITY – ENVIRONMENTAL: Results	SUSTAINABILITY – SOCIAL: Results	SUSTAINABILITY – ECONOMIC: Results
1 Commissioning	Promoter	OVG Real Estate					
	Land owner	OVG Real Estate					
	Client	Deloitte					
	Designer	PLP Architecture					
	Builder	G & S Bouw					
	Type of bid	Private development					
	Final building property	OVG Real Estate					
	Building Manager						
2 Financing	Financing actors	ABN Amro, OGV, Real Estate, Philips, Deloitte					
	Financing type	Progressive financinf to develop innovation during construction					
	Entity						
	Percentage of the total						
3 Program (brief)	Site characteristics	Zuidas business district					
	Project scope	Office Building					
	Architectural characteristics	Orientation and optimisation of site characteristics					
	Timeline						
4 Component Production	Production place	Local					
	Production type	Local					
	Producer/Supplier	Local					
	Production time						
5 Worksite/Construction/Assembly	Worksite Organization						
	Construction Methods						
	Worksite Timing						
	Changes during Construction						
	Work coordination						
	Duration						
	Contingecies/Problems						
6 Tests	Management						
	Structure						
	Services						
	Materials						
	Forniture						
	Trades						
	Construction Systems						
7 Project Management/Control							
8 Drawing development	Preliminary Drawings	PLP Architecture involved users and municipality					
	Architectural Drawings	PLP Architecture and Local Architects					
	Construction Drawings	G & S Bouw					
	As Built Drawings						
9 Work coordination	Type of Management Organization	Project Management					
	Coordination	G & S Bouw					
	Time Control	G & S Bouw					
	Cost Control	G & S Bouw					

			Competence Creating	Competence Destroying	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	No environmental change	Knowledge acquisition	Sustainability achievement	Technological advancement	Resources generation	Social problems generation	No social changes	Knowledge acquisition	Social objectives achievement	Social Improvement	Extra benefit generation	Economic Loss	No economic change	Saving achievement	New jobs creation	Increased revenue	Market expansion
	Quality Control	G & S Bouw	■					■							■				■						■				
	Auditing/Certification Agency														■														
10 **Contractual relations**	**Contract Type**	Engineering and Build Agreement with G & S Bouw	■		■	■								■						■						■			
	Contract Compliance																												
	Contract Termination																												
	Contract Renewal																												
11 **Maintenance/Building Use**	**Maintenance Plan**	Sensors part of the building monitoring system to keep maintenance updated, User's App to participate to the building life		■		■	■	■	■	■							■					■			■				
	Building Use	Deloitte, other tenants include AKD (law), Henkel (consumer goods), Sandvik (mining), Salesforce (CRM software), and Edelman (PR)		■		■	■	■	■	■							■					■			■				
	Defined Maintenance			■																									
	Actual Maintenance			■																									

Ecopolis Plaza
Madrid, Spain
Ecosistema Urbano
2010



Context Characteristics: The project is placed at Rivas Vaciamadrid, a middle sized city located in the Metropolitan area of Madrid with a low urban population density, surrounded by industry and heavy traffic transportation infrastructures

Concpet Characteristics: The concept is to incorporate the idea of sustainability into daily life

Orientation: East-West

Dimension: 3000 sqm

Shape: L-Shaped

Floor number: Three floors

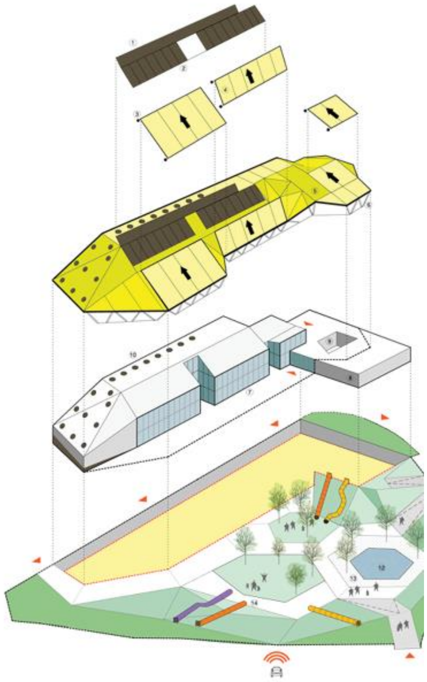
Access and circulation: The circulation within the building is designed in a very simple way: a north-facing corridor distributes to the different rooms of the building

Structure: Steel frame on concrete slab

Construction systems: Glazing in the south facade and concrete and steel walls strcuture

Evironmanetal control systems: The heating system is managed by a heat pump, but thanks to the termal inertia there is a good control of the heating trasmission. Natural lighting and ventilation in the building, as well as advaceclim system to control the perfomance

Water treatment: The treatment of the water is one of the strongest point of the project, the designers introduce an innovative system for the water management as the lagoon with the macrophytes plants. This strategy allow to not waste the grey waters from the building.



1_Building			INNOVATION	DECISION-MAKER	SUSTAINABILITY		
					ENVIRONMENTAL	SOCIAL	ECONOMIC
CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	Type	Decision-maker	Results	Results	Results
1 Context Characteristics	Urban	The project is placed at Rivas Vaciamadrid, a middle sized city located in the Metropolitan area of Madrid with a low urban population density, surrounded by industry and heavy traffic transportation infrastructures					
	Rural	/					
2 Concpet	Characteristics	The concept is to incorporate the idea of sustainability into daily life, consider the public space as an "open environmental classroom", creating an integrated educational program for children with the goal to improve also the urban environment					
3 Orientation	Emisphere	The project is located in Spain, a Country in the northern hemisphere whose features are irrelevant in the design process					
	Axes	The project is oriented east-west axis, in order to have the main facade south oriented, in which a double-glass facade allow solar gain. The orientation also determines the internal distribution, with the kindergarden'room to the south and the distribution corridors to the north.					
4 Architectural Characteristics	Aesthetic Approach	The aesthetic features of the project, with captiving shapes and colors, have made it possible to reach one of the goals of the brief, or transforming a peripheral and industrial area of Madrid both in a service for citizenship (kindergarten) and an attraction capable of improving the context					
5 Dimension	Dimension	The dimensions of the building do not have significant characteristics, in fact they follow standard design procedures for the realization of kindergartens					
6 Shape	Typology	The project is a kindergarten, which has on the outside a public plaza that is meant to be an attraction for all the citizens					
	Geometry	The building is a parallelepiped with a roof featuring triangular shapes with an external metal structure that give character to the façade					
	Volume Shape	The building is a three-storey parallelepiped, one of which is a semi-buried					
	Symmetry	The building is not symmetrical in its shape, which has caused a greater cost in its construction					
7 Floor number and height		The building is on three floors the design of which is linked to the function that is to be performed (kindergarten), a particular feature is connected to the semi-underground floor which allows for thermal inertia savings					
8 Access and circulation	Main access	The main access is located in front of the public square, but it hasn't any special features at the design level					
	Pedestrian access	The pedestrian access corresponds to the main entrance					
	Circulation characteristics	The circulation within the building is free, characterized by a corridor to the north					
	Circulation within the building	The circulation within the building is designed in a very simple way: a north-facing corridor distributes to the different rooms of the building					
9 Structure		Steel on concrete slab					
10 Construction systems	Envelope	Innovative technologies such as the use of solar panels, a south-facing glazing and a shading system are used to bring an economic advantage and energy savings					
	Roof	The roof has an attractive shape, characterized by yellow triangular shapes that enhance the context image. The roof also has thermal and solar panels for the production of sustainable energy and economic savings.					
	Foundation System	The foundations have no characteristics to be detected, they are built following standard procedures with no sustainable changing					
	Other (macrophytes system)	The water purification system is a radical innovations in the architecture technology, in the square in front of the building there is a lagoon where all the waste water from the building is naturally purified by macrophyte plants. All the purified water is stored under the ground in a gravel tank and is used for all the irrigation needs of the plaza. From the aesthetic point of view, this type of system creates an attraction for the population, improving social interactions.					

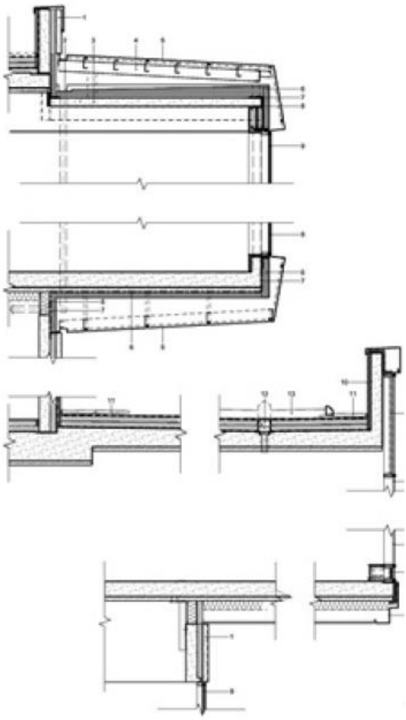
No.	Element	Sub-element	Description	Irrelevant	Incremental	Modular	Architectural	Radical	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	Resource waste	Environmentally Irrelevant	Sustainability strategy introduction	Technological perfomances introduction	Resources generation	Social problems generation	No social changes	Social problem solution	Social purpose definition	Social objective achievement	Extra benefit generation	Economic Loss	Cost invariant	Knowledge acquisition	Comparative advantage	Competitive advantage	Market expansion
11	Internal partition and non-strcutural elements	Vertical (walls)	The vertical partitions do not show any particularity, they are designed according to standard procedures to meet the kindergarten function		■						■	■	■	■				■					■						■				
		Horizontal (ceilings/floors)	The floors were made of linoleum, with bright colors that facilitate social interactions. The material comes from recycled products and is easy to clean, helping to have a good maintenance over time				■				■								■					■						■			
12	Doord and windows		A lare double glass facade (700 sqm) allow a good passive income in winter with the solar gain, and a cooling for ventilation in summer. Furthermore these windows have a low value of transmission.				■				■		■						■	■				■							■		
13	Construction details	Characteristics if innovative	The building presents lots of innovative characteristics, particularly for the sustainable strategy with the macrophytes lagoon in the square that give also good social results				■	■			■	■	■		■				■	■	■				■		■			■		■	
14	Evironmanetal control systems	Water system	The water system is really fondamental in the environmental control system of the building, it represents one of the most interesting aspect of the building					■			■				■				■	■	■						■				■	■	■
		Lighting system	The artificial lighting system isn't so peculiar, because it's a kindergarden and then is mainly used in the morning, while the natural light system is attentive to the school use with a big windows system				■				■				■				■						■						■	■	
		Heating system	The heating system is managed by a heat pump, but thanks to the termal inertia there is a good control of the heating trasmission				■				■				■				■						■						■	■	
		Fire control syustem	Stardard fire control system		■						■				■			■							■				■				
		Communication system	Not provided			■			■	■	■							■									■			■			
		Ventilation system (mechanical, natural or hybrid)	Condition system "advanceclim" and also natural ventilation					■			■	■	■						■	■						■					■	■	
15	Sewage connectionn and water treatment		The treatment of the water is one of the strongest point of the project, the designers introduce an innovative system for the water management as the lagoon with the macrophytes plants. This strategy allow to not waste the grey waters from the building giving advantages from the enviromental and economical point of view, but also creating a point of socialization in the square.					■	■	■	■	■	■		■				■	■	■					■	■					■	■

2_Process			INNOVATION	DECISION-MAKER	SUSTAINABILITY – ENVIRONMENTAL	SUSTAINABILITY – SOCIAL	SUSTAINABILITY – ECONOMIC
CATEGORY	**SUB-CATEGORY**	**DEFINITION Characteristics**	**Type**	**Decision-maker**	**Results**	**Results**	**Results**
1 **Commissioning**	**Promoter**	The promoter is the City Council, its main goal was to improve the area, trying to integrate it into the urban context.					
	Land owner	The land owner and the promoter are the same institution in this case(City Council).					
	Client	The client is also the City Council.					
	Designer	The designer created a really innovative building introducing strategies to reduce the economic and environmental impact.					
	Builder	Conventional building methods.					
	Type of bid	Conventional type of bid.					
	Final building property	The building itself means an acquisition of knowledges which can be applied in future projects.					
	Building Manager	From a social point of view, the building manager improves the area since it is not just a kindergarten but a place where people can interact, and it also reduces the environmental impact.					
2 **Financing**	**Financing actors**	The project was financed by the Spanish nation through a competition					
	Financing type	The financing was programmed by a plan for the stimulation of economy and employement					
	Entity	The costruction cost has been less then the amount financed					
	Percentage of the total	100%					
3 **Program (brief)**	**Site characteristics**	In 2010 the City Council of Rivas Vaciamadrid adopted its Sustainable Urban Mobility Plan (SUMP). The SUMP is linked to the 'Rivas Zero Emissions Plan' (R0EP), the city's strategic plan for sustainability, aiming to reduce greenhouse gas emissions by 50% between 2008 and 2020, and to be carbon neutral by 2030					
	Project scope	Transform an industrial land and build an educational equipment and public space. The City Council of Rivas Vaciamadrid establishes the objective of generating a meeting place bymeans of an attractive public space that invites to the meeting and foments the activity; A friendly place in front of an aggressive, protected but open environment in turn.					
	Architectural characteristics	Even if the building has a classic school typology, the spaces are thought to be more comfortable and innovative. Ecosistema Urbano aims to design an “open environmental classroom”, which promotes sustainability in its use. Promote greater knowledge about natural energy resources through the design of the square.Ecosistema Urbano wins the contest with the priority of: -To turn the building into a pilot experience of maximum energy rating (A), incorporating passive and active systems of saving and energy efficiency. -To transmit the values of sustainability and respect to the environment, incorporating a lagoon of purification in a visible way for the citizens of Rivas. The aim was that of provide an educational infrastructure and a public attractive space that generate social interaction.					
	Timeline	We don't have a precise schedule.					
4 **Component Production**	**Production place**	The main materials for the costruction of the building come from Spain and Germany					
	Production type	All the components are industrial products					
	Producer/Supplier	The producers are big companies from Spain and German					
	Production time	The costruction time for each component is not provided but the time of costruction is one year, as expected then we suppose that are standard.					

5 **Worksite/Construction/Assembly**	**Worksite Organization**	The work has been organizated in order to begin in March, when the weather is being improving to proceed with the wet works with the good weather
	Construction Methods	Preparation of the terrain for the costruction site, excavations and foundations, Concrete costructions, Metal structures, Assembly of the shading system, glazing and panels
	Worksite Timing	From 2009 to 2010
	Changes during Construction	The works have procedeed as in the program
	Work coordination	Seven companies were involved in the costruction
	Duration	About one year of works
	Contingecies/Problems	Not particular problems were noticed
6 **Tests**	**Management**	Conventional tests.
	Structure	Steel and concrete structure tests following conventional methods.
	Services	Termotechnology tests performed by the School of engineering and management of Sevilla.
	Materials	Mechanical and chemical conventional tests.
	Trades	Conventional tests.
	Construction Systems	Conventional Tests.
7 **Project Management/Control**		The architectural part was coordinated by Ecosistema Urbano, with the engineering part was coordinated by David Moreno and Javiero Alonso. The Ecosistema urbano coordinated and management during all the steps of the project in contact with institution/client.
8 **Drawing development**	**Preliminary Drawings**	Preliminary Drawings had been by Ecosistema Urbano from Rivas VacioMAdrid during the concorse.
	Architectural Drawings	Architectural drawing had been by Ecosistema Urbano, while the structural Enginneering was been by Juan Rey | Rinske Daniels Textile engineering: BAT spain Landscaping advisor / Water purification system: Diego Hurtado Had been carried out on it. technical drawing, mechanical drawing, structural drawing, concept he drawing during about 6 mesi and furono controllati anche dal Ayuntamiento de Rivas Vaciamadrid
	Construction Drawings	The technological details were studied by the architect but also in relation to other professionals involved, as the engineer or the guy at the wetlands or textile. Particular focus was made on what already exists in the industrial world.
	As Built Drawings	The final phase of the drawings was developed by the same professionals previous phases.
9 **Work coordination**	**Type of Management Organization**	Conventional methods.
	Coordination	Conventional methods.
	Time Control	Conventional methods.
	Cost Control	Ithe cost control is significant since the building supposes a significant cost reduction in comparison to other buildings.
	Quality Control	Conventional methods.
	Auditing/Certification Agency	Conventional methods.
10 **Contractual relations**	**Contract Type**	Conventional construction contract.
	Contract Compliance	Correct contract compliance.
	Contract Termination	Contract termination according to contract clauses.
	Contract Renewal	No contract renewal.
11 **Maintenance/Building Use**	**Maintenance Plan**	Radical innovation in activities such as the ones performed to make the staff aware of the importance of maintenance.

			Competetmce Creating	Competence Destroying	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	Resource waste	Environmentally Irrelevant	Sustainability strategy introduction	Technological perfomances introduction	Resources generation	Social problems generation	No social changes	Social problem solution	Social purpose definition	Social objective achievement	Extra benefit generation	Economic Loss	Cost invariant	Knowledge acquisition	Comparative advantage	Competitive advantage	Market expansion
	Building Use	Kindergarten and square where social activities will be performed.																											
	Defined Maintenance	Remarkable importance of the water regeneration system.																											
	Actual Maintenance	The actual maintenance is the same as defined.																											

Alder Hay Children's Hospital
Liverpool, UK
BDP
2015



Context Characteristics: Urban

Concpet Characteristics: Integration with landscape

Orientation: North-West/South-East

Dimension: 60.000 sqm

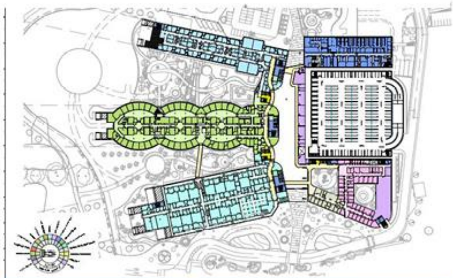
Shape: The building shape reminds of a hand palm

Floor number: 6 Floors

Access and circulation: Public circulation through the atrium experiencing art
The internal circulation is organized differently for sick kids, jealthy kids, staff, and parents

Structure: Precast load bearing walls

Construction systems: Precast concrete panels, double-glazed velfac windows, sprandrel glazed panels, pressed aluminium capping



Evironmanetal control systems: Loop ground source heat pump to produce heating and cooling. Tri-generation via an absorption chiller to maximise CHP run times when use of heat elsewhere in the hospital is low. Air source heat pumps to a number of air-handling units to contribute to carbin saving

Water treatment: Low flush toilets, infrared controlled urinals and water saving taps are used throughout the building.

Certification: BREEAM - 'Excellent'

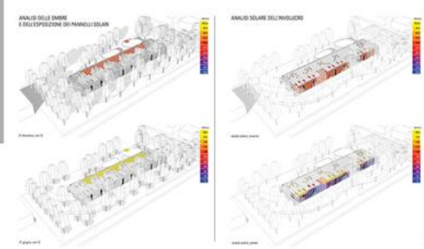
1_Building			INNOVATION	DECISION-MAKER	SUSTAINABILITY: ENVIRONMENTAL	SUSTAINABILITY: SOCIAL	SUSTAINABILITY: ECONOMIC
CATEGORY	**SUB-CATEGORY**	DEFINITION Characteristics	Type	Decision-maker	Results	Results	Results
1 **Context Characteristics**	**Urban**	Located in Liverpool					
	Rural						
2 **Concept**	**Characteristics**	Reciprocity between park and building					
3 **Orientation**	**Emisphere**	North					
	Axes	North-West/South-East					
4 **Architectural Characteristics**	**Aesthetic Approach**	Integration with landscape					
5 **Dimension**		60.000 sqm					
6 **Shape**	**Typology**	Children's Hospital					
	Geometry	Hand shape					
	Volume Shape	Series of parallelepipeds					
	Symmetry	No symmetry					
7 **Floor number and height**		Six Floors					
8 **Access and circulation**	**Main access**	Main access through the central atrium					
	Pedestrian access	From the atrium					
	Circulation characteristics	Public circulation through the atrium experiencing art					
	Circulation within the building	The internal circulation is organized differently for sick kids, jealthy kids, staff, and parents					
9 **Structure**		Steel Frame and Load-bearing precast system					
10 **Construction systems**	**Envelope**	Precast concrete panels, double-glazed velfac windows, sprandrel glazed panels, pressed aluminium capping					
	Roof	Hollow core roof deck, anodised alumonium rainscreen cladding, and green roof on the fingers.					
	Foundation System	Concrete slab					
	Other						
11 **Internal partition and non-strcutural elements**	**Vertical (walls)**	Concrete precast panels or plasterboard panels. There are also internal glass facades to allow the kids vision between spaces					
	Horizontal (ceilings/floors)	Suspended ceilings					
12 **Doors and windows**		Double glazed velfac windows, internal room doors also glazed to allowe the view					
13 **Construction details**	**Characteristics if innovative**	None					
14 **Environmental control systems**	**Water system**	Low flush toilets, infrared controlled urinals and water saving taps are used throughout the building.					
	Lighting system	As by code in Hospitals. Also photovoltaic panels on the roof provide renewable electricity					
	Heating system	Loop ground source heat pump to produce heating and cooling. Tri-generation via an absorption chiller to maximise CHP run times when use of heat elsewhere in the hospital is low					
	Fire control syustem	As by code					
	Communication system	As by code					

			Incremental	Modular	Architectural	System	Radical	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	No environmental change	Knowledge acquisition	Sustainability achievement	Technological advancement	Resources generation	Social problems generation	No social changes	Knowledge acquisition	Social objectives achievement	Social Improvement	Extra benefit generation	Economic Loss	No economic change	Saving achievement	New jobs creation	Increased revenue	Market expansion
	Ventilation system (mechanical, natural or hybrid)	Air source heat pumps to a number of air-handling units to contribute to carbin saving																														
15 **Sewage connectionn and water treatment**		As by code																														

2_Process			INNOVATION	DECISION-MAKER	SUSTAINABILITY: ENVIRONMENTAL	SUSTAINABILITY: SOCIAL	SUSTAINABILITY: ECONOMIC
CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	Type	Decision-maker	Results	Results	Results
1 Commissioning	Promoter	City of Liverpool and NHS Health Trust					
	Land owner	City of Liverpool					
	Client	Alder Hey Children's NHS Foundation Trust					
	Designer	BDP					
	Builder	Laing O'Rourke					
	Type of bid	Competitive tender process in 2010					
	Final building property	Alder Hey Children's NHS Foundation Trust					
	Building Manager	Laing O'Rourke					
2 Financing	Financing actors	City and Alder Hey NHS Trusr					
	Financing type						
	Entity	£167 million					
	Percentage of the total						
3 Program (brief)	Site characteristics	Springflied Park					
	Project scope	Hospital and public park					
	Architectural characteristics	Relation with the park and social aspect of visual relation for the kids in the design of the building layout and spatial relation					
	Timeline	2 years from 2013 to 2015					
4 Component Production	Production place	Europe and Dubai					
	Production type	Prefabrication					
	Producer/Supplier	Explore Industrial Park (EIP)					
	Production time	Very tight, within three years time of construction					
5 Worksite/Construction/Assembly	Worksite Organization	Free worksite organization due to the 'tabularasa' condition of the site after the previous building demolition					
	Construction Methods	PFI Design and Build					
	Worksite Timing	Three years					
	Changes during Construction	None					
	Work coordination	Laing O'Rourke					
	Duration	Three years					
	Contingecies/Problems	None					
6 Tests	Management	Currie & Brown					
	Structure	Currie & Brown					
	Services	Currie & Brown					
	Materials	Currie & Brown					
	Forniture	Currie & Brown					
	Trades	Currie & Brown					
	Construction Systems	Currie & Brown					
7 Project Management/Control		Dave Houghton as project manager					
8 Drawing development	Preliminary Drawings	The project team also involved some of the children in the design process through the Young People's Design Group, which influenced the unique appearance of the hospital.					
	Architectural Drawings	BPD					

				Competence Creating	Competence Destroying	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	No environmental change	Knowledge acquisition	Sustainability achievement	Technological advancement	Resources generation	Social problems generation	No social changes	Knowledge acquisition	Social objectives achievement	Social Improvement	Extra benefit generation	Economic Loss	No economic change	Saving achievement	New jobs creation	Increased revenue	Market expansion
		Construction Drawings	BDP Engineering Consultant. The use of Design for Manufacture and Assembly (DfMA) was crucial to the speedy delivery of the hospital, with over 15,000 components built off site, ranging from lattice floor, twin wall and pre-glazed external panels from Explore Industrial Park (EIP) to mechanical electrical and plant (MEP) modules from CHt's Oldbury facility and bathroom pods from Modulor in Dubai. Digital engineering was also essential in the speed of information transfer between our design team and our manufacturing facilities. This proved particularly pivotal in the coordination with Expanded and EIP to design and track more than 12,000 precast elements, including the facade panels which give the building its distinctive character.																											
		As Built Drawings	BDP																											
9	**Work coordination**	**Type of Management Organization**	Project Management																											
		Coordination	Digital Manufacturing to enhacne coordination and relation with manufacturing plant																											
		Time Control																												
		Cost Control																												
		Quality Control																												
		Auditing/Certification Agency	NHS Trust																											
10	**Contractual relations**	**Contract Type**	Project Management Agreement																											
		Contract Compliance																												
		Contract Termination																												
		Contract Renewal																												
11	**Maintenance/Building Use**	**Maintenance Plan**	Alder Hey Children's NHS Foundation Trust																											
		Building Use	NHS Trust																											
		Defined Maintenance																												
		Actual Maintenance																												

The Guastalla Kindergarden
Guastalla, Italy
MCA - Mario Cucinella Architects
2015



Context Characteristics: Semi-Rural

Concpet Characteristics: Pinocchio's whale belly

Orientation: South-East/North-West

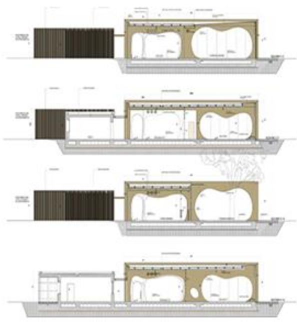
Dimension: 1400 sqm

Shape: Cucinella's idea is to create an environment that is the scene of many occasions of the stimulus and fantasy experience for children, a space constituted by the parallel succession of fifty frames structural laminated wood imagined as the Pinocchio whale.

Floor number: 1 Floor

Access and circulation: Main access for kids

Structure: Sequence of timber portals



Construction systems: Series of bearing frames (18×4,8 m) placed at a distance of 1,56 m allow to switch between opaque and transparent walls.

Evironmanetal control systems: Controlled mechanical ventilation with heat recovery combined with the disposition of the glazed openings which can create a natural circulation of the air from the bottom to the top (stack effect).

System for the self-production of solar panels and photovoltaic panels (with a peack power of 35 kWp) which cover the 40,5% of the total energy required for heating and cooling. The solar system installed as a supplement of the heat pump for the production of sanitary hot water, consists of 4 vacuum tube collectors and 1 vertical steel kettle, equal to 1,500 liters of capacity, able to meet the 60% of the needs of hot water

Water treatment: Rain water collection in order to be used in no-domestic uses (such as toilet flushing, cleaning and irrigation)

1_Building			INNOVATION	DECISION-MAKER	SUSTAINABILITY		
					ENVIRONMENTAL	SOCIAL	ECONOMIC
CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	Type	Decision-maker	Results	Results	Results
1 Context Characteristics	Urban	Urban (surrounded by the rural environment)					
	Rural	/					
2 Concept	Characteristics	Pinocchio's fairytail (Whale's belly)					
3 Orientation	Emisphere	North					
	Axes	South-East/North-West					
4 Architectural Characteristics	Aesthetic Approach	Sustainability related to the use of materials (as wood) and the use of renewable sources system					
5 Dimension		78m x 18m (1.400 m2)					
6 Shape	Typology	Kindergarten					
	Geometry	Rectangular plan					
	Volume Shape	Parallelepiped					
	Symmetry	Regular sections grouped in 3 independent and identical blocks					
7 Floor number and height		Ground floor (Height: 4,80 m)					
8 Access and circulation	Main access	The main acess is on the main facade					
	Pedestrian access	There are different pedestrian acess					
	Circulation characteristics	Linear distribution system there aren't any architectural barriers					
	Circulation within the building	Different ways dedicated to the children, kindergarten staff, and parents.					
9 Structure		wooden structure reinforced concred foundations					
10 Construction systems	Envelope	External series of bearing wood frames					
	Roof	Composition of a sandwich panel OSB, wood, PVC					
	Foundation System	Reinforced concrete plate (thickness: 40 cm)					
	Other	/					
11 Internal partition and non-strcutural elements	Vertical (walls)	wooden and glazed vertical walls					
	Horizontal (ceilings/floors)	wooden celings and glazed partitions					
12 Doors and windows		Glazed and wooden doors and windows					
13 Construction details	Characteristics if innovative	Prefabricated panels innovative only for the final shape (specially for the ecterior frames)					
14 Environmental control systems	Water system	Rain water collection in order to be used in no-domestic uses (such as toilet flushing)					
	Lighting system	Low energy consumption system					
	Heating system	Photovoltaic panels which cover the 40,5% of the total energy required for heating and cooling.					
	Fire control sysytem	As by law					
	Communication system	Amplification sound system					

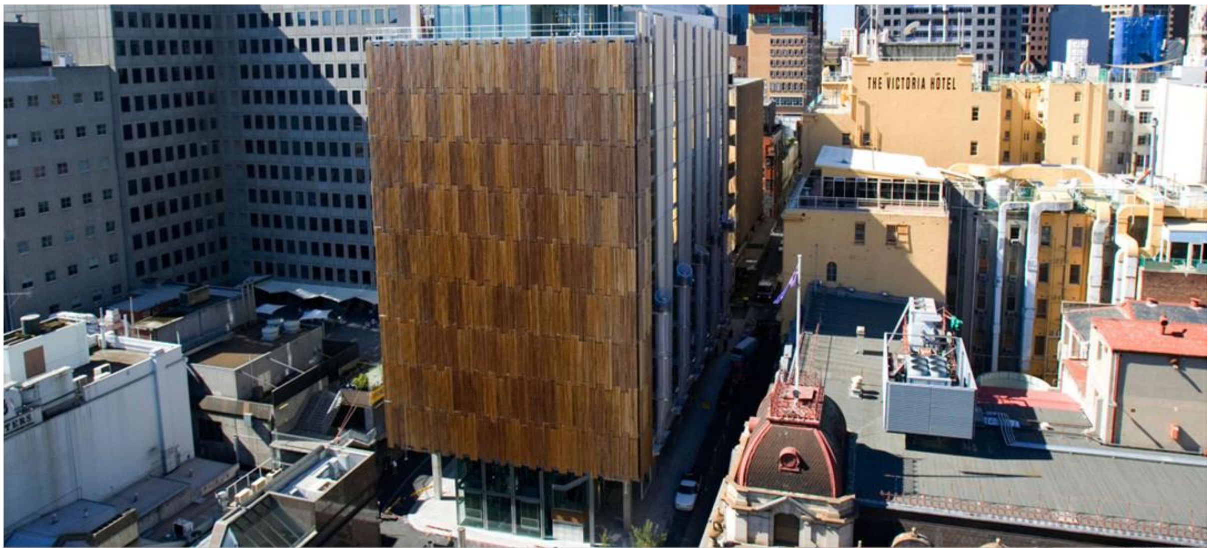
No.	Item	Sub-item	Solution	Irrelevant	Incremental	Modular	Architectural	Radical	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	Resource waste	Environmentally Irrelevant	Sustainability strategy introduction	Technological perfomances introduction	Resources generation	Social problems generation	No social changes	Social problem solution	Social purpose definition	Social objective achievement	Extra benefit generation	Economic Loss	Cost invariant	Knowledge acquisition	Comparative advantage	Competitive advantage	Market expansion
		Ventilation system (mechanical, natural or hybrid)	Hybrid				■				■								■	■			■						■		■		
15	**Sewage connectionn and water treatment**		Rain water collection in order to be used in no-domestic uses (such as toilet flushing)	■					■		■							■					■						■				

2_Process

INNOVATION (Type) | DECISION-MAKER (Decision-maker) | SUSTAINABILITY: ENVIRONMENTAL (Results), SOCIAL (Results), ECONOMIC (Results)

CATEGORY	SUB-CATEGORY	DEFINITION Characteristics
1 Commissioning	Promoter	Comune di Guastalla (Provincia di Reggio Emilia)
	Land owner	Comune di Guastalla (RE)
	Client	Unione Comuni Bassa Reggiana
	Designer	Mario Cucinella Architects
	Builder	Scisciani e Frascarelli Impresa Edile
	Type of bid	Pubblic call for tenders
	Final building property	Comune di Guastalla (RE)
	Building Manager	Engineer of Scisciani e Frascarelli Impresa Edile
2 Financing	Financing actors	Regione Emilia Romagna Concert (Italia loves Emilia) Comune di Guastalla Italian people (SMS solidarity)
	Financing type	Public and Private
	Entity	Regione Emilia Romagna Concert (Italia loves Emilia) Comune di Guastalla Italian people (SMS solidarity)
	Percentage of the total	Total: 100% € 3.150.000 Private: 35 % (€ 1.110.000) Public: 65% € 2.050.000
3 Program (brief)	Site characteristics	Empty area dedicated for a construction of educational purpose building
	Project scope	Replace two old nurses
	Architectural characteristics	Sustainability and innovation
	Timeline	Defined in the brief (45 days for the construction)
4 Component Production	Production place	National territory
	Production type	Processing of raw materials
	Producer/Supplier	Rubner Holzbau SpA for wooden structures
	Production time	//No info//
5 Worksite/Construction/Assembly	Worksite Organization	Technician who chooses site areas and roadworthiness
	Construction Methods	Assembling prefabricated elements
	Worksite Timing	30 days for the structure
	Changes during Construction	No relevant changes
	Work coordination	//No info//
	Duration	30 days
	Contingecies/Problems	No relevant problems
6 Tests	Management	Project management
	Structure	According to Italian law
	Services	According to Italian law
	Materials	Made by the production companies
	Forniture	Specific tests for the child use
	Trades	Made by the differnt companies
	Construction Systems	Made by the builder
7 Project Management/Control		Engineer called by Comune di Guastalla (RE)
8 Drawing development	Preliminary Drawings	Comune di Guastalla (RE)
	Architectural Drawings	Mario Cucinella Architects
	Construction Drawings	Mario Cucinella Architects
	As Built Drawings	Mario Cucinella Architects

			Competence Creating	Competence Destroying	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	Resource waste	Environmentally Irrelevant	Sustainability strategy introduction	Technological perfomances introduction	Resources generation	Social problems generation	No social changes	Social problem solution	Social purpose definition	Social objective achievement	Extra benefit generation	Economic Loss	Cost invariant	Knowledge acquisition	Comparative advantage	Competitive advantage	Market expansion
9 **Work coordination**	**Type of Management Organization**	The contractor and subcontractors shall appoint the technical site manager Safety control	■					■						■					■						■				
	Coordination	Co-ordinating technician works to organize and coordinate the activities of shipyard workers	■					■						■					■						■				
	Time Control						■	■						■					■						■				
	Cost Control	Technician of Comune di Guastalla (RE)	■		■		■							■					■						■				
	Quality Control	Variable depending on the companies	■					■	■					■					■						■				
	Auditing/Certification Agency	Variable depending on the workmanships	■								■			■					■						■				
10 **Contractual relations**	**Contract Type**	Defined in the document for pubblic tender	■		■	■								■					■						■				
	Contract Compliance	According to law	■		■	■								■					■						■				
	Contract Termination	All contracts have come to an end positively	■		■	■								■					■						■				
	Contract Renewal	Not allowed			■	■								■					■						■				
11 **Maintenance/Building Use**	**Maintenance Plan**	The Maintenance Plan for Public Works, pursuant to art. 33 of dpr 207/2010, is a compulsory draft of the executive project.	■		■	■								■					■						■				
	Building Use	Defined in the user manual	■		■	■								■						■	■				■				
	Defined Maintenance	Sustainable maintenance		■	■	■								■					■						■				
	Actual Maintenance	Replacement of windows	■		■	■								■					■						■				



CH2 Melbourne
Melbourne, Australia
Design Inc. and Mike Pearce
2006

Context Characteristics: Urban

Concpet Characteristics: Biomimicry

Orientation: North-West/South East

Dimension: 12500.0 sqm

Shape: Parallelepiped

Floor number: 10 Floors

Access and circulation: Main access from ground floor with public functions

Structure: The concrete structure is relatively conventional insitu construction, except for the use of precast curved concrete ceiling panels. Two rows of concrete columns are located at 8200mm centres just inside the north and south facades, with a further row of columns offset from the centre of the floor plate

Construction systems: Each facade is differently characterised. The main facade is characterised by timber shading system. The other facades displays precast panels and green planting system

Evironmanetal control systems: Nature is used as inspiration for façades that moderate climate, tapered ventilation ducts integrate with day lighting strategies and an evocative undulating concrete floor structure that plays a central role in the building's heating and cooling.
The environmental control systems are many and characterise the nature of the entire building

Certification: The building was utilised to establish the six star rating system in Australia

1_Building			INNOVATION	DECISION-MAKER	SUSTAINABILITY		
					ENVIRONMENTAL	SOCIAL	ECONOMIC
CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	Type	Decision-maker	Results	Results	Results
1 Context Characteristics	Urban	In Melbourne CBD					
	Rural						
2 Concept	Characteristics	Biomimicry					
3 Orientation	Emisphere	South					
	Axes	North-West/South East					
4 Architectural Characteristics	Aesthetic Approach	Expressing the envirnmental behaviour					
5 Dimension		12500.0 sqm					
6 Shape	Typology	Block					
	Geometry	Rectangular layout					
	Volume Shape	Parallelepiped					
	Symmetry	Simmetry					
7 Floor number and height		10 Floors					
8 Access and circulation	Main access	Main access from ground floor with public functions					
	Pedestrian access	Pedestrian access from ground floor					
	Circulation characteristics	The building can be reached via different medium of transport					
	Circulation within the building	Vertical circulation and open floor plan					
9 Structure		Reinforced concrete and precast concrete					
10 Construction systems	Envelope	Precats panels and different facade treatement according to orientation					
	Roof	Wind turbine and usable roof					
	Foundation System	Reinforced concrete					
	Other						
11 Internal partition and non-strcutural elements	Vertical (walls)	Open floor plan					
	Horizontal (ceilings/floors)	Special precats concrete ceilings shaped to facilitate the air flow inside the building, as wel ass chilled ceiling panels					
12 Doors and windows		Open floor plan					
13 Construction details	Characteristics if innovative	Special precats concrete ceilings shaped to facilitate the air flow inside the building, as wel ass chilled ceiling panels					
14 Environmental control systems	Water system	AAAA' fittings and fixtures throughout the building taps and showerheads of low water flow rate – approximately 2.5 litres per minute and nine litres per minute water flow to all hand basin taps controlled by electronic sensors					
	Lighting system	Natiral and artificial light powered by co-generation form of energy production					
	Heating/Cooling system	Radiant cooling, thermal mass and night purge, chlled ceiling panels, phase change material and shower towers					
	Fire control system	As per code					
	Energy generation system	Micro-turbine: co-generation and solar power: photovoltaic cells					

			Incremental	Modular	Architectural	System	Radical	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	No environmental change	Knowledge acquisition	Sustainability achievement	Technological advancement	Resources generation	Social problems generation	No social changes	Knowledge acquisition	Social objectives achievement	Social Improvement	Extra benefit generation	Economic Loss	No economic change	Saving achievement	New jobs creation	Increased revenue	Market expansion
	Ventilation system (mechanical, natural or hybrid)	Natural ventilation				■				■							■	■	■				■							■		
15 **Sewage connectionn and water treatment**		four litre / three litre dual flush toilets and two litre flush urinals.				■				■							■	■	■				■							■		

2_Process			INNOVATION	DECISION-MAKER	SUSTAINABILITY: ENVIRONMENTAL	SUSTAINABILITY: SOCIAL	SUSTAINABILITY: ECONOMIC
CATEGORY	**SUB-CATEGORY**	**DEFINITION Characteristics**	**Type**	**Decision-maker**	**Results**	**Results**	**Results**
1 **Commissioning**	**Promoter**	The City of Melbourne					
	Land owner	The City of Melbourne					
	Client	The City of Melbourne					
	Designer	Design Inc. and Mick Pearce (Design Director), Stephen Webb (Design Architect), Chris Thorne (Design Architect), Jean-Claude Bertoni (Project Architect), Vi Vuong (Architect), Aldona Pajdak (Interior Designer)					
	Builder	Hansen Yuncken					
	Type of bid	Public bid					
	Final building property	The City of Melbourne					
	Building Manager	The City of Melbourne					
2 **Financing**	**Financing actors**	The City of Melbourne					
	Financing type						
	Entity	AUD $51.045 million					
	Percentage of the total						
3 **Program (brief)**	**Site characteristics**	The site is a block in the Melbourne CBD on Swanston Street, which is the main street of the city					
	Project scope	Office building with retail functions at the ground floor					
	Architectural characteristics	Biomimicry					
	Timeline	2 Years					
4 **Component Production**	**Production place**	Both local and internarional					
	Production type	Precast					
	Producer/Supplier	Boral, Meinhardt, bonacci, ardenbuilding, scott development and others					
	Production time	Below 2 years					
5 **Worksite/Construction/Assembly**	**Worksite Organization**	Hans Yuncken					
	Construction Methods	Very small space for construction and area only accessible from laneway, so mostly the construction solution was precast concrete					
	Worksite Timing	2 Years					
	Changes during Construction	Size reduction and save of AUD $ 13 Million					
	Work coordination	Hans Yuncken					
	Duration	2 Years					
	Contingecies/Problems	None					
6 **Tests**	**Management**	File Tranfer Protocol system was tested to maximise coordination operations					
	Structure	Concrete mixture containing fly ash and furnace slag					
	Services	Many tests done on the environmental control systems					
	Materials	Not required					
	Forniture	Not required					
	Trades	Not required					
	Construction Systems	Not required					
7 **Project Management/Control**		TAC pacific					
8 **Drawing development**	**Preliminary Drawings**	Mike Pearce					
	Architectural Drawings	Design Inc.					
	Construction Drawings	Design Inc and Hansen Yuncken					
	As Built Drawings	Design Inc and Hansen Yuncken					

9 **Work coordination**	**Type of Management Organization**	Project Management and Control																											
	Coordination	Rob Adams																											
	Time Control	Lincoln and Scott																											
	Cost Control	Lincoln and Scott																											
	Quality Control	Lincoln and Scott																											
	Auditing/Certification Agency	Environmental auduting group																											
10 **Contractual relations**	**Contract Type**	Modified version of AS2124																											
	Contract Compliance	Yes																											
	Contract Termination	None																											
	Contract Renewal	None																											
11 **Maintenance/Building Use**	**Maintenance Plan**	Standard maintenance plan																											
	Building Use	Offices																											
	Defined Maintenance	Regular manteinance																											
	Actual Maintenance	Replacement of oversized water pumps and split unit and purge system																											
			Competence Creating	Competence Destroying	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	No environmental change	Knowledge acquisition	Sustainability achievement	Technological advancement	Resources generation	Social problems generation	No social changes	Knowledge acquisition	Social objectives achievement	Social Improvement	Extra benefit generation	Economic Loss	No economic change	Saving achievement	New jobs creation	Increased revenue	Market expansion

41 X
Melbourne, Australia
Lyons Architects
2013

Context Characteristics: Urban

Concpet Characteristics: The design explores the idea of a hybridized public and commercial building, placing focus on the activities of the Institute located on the lower levels of the tower, and maximising their public engagement

Orientation: South-East/North-West

Dimension: 5880 sqm

Shape: Parallelepiped with dynamic segment in the facede and in the main stair design

Floor number: 21 Storeys

Access and circulation: Public engagement by conceptually and spatially extending the city street up into the building through a major stair at the buildings edge. In order to optimise the space, one core only is present in the building

Structure: Bubbledeck precast floor panels and precast concrete columns

Construction systems: Precast concrete, high performance glazing, anodised aluminium supported by structural steel

Evironmanetal control systems: HVAC strategy is a floor-by-floor variable volume low temperature system with demand control ventilation and 50% increase in outside air rate. Thermal plant comprises roof top air cooled chiller, tenancy closed circuit heat rejection plant and a forced draft boiler

Sustainability strategy: Measures of energy, materials, transport, waste and certified carbon offsets, the goal is carbon neutrality over a thirty-year period: from design through construction and occupancy

Certification: 5 Stars over the 6 stars certification scheme

1_Building			INNOVATION	DECISION-MAKER	SUSTAINABILITY		
					ENVIRONMENTAL	SOCIAL	ECONOMIC
CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	Type	Decision-maker	Results	Results	Results
1 Context Characteristics	Urban	In Melbourne CBD					
	Rural						
2 Concept	Characteristics	The design explores the idea of a hybridized public and commercial building, placing focus on the activities of the Institute located on the lower levels of the tower and maximising their public engagement					
3 Orientation	Emisphere	South					
	Axes	South-East/North-West					
4 Architectural Characteristics	Aesthetic Approach	Precast soleil and green belt to signify the environmental approach as well as to identify the architecture signature					
5 Dimension		5880 msq					
6 Shape	Typology	Tower					
	Geometry	Rectangular floor plan					
	Volume Shape	Parallelepiped					
	Symmetry	Simmetry					
7 Floor number and height		21 floors					
8 Access and circulation	Main access	Mnain access from the city into the highest part of the building as a way to connect with the urban environment					
	Pedestrian access	Public path into the building throught he vertical circulation					
	Circulation characteristics	The building can be reach by different medium of transpoi					
	Circulation within the building	Public path into the building throught he vertical circulation					
9 Structure		Bubbledeck precast floor panels and precast concrete columns					
10 Construction systems	Envelope	Precast concrete, high performance glazing, anodised aluminium supported by structural steel					
	Roof	Roof top air cooled chillers					
	Foundation System	Reinforced concrete					
	Other						
11 Internal partition and non-strcutural elements	Vertical (walls)	Open plan with glass partitions					
	Horizontal (ceilings/floors)	Concrete slab with carpet as finishing material					
12 Doors and windows		East/west glazing panel decreased in size while the glazing system performance increased					
13 Construction details	Characteristics if innovative	All materials have been selected for the embody energy					
14 Environmental control systems	Water system	Standard					
	Lighting system	Standard					
	Heating system	HVAC strategy is a floor-by-floor variable volue low temperature system with demand control ventilation and 50% increase in outside air rate.					
	Fire control system	Standard					

				Incremental	Modular	Architectural	System	Radical	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	No environmental change	Knowledge acquisition	Sustainability achievement	Technological advancement	Resources generation	Social problems generation	No social changes	Knowledge acquisition	Social objectives achievement	Social Improvement	Extra benefit generation	Economic Loss	No economic change	Saving achievement	New jobs creation	Increased revenue	Market expansion
		Communication system	/																														
		Ventilation system (mechanical, natural or hybrid)	Thermal plant comprises roof top air cooled chiller, tenancy closed circuit heat rejection plant and a forced draft boiler				■				■							■					■						■				
15	**Sewage connectionn and water treatment**		Standard	■							■						■						■						■				

2_Process

INNOVATION	DECISION-MAKER	SUSTAINABILITY		
		ENVIRONMENTAL	SOCIAL	ECONOMIC
Type	Decision-maker	Results	Results	Results

CATEGORY	SUB-CATEGORY	DEFINITION Characteristics
1 **Commissioning**	**Promoter**	Australian Institute of Architects
	Land owner	Australian Institute of Architects
	Client	Australian Institute of Architects
	Designer	Lyons Architects
	Builder	Hickory Group
	Type of bid	Two-stage design competition
	Final building property	Australian Institute of Architects
	Building Manager	Australian Institute of Architects
2 **Financing**	**Financing actors**	Australian Institute of Architects
	Financing type	/
	Entity	AUD$ 31 Million
	Percentage of the total	
3 **Program (brief)**	**Site characteristics**	Very small floor plate of 330 msq
	Project scope	Multi function building
	Architectural characteristics	Geonetric brise soleil and green belt in the facade to communicate environmental intention and signature of the architecture firm
	Timeline	From 2008 to 2013
4 **Component Production**	**Production place**	Local
	Production type	Prefabrication
	Producer/Supplier	Local
	Production time	/
5 **Worksite/Construction/Assembly**	**Worksite Organization**	Hickory Group with the use of REVIT
	Construction Methods	During construction, Hickory used custom-designed components in the protection screen to navigate the perimeter of the intricate facade. Because the site was on such a constrained footprint, and in an extremely high-traffic (both vehicle and pedestrian) area, options were limited for scaffolding, craneage and access systems beyond the building envelope, with one elevation literally adjoining another building
	Worksite Timing	19 months
	Changes during Construction	None
	Work coordination	Hickory Group with the use of REVIT
	Duration	19 months
	Contingecies/Problems	NOne
6 **Tests**	**Management**	Not required
	Structure	Not required
	Services	Not required
	Materials	Not required
	Forniture	Not required
	Trades	Not required
	Construction Systems	Not required
7 **Project Management/Control**		Hickory Group with the use of REVIT
8 **Drawing development**	**Preliminary Drawings**	Lyons Architects
	Architectural Drawings	Lyons Architects
	Construction Drawings	Hickory Group with the use of REVIT
	As Built Drawings	Hickory Group with the use of REVIT

			Competence Creating	Competence Destroying	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	No environmental change	Knowledge acquisition	Sustainability achievement	Technological advancement	Resources generation	Social problems generation	No social changes	Knowledge acquisition	Social objectives achievement	Social Improvement	Extra benefit generation	Economic Loss	No economic change	Saving achievement	New jobs creation	Increased revenue	Market expansion
9 **Work coordination**	**Type of Management Organization**	Hickory Group with the use of REVIT		■		■	■	■						■	■	■			■							■		■	
	Coordination	Hickory Group with the use of REVIT		■		■	■	■						■	■	■			■							■		■	
	Time Control	Hickory Group with the use of REVIT		■		■	■	■						■	■	■			■							■		■	
	Cost Control	Hickory Group with the use of REVIT		■		■	■	■						■	■	■			■							■		■	
	Quality Control	Hickory Group with the use of REVIT and Lyons Architects		■		■	■	■						■	■	■			■							■		■	
	Auditing/Certification Agency	Australian Institute of Architects	■			■	■	■						■	■	■			■							■		■	
10 **Contractual relations**	**Contract Type**	Guaranteed Maximum Price contract for the construction of the new building, subject to finance, final planning approval and review of the final contract conditions by the Project Control Group; formal agreements, including related deeds of novation, with the architect and other key project consultants, and arrangements to obtain project finance up to an agreed limit from a bank or other approved financial institution.	■			■								■						■						■	■		
	Contract Compliance	Yes	■			■								■						■						■	■		
	Contract Termination	None	■			■								■						■						■	■		
	Contract Renewal	None	■			■								■						■						■	■		
11 **Maintenance/Building Use**	**Maintenance Plan**	Lyons Architects	■			■	■							■															
	Building Use	The Sustainability Charter binds tenants to the sustainability agenda for the building to monitor and, where needed, change behaviours. On an annual basis, the measured operational carbon footprint of the building's tenants will be independently assessed. Combined with the quantified embodied carbon of the physical building, the operational carbon will be offset annually.		■			■							■	■	■				■	■	■				■			
	Defined Maintenance	As per defined	■				■							■	■	■				■	■	■				■			
	Actual Maintenance	As per defined	■				■							■	■	■				■	■	■				■			

The Cardboard Cathedral
Christchurch, New Zealand
Shigeru Ban
2011

Context Characteristics: Urban

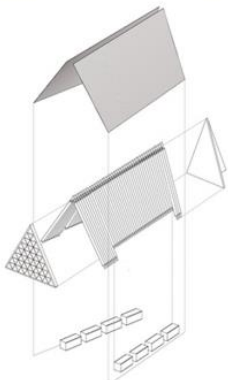
Concpet Characteristics: Golden Ratio and Existing Cathedral Facades

Orientation: Emisphere (Emisfero) Austral Axes (Asse) north (entrance) / south (apse) 43°31’48” S 172°37’13”E.

Dimension: Site: 2500 square metres, Building: 750 square metres

Shape: A shape, there is a gradual change in each angle of paper tubes, narrower toward the apse.
The shape unintentionally recalls the traditiona Maori house.

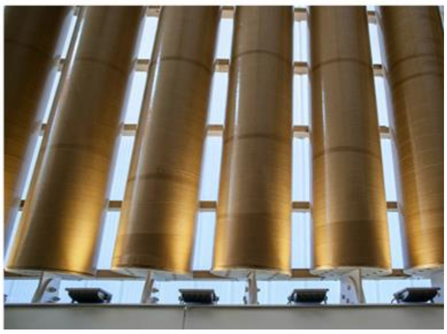
Floor number: One floor, 24 metres, 5 meters vertically



Access and circulation: Main entrance is in the front facade. On each side, between each of the four shipping containers, are located 3 secondary entrances. Two more entrances are located in the back of the altar.

Structure: A-Shape Steel Portals

Construction systems: Locally sourced laminated veneer lumber (LVL) rafters is inserted inside each of the 98, 610-millimeter-diameter (2-foot-diameter) cardboard tubes comprising the A-frame.



Evironmanetal control systems: Transparent/opaque relation: between each cardboard tube the is a gap of 2 inches (5,1 cm), in order to let the light pass through polycarbonate roof
Automated vents at the top and bottom of the opposing ends provide cross ventilation when required
Heating pump for underfloor heating
Maximisation of local material

Water treatment: Standard water collection through gutters, connected to sewerage.

1_Building

CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	INNOVATION – Type: Incremental	Modular	Architectural	System	Radical	DECISION-MAKER – Decision-maker: Institutions	Client	Designer	Builder	Industry	Users	Other	SUSTAINABILITY – ENVIRONMENTAL – Results: Environmental problems	No environmental change	Knowledge acquisition	Sustainability achievement	Technological advancement	Resources generation	SOCIAL – Results: Social problems generation	No social changes	Knowledge acquisition	Social objectives achievement	Social Improvement	Extra benefit generation	ECONOMIC – Results: Economic Loss	No economic change	Saving achievement	New jobs creation	Increased revenue	Market expansion
1 Context Characteristics	Urban	post-quake Christchurch, in front of CCTV building					X	X	X				X				X								X	X				X	X	
	Rural	none																														
2 Concpet	Characteristics	temporary / quick to build / cheap cathedral					X		X	X								X	X							X				X	X	X
3 Orientation	Emisphere	austral		X					X								X					X						X				
	Axes	Christchurch: N/S (43°31'48"S; 172°37'13"E)					X		X								X									X					X	
4 Architectural Characteristics	Aesthetic Approach	depended on budget and availability of local materials				X			X								X	X								X			X	X		
5 Dimension		170 sqm, same as the old cathedral			X			X	X	X					X								X	X		X						
6 Shape	Typology	single nave cathedral				X			X							X										X				X	X	
	Geometry	trapezoidal plan				X				X								X					X							X		
	Volume Shape	A-shape building				X				X								X					X							X		
	Symmetry	longitudinal	X							X						X						X								X		
7 Floor number and height		one floor, 24 meters			X			X	X	X							X					X						X				
8 Access and circulation	Main access	from Hereford St., under Trinity Window			X					X							X							X				X				
	Pedestrian access	same as the main access			X					X							X							X				X				
	Circulation characteristics	standard	X							X							X					X						X				
	Circulation within the building	standard	X							X							X					X						X				
9 Structure		timber beams, cardboard tubes					X		X		X					X										X			X			
10 Construction systems	Envelope	cardboard tubes (sonotubes)					X			X							X									X					X	
	Roof	twisting polycarbonate cladding				X				X									X	X		X					X					
	Foundation System	reinforced concrete			X			X	X	X			X				X						X					X				
	Structure	timber beams (LVL)				X				X								X								X					X	
11 Internal partition and non-strcutural elements	Vertical (walls)	8 shipping containers				X				X							X								X						X	
	Horizontal (ceilings/floors)	floor: polished concrete	X							X							X					X						X				
12 Doors and windows		Trinity Window			X				X	X			X				X									X			X			
13 Construction details	Characteristics if innovative	desing of polycarbonate roof cladding				X				X	X								X			X					X					
14 Evironmanetal control systems	Water system	standard	X					X		X							X					X						X				
	Lighting system	mainly natural (from the roof)				X				X									X			X							X			
	Heating system	floor heating with thermal pump		X						X	X			X			X					X						X				
	Fire control system	polyurethane coating on carboard tubes					X	X		X		X					X								X				X			
	Communication system	standard																														
	Ventilation system (mechanical, natural or hybrid)	2 mechanical fans help natural ventilation		X						X								X				X						X				
15 Sewage connectionn and water treatment		standard	X								X						X					X						X				

2_Process

CATEGORY	SUB-CATEGORY	DEFINITION Characteristics
1 Commissioning	Promoter	Rev. Dixon (Anglican Diocese)
	Land owner	CPT, loaned to St. John Congregation
	Client	Anglican Diocese
	Designer	Shigeru Ban Architects (+ local)
	Builder	Naylor Love
	Type of bid	Direct assignment
	Final building property	CPT (Anglican Diocese, St John Congregation)
	Building Manager	Anglican Diocese
2 Financing	Financing actors	Various (community involvement)
	Financing type	Crowdfunding
	Entity	NZ$ 5,9 million dollars
	Percentage of the total	100%
3 Program (brief)	Site characteristics	Post-earthquake urban context
	Project scope	Transitional replacement for Old Cathedral
	Architectural characteristics	Temporary / Replaceable
	Timeline	Feb 2012 / Jul 2013 (2 years after quake)
4 Component Production	Production place	Ban insisted on using local materials
	Production type	Sometimes standards, sometimes challenging
	Producer/Supplier	Almost entirely from New Zealand
	Production time	Materials had to be delivered in short times
5 Worksite/Construction/Assembly	Worksite Organization	Project manager and building decisions
	Construction Methods	Critical Path
	Worksite Timing	Quick building
	Changes during Construction	From a trussed structure to A-frame
	Work coordination	Project manager and building decisions
	Duration	11 months
	Contingecies/Problems	Carboard tubes were replaced once (soaked in rain)
6 Tests	Management	Shigeru Ban + local industries
	Structure	Cardboard
	Services	///// IMPIANTI
	Materials	Needed to be locally sourced
	Trades	Builder was responsable for on-site trades
	Construction Systems	Timber + Cardboard
7 Project Management/Control		Standard
8 Drawing development	Preliminary Drawings	Shigeru Ban
	Architectural Drawings	Yoshie Narimatsu (Shigeru Ban Architects)
	Construction Drawings	Warren and Mahoney + Steel Pencil
	As Built Drawings	Warren and Mahoney + Builder
9 Work coordination	Type of Management Organization	Standard
	Coordination	BECA
	Time Control	BECA + Rev. Dixon
	Cost Control	Ban + BECA + Rev. Dixon
	Quality Control	Ban + Naylor Love
10 Contractual relations	Contract Type	Standard
	Contract Compliance	Standard
	Contract Termination	At the end of constructions
	Contract Renewal	None
11 Maintenance/Building Use	Maintenance Plan	Standard
	Building Use	Religious + Public events
	Defined Maintenance	Building will last 50+ years, then will be recycled
	Actual Maintenance	Standard

INNOVATION — Type: Competence Creating; Competence Destroying

DECISION-MAKER — Decision-maker: Institutions; Client; Designer; Builder; Industry; Users; Other

SUSTAINABILITY

- ENVIRONMENTAL — Results: Environmental problems; No environmental change; Knowledge acquisition; Sustainability achievement; Technological advancement; Resources generation
- SOCIAL — Results: Social problems generation; No social changes; Knowledge acquisition; Social objectives achievement; Social Improvement; Extra benefit generation
- ECONOMIC — Results: Economic Loss; No economic change; Saving achievement; New jobs creation; Increased revenue; Market expansion


Photographer: Pasi Aalto

CASSIA COOP TRAINING CENTER

Sumatra
TYIN tegnestau
2011

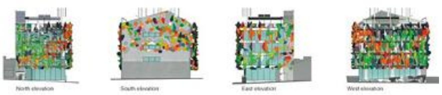
Context Characteristics:	Rural
Concpet Characteristics:	Courtyard building with light wooden construction on a base of heavy brick and concrete. The wooden construction gives a feeling of being within a cinnamon forest as where it is built.
Orientation:	North/South
Dimension:	484.0 sqm
Shape:	The building shape in plan is a rectangular geometry With a slope unattached roof, the whole building forms a prism in volumtric shape.
Floor number:	Single Storey
Access and circulation:	Main access on the lake-around road and flows for people(mainly), livestock, cars and tracks.
Structure:	Load bearing walls, wooden Y-shape pillars.
Construction systems:	Locally crafted brick to construct the load bearing wall,which mainly intended to divide the outdoor and indoor space. The trunk of the cinnamon tree is shaped into timber bar and joint with steel elements to form the Y-shape pillar to support the roof system.
Evironmanetal control systems:	Overheaded roof which means passive ventilation can easily go through the whole building site. provides a good solution to hot and humid local climate,
Water treatment:	Slope roof guides rainwater to flow into natural terrain which normally can absorb the water quickly,moreover in tropic climate, water evaporates soon. Standard wastewater treatment system.
Certification:	NONE

Resource: Cassia Co-op Training Centre<http://www.tyinarchitects.com/works/cassia-coop-training-centre/>
Cassia Coop Training Centre / TYIN Tegnestue Architects<http://www.archdaily.com/274835/casia-coop-training-centre-tyin-tegnestue-architects>

1_Building			INNOVATION					DECISION-MAKER							SUSTAINABILITY																	
															ENVIRONMENTAL						SOCIAL						ECONOMIC					
CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	Type					Decision-maker							Results						Results						Results					
			Incremental	Modular	Architectural	System	Radical	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	No environmental change	Knowledge acquisition	Sustainability achievement	Technological advancement	Resources generation	Social problems generation	No social changes	Knowledge acquisition	Social objectives achievement	Social Improvement	Extra benefit generation	Economic Loss	No economic change	Saving achievement	New jobs creation	Increased revenue	Market expansion
1 Context Characteristics	Urban	Not in urban context																														
	Rural	Cinnamon farmland context																														
2 Concpet	Characteristics	Light wooden construction on a base of brick wall and concrete. An educational building for teaching local farmers sustainable agricultural																														
3 Orientation	Emisphere	Not specific																														
4 Architectural Characteristics	Aesthetic Approach	Use basic local material to make the building integrated with surroundings																														
5 Dimension		22m X 22m X 2.5m(wall height)																														
6 Shape	Typology	Courtyard building																														
	Geometry	Rectangular																														
	Volume Shape	Prism																														
	Symmetry	Symmetry																														
7 Floor number and height		Only one floor, 2.5high(wall height)																														
8 Access and circulation	Main access	Entrance only at the Lake round road to the north																														
	Pedestrian access	Not specific																														
	Circulation characteristics	Main for pedestrian circulation, but small tracks are allowed as well																														
	Circulation within the building	Not specific																														
9 Structure		Y shape Pillar supporting structure made by cinnamon trunks																														
10 Construction systems	Envelope	Common brick wall with prefabricated cinnamon-made windows																														
	Roof	Timber structure with bamboo sheet and metal wave panel																														
	Foundation System	Concrete slab																														
	Other	Not specific																														
11 Internal partition and non-strcutural elements	Vertical (walls)	Common brick wall																														
	Horizontal (ceilings/floors)																															
12 Door and windows		Prefabricated Door and cinnamon-made windows																														
13 Construction details	Characteristics if innovative	Cinnamon timber joint by metal links forms a Y shape pillar																														
14 Evironmanetal control systems	Water system	Not specific																														
	Lighting system	Not specific																														
	Heating system	Not specific																														
	Fire control syustem	Not specific																														
	Communication system	Not specific																														
	Ventilation system (mechanical, natural or hybrid)	Detached roof upon the wall introduces natural ventilation go through the whole complex																														
15 Sewage connectionn and water treatment		Not specific																														

2_Process			INNOVATION	DECISION-MAKER	SUSTAINABILITY: ENVIRONMENTAL	SUSTAINABILITY: SOCIAL	SUSTAINABILITY: ECONOMIC
CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	Type	Decision-maker	Results	Results	Results
1 Commissioning	Promoter	Member of the Board of Directors of the client					
	Land owner	Client Own					
	Client	Cassia Coop Co.Ltd					
	Designer	TYIN Tegnestue Architects with some students					
	Builder	TYIN Tegnestue Architects, students, unskilled local workers who are employees of the client and livestocks					
	Type of bid	Job offer					
	Final building property	Client Own					
	Building Manager	TYIN Tegnestue Architects					
2 Financing	Financing actors	CASSIA Coop Co.Ltd & LINK Arkitektur (Public and international level)					
	Financing type	Direct finance					
	Entity	around 30,000 Euro					
	Percentage of the total	Not specific					
3 Program (brief)	Site characteristics	Cinnamon Farmland, Rural Forest Site					
	Project scope	Local, small size project					
	Architectural characteristics	Educational Building with low cost					
	Timeline	Several months					
4 Component Production	Production place	In-site production					
	Production type	Manually produce with low-tech machines					
	Producer/Supplier	Local factories and in-site builders					
	Production time	around 3 months					
5 Worksite/Construction/Assembly	Worksite Organization	Design team takes all responsibility					
	Construction Methods	Design and construction at the same time					
	Worksite Timing	Very short construction time					
	Changes during Construction	Not specific					
	Work coordination	Design team					
	Duration	around 3 month					
	Contingecies/Problems	Not specific					
6 Tests	Management	Not specific					
	Structure	unexpected earthquake test the whole structure					
	Services	Not specific					
	Materials	Not specific					
	Trades	Not specific					
	Construction Systems	unexpected earthquake test the whole structure					
7 Project Management/Control		Design team and Client are both in charge					
8 Drawing development	Preliminary Drawings	Handsketches in site.					
	Architectural Drawings	sketches and digital drawings					
	Construction Drawings	sketches and digital drawings					
	As Built Drawings	sketches and digital drawings					
9 Work coordination	Type of Management Organization	Design team is in charge of management and other responsibiliies					
	Coordination	Design team					
	Time Control	Design team					
	Cost Control	Design team					
	Quality Control	Design team					
	Auditing/Certification Agency	Not specific(probably not exsit)					
10 Contractual relations	Contract Type	Not specific					
	Contract Compliance	Not specific					
	Contract Termination	Not specific					
	Contract Renewal	Not specific					
11 Maintenance/Building Use	Maintenance Plan	Local workers do the maintenance					
	Building Use	Educational Building for teaching sustainable agriculture					
	Defined Maintenance	Local workers do the maintenance					
	Actual Maintenance	Local workers do the maintenance					
			Competence Creating; Competence Destroying	Institutions; Client; Designer; Builder; Industry; Users; Other	Environmental problems; No environmental change; Knowledge acquisition; Sustainability achievement; Technological advancement; Resources generation	Social problems generation; No social changes; Knowledge acquisition; Social objectives achievement; Social Improvement; Extra benefit generation	Economic Loss; No economic change; Saving achievement; New jobs creation; Increased revenue; Market expansion

Pixel Building
Melbourne, Australia
Studio 505
2010



Context Characteristics: Urban

Concpet Characteristics: Pixel

Orientation: North-South

Dimension: 1136 sqm

Shape: Parallelepiped block

Floor number: 3 Storeys

Access and circulation: Access from main entrance, free plan circulation inside the building. The building can be reach by different medium of transport

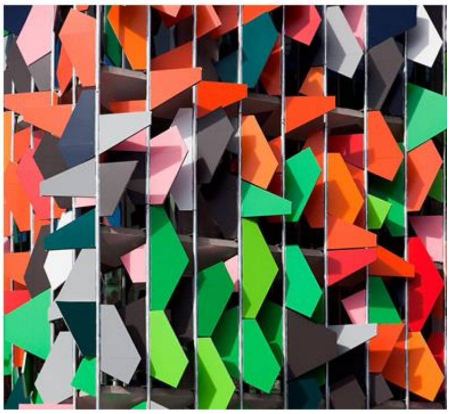
Structure: Concrete slabs and concrete columns

Construction systems: Glazed curtain wall with pixelcrete shading system

Evironmanetal control systems: Rainwater harvesting, Photovoltaic panels with tracking system and wind turbine to produce electricity, a water-ammonia absorption pump is used to heat and cool the building, also thermally active floors works with radiant cooling, smart window system opens automatically allowing 100% fresh air circulation. A heat exchanger captures ebergy from the exhaust

Water treatment: Innovative vacuum toilets system

Certification: 6 Stars over the 6 stars rating system scheme



1_Building			INNOVATION	DECISION-MAKER	SUSTAINABILITY		
					ENVIRONMENTAL	SOCIAL	ECONOMIC
CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	Type	Decision-maker	Results	Results	Results
1 **Context Characteristics**	**Urban**	In Melbourne CBD					
	Rural						
2 **Concept**	**Characteristics**	Pixel building					
3 **Orientation**	**Emisphere**	South					
	Axes	North-South					
4 **Architectural Characteristics**	**Aesthetic Approach**	Pixel as metaphor of future technological development					
5 **Dimension**		1136 msq					
6 **Shape**	**Typology**	Single block					
	Geometry	Rectangular open plan					
	Volume Shape	Parallelepiped					
	Symmetry	Symmetry					
7 **Floor number and height**		3 Floors					
8 **Access and circulation**	**Main access**	Main access from main door					
	Pedestrian access	Access from main door					
	Circulation characteristics	The building can be reach by different medium of transport					
	Circulation within the building	Open plan and free circulation					
9 **Structure**		Concrete slabs and columns					
10 **Construction systems**	**Envelope**	Glazed curtain wall with pixelcrete shading system					
	Roof	Roof sheeting					
	Foundation System	Reinforced concrete					
	Other						
11 **Internal partition and non-strcutural elements**	**Vertical (walls)**	Open plan					
	Horizontal (ceilings/floors)	Suspended floors					
12 **Doors and windows**		Smart window system opens automatically and pixel shading system					
13 **Construction details**	**Characteristics if innovative**	Pixel crete panels attachment system					
14 **Environmental control systems**	**Water system**	Rainwater harvesting					
	Lighting system	Photovoltaic panels with tracking system and wind turbine to produce electricity					
	Heating system	A water-ammonia absorption pump is used to heat and cool the building, also Thermally active floors works with radiant cooling.					
	Fire control syustem	by code					
	Communication system	by code					
	Ventilation system (mechanical, natural or hybrid)	Smart window system opens automatically allowing 100% fresh air circulation. A heat exchanger captures ebergy from the exhaust.					

				Incremental	Modular	Architectural	System	Radical	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	No environmental change	Knowledge acquisition	Sustainability achievement	Technological advancement	Resources generation	Social problems generation	No social changes	Knowledge acquisition	Social objectives achievement	Social Improvement	Extra benefit generation	Economic Loss	No economic change	Saving achievement	New jobs creation	Increased revenue	Market expansion
15	**Sewage connectionn and water treatment**		Vacuum toilets																														

2_Process			INNOVATION	DECISION-MAKER	SUSTAINABILITY		
					ENVIRONMENTAL	SOCIAL	ECONOMIC
CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	Type	Decision-maker	Results	Results	Results
1 Commissioning	Promoter	Daniel Grollo					
	Land owner	Grocon					
	Client	Grocon					
	Designer	Studio 505					
	Builder	Grocon Consgtruction Ltd					
	Type of bid	Direct agreement					
	Final building property	Grocon for lease					
	Building Manager	Grocon					
2 Financing	Financing actors	Grocon					
	Financing type	/					
	Entity	AUD $6 Million					
	Percentage of the total						
3 Program (brief)	Site characteristics	Block in the CBD					
	Project scope	Office building					
	Architectural characteristics	Carbon Neutral Building expressed in a metaphor of technological advancement					
	Timeline	From 2007 to 2010					
4 Component Production	Production place	Europe and Australia					
	Production type	Prefabrication					
	Producer/Supplier	Local and International					
	Production time	/					
5 Worksite/Construction/Assembly	Worksite Organization	Grocon and Blythe-Sanderson Group					
	Construction Methods						
	Worksite Timing	From May 2009 to June 2010					
	Changes during Construction	None					
	Work coordination	Grocon and Aconex					
	Duration	From May 2009 to June 2010					
	Contingecies/Problems	None					
6 Tests	Management	Individual companies					
	Structure	VDM pty ltd					
	Services	Vacum toilets and grey water system by CSIRO					
	Materials	Pixelcrete by RMIT					
	Forniture	Not required					
	Trades	Not required					
	Construction Systems	Not required					
7 Project Management/Control							
8 Drawing development	Preliminary Drawings	Studio 505					
	Architectural Drawings	Studio 505					
	Construction Drawings	Studio 505					
	As Built Drawings	Studio 505					
9 Work coordination	Type of Management Organization	Project and construction management					
	Coordination	Grocon					
	Time Control	Grocon					
	Cost Control	Grocon					
	Quality Control	Grocon					

			Competence Creating	Competence Destroying	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	No environmental change	Knowledge acquisition	Sustainability achievement	Technological advancement	Resources generation	Social problems generation	No social changes	Knowledge acquisition	Social objectives achievement	Social Improvement	Extra benefit generation	Economic Loss	No economic change	Saving achievement	New jobs creation	Increased revenue	Market expansion
	Auditing/Certification Agency	Not required																											
10 **Contractual relations**	**Contract Type**	Design and build																											
	Contract Compliance	Yes																											
	Contract Termination	Not required																											
	Contract Renewal	Not required																											
11 **Maintenance/Building Use**	**Maintenance Plan**	Grocon and Studio 505																											
	Building Use	Office building																											
	Defined Maintenance	Use of building technologies																											
	Actual Maintenance	Issues and replacement of lighting system, vacuum toilets, and photovoltaic tracking system																											

Terra dei Bambini - Earth Bag School
Um Al Nasser, Gaza Strip
MCArchitects and Arcò Architettura e cooperazione
2011

Context Characteristics: Rural - Desert

Concpet Characteristics: Reinterpreting the Bedouin tent

Orientation: North-WSouth

Dimension: 400 sqm

Shape: Court building shape

Floor number: 1 Floor

Access and circulation: Access from main opening and internal circulation through the court yard

Structure: Bag of sand as load-bearing walls

Construction systems: Earthbags and timber frame. The roof is a steel frame construction, covered by a material that can be folded.

Evironmanetal control systems: The roof is a folding system that can change according to solar incidence, as well as it is intagrated by photovoltaic panels

Water treatment: An ad-hoc water depuration system has been built for the building in the courtyard. From the roof the rainwater is collected into the central courtyard

Note: A bombing attack destroyed the building in 2014

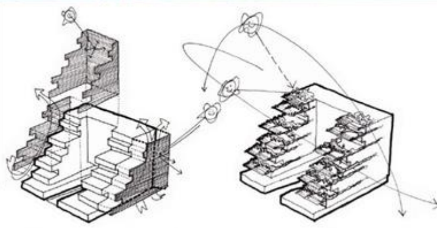
1_Building

CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	INNOVATION – Type					DECISION-MAKER – Decision-maker							SUSTAINABILITY – ENVIRONMENTAL – Results						SUSTAINABILITY – SOCIAL – Results						SUSTAINABILITY – ECONOMIC – Results					
			Incremental	Modular	Architectural	System	Radical	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	No environmental change	Knowledge acquisition	Sustainability achievement	Technological advancement	Resources generation	Social problems generation	No social changes	Knowledge acquisition	Social objectives achievement	Social Improvement	Extra benefit generation	Economic Loss	No economic change	Saving achievement	New jobs creation	Increased revenue	Market expansion
1 Context Characteristics	Urban																															
	Rural	Deserrtic area of the Gaza Strip					X		X	X							X	X	X				X	X	X				X			
2 Concept	Characteristics	Bedouin tent					X			X																			X			
3 Orientation	Emisphere	North		X						X							X	X	X				X	X	X				X			
	Axes	North-South		X						X							X	X	X				X	X	X				X			
4 Architectural Characteristics	Aesthetic Approach	Reinterpretation of the Bedouin Tent and use of local materials					X			X							X	X	X				X	X	X				X			
5 Dimension		400 mqs			X				X	X							X	X	X				X	X	X				X			
6 Shape	Typology	Courtyard typology			X					X							X	X					X	X	X			X				
	Geometry	Rectangular layout with central court			X					X							X	X					X	X	X			X				
	Volume Shape	Parallelepiped with detached cover reminding of the tent			X					X							X	X					X	X	X			X				
	Symmetry	Simmetry			X					X							X	X					X	X	X			X				
7 Floor number and height		1 floor			X					X							X	X					X	X				X	X			
8 Access and circulation	Main access	Main access to the courtyard				X				X							X						X	X				X				
	Pedestrian access	Access is from main entrance to keep the area sfae				X				X							X						X	X				X				
	Circulation characteristics	Circulation is from internal courtyard				X				X							X						X	X				X				
	Circulation within the building	Circulation is from internal courtyard				X				X							X						X	X				X				
9 Structure		Earthbags , timber frame and steel frame to the roof					X		X	X	X						X	X	X				X	X	X				X	X	X	
10 Construction systems	Envelope	Eartbags			X				X	X	X						X	X	X				X	X	X	X			X	X	X	
	Roof	Steel structure with tent system					X			X	X						X	X	X				X	X	X	X			X	X	X	
	Foundation System	Concrete	X							X	X						X	X	X				X	X	X	X			X	X	X	
	Other																															
11 Internal partition and non-strcutural elements	Vertical (walls)	Timber panels		X						X	X						X	X	X				X	X	X	X			X	X	X	
	Horizontal (ceilings/floors)	Timber floor		X						X	X						X	X	X				X	X	X	X			X	X	X	
12 Doors and windows		Timber frame		X						X	X						X	X	X				X	X	X	X			X	X	X	
13 Construction details	Characteristics if innovative	Earth bags system					X			X	X						X	X	X				X	X	X	X			X	X	X	
14 Environmental control systems	Water system	Depuration system					X			X	X						X	X	X				X	X	X	X			X	X	X	
	Lighting system	Natural light				X				X	X						X	X	X				X	X	X	X		X				
	Heating system	No needed				X				X	X					X						X						X				
	Fire control syustem	Not needed				X				X	X					X						X						X				
	Communication system	Not needed				X				X	X					X						X						X				
	Ventilation system (mechanical, natural or hybrid)	Natural ventilation through windows and roof				X				X	X						X	X	X				X	X	X	X				X	X	
15 Sewage connectionn and water treatment		Rainwater collection, depuration system and tank collector in thecentral courtyard				X	X			X	X						X	X	X				X	X	X	X			X	X	X	

2_Process			INNOVATION	DECISION-MAKER	SUSTAINABILITY		
					ENVIRONMENTAL	SOCIAL	ECONOMIC
CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	Type	Decision-maker	Results	Results	Results
1 Commissioning	Promoter	NGO Vento di Terra and Cooperativa Italiana per lo Sviluppo					
	Land owner	Um Al Nasser Local Community					
	Client	NGO Vento di Terra					
	Designer	Arcò Architettura e Cooperazione and MCArchitects					
	Builder	Local community					
	Type of bid	Design competition					
	Final building property	NGO Vento di Terra					
	Building Manager	NGO Vento di Terra					
2 Financing	Financing actors	Ministero degli affari esteri; Cooperazione italiana; Comune di Milano; Comune di Sesto San Giovanni; L.U.S.H. Italia; Rete sostenitori di NGO Vento di Terra					
	Financing type	Donation					
	Entity	/					
	Percentage of the total	180.000 euro					
3 Program (brief)	Site characteristics	North area of the strip of Gaza, near the Erez Pass, premdoninantly desertic area					
	Project scope	Kindergarden					
	Architectural characteristics	Reinterpretation of the Bedouin Tent and use of local materials					
	Timeline	Few weeks					
4 Component Production	Production place	Local					
	Production type	Self made					
	Producer/Supplier	Local producers and materials					
	Production time	Few weeks					
5 Worksite/Construction/Assembly	Worksite Organization	Arcò Architettura e Cooperazione and NGO Vento di Terra					
	Construction Methods	Critical Path					
	Worksite Timing	Few Weeks					
	Changes during Construction	Problems due to bombing risks					
	Work coordination	NGO Vento di Terra					
	Duration	Few weeks					
	Contingecies/Problems	Problems due to attacks by Israel army					
6 Tests	Management	Not done					
	Structure	E-Plus Studio					
	Services	Rete solare per l'autocostruzione srl and ARTECambiente srl					
	Materials	E-Plus Studio					
	Forniture	Not done					
	Trades	E-Plus Studio					
	Construction Systems	E-Plus Studio					
7 Project Management/Control							
8 Drawing development	Preliminary Drawings	MCArchitects					
	Architectural Drawings	Arcò Architettura e Cooperazione					
	Construction Drawings	Arcò Architettura e Cooperazione					
	As Built Drawings	Not done					
9 Work coordination	Type of Management Organization	Arcò Architettura e Cooperazione					

			Competence Creating	Competence Destroying	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	No environmental change	Knowledge acquisition	Sustainability achievement	Technological advancement	Resources generation	Social problems generation	No social changes	Knowledge acquisition	Social objectives achievement	Social Improvement	Extra benefit generation	Economic Loss	No economic change	Saving achievement	New jobs creation	Increased revenue	Market expansion
	Coordination	Arcò Architettura e Cooperazione		■		■	■							■						■						■			
	Time Control	Arcò Architettura e Cooperazione		■		■	■							■						■						■			
	Cost Control	Arcò Architettura e Cooperazione		■		■	■							■						■						■			
	Quality Control	Arcò Architettura e Cooperazione		■		■	■							■						■						■			
	Auditing/Certification Agency	/																											
10 **Contractual relations**	**Contract Type**	Direct agreement	■			■							■						■						■				
	Contract Compliance	/																											
	Contract Termination	/																											
	Contract Renewal	/																											
11 **Maintenance/Building Use**	**Maintenance Plan**	Arcò Architettura e Cooperazione		■		■								■						■					■				
	Building Use	Um Al Nasser Local Community		■		■								■						■					■				
	Defined Maintenance	Um Al Nasser Local Community		■		■								■						■					■				
	Actual Maintenance	The building was destroyed in 2014	■								■	■						■						■					

SIEEB
Beijing, China
MCArchitects
2006



Context Characteristics: Urban

Concpet Characteristics: Sun path as shape optimisation

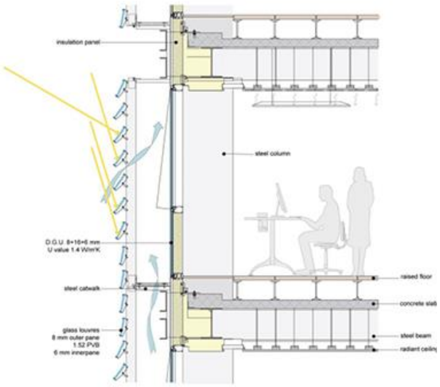
Orientation: North-South with courtyard opening to the South

Dimension: 20.000 msq

Shape: C Shape with sequence of roof gardens

Floor number: 10 Floors

Access and circulation: The circulation is designed to connect the internal courtayrd to the back part of the North facede of the building and therefore giving permeability to the ground floor of the building. The main access is from North side of the building



Structure: Steel structure

Construction system: Different systems of ventilated façades are used for the internal "skin" . The building's east and west external sides are clad with a "double skin" of a simple curtain wall with a design of opaque/transparent modules and a screen-printed ex¬ternal façade. The east and west façades include special complements like inside and outside light shelf elements and interior blinds to control reflection and optimize the spread of daylight. The sunbreaker structure is made of reflecting glass blades that are inclined at different angles to control the sunrays and light's penetration in the offices spaces

Environmental control systems: The building has a number os environmental control strategies both artificial and natural. In summer, the building relies on solar protection, green surfaces, photovoltaic system, open space ventilation, and rainwater collection. In winter, the building relies on solar support, high insulation wrap, winter winds protection thanks to its shape, and rainwater collection. Moreover the buiding has a system of energy co-generation

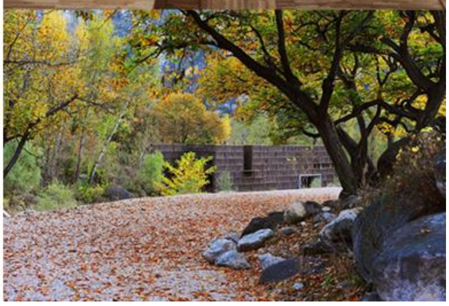
1_Building			INNOVATION	DECISION-MAKER	SUSTAINABILITY: ENVIRONMENTAL	SUSTAINABILITY: SOCIAL	SUSTAINABILITY: ECONOMIC
CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	Type	Decision-maker	Results	Results	Results
1 **Context Characteristics**	**Urban**	Campus of Tsinghua University in Beijing					
	Rural						
2 **Concept**	**Characteristics**	Shape by solar efficiency					
3 **Orientation**	**Emisphere**	North					
	Axes	North-South					
4 **Architectural Characteristics**	**Aesthetic Approach**	Energy efficiency by expressing solar					
5 **Dimension**		20.000 msq					
6 **Shape**	**Typology**	Courtyard					
	Geometry	C Shape					
	Volume Shape	Steps					
	Symmetry	Symmetry					
7 **Floor number and height**		10 Floors					
8 **Access and circulation**	**Main access**	Main access from North facade					
	Pedestrian access	Pedestrian can access the building from different direction					
	Circulation characteristics	Permeability on the ground floor					
	Circulation within the building	Lift, stairs, corridor and services are located in the areas of the building with the less favourable solare incidence					
9 **Structure**		Steel structure					
10 **Construction systems**	**Envelope**	Double skin ventilated facade					
	Roof	The roof hosts photovltaic systems and solar panels					
	Foundation System	Concrete slab					
	Other						
11 **Internal partition and non-strcutural elements**	**Vertical (walls)**	Mostly open plan with some glass partitions					
	Horizontal (ceilings/floors)	Suspended ceiling					
12 **Doors and windows**		Glazed steel frame winwod system					
13 **Construction details**	**Characteristics if innovative**	Different systems of ventilated façades are used for the internal “skin” that faces the garden and for the external envelope on the east and west sides. The southern façades are shaded by the floors and projecting structures and are treated to ap¬pear more transparent. The building’s east and west external sides are clad with a “double skin” of a simple curtain wall with a design of opaque/transparent modules and a screen-printed ex¬ternal façade. Because of their critical exposure to sunrays, the east and west façades include special complements like inside and outside light shelf elements and interior blinds to control reflection and optimize the spread of daylight.					
14 **Environmental control systems**	**Water system**	Rainwater collector					
	Lighting system	Both natural and artificial light					

	Subsystem	Description	Incremental	Modular	Architectural	System	Radical	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	No environmental change	Knowledge acquisition	Sustainability achievement	Technological advancement	Resources generation	Social problems generation	No social changes	Knowledge acquisition	Social objectives achievement	Social Improvement	Extra benefit generation	Economic Loss	No economic change	Saving achievement	New jobs creation	Increased revenue	Market expansion
	Heating system	Natiral heating by solar radiation				X				X							X	X	X				X							X		
	Fire control system	As per code	X							X						X						X						X				
	Communication system	Not required	X							X						X						X						X				
	Ventilation system (mechanical, natural or hybrid)	Double skin ventilated facade top allow passive cooling				X				X							X	X	X				X							X		
	Energy creation	Co-generation				X				X							X	X	X				X							X		
15 **Sewage connectionn and water treatment**		Standard	X							X						X							X					X				

2_Process			INNOVATION	DECISION-MAKER	SUSTAINABILITY: ENVIRONMENTAL	SUSTAINABILITY: SOCIAL	SUSTAINABILITY: ECONOMIC
CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	Type	Decision-maker	Results	Results	Results
1 **Commissioning**	**Promoter**	Joint Venture between Italian and Chinese Government					
	Land owner	Tsingua University					
	Client	IMET and MOST					
	Designer	MCArchitect					
	Builder	Impregilo spa					
	Type of bid	Direct agreement					
	Final building property	IMET and MOST					
	Building Manager	Tsingua University					
2 **Financing**	**Financing actors**	Chinese Government					
	Financing type						
	Entity	20,500,000 euro					
	Percentage of the total						
3 **Program (brief)**	**Site characteristics**	The site is urban block of land 60x60 meters and it is characterised by hot summer, cold winters and often strong winds from the North					
	Project scope	Chinese Italian Centre for environmental protection and education					
	Architectural characteristics	The architectural idea is to make the building work as a leaf, miximising the solar exposure and minimising the heat dispersion					
	Timeline	2 Years					
4 **Component Production**	**Production place**	Italy					
	Production type	Moatly prefabrication, except for in situ concrete for foundations and slabs					
	Producer/Supplier	Italian companies					
	Production time	Accordin to construction sequence					
5 **Worksite/Construction/Assembly**	**Worksite Organization**	PMC Italia					
	Construction Methods	Foundation contruction from North-West following a clockwise path. The strcuture started from South Eats					
	Worksite Timing	1 Year					
	Changes during Construction	None					
	Work coordination	PMC Italia plus subcontractors					
	Duration	1 Year					
	Contingecies/Problems	None					
6 **Tests**	**Management**	PMC Italia					
	Structure	PMC Italia					
	Services	PMC Italia					
	Materials	PMC Italia					
	Forniture	PMC Italia					
	Trades	PMC Italia					
	Construction Systems	PMC Italia					
7 **Project Management/Control**		PMC Italia					
8 **Drawing development**	**Preliminary Drawings**	MCArchitect					
	Architectural Drawings	MCArchitect					
	Construction Drawings	Impregilo spa					
	As Built Drawings	Impregilo spa					
9 **Work coordination**	**Type of Management Organization**	PCM Italia					
	Coordination	PCM Italia					
	Time Control	PCM Italia					

			Competence Creating	Competence Destroying	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	No environmental change	Knowledge acquisition	Sustainability achievement	Technological advancement	Resources generation	Social problems generation	No social changes	Knowledge acquisition	Social objectives achievement	Social Improvement	Extra benefit generation	Economic Loss	No economic change	Saving achievement	New jobs creation	Increased revenue	Market expansion
	Cost Control	PCM Italia																											
	Quality Control	PCM Italia																											
	Auditing/Certification Agency	PCM Italia																											
10 **Contractual relations**	**Contract Type**	By following Italian contract type																											
	Contract Compliance	Yes																											
	Contract Termination	None																											
	Contract Renewal	None																											
11 **Maintenance/Building Use**	**Maintenance Plan**	Standard routine maintenance																											
	Building Use	The building is used by a higher number of people that the one imagined in the preliminary phase																											
	Defined Maintenance	Standard routine maintenance																											
	Actual Maintenance	Piping system did not required maintenance up to 2009																											

WATTLE SCHOOL
Bejing, China
Li Xiadong
2015



Context Characteristics:	Rural - Wisdom Valley in the Huairou District of Beijing
Concpet Characteristics:	Integration with landscape
Orientation:	East-West
Dimension:	175 sqm
Shape:	Parallelepiped made in wattle sticks
Floor number:	2 Storeys
Access and circulation:	The location is only accessible via a winding mountain road. The building has a main entrance.
Structure:	Concrete foundation with steel structure and stone retaining walls
Construction systems:	The envelope of the building is built with the use of locally sourced wattle sticks. Opening are steel frame windows
Evironmanetal control systems:	The building relies entirely on natural and passive environmental control system. The building relies on natural light thanks to the large glass envelope surface, which uses wattle sticks as brise soleil; as well as passive ventilation thanks to openings and roof shape

1_Building

CATEGORY	SUB-CATEGORY	DEFINITION Characteristics
1 **Context Characteristics**	**Urban**	
	Rural	Wisdom Valley in the Huairou District of Beijing
2 **Concpet**	**Characteristics**	The idea of the project was to collaborate with the nature.
3 **Orientation**	**Emisphere**	North
	Axes	West-east.
4 **Architectural Characteristics**	**Aesthetic Approach**	Simple stripe shape concentrate the natural landscape.
5 **Dimension**		175m2
6 **Shape**	**Typology**	stripe shape
	Geometry	rectangle
	Volume Shape	143,876m3
	Symmetry	symmetry
7 **Floor number and height**		1floor and partily 2floors
8 **Access and circulation**	**Main access**	at ground floor
	Pedestrian access	over a bridge at ground floor
	Circulation characteristics	The building is one 30m long space
	Circulation within the building	inside space without partition walls or furniture
9 **Structure**		steel with double-glass structure
10 **Construction systems**	**Envelope**	wattles
	Roof	double-glass with wattles
	Foundation System	concrete
	Other	steel bars
11 **Internal partition and non-strcutural elements**	**Vertical (walls)**	no
	Horizontal (ceilings/floors)	Compound cedar boards
12 **Doord and windows**		door is at the bottom of the building
13 **Construction details**	**Characteristics if innovative**	using the wattles as the envelope makes the building blend into nature.
14 **Evironmanetal control systems**	**Water system**	no water supply, dealing with the foundation near river.
	Lighting system	no electricity supply, using the natural light.
	Heating system	no heating system, using natural methods
	Fire control syustem	only a stove in the library
	Communication system	the inner space is a whole, people can communicate freely
	Ventilation system (mechanical, natural or hybrid)	natural methods have been applied achieve the ventilation circulation
15 **Sewage connectionn and water treatment**		no sewage system

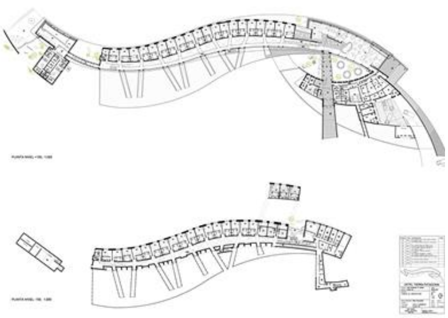
INNOVATION					DECISION-MAKER						
Type					Decision-maker						
Irrelevant	Incremental	Modular	Architectural	Radical	Institutions	Client	Designer	Builder	Industry	Users	Other

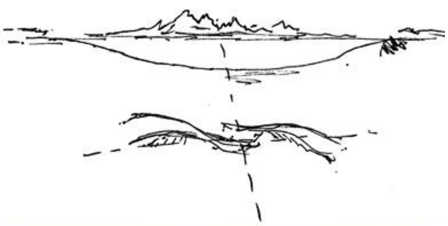
SUSTAINABILITY																	
ENVIRONMENTAL						SOCIAL						ECONOMIC					
Results						Results						Results					
Environmental problems	Resource waste	Environmentally Irrelevant	Sustainability strategy introduction	Technological perfomances introduction	Resources generation	Social problems generation	No social changes	Social problem solution	Social purpose definition	Social objective achievement	Extra benefit generation	Economic Loss	Cost invariant	Knowledge acquisition	Comparative advantage	Competitive advantage	Market expansion

2_Process			INNOVATION		DECISION-MAKER							SUSTAINABILITY: ENVIRONMENTAL						SUSTAINABILITY: SOCIAL						SUSTAINABILITY: ECONOMIC					
CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	Type		Decision-maker							Results						Results						Results					
			Competence Creating	Competence Destroying	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	Resource waste	Environmentally Irrelevant	Sustainability strategy introduction	Technological perfomances introduction	Resources generation	Social problems generation	No social changes	Social problem solution	Social purpose definition	Social objective achievement	Extra benefit generation	Economic Loss	Cost invariant	Knowledge acquisition	Comparative advantage	Competitive advantage	Market expansion
1 Commissioning	Promoter	Li Xiaodong, the main architect		X			X									X							X			X			
	Land owner	village committee of Jiaojiehe Village	X			X										X							X			X			
	Client	village committee of Jiaojiehe Village	X				X			X				X									X				X		
	Designer	Li Xiaodong, the main architect	X			X	X									X							X			X			
	Builder	Wang Hongli construction team	X			X	X				X			X								X			X				
	Type of bid	private relationship	X			X	X				X		X												X				
	Final building property	village committee of Beijing Huairou District	X				X				X				X				X				X		X				
	Building Manager	Pan Xi	X				X						X									X			X				
2 Financing	Financing actors	the Lu Qianshou Trust Fund for rural projects	X				X				X			X								X				X			
	Financing type	donation		X			X							X									X		X				
	Entity	1050000RMB,building	X		X											X							X				X		
	Percentage of the total	100\105	X				X	X			X			X									X					X	
3 Program (brief)	Site characteristics	forest land, "unused land "category.	X				X									X							X				X		
	Project scope	library	X			X	X								X								X		X				
	Architectural characteristics	no specific requirements but blend into the nature.	X				X									X							X				X		
	Timeline	10 months	X				X	X								X					X				X				
4 Component Production	Production place	the local village and villagers' home		X					X	X						X							X				X		
	Production type	self-producted, volunteer, low-paid work		X			X			X						X							X					X	
	Producer/Supplier	the villagers		X			X				X					X							X					X	
	Production time	the winter before the project started		X			X	X			X				X							X				X			
5 Worksite/Construction/Assembly	Worksite Organization	by the site architect Liu Yayun	X				X				X				X						X				X				
	Construction Methods	regular system，scaffold structure	X				X	X								X				X						X			
	Worksite Timing	ten months	X				X	X			X					X						X					X		
	Changes during Construction	no change but site discussion	X				X	X			X				X						X					X			
	Work coordination	Pan Xi, only one company involved	X								X			X								X					X		
	Duration	2011.5-2011.10	X					X			X			X								X			X				
	Contingecies/Problems	no brife caused a lot of problems		X			X	X			X				X					X					X				
6 Tests	Management	Li Xiaodong, the main architect		X			X				X					X						X						X	
	Structure	no specific tests	X				X	X							X					X						X			
	Services	no specific tests	X			X				X						X							X				X		
	Materials	the site architect, Liu Yayun		X			X		X								X						X				X		
	Trades	Huang Chengwen		X		X	X				X					X						X					X		
	Construction Systems	no specific tests	X				X	X								X						X			X				
7 Project Management/Control		the coordinator Pan Xi	X				X				X					X							X				X		
8 Drawing development	Preliminary Drawings	sketchs	X				X									X						X					X		
	Architectural Drawings	not completed		X			X								X							X				X			
	Construction Drawings	not completed drawings with no details		X			X	X							X						X				X				
	As Built Drawings	decided on the site with the construction team		X			X	X			X					X							X				X		
9 Work coordination	Type of Management Organization	the site architect, Liu Yayun, the coordinator Pan Xi		X			X				X					X							X			X			
	Coordination	the coordinator Pan Xi		X							X						X						X				X		
	Time Control	Li Xiaodong, the main architect		X				X			X				X						X						X		
	Cost Control	the finance officer, Huang Chengwen		X			X				X					X						X					X		
	Quality Control	the site architect, Liu Yayun		X			X	X			X				X						X					X			
	Auditing/Certification Agency	no	X		X									X					X						X				
10 Contractual relations	Contract Type	private relationship	X			X	X				X			X					X						X				
	Contract Compliance	yes		X		X		X			X			X					X							X			
	Contract Termination	no	X			X	X						X						X						X				
	Contract Renewal	no	X				X	X			X			X					X						X				
11 Maintenance/Building Use	Maintenance Plan	the villagers volunteer		X		X	X			X							X						X					X	
	Building Use	public use for the library	X			X	X										X						X						X
	Defined Maintenance																												
	Actual Maintenance																												

HOTEL PATAGONIA
Lago Saramiento, Chile
Cazù Zegres
2011

Context Characteristics:	The building is located in the proximity of the lake Saramiento, at the end of the mountain and sourrounded by nature
Concpet Characteristics:	The hotel's image looks like an ancient fossil of a prehistoric animal, stranded on the shore of the lake
Orientation:	North-South/East-West
Dimension:	4,900 sqm
Shape:	The building shape emerges from the wind, natural element which is characteristic of the zone. The form seeks to join the metaphysical landscape of the place.
Floor number:	2 floors
Access and circulation:	The space is structured from the interior routes, which are the way of inhabiting this extension. In the bedroom`s area the path is made with bridges suspended over the void.
Structure:	Reinforced concrete
Construction systems:	The hotel is anchored to the ground with stone embankments and entirely coated with wood paneling of washed lenga, in order to get the silver color which is common of wood corroded by water
Evironmanetal control systems:	Building shape and materials, and radiant floor heating. Passive ventilation system and Led lighting system
Water treatment:	Water storage system





1_Building				INNOVATION	DECISION-MAKER	SUSTAINABILITY		
						ENVIRONMENTAL	SOCIAL	ECONOMIC
CATEGORY		SUB-CATEGORY	DEFINITION Characteristics	Type	Decision-maker	Results	Results	Results
1	**Context Characteristics**	**Urban**						
		Rural	Rural on the lake of Sramiento, Chile					
2	**Concept**	**Characteristics**	The hotel's image looks like an ancient fossil of a prehistoric animal stranded on the shore of the lake					
3	**Orientation**	**Emisphere**	South					
		Axes	North-South/East-West					
4	**Architectural Characteristics**	**Aesthetic Approach**	The building shape emerges from the wind, natural element which is characteristic of the zone. The form seeks to join the metaphysical landscape of the place.					
5	**Dimension**		4,900 sqm					
6	**Shape**	**Typology**	Curved strip					
		Geometry	Multiple curves					
		Volume Shape	Bending elements on the roof as shaped by the wind					
		Symmetry	Symmetry					
7	**Floor number and height**		2 Floors					
8	**Access and circulation**	**Main access**	Main access located to contrast the cold wind from the mountains and to protect people entering the hotel					
		Pedestrian access	The access is pedestrian due to the remote location					
		Circulation characteristics	The building is conceived as the heart of the land and the landscape around is the rest of the body and the tourist conquer the land by waling around it and making it landscape					
		Circulation within the building	The space is structured from the interior routes, which are the way of inhabiting this extension. In the bedroom`s area the path is made with bridges suspended over the void.					
9	**Structure**		Reinforced concrete, Metal frames and timber trusses					
10	**Construction systems**	**Envelope**	Coated with wood paneling of washed lenga, in order to get the silver color which is common of wood corroded by water					
		Roof	Lenga wood, acoustic insulation and concrete structure					
		Foundation System	Reinforced concrete piles					
		Other						
11	**Internal partition and non-strcutural elements**	**Vertical (walls)**	Timber walls					
		Horizontal (ceilings/floors)	Lenga wood, acoustic insulation and concrete structure					
12	**Doors and windows**		Timber frame windows and doors					
13	**Construction details**	**Characteristics if innovative**	Treatment of Legna wood in the roof and structure designed by parametric systems					
14	**Environmental control systems**	**Water system**	Standard					
		Lighting system	LED system					
		Heating system	Radiant panels					

			Incremental	Modular	Architectural	System	Radical	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	No environmental change	Knowledge acquisition	Sustainability achievement	Technological advancement	Resources generation	Social problems generation	No social changes	Knowledge acquisition	Social objectives achievement	Social Improvement	Extra benefit generation	Economic Loss	No economic change	Saving achievement	New jobs creation	Increased revenue	Market expansion
	Fire control system	Standard																														
	Communication system	/																														
	Energy generation	Passive ventilation systems																														
	Buildign Control System																															
	Ventilation system (mechanical, natural or hybrid)	Natural ventilation through passive air flow																														
15 **Sewage connectionn and water treatment**																																

2_Process			INNOVATION	DECISION-MAKER	SUSTAINABILITY: ENVIRONMENTAL	SUSTAINABILITY: SOCIAL	SUSTAINABILITY: ECONOMIC
CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	Type	Decision-maker	Results	Results	Results
1 Commissioning	Promoter	katari s.a.					
	Land owner	katari s.a.					
	Client	katari s.a.					
	Designer	Cazu Zegres and rodrigo ferrer and roberto benavente					
	Builder	salfa corp					
	Type of bid	Direct agreement					
	Final building property	katari s.a.					
	Building Manager	katari s.a.					
2 Financing	Financing actors	katari s.a.					
	Financing type	/					
	Entity	/					
	Percentage of the total	/					
3 Program (brief)	Site characteristics	The territory is like a body, in the head is located the Paine massif, the arms are geographical landmarks that define the boundaries of the lake, the legs are the way to access the site and in the heart you find the hotel.					
	Project scope	Hotel					
	Architectural characteristics	The building shape emerges from the wind, natural element which is characteristic of the zone. The form seeks to join the metaphysical landscape of the place. The hotel's image looks like an ancient fossil of a prehistoric animal, stranded on the shore of the lake. The hotel is anchored to the ground with stone embankments and entirely coated with wood paneling of washed lenga, in order to get the silver color which is common of wood corroded by water.					
	Timeline	/					
4 Component Production	Production place	Local					
	Production type	Both in situ and precast					
	Producer/Supplier	Arteknia, Atika, Ventanas Chile, Impa, Intertrade, GAF, Finning Chile, Aquasol, Maigas					
	Production time	Longer than usual due to the remote location					
5 Worksite/Construction/Assembly	Worksite Organization	Difficult organization due to the remote location					
	Construction Methods	Critical path					
	Worksite Timing	/					
	Changes during Construction						
	Work coordination						
	Duration						
	Contingecies/Problems	Difficulties organization due to the remote location such as Material logistic, need of big fires in winter to heat the water in order to make the concrete. There were many others, such as: Another difficulty: the energy generation. Having 300 hundred people working in remote zones. The stress of time v/s budget.					
6 Tests	Management	Not required					
	Structure	Not required					
	Services	Not required					
	Materials	Not required					
	Forniture	Not required					
	Trades	Not required					
	Construction Systems						
7 Project Management/Control							

			Competence Creating	Competence Destroying	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	No environmental change	Knowledge acquisition	Sustainability achievement	Technological advancement	Resources generation	Social problems generation	No social changes	Knowledge acquisition	Social objectives achievement	Social Improvement	Extra benefit generation	Economic Loss	No economic change	Saving achievement	New jobs creation	Increased revenue	Market expansion
8 **Drawing development**	**Preliminary Drawings**	Cazu Zegres																											
	Architectural Drawings	Cazu Zegres with parametric design																											
	Construction Drawings	Not required																											
	As Built Drawings																												
9 **Work coordination**	**Type of Management Organization**	Construction management and engineering supervision																											
	Coordination	Cazy Zegres and construction management																											
	Time Control	Cazy Zegres and construction management																											
	Cost Control	Cazy Zegres and construction management																											
	Quality Control	Mot required																											
	Auditing/Certification Agency																												
10 **Contractual relations**	**Contract Type**	/																											
	Contract Compliance	/																											
	Contract Termination	/																											
	Contract Renewal																												
11 **Maintenance/Building Use**	**Maintenance Plan**	As defined by program scope																											
	Building Use	Standard																											
	Defined Maintenance	Not required																											
	Actual Maintenance																												

RAINBOW IN THE DESERT
Ventanilla, Perù
51 - 1 Arquitectos
2013

Context Characteristics:	Rural - Desert
Concpet Characteristics:	Rainbow in the desert
Orientation:	North-South
Dimension:	54 sqm
Shape:	Rectangular layout, parallelepiped volume with sloping roof
Floor number:	1 Floor
Access and circulation:	Pedestrian access through a ramp to facilitate circulation of kids or disable people
Structure:	Reinforced concrete
Construction systems:	Oriented strand boards (wood) and corrugated metal sheet
Evironmanetal control systems:	Cross ventilation for air circulation. Materials with high thermal resistance and thick walls protect it from overheating. Windows strategically placed to generate natural ventilation and good air circulation, and to allow the view to the garden, in which the kid's cultivations are placed.
Water treatment:	To overcome the lack of water in the desert, an alternative and resourceful techniques for soil generation and irrigation with the agronomist Luis Camacho, who also chose a variety of crops that require little water.

1_Building			INNOVATION					DECISION-MAKER							SUSTAINABILITY																	
															ENVIRONMENTAL						SOCIAL						ECONOMIC					
CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	Type					Decision-maker							Results						Results						Results					
1 Context Characteristics	Urban	/																														
	Rural	Desertic context			■									■			■	■	■				■	■	■	■		■				
2 Concept	Characteristics	A rainbow in a very desertic area					■			■							■						■	■	■			■				
3 Orientation	Emisphere	South		■				■	■								■						■					■				
	Axes	Nort-South/East-West		■				■	■								■						■					■				
4 Architectural Characteristics	Aesthetic Approach	Brightness of the colors of a rainbow					■	■	■	■							■						■	■	■	■		■				
5 Dimension		54 smq		■						■				■			■						■					■	■			
6 Shape	Typology	Kitchen/School					■	■	■	■				■			■	■	■				■	■	■	■		■				
	Geometry	Rectangular open plan layout				■				■							■	■					■						■			
	Volume Shape	Parallelepiped with sloping roof				■				■							■	■					■						■			
	Symmetry	Simmetry				■				■							■	■					■						■			
7 Floor number and height		1 floor			■					■						■							■						■			
8 Access and circulation	Main access	Main access through a ramp				■				■							■	■					■	■	■			■				
	Pedestrian access	The entire site is pedestrian				■				■							■	■	■				■	■	■			■				
	Circulation characteristics	Kids can circulate from the kitchen to the outdoor garden				■				■							■	■	■				■	■	■			■				
	Circulation within the building	Outside the building there is a garden for the cultivation and plantation					■			■				■			■	■	■				■	■	■			■				
9 Structure		Reinforced concrete		■							■	■					■					■						■	■			
10 Construction systems	Envelope	Osb boards and corrugates steel			■					■	■						■						■	■	■			■	■			
	Roof	Osb boards and corrugates steel			■					■	■						■						■	■	■			■				
	Foundation System	Reinforced concrete			■					■	■						■					■						■	■			
	Other	/																														
11 Internal partition and non-strcutural elements	Vertical (walls)	Not present due to open space layout	■							■								■					■						■			
	Horizontal (ceilings/floors)	Timber flooring		■						■							■						■					■				
12 Doors and windows		Timber frame windows and doors		■						■							■						■					■				
13 Construction details	Characteristics if innovative	/																														
14 Environmental control systems	Water system	Standard	■									■					■					■						■				
	Lighting system	Natural light and simple lighting system				■				■								■					■	■	■			■	■			
	Heating system	Thermal controll through materials mass				■				■								■					■	■	■			■	■			
	Fire control system	Not present				■				■								■					■	■	■			■	■			
	Communication system	Not present	■							■								■					■	■	■				■			
	Energy generation	Soil generation system					■			■				■				■	■				■	■	■	■			■			
	Buildign Control System	Not present	■							■								■					■	■	■				■			
	Ventilation system (mechanical, natural or hybrid)	Natural ventilation through passive air flow				■				■								■					■	■	■							
15 Sewage connectionn and water treatment		Irrigation system					■			■				■				■	■	■			■	■	■	■			■			
			Incremental	Modular	Architectural	System	Radical	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	No environmental change	Knowledge acquisition	Sustainability achievement	Technological advancement	Resources generation	Social problems generation	No social changes	Knowledge acquisition	Social objectives achievement	Social Improvement	Extra benefit generation	Economic Loss	No economic change	Saving achievement	New jobs creation	Increased revenue	Market expansion

2_Process			INNOVATION	DECISION-MAKER	SUSTAINABILITY		
					ENVIRONMENTAL	SOCIAL	ECONOMIC
CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	Type	Decision-maker	Results	Results	Results
1 Commissioning	Promoter	Peruvian chef Gaston Acurio					
	Land owner	Early Childhood Education Centre No.129					
	Client	Ministerio de Desarrollo e Inclusión Social					
	Designer	51-1 Arquitectos					
	Builder	Freddy Ramos (casco)					
	Type of bid	Direct agreement					
	Final building property	Early Childhood Education Centre No.129					
	Building Manager	Early Childhood Education Centre No.129					
2 Financing	Financing actors	Ministerio de Desarrollo e Inclusión Social					
	Financing type	Donations					
	Entity	Not known					
	Percentage of the total	/					
3 Program (brief)	Site characteristics	Desertic land					
	Project scope	Kitchen for a primary school					
	Architectural characteristics	The building wants to dispay bright colors to represent the rainbow within the desert, to contrast the dry environment, communicating the fresh food culture that can be brought anywhere					
	Timeline	Not known					
4 Component Production	Production place	Local					
	Production type	In situ construction					
	Producer/Supplier	Local suppliers/donors					
	Production time	Concrete timing to cast					
5 Worksite/Construction/Assembly	Worksite Organization	Freddy Ramos (casco)					
	Construction Methods	Critical path					
	Worksite Timing	Standard timing for concrete construction					
	Changes during Construction	None					
	Work coordination						
	Duration	Not known					
	Contingecies/Problems	Not known					
6 Tests	Management	Not required					
	Structure	Not required					
	Services	Luis Camacho - Agricultural engineer					
	Materials	Not required					
	Forniture	Not required					
	Trades	Emilio Rueda - Structural engineer consultant					
	Construction Systems	Not required					
7 Project Management/Control		51 - 1 Arquitectos					
8 Drawing development	Preliminary Drawings	51 - 1 Arquitectos					
	Architectural Drawings	51 - 1 Arquitectos					
	Construction Drawings	Freddy Ramos (casco)					
	As Built Drawings	Not requiered					
9 Work coordination	Type of Management Organization	Full direction by 51 - 1 Arquitectos					
	Coordination	51 - 1 Arquitectos					
	Time Control	51 - 1 Arquitectos					
	Cost Control	Freddy Ramos (casco)					

			Competence Creating	Competence Destroying	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	No environmental change	Knowledge acquisition	Sustainability achievement	Technological advancement	Resources generation	Social problems generation	No social changes	Knowledge acquisition	Social objectives achievement	Social Improvement	Extra benefit generation	Economic Loss	No economic change	Saving achievement	New jobs creation	Increased revenue	Market expansion
	Quality Control	Freddy Ramos (casco)	■					■						■						■					■				
	Auditing/Certification Agency	None	■		■																								
10 **Contractual relations**	**Contract Type**	Standard agreement	■			■							■							■					■				
	Contract Compliance	/				■																							
	Contract Termination	/				■																							
	Contract Renewal	/				■																							
11 **Maintenance/Building Use**	**Maintenance Plan**	Instructions by 51 - 1 Arquitectos and Luis Chamaco		■			■									■						■					■		
	Building Use	Orchard and a kitchen where children from 3-5 years can learn to grow food and cook it by themselves with the help of the volunteers (Teachers and children´s families)		■						■							■						■				■		
	Defined Maintenance	Volunteers, teachers, kids and parents		■						■							■						■				■		
	Actual Maintenance	Volunteers, teachers, kids and parents		■						■							■						■				■		

EARTHSHIP SCHOOL
Jaureguiberry, Uruguay
Earthship Biotecture
2016

Context Characteristics: Rural

Concpet Characteristics: Re-use and re-cycle

Orientation: The building is North oriented to maximise solar exposition, being placed in the Southern emisphere

Dimension: 270 sqm

Shape: Rectangular and symmetric layout

Floor number: 1 Floor

Access and circulation: Single corridor gives acess to the whole building. Circulation works in a linear manner

Structure: Concrete slab and tires

Construction systems: The school was built by volunteers who learnt in loco how to work with the construction system, developed by Earthship Biotecture. The materials used to build the school comprehend 2200 tires, 14000 cans, 5,000 plastic bottles and glass, 2,000 square meters of cardboard, concrete, earth and metal foil

Evironmanetal control systems: The building has 12 solar thermal panels to produce its own energy, as well a system of reuse of rain water

Water treatment: Treatment of gray and black water

1_Building		
CATEGORY	SUB-CATEGORY	DEFINITION Characteristics
1 Context Characteristics	Urban	This is not a project inserted in an urban context.
	Rural	The school is inserted in Jaureguiberry, with only 500 residents
2 Concpet	Characteristics	An innovative public school built with 60% of recycle materials
3 Orientation	Emisphere	South
	Axes	34°46'53.1"S 55°24'10.1"W
4 Architectural Characteristics	Aesthetic Approach	Built with Natural & Recycled Materials
5 Dimension		270 m²
6 Shape	Typology	Elementary school
	Geometry	Regular
	Volume Shape	Prismatic
	Symmetry	Yes
7 Floor number and height		1 floor
8 Access and circulation	Main access	3 main doors, 1 lateral door
	Pedestrian access	Sidewalks guide the pedestrain to the main accesses
	Circulation characteristics	Linear
	Circulation within the building	Single corridor that gives access to classrooms
9 Structure		Made with tires, wood, bottles, can, ciment and concrete
10 Construction systems	Envelope	Tires, wood, glass, bottles, cans, earth
	Roof	Wood, metal roof tiles
	Foundation System	Reinforced concrete slab on floor
	Other	-
11 Internal partition and non-strcutural elements	Vertical (walls)	3 Classrooms, 2 bathrooms, 2 Technical rooms
	Horizontal (ceilings/floors)	Just 1 floor, ceiling made with wood structure
12 Doord and windows		Wood frame and glass, they open to the north to higher solar incidence
13 Construction details	Characteristics if innovative	Use of thick retaining wall on the south, increasing the thermal inertia of the building
14 Evironmanetal control systems	Water system	Reuse of rain water, treatment of gray and black water
	Lighting system	PV panels produce electricity to the building. Natural light also illuminates the building during the day
	Heating system	No artificial heating system. The internal temperature is naturally regulated
	Fire control sysutem	No fire control system
	Communication system	No communication system
	Ventilation system (mechanical, natural or hybrid)	Natural
15 Sewage connectionn and water treatment		Reuse of rain water, treatment of gray and black water

INNOVATION	DECISION-MAKER	SUSTAINABILITY – ENVIRONMENTAL	SUSTAINABILITY – SOCIAL	SUSTAINABILITY – ECONOMIC
Type	Decision-maker	Results	Results	Results
Irrelevant	Institutions	Environmental problems	Social problems generation	Economic Loss
Incremental	Client	Resource waste	No social changes	Cost invariant
Modular	Designer	Environmentally Irrelevant	Social problem solution	Knowledge acquisition
Architectural	Builder	Sustainability strategy introduction	Social purpose definition	Comparative advantage
Radical	Industry	Technological perfomances introduction	Social objective achievement	Competitive advantage
	Users	Resources generation	Extra benefit generation	Market expansion
	Other			

2_Process

CATEGORY	SUB-CATEGORY	DEFINITION Characteristics
1 Commissioning	Promoter	Arq. Michael Reynolds and Martín Espósito
	Land owner	Intendencia de Canelones
	Client	Martín Espósito
	Designer	Federico Palermo in collaboration with Arq. Michael Reynolds
	Builder	Architect / Client / volunteers
	Type of bid	Direct call
	Final building property	Government of Canelones and ANEP - Administración Nacional de Educación Pública and CEIP Consejo de Educación Inicial y Primaria
	Building Manager	ANEP - Administración Nacional de Educación Pública
2 Financing	Financing actors	Private Companies
	Financing type	Donations and fee pays from voluntrees
	Entity	Private Companies**
	Percentage of the total	90% of the final budget came from the company Nevex
3 Program (brief)	Site characteristics	Semi-rural
	Project scope	School
	Architectural characteristics	A Sustainable Public Elementay School.
	Timeline	7 - 8 weeks
4 Component Production	Production place	Jaureguiberry, Departamento de Canelones, Uruguay
	Production type	Manual
	Producer/Supplier	Material colected in the city
	Production time	1 year of recolecting materials
5 Worksite/Construction/Assembly	Worksite Organization	Michael Reynolds
	Construction Methods	The construction was in the form of an academy
	Worksite Timing	7 weeks
	Changes during Construction	None
	Work coordination	Earthship Biotecture team
	Duration	7 weeks
	Contingecies/Problems	None
6 Tests	Management	Not required
	Structure	Not required
	Services	Not required
	Materials	Not required
	Trades	Not required
	Construction Systems	Not required
7 Project Management/Control		Reynold
8 Drawing development	Preliminary Drawings	Arq. Michael Reynolds
	Architectural Drawings	Arq. Michael Reynolds and Federico Palermo
	Construction Drawings	Earthship Biotecture
	As Built Drawings	Not produced
9 Work coordination	Type of Management Organization	Work hierarchica
	Coordination	Michael Reynolds
	Time Control	7 weeks
	Cost Control	
	Quality Control	
	Auditing/Certification Agency	Eathship Biotecture
10 Contractual relations	Contract Type	As per Michael Reynolds Agreement
11 Maintenance/Building Use	Maintenance Plan	
	Building Use	Public school
	Defined Maintenance	
	Actual Maintenance	

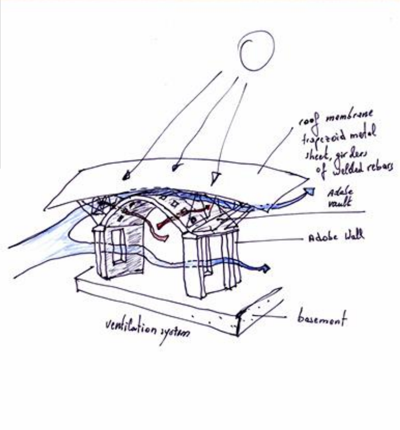
INNOVATION – Type: Competence Creating; Competence Destroying

DECISION-MAKER – Decision-maker: Institutions; Client; Designer; Builder; Industry; Users; Other

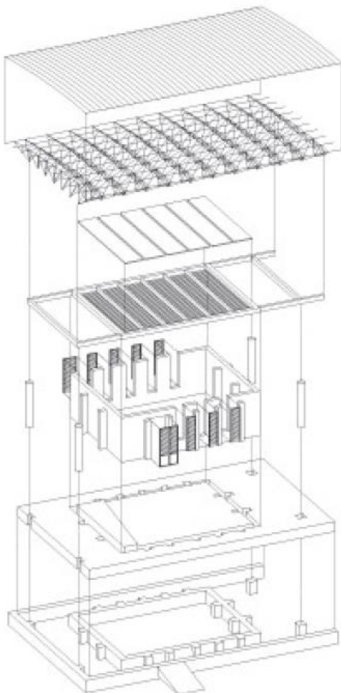
SUSTAINABILITY

- **ENVIRONMENTAL** – Results: Environmental problems; Resource waste; Environmentally Irrelevant; Sustainability strategy introduction; Technological perfomances introduction; Resources generation
- **SOCIAL** – Results: Social problems generation; No social changes; Social problem solution; Social purpose definition; Social objective achievement; Extra benefit generation
- **ECONOMIC** – Results: Economic Loss; Cost invariant; Knowledge acquisition; Comparative advantage; Competitive advantage; Market expansion

Gando Primary School
Gando, Burkina Faso
Kere Architecture
2001



Context Characteristics:	Rural
Concpet Characteristics:	participatory design - local materials - community engagement - passive systems - self-sufficiency
Orientation:	it varies according to site conditions - openeings and ventilation holes position changes accordingly
Dimension:	520 sqm
Shape:	Parallelepiped
Floor number:	1 Floor
Access and circulation:	The main acess is from the porch, and blocks connected one to the other through a covered path (porch)
Structure:	Locally produced bricks masonry walls reinforced with vertical rebars
Construction systems:	Bricks masonry (20 cm thick - flemish bond)
Evironmanetal control systems:	Environmental control systems are based on natutal systems.Placing the main roof under a 7 meters spanning roof allowed to control the heat gain, protecting the space from direct sun radiation, as well as the shape of the roof and opening allow the natural ventilation of the rooms and also contribute to maintain the internal temperature comfortable.
Award:	Aga Khan Award for Architecture 2004 Global Award for Sustainable Architecture 2009



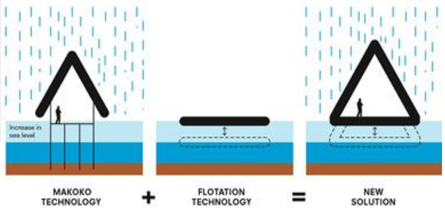
1_Building			INNOVATION	DECISION-MAKER	SUSTAINABILITY		
					ENVIRONMENTAL	SOCIAL	ECONOMIC
CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	Type	Decision-maker	Results	Results	Results
1 **Context Characteristics**	**Urban**	/					
	Rural	Rural					
2 **Concept**	**Characteristics**	From traditional technology to climatic efficiency					
3 **Orientation**	**Emisphere**	North					
	Axes	North-East/South-West					
4 **Architectural Characteristics**	**Aesthetic Approach**	Vernacular Architecture					
5 **Dimension**		526 smq					
6 **Shape**	**Typology**	Primary School					
	Geometry	Strip block					
	Volume Shape	Parallelepiped					
	Symmetry	Symmetry					
7 **Floor number and height**		One floor					
8 **Access and circulation**	**Main access**	From porch to the three main rooms					
	Pedestrian access	Pedestrian accesso only					
	Circulation characteristics	Internal pedestrian paths					
	Circulation within the building	Circulation around the three teaching rooms					
9 **Structure**		Load bearing walls					
10 **Construction systems**	**Envelope**	Brick clay					
	Roof	Corrugated metal sheets and grided of welded reinforced steel					
	Foundation System	Continuos foundation with non-reinforced concrete					
	Other	/					
11 **Internal partition and non-strcutural elements**	**Vertical (walls)**	Compressed clay					
	Horizontal (ceilings/floors)	Suspended ceiling (adobe seiling)					
12 **Doors and windows**		Steel lamella elements					
13 **Construction details**	**Characteristics if innovative**	/					
14 **Environmental control systems**	**Water system**	No water system					
	Lighting system	Natural light					
	Heating system	Classroom placement under the roof shadow to control the heat gain					
	Fire control syustem	No system					
	Communication system	No system					
	Energy generation	No system					
	Buildign Control System	No system					
	Ventilation system (mechanical, natural or hybrid)	Natural venlation through windows and roof					

			Incremental	Modular	Architectural	System	Radical	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	No environmental change	Knowledge acquisition	Sustainability achievement	Technological advancement	Resources generation	Social problems generation	No social changes	Knowledge acquisition	Social objectives achievement	Social Improvement	Extra benefit generation	Economic Loss	No economic change	Saving achievement	New jobs creation	Increased revenue	Market expansion
15 **Sewage connectionn and water treatment**		No system																														

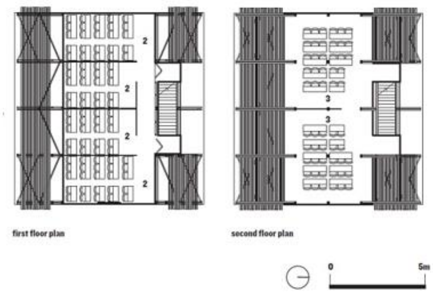
2_Process			INNOVATION	DECISION-MAKER	SUSTAINABILITY: ENVIRONMENTAL	SUSTAINABILITY: SOCIAL	SUSTAINABILITY: ECONOMIC
CATEGORY	**SUB-CATEGORY**	**DEFINITION Characteristics**	**Type**	**Decision-maker**	**Results**	**Results**	**Results**
1 **Commissioning**	**Promoter**	Diebedò Francis Kerè					
	Land owner	Village Community of Gando					
	Client	Community of Gando					
	Designer	Diebedò Francis Kerè					
	Builder	Local community					
	Type of bid	Private development					
	Final building property	Community of Gando					
	Building Manager	Weyneida Kerè					
2 **Financing**	**Financing actors**	Schulbausteine für Gando e. V.					
	Financing type	Fund raising					
	Entity	CFA Francs 22,750,000 (US$ 29,830)					
	Percentage of the total	/					
3 **Program (brief)**	**Site characteristics**	Rural area of Gando, located South East of Ouagadougou					
	Project scope	Primary school					
	Architectural characteristics	Optimisation of climatic condition on the basis of the use of traditional construction system and local materials availability					
	Timeline	1998-2001					
4 **Component Production**	**Production place**	Gando					
	Production type	Self made production					
	Producer/Supplier	Local sources					
	Production time	one year					
5 **Worksite/Construction/Assembly**	**Worksite Organization**	Weyneida Kerè and local community					
	Construction Methods	Clay and steel construction system					
	Worksite Timing	One year					
	Changes during Construction	Water sourcing system					
	Work coordination	Weyneida and Francis Kerè					
	Duration						
	Contingecies/Problems	The scarcity of water was a big challenge for the projects. As women of village mostly fetch water so they were used for fetching water 4 kM far from site. Harsh weather was also a problem in construction time .					
6 **Tests**	**Management tests**	Weyneida, Francis Kerè, and local community					
	Structure test	Weyneida, Francis Kerè, and local community					
	Services test	/					
	Materials test	Weyneida, Francis Kerè, and local community					
	Forniture test	/					
	Trades test	Weyneida, Francis Kerè, and local community					
	Construction Systems test	Weyneida, Francis Kerè, and local community					
7 **Project Management/Control**							
8 **Drawing development**	**Preliminary Drawings**	Francis Kerè Architects					
	Architectural Drawings	Francis Kerè Architects					
	Construction Drawings	Francis Kerè Architects					

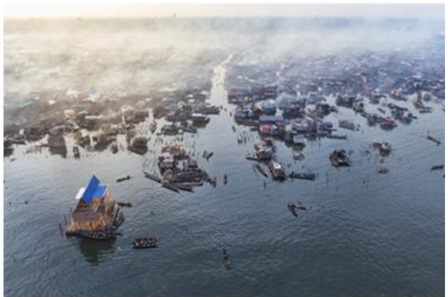
	As Built Drawings	/																											
9 **Work coordination**	**Type of Management Organization**	Worksite coordination																											
	Coordination	Weyneida, Francis Kerè, and local community																											
	Time Control	Weyneida, Francis Kerè, and local community																											
	Cost Control	Weyneida, Francis Kerè, and local community																											
	Quality Control	Weyneida, Francis Kerè, and local community																											
	Auditing/Certification Agency	/																											
10 **Contractual relations**	**Contract Type**	Agreement between parties																											
	Contract Compliance	/																											
	Contract Termination	/																											
	Contract Renewal	/																											
11 **Maintenance/Building Use**	**Maintenance Plan**	Local community																											
	Building Use	Local community																											
	Defined Maintenance	/																											
	Actual Maintenance	Need of maintenancance due to sign of corrosion of bruck and steel structures																											
			Competence Creating	Competence Destroying	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	No environmental change	Knowledge acquisition	Sustainability achievement	Technological advancement	Resources generation	Social problems generation	No social changes	Knowledge acquisition	Social objectives achievement	Social Improvement	Extra benefit generation	Economic Loss	No economic change	Saving achievement	New jobs creation	Increased revenue	Market expansion

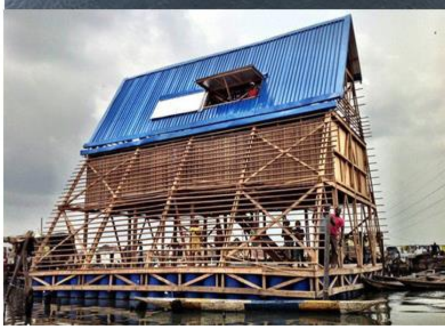
Makoko Floating School
Lagos, Nigeria
NLE' Architects
2013



Context Characteristics:	Rural
Concpet Characteristics:	Re-adapt the idea of the stilt house, a typical construction of the city of Lagos, to build a school that can accommodate 100 children in the district of Makoko
Orientation:	Variable due to the floating movement
Dimension:	220 msq
Shape:	Triangular frame on a rectangular layout
Floor number:	3 Floors
Access and circulation:	Access is to open plan circulation system with vertical distribution
Structure:	16 wooden modules, each containing 16 plastic reused barrels, as well as bamboo of local origin
Construction systems:	Timber construction on floating plastic barrels
Evironmanetal control systems:	Natural lighting, natural ventilation, rainwater storage and depuration, and solar panels
Water treatment:	Waste reduction and sewage treatment







1_Building			INNOVATION	DECISION-MAKER	SUSTAINABILITY		
					ENVIRONMENTAL	SOCIAL	ECONOMIC
CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	Type	Decision-maker	Results	Results	Results
1 **Context Characteristics**	**Urban**						
	Rural	Lagos lagoon- Nigeria					
2 **Concept**	**Characteristics**	Re-adapt the idea of the stilt house, a typical construction of the city of Lagos, to build a school that can accommodate 100 children in the district of Makoko.					
3 **Orientation**	**Emisphere**	North					
	Axes	Moving					
4 **Architectural Characteristics**	**Aesthetic Approach**	Vernacular - stilt house					
5 **Dimension**		220 msq					
6 **Shape**	**Typology**	Floating school building					
	Geometry	Rectangular floor plan					
	Volume Shape	Triangular A–Frame					
	Symmetry	Simmetry					
7 **Floor number and height**		3 floors					
8 **Access and circulation *****	**Main access**	Main access from triangular frame					
	Pedestrian access	Free circulation on the					
	Circulation characteristics	Acess from peers and acorss modules					
	Circulation within the building	Both free and vertical circulation					
9 **Structure**		16 wooden modules, each containing 16 plastic reused barrels, as well as bamboo of local origin					
10 **Construction systems**	**Envelope**	Movable sunshading					
	Roof	Timber ventilated roof					
	Foundation System	Not required					
	Other						
11 **Internal partition and non-strcutural elements**	**Vertical (walls)**	Timber					
	Horizontal (ceilings/floors)	Timber					
12 **Doors and windows**		Not required					
13 **Construction details**	**Characteristics if innovative**	Local timber assemblied with easy systems by Makoko community					
14 **Environmental control systems**	**Water system**	Rainwater harvest system					
	Lighting system	Natural lighting					
	Heating system	Not required					
	Fire control system	Standard					
	Energy Production	Solar panels					
	Ventilation system (mechanical, natural or hybrid)	Natural ventilation					

				Incremental	Modular	Architectural	System	Radical	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	No environmental change	Knowledge acquisition	Sustainability achievement	Technological advancement	Resources generation	Social problems generation	No social changes	Knowledge acquisition	Social objectives achievement	Social Improvement	Extra benefit generation	Economic Loss	No economic change	Saving achievement	New jobs creation	Increased revenue	Market expansion
15	**Sewage connectionn and water treatment**		Waste reduction and sewage treatment																														

2_Process			INNOVATION	DECISION-MAKER	SUSTAINABILITY – ENVIRONMENTAL	SUSTAINABILITY – SOCIAL	SUSTAINABILITY – ECONOMIC
CATEGORY	**SUB-CATEGORY**	**DEFINITION Characteristics**	**Type**	**Decision-maker**	**Results**	**Results**	**Results**
1 **Commissioning**	**Promoter**	United Nations Development Programme/Federal Ministry of Environment (AAP), Heinrich Böll Foundation, Tafeta & Partners					
	Land owner	Makoko Lagoon					
	Client	United Nations Development Programme/Federal Ministry of Environment (AAP), Heinrich Böll Foundation, Tafeta & Partners					
	Designer	NLÉ architects - Kunlé Adeyemi and local community					
	Builder	Local community					
	Type of bid	Not required					
	Final building property	Makoko local community					
	Building Manager	Makoko community					
2 **Financing**	**Financing actors**	UN (UNDP) and Heinrich Boell Foundation, with a large number of other partners and donors					
	Financing type	/					
	Entity	6000 dollari					
	Percentage of the total						
3 **Program (brief)**	**Site characteristics**	Very small floor plate of 220 msq floating on the lagoon					
	Project scope	School, Community Building					
	Architectural characteristics	Stilt house reference					
	Timeline	From 2011 to 2013					
4 **Component Production**	**Production place**	Local and import from China and USA					
	Production type	Re-use					
	Producer/Supplier	Local and import from China and USA					
	Production time	From 2012 to 2013					
5 **Worksite/Construction/Assembly**	**Worksite Organization**	Local community					
	Construction Methods	Self-assembly					
	Worksite Timing	From 2012 to 2013					
	Changes during Construction	None					
	Work coordination	NLÉ architects - Kunlé Adeyemi					
	Duration	Over a year					
	Contingecies/Problems	None					
6 **Tests**	**Management**	Makoko/Iwaya Waterfront Community Secretariat					
	Structure	Preliminary studies by NLÉ architects - Kunlé Adeyemi and local community					
	Services	Preliminary studies by NLÉ architects - Kunlé Adeyemi and local community					
	Materials	Preliminary studies by NLÉ architects - Kunlé Adeyemi and local community					
	Forniture	Preliminary studies by NLÉ architects - Kunlé Adeyemi and local community					
	Trades	Preliminary studies by NLÉ architects - Kunlé Adeyemi and local community					
	Construction Systems	Preliminary studies by NLÉ architects - Kunlé Adeyemi and local community					
7 **Project Management/Control**		NLÉ architects - Kunlé Adeyemi and local community					
8 **Drawing development**	**Preliminary Drawings**	NLÉ architects - Kunlé Adeyemi and local community					
	Architectural Drawings	NLÉ architects - Kunlé Adeyemi and local community					
	Construction Drawings	NLÉ architects - Kunlé Adeyemi and local community					
	As Built Drawings	NLÉ architects - Kunlé Adeyemi and local community					

No.	Item	Sub-item	Description	Competence Creating	Competence Destroying	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	No environmental change	Knowledge acquisition	Sustainability achievement	Technological advancement	Resources generation	Social problems generation	No social changes	Knowledge acquisition	Social objectives achievement	Social Improvement	Extra benefit generation	Economic Loss	No economic change	Saving achievement	New jobs creation	Increased revenue	Market expansion
9	**Work coordination**	**Type of Management Organization**	NLÉ architects - Kunlé Adeyemi and local community																											
		Coordination	NLÉ architects - Kunlé Adeyemi and local community																											
		Time Control	NLÉ architects - Kunlé Adeyemi and local community																											
		Cost Control	NLÉ architects - Kunlé Adeyemi and local community																											
		Quality Control	NLÉ architects - Kunlé Adeyemi and local community																											
		Auditing/Certification Agency	Since its completion in March 2013, several government delegates from various ministries have carried out due diligence assessments of the structure and have reported positively on its performance																											
10	**Contractual relations**	**Contract Type**	Internal agreement between parties and local permit beaurocracy																											
		Contract Compliance	The acceptance of the project has been largely debated by the local government																											
		Contract Termination	Not relevant																											
		Contract Renewal	Not relevant																											
11	**Maintenance/Building Use**	**Maintenance Plan**	Makoko/Iwaya Waterfront Community Secretariat																											
		Building Use	Due to a strong hurricane the floating school has been destroyed																											
		Defined Maintenance	Makoko/Iwaya Waterfront Community Secretariat																											
		Actual Maintenance	Reconstruction has to be considered																											

ECDC
Various Location in rural Rwanda
ASAStudio
2013-2016

Context Characteristics: Rural

Concpet Characteristics: participatory design - local materials - community engagement - passive systems - self-sufficiency

Orientation: it varies according to site conditions - openeings and ventilation holes position changes accordingly

Dimension: 500 sqm

Shape: 2 models have been developed: S shape / circular shape

Floor number: 1 Floor

Access and circulation: The main acess is from the porch, and blocks connected one to the other through a covered path (porch)

Structure: Locally produced bricks masonry walls reinforced with vertical rebars

Construction systems: Bricks masonry (20 cm thick - flemish bond)

Evironmanetal control systems: Rain water harvesting from roofs to underground water tank. Water is used for cleaning, irrigation, cooking. bricks masonry to control heat. Clay tiles without ceiling for ventilation and to protect from irradiation). One prototype of ECD is provided with solar pales devices (greatlakes energy supplier) with socket connected to charge phones or as portable lamps. Permanent ventialtion through holes in the masonry (removing 1 header brick here and there).

Water treatment: composting toilets: each cubicle has 2 pits each of them is used for 6 months while the other is resting (and transforming waste in compost). After 6 months the compost is removed manually and the pit is switched again. Urine is separated and collected in a tank and used as fertilizer as well. Storm water is addressed towards soak pits as well as the underground tank overflow

1_Building			INNOVATION	DECISION-MAKER	SUSTAINABILITY		
					ENVIRONMENTAL	SOCIAL	ECONOMIC
CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	Type	Decision-maker	Results	Results	Results
1 Context Characteristics	Urban	/					
	Rural	Several locations in Rwandan country side					
2 Concept	Characteristics	participatory design - local materials - community engagement - passive systems - self-sufficiency					
3 Orientation	Emisphere	South					
	Axes	it varies according to site conditions - openeings and ventilation holes position changes accordingly					
4 Architectural Characteristics	Aesthetic Approach	participatory design - local materials - community engagement - passive systems - self-sufficiency					
5 Dimension		500 sqm					
6 Shape	Typology	ECD (early childhood development) centre + community centre					
	Geometry	2 models: S shape / circular shape					
	Volume Shape	Parallelepiped					
	Symmetry	Simmetry					
7 Floor number and height		Single floor					
8 Access and circulation	Main access	The main acess is from the porch					
	Pedestrian access	Mainly pedestrian access					
	Circulation characteristics	Linear distribution system					
	Circulation within the building	blocks connected one to the other through a covered path (porch)					
9 Structure		locally produced bricks masonry walls reinforced with vertical rebars					
10 Construction systems	Envelope	bricks masonry (20 cm thick - flemish bond)					
	Roof	locally produced clay tiles / or iron sheet (in some of the cases)					
	Foundation System	concrete ringbeam					
	Other	/					
11 Internal partition and non-strcutural elements	Vertical (walls)	bricks masonry					
	Horizontal (ceilings/floors)	locally produced bricks masonry walls reinforced with vertical rebars					
12 Doors and windows		metal frames (anti-rust paint and color paint) + single glass (4 mm thick)					
13 Construction details	Characteristics if innovative	/					
14 Environmental control systems	Water system	rain water harvesting from roofs to underground water tank (bricks dome of 35.000 lt capacity). Water is used for cleaning, irrigation, cooking.					
	Lighting system	natural light: child friendly windows, ventilation holes, clerestory. White washed bricks to reflect light. Artificial light is implemented in some of the centres (the ones connected to the grid): mainly fluorescent lamps.					

	Heating system	bricks masonry to control heat. Clay tiles without ceiling for ventilation and to protect from irradiation. In iron sheet roof type: addition of river cane ceiling to reduce noise and heat (it helps but doens't resolve the overheat problem)																														
	Fire control syustem	only fire extinguishers provided. 2 doors per classroom as escape routes in case of fire. The kitchen is the only critical place (charcoal / wood stove) but the kitchen is opened to the exterior. No fire proof materials, no fire doors.																														
	Communication system	Amplification sound system																														
	Energy generation	One prototype of ECD is provided with solar pales devices (greatlakes energy supplier) with socket connected to charge phones or as portable lamps. They have been stolen after few monhts.																														
	Buildign Control System	not provided. People is the only system																														
	Ventilation system (mechanical, natural or hybrid)	permanent ventialtion: holes in the masonry (removing 1 header brick here and there). Orientation of the holes depending on the main wind/rain direction to avoid water infiltration; clay tiles roof without ceiling (venitaltion see above). Windows and doors to be opened if needed.																														
15 **Sewage connectionn and water treatment**		composting toilets: each cubicle has 2 pits each of them is used for 6 months while the other is resting (and transforming waste in compost). After 6 months the compost is removed manually and the pit is switched again. Urine is separated and collected in a tank and used as fertilizer as well. Storm water is addressed towards soak pits as well as the underground tank overflow																														
			Incremental	Modular	Architectural	System	Radical	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	No environmental change	Knowledge acquisition	Sustainability achievement	Technological advancement	Resources generation	Social problems generation	No social changes	Knowledge acquisition	Social objectives achievement	Social Improvement	Extra benefit generation	Economic Loss	No economic change	Saving achievement	New jobs creation	Increased revenue	Market expansion

2_Process			INNOVATION	DECISION-MAKER	SUSTAINABILITY		
					ENVIRONMENTAL	SOCIAL	ECONOMIC
CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	Type	Decision-maker	Results	Results	Results
1 Commissioning	Promoter	Governement of Rwanda / UNICEF Rwanda					
	Land owner	Governement of Rwanda (Sector authority)					
	Client	UNICEF Rwanda					
	Designer	ASA studio					
	Builder	Different depending on the site: ADRA, Betex are the main ones. The contractor provides only technical experts and the manpower is found on site from local community					
	Type of bid	UNICEF Rwanda engages with a local partner (ADRA or PLAN International or IMBUTO foundation). ADRA has building capacity and builds directly; PLAN collaborates with a contractor (Betex) - direct award. IMBUTO asked the support of the district authorities to find a contractor to build the ECD: in this case a public tender is published.					
	Final building property	local community (sector level)					
	Building Manager	local community (sector level)					
2 Financing	Financing actors	UNICEF Rwanda (main) + local partner (ADRA or IMBUTO or PLAN for 3-5%) + District					
	Financing type	mixed					
	Entity	average 105.000 USD per ECD					
	Percentage of the total	/					
3 Program (brief)	Site characteristics	Different sites: mainly on a hill side (5-20% slope). Rural area, most of the times closed to a village. The site is chosen by UNICEF depending of different paramenters: povery of the area, closest educational facility, catchable area, local autorithies collaboration etc					
	Project scope	Pre primary school for children from 0 to 6 y and community center. 3 stimulation rooms, 1 open kitchen, 1 administration building, 1 toilet building,1 multipurpose hall, playground, kitchen garden, meeting-gathering space. The school is designed for 25 children per class (75 in total). In some cases it is used by more than 150 children.					
	Architectural characteristics	holistic approach / self sufficiency: toilet-compost-kitchen garden-vegetables-kitchen-children-better nutrition-better education-better job opportunities-poverty reduction etc / modular structures: the ECD is composed by blocks that can be assembled in different ways / central courtyard: the role of the central gathering space comes from the traditional settlements					
	Timeline	construction: 8-12 months					
4 Component Production	Production place	Local Production of clay components (villages near the site) + cement and metal from Kigali					
	Production type	small local producers					
	Producer/Supplier	Bricks and clay tiles: local producers timber: locally sourced (villages near the site) cement: Kigali (Cimerwa) metal: Kigali (Sonatubes) or closest biggest village - imported glass: Kigali - (Anik) - imported stones: found on site or locally sourced (villages near the site)					
	Production time						
5 Worksite/Construction/Assembly	Worksite Organization						
	Construction Methods						
	Worksite Timing	8-12 months					
	Changes during Construction	every time depending on site conditions, soil conditions, availability of materials, contractors skills					
	Work coordination						

			Competence Creating	Competence Destroying	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	No environmental change	Knowledge acquisition	Sustainability achievement	Technological advancement	Resources generation	Social problems generation	No social changes	Knowledge acquisition	Social objectives achievement	Social Improvement	Extra benefit generation	Economic Loss	No economic change	Saving achievement	New jobs creation	Increased revenue	Market expansion
	Duration																												
	Contingecies/Problems	leaking roof, cement pavement cracks, roof tiles leaking, bad quality supply in general: metal profiles bending because of fake nominal thickness etc																											
6 **Tests**	**Management**																												
	Structure																												
	Services																												
	Materials																												
	Forniture																												
	Trades																												
	Construction Systems																												
7 **Project Management/Control**		ASA studio																											
8 **Drawing development**	**Preliminary Drawings**	ASA studio																											
	Architectural Drawings	ASA studio																											
	Construction Drawings	ASA studio																											
	As Built Drawings	Not Done																											
9 **Work coordination**	**Type of Management Organization**	ASA studio																											
	Coordination	contractor																											
	Time Control	ASA studio - contractor																											
	Cost Control	ASA studio - contractor																											
	Quality Control																												
	Auditing/Certification Agency																												
10 **Contractual relations**	**Contract Type**	ASA studio: 2 years LTA with UNICEF Rwanda for architectural and engineering services and related construction administration services Contractor - client: refer 2.1.6																											
	Contract Compliance																												
	Contract Termination																												
	Contract Renewal																												
11 **Maintenance/Building Use**	**Maintenance Plan**	Not defined																											
	Building Use	Some centres are used while others abbandoned																											
	Defined Maintenance																												
	Actual Maintenance																												

Library of Muyinga
Muyinga, Burundi
BC Architects
2012

Context Characteristics:	Rural
Concpet Characteristics:	Vernacular culture of construction in Burundi
Orientation:	South-West
Dimension:	140 sqm
Shape:	2 models have been developed: S shape / circular shape
Floor number:	2 Floors
Access and circulation:	The library is organized along a covered longitudinal circulation space. There are two different accesses on two different levels.
Structure:	Brick mansory and a lightweight concrete skeleton structure inside the CEB columns.
Construction systems:	Bricks masonry locally produced
Evironmanetal control systems:	On the longitudinal end there are blinders control access, also a high interior with continuous cross-ventilation. Transparent doors between the columns create the interaction between inside space and porch. The façade is perforated according to the rhythm of the Compressed Earth Blocks (CEB) masonry. Three façades of four are windowed with a great transparent/opaque relation that facilitate the natural internal ventilation. All the materials used for the construction was local, with a low energy producti
Water treatment:	None

1_Building				INNOVATION	DECISION-MAKER	SUSTAINABILITY		
						ENVIRONMENTAL	SOCIAL	ECONOMIC
	CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	Type	Decision-maker	Results	Results	Results
1	Context Characteristics	Urban						
		Rural	semi-rural area					
2	Concept	Characteristics	Community inclusion					
3	Orientation	Emisphere	South					
		Axes	South-West					
4	Architectural Characteristics	Aesthetic Approach	Vernacular architecture					
5	Dimension		140 smq					
6	Shape	Typology	Library					
		Geometry	Single block					
		Volume Shape	Parallepiped					
		Symmetry	Simmetry					
7	Floor number and height		2 floors					
8	Access and circulation	Main access	There are two different access on different levels					
		Pedestrian access	The all area is pedestrian					
		Circulation characteristics	The library is organized along a covered longitudinal circulation space.					
		Circulation within the building	The library is organized along a covered longitudinal circulation space.					
9	Structure		Brick mansory and a lightweight concrete skeleton structure inside the CEB columns					
10	Construction systems	Envelope	Brick mansory					
		Roof	Tiles					
		Foundation System	Concrete slab					
		Other						
11	Internal partition and non-strcutural elements	Vertical (walls)	None					
		Horizontal (ceilings/floors)	Amac made by the villagers					
12	Doord and windows		Transparent doors between the columns create the interaction between inside space and porch. Fully opened, these doors make the library open up towards the adjacent square. On the longitudinal end, the hallway porch ows onto the street, where blinders control access. These blinders are an important architectural element of the street facade, showing clearly when the library is open or closed.					
13	Construction details	Characteristics if innovative	Standard					
14	Evironmanetal control systems	Water system	No water provided					
		Lighting system	Transparent doors between the columns create the interaction between inside space and porch. The façade is perforated according to the rhythm of the Compressed Earth Blocks (CEB) masonry.					
		Heating system	On the longitudinal end there are blinders control access, also a high interior with continuous cross-ventilation helps to guide the humid and hot air away.					
		Fire control syustem	None					
		Communication system	NOne					

No.	Element	Sub-element	Solution	Irrelevant	Incremental	Modular	Architectural	Radical	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	Resource waste	Environmentally Irrelevant	Sustainability strategy introduction	Technological perfomances introduction	Resources generation	Social problems generation	No social changes	Social problem solution	Social purpose definition	Social objective achievement	Extra benefit generation	Economic Loss	Cost invariant	Knowledge acquisition	Comparative advantage	Competitive advantage	Market expansion
		Ventilation system (mechanical, natural or hybrid)	Natural ventulation																														
15	**Sewage connectionn and water treatment**		None																														

2_Process

CATEGORY	SUB-CATEGORY	DEFINITION Characteristics
1 Commissioning	Promoter	Odedim NGO
	Land owner	Odedim Muyinga NGO
	Client	Odedim NGO
	Designer	BC Architects
	Builder	Local community
	Type of bid	Directly assigned by ODEDIM NGO
	Final building property	Local community
	Building Manager	None
2 Financing	Financing actors	Satimo Vzw, Rotary Aalst, Zonta Brugge, Province of West-Flanders
	Financing type	Internal management
	Entity	40.000 €
	Percentage of the total	Not known
3 Program (brief)	Site characteristics	Ruralo context
	Project scope	Linked to an inclusive boarding school for deaf children, creates the possibility to belong to a group, to belong to the wider community of Muyinga through public infrastructure as the first of its kind in Muyinga
	Architectural characteristics	Open strcuture with holistic approach
	Timeline	two years
4 Component Production	Production place	Muyinga, Burundi
	Production type	Self-production from the community
	Producer/Supplier	Local community
	Production time	Along construction time
5 Worksite/Construction/Assembly	Worksite Organization	BC Architects
	Construction Methods	BC Architects
	Worksite Timing	BC Architects
	Changes during Construction	BC Architects
	Work coordination	BC Architects
	Duration	Two years
	Contingecies/Problems	None
6 Tests	Management	BC Architects
	Structure	BC Architects
	Services	BC Architects
	Materials	BC Architects
	Trades	BC Architects
	Construction Systems	BC Architects
7 Project Management/Control		
8 Drawing development	Preliminary Drawings	BC Architects
	Architectural Drawings	BC Architects
	Construction Drawings	BC Architects
	As Built Drawings	None
9 Work coordination	Type of Management Organization	BC Architects/BC Studies
	Coordination	BC Studies
	Time Control	Every 4 months
	Cost Control	Every 4 months
	Quality Control	Every 4 months
	Auditing/Certification Agency	None
10 Contractual relations	Contract Type	Agreement between BCArchitects and ODEDIM
	Contract Compliance	No info
	Contract Termination	No info
	Contract Renewal	No info
11 Maintenance/Building Use	Maintenance Plan	None
	Building Use	None
	Defined Maintenance	None
	Actual Maintenance	None

Group	Sub-group	Columns
INNOVATION	Type	Competence Creating; Competence Destroying
DECISION-MAKER	Decision-maker	Institutions; Client; Designer; Builder; Industry; Users; Other
SUSTAINABILITY – ENVIRONMENTAL	Results	Environmental problems; Resource waste; Environmentally Irrelevant; Sustainability strategy introduction; Technological perfomances introduction; Resources generation
SUSTAINABILITY – SOCIAL	Results	Social problems generation; No social changes; Social problem solution; Social purpose definition; Social objective achievement; Extra benefit generation
SUSTAINABILITY – ECONOMIC	Results	Economic Loss; Cost invariant; Knowledge acquisition; Comparative advantage; Competitive advantage; Market expansion

One Airport Square
Accra, Ghana
MCArchitects
2015

Context Characteristics:	Urban
Concpet Characteristics:	The main approach to the project starts from the idea that the building is an opportunity to create public space, an area similar to a European square, a meeting place for people
Orientation:	Variable
Dimension:	17000 msq
Shape:	Irregular shape following the land shape
Floor number:	10 Floors
Access and circulation:	A main square is created as meeting area. The paved surfaces link the street with the upper level of the square, where we find the main entrance to the offices and commercial area
Structure:	The structural mechanics is a unique and organic collaboration between all its variable elements in reinforced concrete. This is a complex framework with a high degree of hyperstaticity where each element in any load condition works as a unit to balance the system of forces
Construction systems:	The enclosure is made up of a system of cantilever projecting slabs that protect the building from solar radiation, from a sun-protected glass façade protected from the sun, and from a diagonal structural weave in reinforced concrete that in an organic way surrounds the building
Evironmanetal control systems:	Natural lighting and ventilation system
Water treatment:	Reuse of gray water for flushing toilets
Certification:	4-Stars (Design Stage) by the Green Building Council of South Africa (GBCSA).

1_Building				INNOVATION	DECISION-MAKER	SUSTAINABILITY		
						ENVIRONMENTAL	SOCIAL	ECONOMIC
	CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	Type	Decision-maker	Results	Results	Results
1	**Context Characteristics**	**Urban**	Commercial area of Airport City - Accra - Ghana					
		Rural						
2	**Concept**	**Characteristics**	The main approach to the project starts from the idea that the building is an opportunity to create public space, an area similar to a European square, a meeting place for people					
3	**Orientation**	**Emisphere**	North					
		Axes	/					
4	**Architectural Characteristics**	**Aesthetic Approach**	The aesthetic and architectural elements of the project are inspired by local traditional art and are closely linked to environmental strategies to provide a valid solution to climate problems					
5	**Dimension**		17000 msq					
6	**Shape**	**Typology**	Court/Plaza					
		Geometry	Variation of depth of the shafts determines the configuration of three office types: maxi, midi and mini					
		Volume Shape	Irregular volume					
		Symmetry	No simmetry					
7	**Floor number and height**		10 floors					
8	**Access and circulation**	**Main access**	The paved surfaces link the street with the upper level of the square, where we find the main entrance to the offices and commercial area					
		Pedestrian access	Access from the paved area					
		Circulation characteristics	Vertical through elevators					
		Circulation within the building	A pair of escalators directly join the public space and the two floors of the underground car park					
9	**Structure**		The design complexity lies mainly in the analysis of the static support between the various parts of the structure. From an operative point of view, the structural mechanics is a unique and organic collaboration between all its variable elements in reinforced concrete. One cannot imagine a separation between the components providing resistance to vertical and horizontal loads, as well as the contribution of membrane stiffness. This is a complex framework with a high degree of hyperstaticity where each element in any load condition works as a unit to balance the system of forces.					
10	**Construction systems**	**Envelope**	The enclosure is made up of a system of cantilever projecting slabs that protect the building from solar radiation, from a sun-protected glass façade protected from the sun, and from a diagonal structural weave in reinforced concrete that in an organic way surrounds the building					
		Roof	Reinforced concrete slab					
		Foundation System	Reinforced concrete					
		Other						
11	**Internal partition and non-strcutural elements**	**Vertical (walls)**	Open plan					

		Horizontal (ceilings/floors)	Concrete slab		X						X						X	X	X				X	X					X			
12	**Doors and windows**		The glazed façade is composed of a fixed element and a movable one in the lower part					X			X	X						X	X	X			X	X						X			
13	**Construction details**	**Characteristics if innovative**	The 3D modeling of the grid's intersections and angles with the floor slabs (always different for each node) is an example of the complex framework generated by the balance of the structural flows of the whole organism. The building is characterized by an on-site concrete exoskeleton that resembles a sort of self-supporting basket, explains Fabio Camorani, Politecnica director of structural engineering and site management. The angle of the inclined pillars has been designed to balance the horizontal forces generated by the nonalignment of the axes of the pillars themselves; within each slab there are struts and tie rods of large diameter and anchorage nodes.					X			X	X						X	X	X				X							X	X	X
14	**Environmental control systems**	**Water system**	To limit the consumption of drinking water technologies are used that limit the amount of outflow, duration and time of delivery					X		X	X							X	X	X				X							X		
		Lighting system	Natural lighting				X			X	X							X	X	X				X							X		
		Heating/Cooling system	Distribution of fresh air carried in the floating floor that reaches the entire floor in a uniform way.				X			X	X							X	X	X				X							X		
		Fire control system	/																														
		Communication system	/																														
		Ventilation system (mechanical, natural or hybrid)	The opening of the movable part in the façade allows a correct natural ventilation that from the façade reaches the atrium that works like a chimney that brings air into the offices				X			X	X							X	X	X				X							X		
15	**Sewage connectionn and water treatment**		Reuse of gray water for flushing toilets				X			X	X							X	X	X				X							X		
				Incremental	Modular	Architectural	System	Radical	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	No environmental change	Knowledge acquisition	Sustainability achievement	Technological advancement	Resources generation	Social problems generation	No social changes	Knowledge acquisition	Social objectives achievement	Social Improvement	Extra benefit generation	Economic Loss	No economic change	Saving achievement	New jobs creation	Increased revenue	Market expansion

2_Process			INNOVATION	DECISION-MAKER	SUSTAINABILITY: ENVIRONMENTAL	SUSTAINABILITY: SOCIAL	SUSTAINABILITY: ECONOMIC
CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	Impact	Decision-maker	Results	Results	Results
1 Commissioning	Promoter	Laurus Development Partners					
	Land owner	Myma Belo Osagie					
	Client	Actis Boston Tower Development Limited					
	Designer	Mario Cucinella Architects					
	Builder	Micheletti LTD					
	Type of bid	Private development					
	Final building property	Laurus Development Partners					
	Building Manager	Laurus Development Partners					
2 Financing	Financing actors	Joint venture between Actis and Myma Belo Osagie of Boston Investments Limited					
	Financing type						
	Entity	$62.5m					
	Percentage of the total	Stanbic Bank Ghana Limited and The Standard Bank of South Africa Limited partially financed it with a $31.2m medium-term loan facility.					
3 Program (brief)	Site characteristics	Commerical area of Airport City at Accra, Ghana.					
	Project scope	Multi functional building					
	Architectural characteristics	Reference to land form and local cultural art pieces					
	Timeline	From 2012to 2015					
4 Component Production	Production place	The “kit of parts” of the formwork has been designed by Politecnica and manufactured offsite using customized machines in order to be economically viable both in terms of capital costs and efficiency. For example, the shoes were produced in Italy, shipped to Accra and assembled onsite. This hybrid prefabrication system has reduced work time and enhanced safety while saving money and time.					
	Production type	Precats and local indistrialuzation					
	Producer/Supplier	Italia and local					
	Production time	Not known					
5 Worksite/Construction/Assembly	Worksite Organization	Luciano Gasparini, Politecnica					
	Construction Methods	Process of “industrialization onsite.” The modular and reusable metal formworks of the inclined pillars are a case in point. Since the pillars have very different diagonal angles and lengths, their formworks have been designed, dividing each pillar into three parts: the central part consists of blocks of standard length, made of two assembled modular metal slates; the two terminal parts, referred to as “shoes,” are made of two profiled metal sheets bolted together.					
	Worksite Timing	2012 - 2015					
	Changes during Construction	Not known					
	Work coordination	Partecipated process by design and management group					
	Duration	2012 - 2015					
	Contingecies/Problems	Not known					
6 Tests	Management	/					
	Structure	Politecnica Ingegneria e Architettura					
	Services	Chapman-BDSP					
	Materials	Politecnica Ingegneria e Architettura					
	Forniture	Certification from suppliers					
	Trades	Local MEP Engineering					
	Construction Systems	Politecnica Ingegneria e Architettura					

7 **Project Management/Control**		MACE
8 **Drawing development**	**Preliminary Drawings**	Mario Cucinella Architects - BIM-based parametric analysis
	Architectural Drawings	Mario Cucinella Architects - BIM-based parametric analysis
	Construction Drawings	Mario Cucinella Architects - BIM-based parametric analysis
	As Built Drawings	Mario Cucinella Architects - BIM-based parametric analysis
9 **Work coordination**	**Type of Management Organization**	BIM-based parametric analysis
	Coordination	Laurus Development Partners
	Time Control	Aecom
	Cost Control	Aecom
	Quality Control	Aecom
	Auditing/Certification Agency	Not required
10 **Contractual relations**	**Contract Type**	Integrated design
	Contract Compliance	Yes
	Contract Termination	Not relevant
	Contract Renewal	Note relevant
11 **Maintenance/Building Use**	**Maintenance Plan**	Standard
	Building Use	Office and leaisure space in the square
	Defined Maintenance	Standard
	Actual Maintenance	STandard

Competence Creating	Competence Destroying	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	No environmental change	Knowledge acquisition	Sustainability achievement	Technological advancement	Resources generation	Social problems generation	No social changes	Knowledge acquisition	Social objectives achievement	Social Improvement	Extra benefit generation	Economic Loss	No economic change	Saving achievement	New jobs creation	Increased revenue	Market expansion	

Ballard Libray
Seattle, WA, USA
Bohlin Cywinski Jackson
2005

Context Characteristics:	Urban
Concpet Characteristics:	Ballard neighborhood is deeply rooted in Scandinavian tradition and culture, and the nearby working waterfront lends a strong maritime tradition.Remember a boat shape
Orientation:	North/South
Dimension:	15000.0 msq
Shape:	Basically a box; is based on a grid of columns that are the structure of the building. The roof is not a perfect geometrical curve, but rather a series of straight line segments that remember a boat
Floor number:	One floor
Access and circulation:	It is easily accessible by public transit, bicycles, and pedestrians
Structure:	Structure designed as a large open space surrounded by a curtain wall of clear glass.Three-dimensional network of the load-bearing part of a building with structure formed by linear elements like beams and pillars
Construction systems:	Tapered steel columns support a lilting roof, center components with its edges softened by wood purlins. Vegetated roof system.
Evironmanetal control systems:	Vegetated roof system. The plants provide insulation. Solar photovoltaic panels. Recycled-glass backfill, concrete forms made from milk cartons. Refrigerating and Air-Conditioning
Water treatment:	When possible, water comes from an on-site 38,500-gallon rainwater collection tank; the "sod" roof is a European system that absorbs water to be used later by planting material; interior water use reduced by metered faucets; no-flush urinals and efficient mechanical equipment

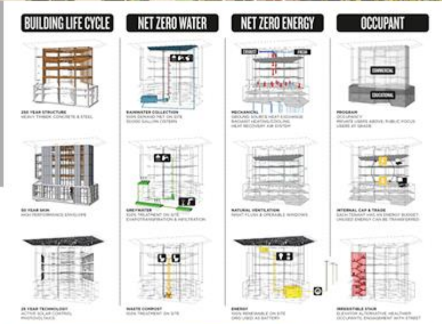
1_Building				INNOVATION	DECISION-MAKER	SUSTAINABILITY		
						ENVIRONMENTAL	SOCIAL	ECONOMIC
	CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	Type	Decision-maker	Results	Results	Results
1	Context Characteristics	Urban	Based on the urban regenaration of the Ballard neighborhood.					
		Rural						
2	Concpet	Characteristics	sustainable building with low budget.					
3	Orientation	Hemisphere	Northern hemisphere					
		Axes	Axes north/south					
4	Architectural Characteristics	Aesthetic Approach	Roof boat shape					
5	Dimension		33,200 square feet.					
6	Shape	Typology	Boxes in box with curved roof, sustained by pillars					
		Geometry	is based on a grid of columns inside of a rectangular shape, roof					
		Volume Shape	Basically a box					
		Symmetry	no symmetry in this project					
7	Floor number and height		Exist only a ground floor with the peculiarity of the double height that can reaches a maximum of 7,2 meter					
8	Access and circulation	Main access	Ground floor, main street.					
		Pedestrian access	Ground floor, main street.					
		Circulation characteristics	open space, free circulation, easily accessible by public transit, bicycles, and pedestrians.					
		Circulation within the building	Open space, free circulation but we can difference between Library, Staff and Service Center					
9	Structure		Three-dimensional network of the load-bearing part of a building with structure formed by beams made of GLU-LAM wood and pillars.					
10	Construction systems	Envelope	Glass skin bends, first application of thin-film solar cells, galvanized shingles					
		Roof	Vegetated roof system.					
		Foundation System	A spread footing foundation.					
		Other						
11	Internal partition and non-strcutural elements	Vertical (walls)	recycled-glass backfill, concrete forms made from milk cartons, and artwork made from heated sheets of post-consumer plexiglass originally manufactured from recycled milk cartons.					
		Horizontal (ceilings/floors)	soundproof panels and moquette.					
12	Doord and windows		Traditional doors that have two panels mobile sections,					
13	Construction details	Characteristics if innovative	products with recycled content. recycled-glass backfill, concrete forms made from milk cartons, and artwork made from heated sheets of post-consumer plexiglass originally manufactured from recycled milk cartons.					
14	Evironmanetal control systems	Water system	Reduced use of water and use of rain water for irrigation					
		Lighting system	Electric system and natural system/Photovoltaic panels					
		Heating system	HVAC - Heating, ventilation and air conditioning/Photovoltaic panels					
		Fire control syustem	Standard					
		Communication system	Standard					
		Ventilation system (mechanical, natural or hybrid)	Mechanical ventilation system					

				Irrelevant	Incremental	Modular	Architectural	Radical	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	Resource waste	Environmentally Irrelevant	Sustainability strategy introduction	Technological perfomances introduction	Resources generation	Social problems generation	No social changes	Social problem solution	Social purpose definition	Social objective achievement	Extra benefit generation	Economic Loss	Cost invariant	Knowledge acquisition	Comparative advantage	Competitive advantage	Market expansion
15	**Sewage connectionn and water treatment**		Reduced use of water for the toilets			■				■	■								■				■							■			

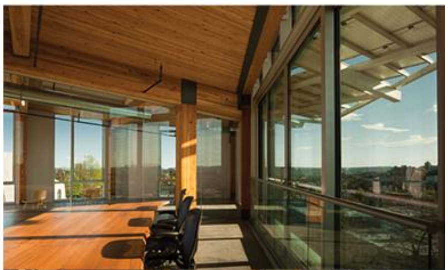
2_Process			INNOVATION	DECISION-MAKER	SUSTAINABILITY: ENVIRONMENTAL	SUSTAINABILITY: SOCIAL	SUSTAINABILITY: ECONOMIC
CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	Type	Decision-maker	Results	Results	Results
1 Commissioning	Promoter	Seattle Public Library					
	Land owner	U.S. Bank					
	Client	Seattle Public Library					
	Designer	Bohlin Cywinski Jackson					
	Builder	PCL Conctruction					
	Type of bid	Competition to chose the architects					
	Final building property	Innovate financial strategy: bank that was originally part of the project pulled out during the design development phase					
	Building Manager	David Kunselman					
2 Financing	Financing actors	Seattle Public Library, U.S: Bank					
	Financing type	Public Finances					
	Entity	Seattle Public Library					
	Percentage of the total	$196.4 milion for all libraries, 6% is for Ballard Library					
3 Program (brief)	Site characteristics	The site is located one block from the main marketing street in Ballard. Location is ideal for its proximity to bus routes, a new park, and businesses, the neighborhood has a strong pedestrian nature					
	Project scope	Renew le libraries in Seattle. The public nature of this building called for a public design process					
	Architectural characteristics	The library design resumes the Scandinavian tradition					
	Timeline	March 2000 library board selects BCJ-October 2002 approved schematics design plans-April 2003 approved the final plans					
4 Component Production	Production place	Everything produced locally, except photovoltaic panels that are imported from Germany.					
	Production type	Standard					
	Producer/Supplier	Local producers and suppliers.					
	Production time	Standard					
5 Worksite/Construction/Assembly	Worksite Organization	David Cinamon and PCL Construction					
	Construction Methods	Critical path					
	Worksite Timing	April 2004- May 2005					
	Changes during Construction	the contractor chose to install temporary glazing to allowefficient conditioning of the space during constrution. The solar installation resulted i several modifications rispect the project.					
	Work coordination	David Cinamon and PCL Construction					
	Duration	1 year					
	Contingecies/Problems	Inverters of photovoltaic panels change					
6 Tests	Management	The tests carried out were done by the companies that provide the material and not specifically for the building.					
	Structure	Testing of the structure was not found. It is not a complex structure.					
	Services	Standard certification					
	Materials	Materials used are very common in construction in this area.					
	Trades	Standard					
	Construction Systems	Roof construction system required tests.					
7 Project Management/Control		The project manager was Robert Miller.					
8 Drawing development	Preliminary Drawings	Done by BCJ architects and approved by the users (neighbors of Ballard).					
	Architectural Drawings	Done by BCJ architects and approved by the users (neighbors of Ballard).					
	Construction Drawings	Some developed by the architects but others from the supplier companies.					
	As Built Drawings	We have not found as built drawings which is an indicator that not many things changed.					

				Competence Creating	Competence Destroying	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	Resource waste	Environmentally Irrelevant	Sustainability strategy introduction	Technological perfomances introduction	Resources generation	Social problems generation	No social changes	Social problem solution	Social purpose definition	Social objective achievement	Extra benefit generation	Economic Loss	Cost invariant	Knowledge acquisition	Comparative advantage	Competitive advantage	Market expansion
9	**Work coordination**	**Type of Management Organization**	Project Management carried out by Robert Miller from BCJ architects.	■				■	■							■						■						■		
		Coordination	Simple Coordination because actors involved all have offices in Seattle, excepting the Solar Panels Provider, which needed a higher implication for coordination.		■			■	■	■						■					■							■		
		Time Control	The completion of the Library was on time, even some weeks earlier.	■				■	■							■					■							■		
		Cost Control	The cost Control was carried out by the Robinson Company (Dan Cassady).	■								■			■					■								■		
		Quality Control	Standard	■								■					■						■					■		
		Auditing/Certification Agency	AIA Certification, LEED Certification	■								■					■						■					■		
10	**Contractual relations**	**Contract Type**	General Contracting	■			■	■	■	■						■						■						■		
		Contract Compliance	The contract was complied	■			■	■	■	■					■					■								■		
		Contract Termination	The contract ended with the delivery of the Library	■			■	■	■	■					■					■								■		
		Contract Renewal	There was no contract renewal	■			■	■	■	■					■					■						■				
11	**Maintenance/Building Use**	**Maintenance Plan**	First maintenance carried out in 2013 and 2016. Ten years later of the completion of the building	■			■	■			■					■				■								■		
		Building Use	High use of the Ballard Neighbors.	■							■					■							■					■		
		Defined Maintenance	Standard plan of maintenance	■			■	■							■					■						■				
		Actual Maintenance	Maintenances carried out in 2013/2016	■			■				■				■						■				■					

Bullit Center
Seattle, WA, USA
Miller Hull Partnership
2012



Context Characteristics:	Urban
Concpet Characteristics:	Building a NET zero energy building
Orientation:	North/West
Dimension:	50000 msq
Shape:	Trapezoidal block
Floor number:	6 Floors
Access and circulation:	The building can be reached by different medium of transport
Structure:	Heavy timber, concrete anc steel
Construction systems:	High perfomance facade with both opaque and glazing surfaces
Evironmanetal control systems:	Photovoltaic panels, ground source heat exchange, radiant heating and cooling, heat recovery air system, natural ventilation through operable window, waste compost treatment of site, renewable grid used as a battery, internal cap and trade on user’s energy budget
Water treatment:	Water collection and 50 gallons collection tank, grey gray water treatment



1_Building			INNOVATION					DECISION-MAKER							SUSTAINABILITY: ENVIRONMENTAL						SUSTAINABILITY: SOCIAL						SUSTAINABILITY: ECONOMIC					
			Type					Decision-maker							Results						Results						Results					
CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	Irrelevant	Incremental	Modular	Architectural	Radical	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	Resource waste	Environmentally Irrelevant	Sustainability strategy introduction	Technological perfomances introduction	Resources generation	Social problems generation	No social changes	Social problem solution	Social purpose definition	Social objective achievement	Extra benefit generation	Economic Loss	Cost invariant	Knowledge acquisition	Comparative advantage	Competitive advantage	Market expansion
1 **Context Characteristics**	**Urban**	This project is in Siatel down twon			■			■	■								■					■						■				
	rural	not relevant		طط	■			■	■								■					■						■				
2 **Concpet**	**Characteristics**	Building a NET zero energy building which supply its needs					■	■		■				■						■				■								■
3 **Orientation**	**Emisphere**	North	■							■				■			■					■						■				
	Axes	West	■							■				■			■					■						■				
4 **Architectural Characteristics**	**Aesthetic Approach**	This project is not evaulated fully and it would be evaulated in the next few years				■		■		■								■				■								■		
5 **Dimension**		50000 sq ft: building gross interior area			■			■	■	■				■			■					■						■				
6 **Shape**	**Typology**	block				■				■	■			■						■		■									■	
	Geometry	trapzode				■				■	■			■						■		■									■	
	Volume Shape	cube				■				■	■			■						■		■									■	
	Symmetry	No	■							■	■			■			■					■						■				
7 **Floor number and height**		six story building, 19.81 meters			■			■	■									■				■									■	
8 **Access and circulation**	**Main access**	the main access is from the avenue				■				■							■					■						■				
	Pedestrian access	the pedestrain access is from the allay				■				■							■					■						■				
	Circulation characteristics	it has a simple cerculation			■					■							■					■						■				
	Circulation within the building	the circulation in the building is not mention in the current data			■					■							■					■						■				
9 **Structure**		the main structure is heavy timber					■			■	■			■						■		■									■	
10 **Construction systems**	**Envelope**	the building's form,envelope, and organization was informed by the climate					■	■		■	■	■		■						■		■										■
	Roof	the roof is made by steel and covered by pv panels				■				■	■									■		■									■	
	Foundation System	standard			■						■		■					■				■								■		
	Other	no other data is available	■											■				■				■						■				
11 **Internal partition and non-strcutural elements**	**Vertical (walls)**	there is some walls in the project which are partition and are used for seprating spaces			■					■	■			■					■			■							■			
	Horizontal (ceilings/floors)	in this project cieling is not used and the structure can be seen					■			■	■								■			■									■	
12 **Doord and windows**		doors and windows were chosen carefully and they are completly isolated					■			■	■	■								■		■									■	
13 **Construction details**	**Characteristics if innovative**	In this project there were lots of innovation in construction and assembling the systems.					■			■	■	■		■						■				■								■
14 **Evironmanetal control systems**	**Water system**	The water management system provide example of the watershed- level ecosystem service impacts of living building features					■	■		■				■						■		■										■
	Lighting system	The lighting system is quiet complex. The designers tried to natural light.					■			■				■						■		■										■
	Heating system	for heating system, heat pump was chosen					■	■		■	■			■						■		■										■
	Fire control system	there are some sensors in the building for controling heating and fire					■							■				■				■								■		
	Communication system	There is no communication system in this project	■											■			■					■						■				
	Ventilation system (mechanical, natural or hybrid)	natural ventilation					■	■		■				■						■		■								■		
15 **Sewage connectionn and water treatment**		very complex system is used in this building in order to recycle sewage and make it clean and usable					■	■						■						■		■										■

2_Process			INNOVATION	DECISION-MAKER	SUSTAINABILITY: ENVIRONMENTAL	SUSTAINABILITY: SOCIAL	SUSTAINABILITY: ECONOMIC
CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	Type	Decision-maker	Results	Results	Results
1 **Commissioning**	**Promoter**	KBA Construction Management					
	Land owner	Seattle Department of Transportation (SDOT)					
	Client	Bullitt Foundation					
	Designer	Integrated Design Team Miller Hull					
	Builder	Schuchart Construction					
	Type of bid	direct					
	Final building property	Bullitt Foundation					
	Building Manager	Nai Chao, Bullitt Foundation					
2 **Financing**	**Financing actors**	private and public					
	Financing type	loan and investigating					
	Entity						
	Percentage of the total						
3 **Program (brief)**	**Site characteristics**	the site selection process was focused on finding a location close to downtown with all of the natural amenities necessary to achieve the LBC goals. The project site must not be more 6 story building.					
	Project scope	commercial office					
	Architectural characteristics	standard prestige					
	Timeline	standard prestige: July 2009 Opening date: April 22, 2013					
4 **Component Production**	**Production place**	From the onset of the design process, the team understood that for this place to be truly sustainable, it must be resilient, diverse, "locally" attuned and responsive, able to leverage interdependencies and allow for change over time.					
	Production type	All the building materials and compound were largely sourced, extracted, manufactured, and produced within 500 Kilo- meters of Seattle. And they are assembled by manufacturer					
	Producer/Supplier	The building materials were largely sourced, extracted, manufactured, and produced within 500 Kilo- meters of Seattle.					
	Production time	Assembling documentation for complex products including "articles" and complex equipment such as pumps and circuitry was very difficult. In most cases, despite the manufacturer's best effort, it was very hard to obtain written confirmation that the product was in compliance with the Living Building Challenge "10% rule". This is largely due to the complex supply chains.					
5 **Worksite/Construction/Assembly**	**Worksite Organization**	Point 32 managed site and design team selection, permitting, financing, construction, media and communications.					
	Construction Methods	Much of the construction methods used in the Bullitt Center involved standard industry practices, but there were several approaches that were relatively special to the process. These included the use of heavy-timber framing, the coordinated process by which green elements were integrated, and the selection process for materials used in the building.					
	Worksite Timing	15 months					
	Changes during Construction	There were two small changes during construction which did'nt couse any spesefic problem					
	Work coordination	Schuchart Construction receives construction documents from the Structural Engineer, DCI Structural Engineers, and delivers them to the subcontractor, Stearn's Design Build of Lake Oswego, Oregon.					
	Duration	Work site starting date 2011 Worksite completion date 2013					
	Contingecies/Problems	there was no problem in this project as far as they mention					
6 **Tests**	**Management**	RDH					

	Structure	Several strategies were used to ensure actual performance versus what the modeling predicts. There is a small margin for error built in. Through a special introductory meeting, each subcontractor learned aboutthe building and accepted a vested interest to meet the unusually ambitious goals. There was also a high level of monitoring during the construction: testing of assemblies such as the envelope to see if it met the design criteria; commissioning to work out the bugs; and ongoing monitoring and testing.
	Services	
	Materials	Since the Living Building Challenge (LBC) requires indoor air testing for VOC's, Joe took it upon himself to select materials that meet standards for both priorities.While the third floor was still a finished shell, complex tests were undertaken to assess the indoor air quality of the space.
	Trades	LBC requires a full year of occupation data before it can become certified as living. This ensures not just well thought design measures and modeling but also that the tenants and building continues to operate as planned during actual use.The monitoring of the Bullitt Center took place from January to December 2014. The building met, and in many cases exceeded, all of its benchmarks. Monitoring will continue for the foreseeable future but reporting directly to LBC will not be required.
	Construction Systems	The treatment system was designed and constructed to allow for several different water treatment sequences to be tested and evaluated.By operating a few valves,water can be filtered through a series of cartridge filters,an ultrafilter, and an ultraviolet disinfection system to evaluate the performance of the different water treatment methods.
7 **Project Management/Control**		The Bullitt Foundation started the process by bringing in Point32 as project manager
8 **Drawing development**	**Preliminary Drawings**	Miller Hull Partnership Company:Craig Curtis
	Architectural Drawings	Miller Hull Partnership Company:Maaike Post
	Construction Drawings	DIC engieers
	As Built Drawings	Miller Hull Partnership Company
9 **Work coordination**	**Type of Management Organization**	functional
	Coordination	Casey Schuchart
	Time Control	The monitoring of the performance of the Bullitt Center extended from "January to December 2014 and, according to the foundation, the building has met all its benchmarks.
	Cost Control	
	Quality Control	Manufacturers were contacted one-by-one and MSDS and product questionnaires were procured. The project team relied heavily on the Pharos Project chemical database to evaluate the chemical constituents identified through this process.
	Auditing/Certification Agency	Living Building Challenge(LBC), LEED, Net Zero Energy; Net Zero Water.
10 **Contractual relations**	**Contract Type**	Price-based Construction Contracts
	Contract Compliance	"Representatives of Point32, Miller Hull, PAE, Schuchart, and the University of Washington's Integrated Design Lab met with Hayes every week for the next 12 months. Rather than a sequential process—from architect to engineer to contractor all of the parties were involved in a deeply integrated design process, solving all the identified problems
	Contract Termination	not relevant
	Contract Renewal	not relevant

			Competence Creating	Competence Destroying	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	Resource waste	Environmentally Irrelevant	Sustainability strategy introduction	Technological perfomances introduction	Resources generation	Social problems generation	No social changes	Social problem solution	Social purpose definition	Social objective achievement	Extra benefit generation	Economic Loss	Cost invariant	Knowledge acquisition	Comparative advantage	Competitive advantage	Market expansion
11 **Maintenance/Building Use**	**Maintenance Plan**	Unico Properties is responsible for the building operations and tenant billing and employs a full-time, on-site building engineer for the center.																											
	Building Use	It was designed for office commercial																											
	Defined Maintenance	Bullitt Foundation and the Unico																											
	Actual Maintenance	Till now the Unico is responsible for maintenance																											

West Branch Berkley Library
Berkley, CA, USA
Harley Ellis Devereaux
2013

Context Characteristics:	Urban
Concpet Characteristics:	Building's zero net energy design
Orientation:	North/South
Dimension:	500 msq
Shape:	Parallelepiped with communication strategy to explain climatic conditions and social mission of the project
Floor number:	One floor with double height to allow future vertical extensions
Access and circulation:	Located in close proximity to public transportation, with adequate space for bike parking, no auto parking was provided on site. Rather the building encourages patrons to bike or walk, while it enhances the streetscape and the pedestrian experience
Structure:	Wood-framed building, 97.1% FSC certified. Renewable resource
Construction systems:	Fiber cement panels with a fiber-cement panel rain screen façade above a concrete base provides and a high performance envelope and an elegantly organized façade that befits a civic structure.
Evironmanetal control systems:	Natural lighting through skylight, natural ventilation No conventional air handling system is needed, with heating and cooling provided by a radiant floor and pre-tempering radiators at the north windows. Energy production with solar and photovoltaic panels
Water treatment:	All roof runoff is collected in Flow-Through Planters integrated into the base of the building. Potable water use is reduced by 58.2% from the LEED baseline through low flow plumbing fixtures.
Certification:	LEED Platinum certified in 2016

1_Building			INNOVATION	DECISION-MAKER	SUSTAINABILITY		
					ENVIRONMENTAL	SOCIAL	ECONOMIC
CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	Type	Decision-maker	Results	Results	Results
1 **Context Characteristics**	**Urban**	University Avenue in Berkley, CA					
	Rural						
2 **Concpet**	**Characteristics**	Building's zero net energy design					
3 **Orientation**	**Hemisphere**	North					
	Axes	North-South					
4 **Architectural Characteristics**	**Aesthetic Approach**	Major facade to express the relation with the community as well expression of microclimat characteristics of the site					
5 **Dimension**		874 msq					
6 **Shape**	**Typology**	Block					
	Geometry	Rectangular layout					
	Volume Shape	Parallelepiped					
	Symmetry	Overall symmetric					
7 **Floor number and height**		One with overhanged floors using the total height of the building					
8 **Access and circulation**	**Main access**	Main facade with entrance to represent a welcoming gesture for the local community					
	Pedestrian access	The building can be reached by pedestrian					
	Circulation characteristics	Located in close proximity to public transportation, with adequate space for bike parking, no auto parking was provided on site. Rather the building encourages patrons to bike or walk, while it enhances the streetscape and the pedestrian experience.					
	Circulation within the building	Open plan and open level using the height of the building					
9 **Structure**		Wood-framed building, 97.1% FSC certified. Renewable resource					
10 **Construction systems**	**Envelope**	Fiber cement panels with a fiber-cement panel rain screen façade above a concrete base provides and a high performance envelope and an elegantly organized façade that befits a civic structure.					
	Roof	Roof is equipped with solar panel and Photovoltaic panles, as well as fans, and operable skylights					
	Foundation System	Concrete slabs					
	Other						
11 **Internal partition and non-strcutural elements**	**Vertical (walls)**	Timber frame panels and Glulams, casework. 100% of adhesives, sealants and coatings meet LEED low emitting materials criteria. Wood timber and paneling is employed inside and out to humanize the project in concert with a bright color palette					
	Horizontal (ceilings/floors)	100% of flooring systems meet LEED low emitting material criteria. Shaw Ecoworx carpet, Forbo wall base, Dal Tile, Forbo Marmoleum sheet flooring.					
12 **Doord and windows**		88% of all wood products meet low emitting criteria. Glulams, wood doors, casework.					
13 **Construction details**	**Characteristics if innovative**	Not a thermal bridge					
14 **Evironmanetal control systems**	**Water system**	All roof runoff is collected in Flow-Through Planters integrated into the base of the building.					

			Incremental	Modular	Architectural	System	Radical	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	No environmental change	Knowledge acquisition	Sustainability achievement	Technological advancement	Resources generation	Social problems generation	No social changes	Knowledge acquisition	Social objectives achievement	Social Improvement	Extra benefit generation	Economic Loss	No economic change	Saving achievement	New jobs creation	Increased revenue	Market expansion
	Lighting system	Proper daylighting was a primary goal. The south-facing front façade received a large window-wall over the full width of the main library space, with a horizontal solar shading system. Skylights face north to minimize glare. At the north wall, a reading nook in the children's area is generously glazed towards a small garden. Interior glazed walls and clerestory windows allow internal spaces to connect to the natural light. As a result, the library is 97 percent daylit, with views of the outdoors from 95% of occupied spaces.																														
	Heating system	No conventional air handling system is needed, with heating and cooling provided by a radiant floor and pre-tempering radiators at the north windows																														
	Building control system	A building management system tied to a roof-top weather station coordinates the systems, switching modes from natural ventilation to full cooling for comfort control. There is no additional HVAC system in the facility.																														
	Energy production	Solar and photovoltaic panels																														
	Ventilation system (mechanical, natural or hybrid)	The natural ventilation system provides excellent indoor air quality. A small garden at the north side of the building forms a micro-climate from which the fresh air for the natural ventilation is drawn. A series of transfer ducts and ceiling fans within the building facilitates the flow of air throughout the various library spaces. The building management system's CO2 sensors connected to window motors ensure windows are open when fresh air is needed.																														
15 **Sewage connectionn and water treatment**		Potable water use is reduced by 58.2% from the LEED baseline through these irrigation strategies and through low flow plumbing fixtures.																														

2_Process			INNOVATION	DECISION-MAKER	SUSTAINABILITY: ENVIRONMENTAL	SUSTAINABILITY: SOCIAL	SUSTAINABILITY: ECONOMIC
CATEGORY	**SUB-CATEGORY**	**DEFINITION Characteristics**	**Type**	**Decision-maker**	**Results**	**Results**	**Results**
1 **Commissioning**	**Promoter**	City of Berkeley					
	Land owner	City of Berkeley					
	Client	City of Berkeley					
	Designer	Harley Ellis Devereaux					
	Builder	Kitchel CEM - West Bay Builders					
	Type of bid	public bid project					
	Final building property	City of Berkeley					
	Building Manager	City of Berkeley					
2 **Financing**	**Financing actors**	City of Berkeley					
	Financing type	Public bid project					
	Entity	$7,900,000.00					
	Percentage of the total	/					
3 **Program (brief)**	**Site characteristics**	Existing building site					
	Project scope	Extension for the new public library					
	Architectural characteristics	A tuned project aimed at expressing the geography and climate as well as its public mission					
	Timeline	2013					
4 **Component Production**	**Production place**	31.2% Regional Materials Content, sourced within 500 miles of site. 90.53% of construction waste diverted from landfill, Waste comingled and tracked using GreenHalo.					
	Production type	Reuse and prefab					
	Producer/Supplier	Local					
	Production time	/					
5 **Worksite/Construction/Assembly**	**Worksite Organization**	West Bay Builders					
	Construction Methods	Critical path with attentio to the proximity to existing buildings					
	Worksite Timing	/					
	Changes during Construction	None					
	Work coordination	Kitchel CEM					
	Duration	None					
	Contingecies/Problems	None					
6 **Tests**	**Management**	Harley Ellis Devereaux					
	Structure	Tipping Mar					
	Services	Timmons Design					
	Materials	Kitchel CEM					
	Trades	Kitchel CEM					
	Construction Systems	Kitchel CEM					
7 **Project Management/Control**		Harley Ellis Devereaux					
8 **Drawing development**	**Preliminary Drawings**	Harley Ellis Devereaux					
	Architectural Drawings	Harley Ellis Devereaux					
	Construction Drawings	Harley Ellis Devereaux					
	As Built Drawings	Harley Ellis Devereaux					
9 **Work coordination**	**Type of Management Organization**	Project Management					
	Coordination	Harley Ellis Devereaux					
	Time Control	Harley Ellis Devereaux					
	Cost Control	Harley Ellis Devereaux					
	Quality Control	Harley Ellis Devereaux					
	Auditing/Certification Agency	None					
10 **Contractual relations**	**Contract Type**	As per code of public projects					
	Contract Compliance	Yes					
	Contract Termination	None					
	Contract Renewal	None					

			Competence Creating	Competence Destroying	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	No environmental change	Knowledge acquisition	Sustainability achievement	Technological advancement	Resources generation	Social problems generation	No social changes	Knowledge acquisition	Social objectives achievement	Social Improvement	Extra benefit generation	Economic Loss	No economic change	Saving achievement	New jobs creation	Increased revenue	Market expansion
11 **Maintenance/Building Use**	**Maintenance Plan**	A building management system tied to a roof-top weather station coordinates the systems, switching modes from natural ventilation to full cooling for comfort control																											
	Building Use	Local community																											
	Defined Maintenance	The main library stacks and reading areas were designed as a single open space to allow for possible reconfigurations in the future, in anticipation of needing less books and shelving due to the rise of new media.																											
	Actual Maintenance	No changes up to date																											

The Jacob Institute of Innovation
UC Berkley, CA, USA
Leddy Maytum Stacy Architects
2015

Context Characteristics: Urban

Concpet Characteristics: "Beacon of innovation" expressing the sustainable values of the Institute and the University

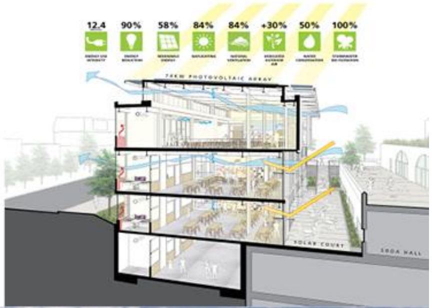
Orientation: East/West

Dimension: 2232 sqm

Shape: Aggregation of parallelepiped shapes

Floor number: 3 Floors

Access and circulation: The building is accessible by pedestrian path and public trasport. Inside the building, the compact floorplan minimizes circulation and service space while optimizing flexible teaching spaces



Structure: Steel frame

Construction systems: A highly insulated envelope, with exterior insulation, rain screen cladding and integrated sun-shading on three exposures, manages external building loads

Evironmanetal control systems: Space heating is provided by hydronic radiators, augmented by tempered mechanical ventilation air. Cooling is provided by natural ventilation and ceiling fans, augmented by "bump cooling" delivered by the mechanical system. The building is naturally ventilated, augmented by code-required mechanical ventilation in internal areas and the basement. 30% with more air than ASHRAE standards is provided to enhance indoor air quality when windows are closed.

Water treatment: Ultra-low flow fixtures reduce building water consumption by 50% from baseline, storm water management with excess filtered stormwater is delivered to the city storm sewer

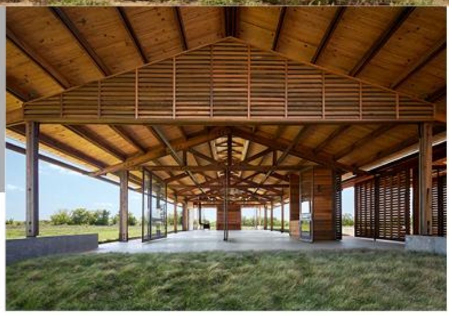
1_Building			INNOVATION					DECISION-MAKER							SUSTAINABILITY: ENVIRONMENTAL						SOCIAL						ECONOMIC					
CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	Type					Decision-maker							Results						Results						Results					
1 Context Characteristics	Urban	Berkley California	x						x								x	x	x				x								x	
	Rural																															
2 Concept	Characteristics	Collaborative, project-based educational space and a symbol to the region of the University's commitment to sustainable innovation					■		■	■							■	■	■				■	■	■							■
3 Orientation	Emisphere	North		■										■		■																
	Axes	East/West				■				■							■	■	■				■					■				
4 Architectural Characteristics	Aesthetic Approach	The project was envisioned as a striking new threshold to the campus - a "beacon of innovation" expressing the sustainable values of the Institute and the University					■		■	■							■	■	■				■	■								■
5 Dimension		2232 msq			■				■	■						■						■								■		
6 Shape	Typology	Education		■					■	■							■	■	■				■	■	■					■		
	Geometry	Agrregation of rectangular layouts			■				■	■							■					■							■			
	Volume Shape	Aggregation of parallelepiped volumes			■				■	■							■					■							■			
	Symmetry	Symmetric			■				■	■							■					■							■			
7 Floor number and height		3 Floors			■				■	■						■						■							■			
8 Access and circulation	Main access	Starirs to level 1			■				■	■							■						■	■				■				
	Pedestrian access	The building can be reach by pedestrian paths from any side			■				■	■							■						■	■				■				
	Circulation characteristics	The building can be reached by pedestrian and or by public transport and shuttles			■				■	■							■						■	■				■				
	Circulation within the building	The compact floorplan minimizes circulation and service space while optimizing flexible teaching spaces			■				■	■							■						■	■				■				
9 Structure		Steel frame		■					■	■	■						■	■				■	■					■				
10 Construction systems	Envelope	A highly insulated envelope, with exterior insulation, rain screen cladding and integrated sun-shading on three exposures, manages external building loads					■		■	■	■						■	■	■			■	■								■	
	Roof	Energy Star-rated cool roofing and high-albedo paving help to further reduce cooling loads in warm weather.					■		■	■	■						■	■	■			■	■								■	
	Foundation System	Fly ash concrete floor				■			■	■	■						■	■	■			■	■								■	
	Other																															
11 Internal partition and non-strcutural elements	Vertical (walls)	Rapidly renewable materials					■		■	■	■						■	■	■				■	■	■						■	
	Horizontal (ceilings/floors)	Rapidly renewable materials include rubber flooring and base, linoleum flooring, and					■		■	■	■						■	■	■				■	■	■							
12 Doors and windows		Agrifiber door cores.					■		■	■	■	■					■	■	■				■						■			
13 Construction details	Characteristics if innovative	Standard and according to ease of manufacturing and construction	■						■	■	■	■					■	■	■				■						■			
14 Environmental control systems	Water system	Ultra-low flow fixtures reduce building water consumption by 50% from baseline.				■			■	■	■						■	■	■												■	

			Incremental	Modular	Architectural	System	Radical	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	No environmental change	Knowledge acquisition	Sustainability achievement	Technological advancement	Resources generation	Social problems generation	No social changes	Knowledge acquisition	Social objectives achievement	Social Improvement	Extra benefit generation	Economic Loss	No economic change	Saving achievement	New jobs creation	Increased revenue	Market expansion
	Lighting system	The narrow building floorplate presents a shaded façade to the south for optimum daylight harvesting. Large north-facing windows and interior glazing help to reduce internal glare. 100% of instructional spaces above the basement and 85% of all regularly occupied spaces are day-lit.					■		■	■	■						■	■	■												■	
	Heating system	Space heating is provided by hydronic radiators, augmented by tempered mechanical ventilation air. Cooling is provided by natural ventilation and ceiling fans, augmented by "bump cooling" delivered by the mechanical system.					■		■	■	■						■	■	■												■	
	Fire control system	By code	■						■	■	■					■												■				
	Communication system	By code	■						■	■	■					■												■				
	Energy generation	A cantilevered 74kW photovoltaic array, celebrated as a signature architectural element, provides 58% of the building's energy requirement.					■		■	■	■						■	■	■	■											■	
	Buildign Control System	By code	■						■	■	■					■												■				
	Ventilation system (mechanical, natural or hybrid)	The building is naturally ventilated, augmented by code-required mechanical ventilation in internal areas and the basement. 30% more outdoor air than ASHRAE standards is provided to enhance indoor air quality when windows are closed.					■		■	■	■						■	■	■												■	
15 **Sewage connectionn and water treatment**		LANDSCAPE WATER USE: Drought-tolerant landscaping, sub-surface drip irrigation systems and advanced, weather-based irrigation controllers combine to reduce landscape water use by 50% from baseline. The small size of the site's landscaped area makes efficient use of available land while further reducing water consumption for landscaping. • STORM WATER MANAGEMENT: 100% of the project's roof drainage is piped from the south to the small, 1,400 SF northern landscaped area, where it is delayed, absorbed and filtered by a bio-swale and rain garden. Excess filtered stormwater is delivered to the city storm sewer.					■		■	■	■						■	■	■	■			■	■	■						■	■

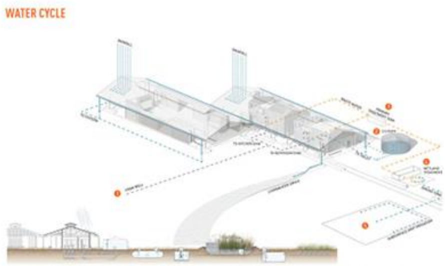
2_Process			INNOVATION	DECISION-MAKER	SUSTAINABILITY		
					ENVIRONMENTAL	SOCIAL	ECONOMIC
CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	Type	Decision-maker	Results	Results	Results
1 **Commissioning**	**Promoter**	University of California, Berkeley					
	Land owner	University of California, Berkeley					
	Client	University of California, Berkeley					
	Designer	Leddy Maytum Stacy Architects					
	Builder	Hathaway Dinwiddie					
	Type of bid	The project process comprehensively engaged all design team					
	Final building property	University of California, Berkeley					
	Building Manager	University of California, Berkeley					
2 **Financing**	**Financing actors**	Funded by philanthropy					
	Financing type	Funded by philanthropy.					
	Entity	$25 million					
	Percentage of the total						
3 **Program (brief)**	**Site characteristics**	Previously Developed Land					
	Project scope	Education – College/University (campus-level) The program, intended to accommodate up to 2,000 students per semester, includes flexible design studios, project rooms, support spaces and fabrication equipment rooms containing a variety of rapid prototyping tools and equipmen					
	Architectural characteristics	“Beacon of innovation” expressing the sustainable values of the Institute and the University. The architecture outwardly demonstrates sustainable design innovation, integrating economic strategies that foster practical and poetic connections between students and the natural world.					
	Timeline	/					
4 **Component Production**	**Production place**	Local					
	Production type	Straightforward structural system and conventional manufacturing dimensions					
	Producer/Supplier	Local					
	Production time	Standard					
5 **Worksite/Construction/Assembly**	**Worksite Organization**	IAQ Management Plans were implemented during the construction and pre-occupancy periods, including a two-week					
	Construction Methods	Critical Path					
	Worksite Timing	Standard					
	Changes during Construction	None					
	Work coordination	Hathaway Dinwiddie					
	Duration	/					
	Contingecies/Problems	None					
6 **Tests**	**Management**	Hathaway Dinwiddie					
	Structure	Forell/Elsesser					
	Services	Integral Group Engineers					
	Materials	Topflight Specs and other local consultants					
	Forniture	UC Berkeley Student					
	Trades	Hathaway Dinwiddie					
	Construction Systems	Hathaway Dinwiddie					
7 **Project Management/Control**		Real Estate Division UC Berkley					
8 **Drawing development**	**Preliminary Drawings**	Leddy Maytum Stacy Architects with the engagement of the entire design team					
	Architectural Drawings	Leddy Maytum Stacy Architects with the engagement of the entire design team					

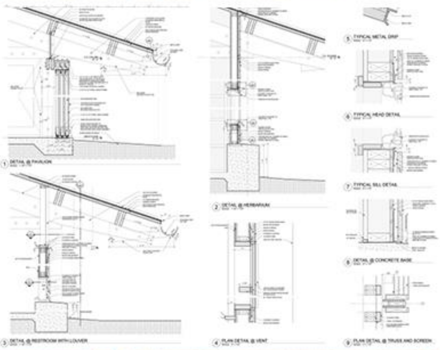
			Competence Creating	Competence Destroying	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	No environmental change	Knowledge acquisition	Sustainability achievement	Technological advancement	Resources generation	Social problems generation	No social changes	Knowledge acquisition	Social objectives achievement	Social Improvement	Extra benefit generation	Economic Loss	No economic change	Saving achievement	New jobs creation	Increased revenue	Market expansion
	Construction Drawings	Leddy Maytum Stacy Architects with the engagement of the entire design team																											
	As Built Drawings	Leddy Maytum Stacy Architects with the engagement of the entire design team																											
9 **Work coordination**	**Type of Management Organization**	Construction Management																											
	Coordination	Hathaway Dinwiddie																											
	Time Control	Davis Langdon / AECOM																											
	Cost Control	Davis Langdon / AECOM																											
	Quality Control	Davis Langdon / AECOM																											
	Auditing/Certification Agency	KSD Group																											
10 **Contractual relations**	**Contract Type**	Standard																											
	Contract Compliance	Yes																											
	Contract Termination	None																											
	Contract Renewal	None																											
11 **Maintenance/Building Use**	**Maintenance Plan**	Standard																											
	Building Use	Education																											
	Defined Maintenance	University of California, Berkeley																											
	Actual Maintenance	University of California, Berkeley																											

Dixon Water Foundation Pavilion
Decatur, TX, USA
Lake|Flato Architects
2014



Context Characteristics:	Rural
Concpet Characteristics:	Vernacular regionalism. In particular the building is aimed at promoting healthy watersheds through sustainable land management, ensuring the preservation of our water resources
Orientation:	North/South - East/West
Dimension:	500 msq
Shape:	Two similarly scaled buildings connected by a shady porch
Floor number:	One floor
Access and circulation:	The building can be openale in all its side and and therefore it allows the full acees and permeability
Structure:	Timber structure in live oak
Construction systems:	Timber frame and shading, as well as some insertion of steel frame
Evironmanetal control systems:	100% of wastewater is treated onsite and returned to the natural water cycle. At least 100% of the energy used is produced by solar panels and testing has confirmed that indoor air quality is almost indistinguishable from surrounding outdoor fresh air. The structure captures cool breezes in summer and blocks cold winter winds
Water treatment:	13000 gallons water storage tank Use of acquifer below the building to potable water Greywater for the sink and blackwater to the toilet Wetlands cleans the water circulation After cleaning, clean water back into the acquifer
Certification:	First Living Building Project in Texas





1_Building

CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	INNOVATION – Type					DECISION-MAKER – Decision-maker							SUSTAINABILITY – ENVIRONMENTAL – Results						SUSTAINABILITY – SOCIAL – Results						SUSTAINABILITY – ECONOMIC – Results					
			Incremental	Modular	Architectural	System	Radical	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	Resource waste	Environmentally Irrelevant	Sustainability strategy introduction	Technological perfomances introduction	Resources generation	Social problems generation	No social changes	Social problem solution	Social purpose definition	Social objective achievement	Extra benefit generation	Economic Loss	Cost invariant	Knowledge acquisition	Comparative advantage	Competitive advantage	Market expansion
1 Context Characteristics	Urban																															
	Rural	Rural		X					X								X						X								X	
2 Concpet	Characteristics	The building is aimed at promoting healthy watersheds through sustainable land management, ensuring the preservation of our water resources					X		X	X							X	X	X				X	X	X						X	X
3 Orientation	Hemisphere	North			X				X								X					X							X			
	Axes	North/South - East/West			X					X							X	X	X			X							X			
4 Architectural Characteristics	Aesthetic Approach	Vernacular regionalism				X				X							X	X	X				X	X	X				X			
5 Dimension		500 msq			X				X	X							X					X						X				
6 Shape	Typology	Two stripe connected with a porch			X					X							X	X	X				X						X			
	Geometry	Each building is parallelepiped			X					X							X	X	X				X						X			
	Volume Shape	Portal fram extrusion			X					X							X	X	X				X						X			
	Symmetry	Symmetry			X					X							X	X	X				X						X			
7 Floor number and height		One floor			X					X						X						X							X			
8 Access and circulation	Main access	Access changes depending on the degree of openess				X				X							X	X	X				X	X					X			
	Pedestrian access	All the building can be reach by pedestrian				X				X							X	X	X				X	X					X			
	Circulation characteristics	Open circulation				X				X							X	X	X				X	X					X			
	Circulation within the building	Open circulation				X				X							X	X	X				X	X					X			
9 Structure		Live oak timber structure			X					X	X						X	X	X				X	X						X		
10 Construction systems	Envelope	Timber and steel frame			X					X	X						X	X	X				X						X			
	Roof	The rooftop cupola provides daylight for the central pavilion while also drawing hot air out				X				X	X						X	X	X				X						X			
	Foundation System	Concrete slab		X						X	X					X							X						X			
	Other																															
11 Internal partition and non-strcutural elements	Vertical (walls)	Movable walls					X			X	X						X	X	X				X	X					X			
	Horizontal (ceilings/floors)	Concrete finish	X							X	X					X						X							X			
12 Doord and windows		Movable walls and windows					X			X	X						X	X	X				X	X				X				
13 Construction details	Characteristics if innovative	timber joints			X					X	X					X						X							X			
14 Evironmanetal control systems	Water system	13000 gallons water storage tank, use of acquifer below the building to potable water					X		X	X	X						X	X	X	X			X	X	X						X	
	Lighting system	Natural light				X				X	X						X	X	X				X	X	X						X	
	Heating system	Heating system managed by air flow				X				X	X						X	X	X				X	X	X						X	
	Fire control system	By code	X							X	X					X						X						X				
	Energy production	Solar panels				X				X	X						X	X	X				X	X							X	
	Ventilation system (mechanical, natural or hybrid)	Natural ventilation				X				X	X						X	X	X				X	X	X						X	
15 Sewage connectionn and water treatment		Greywater for the sink and blackwater to the toilet, wetlands cleans the water circulation, after cleaning, clean water back into the acquifer					X		X	X	X						X	X	X	X			X	X	X						X	

2_Process			INNOVATION	DECISION-MAKER	SUSTAINABILITY: ENVIRONMENTAL	SUSTAINABILITY: SOCIAL	SUSTAINABILITY: ECONOMIC
CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	Type	Decision-maker	Results	Results	Results
1 Commissioning	Promoter	Dixon Water Foundation					
	Land owner	Previous undeveloped site					
	Client	Dixon Water Foundation					
	Designer	Lake|Flato Architects					
	Builder	Lincoln Builders					
	Type of bid	Integrated design					
	Final building property	Dixon Water Foundation					
	Building Manager	Dixon Water Foundation					
2 Financing	Financing actors	Dixon Water Foundation					
	Financing type						
	Entity	$1.8 million					
	Percentage of the total						
3 Program (brief)	Site characteristics	Rural					
	Project scope	Education					
	Architectural characteristics	Vernacular regionalism. In particular the building is aimed at promoting healthy watersheds through sustainable land management, ensuring the preservation of our water resources					
	Timeline						
4 Component Production	Production place	Local					
	Production type	On site assembly					
	Producer/Supplier	Local					
	Production time						
5 Worksite/Construction/Assembly	Worksite Organization	Lincoln Builders					
	Construction Methods	Critical path					
	Worksite Timing						
	Changes during Construction	None					
	Work coordination	Design team					
	Duration						
	Contingecies/Problems	None					
6 Tests	Management	Desing Team					
	Structure	Datum Engineers					
	Services	TLC Engineering for Architecture with CFD Modelling					
	Materials	Biohabitats					
	Trades	Local companies					
	Construction Systems	Lincoln Builders					
7 Project Management/Control		Lake | Flato Architects on the basis of holistic management					
8 Drawing development	Preliminary Drawings	Lake | Flato Architects					
	Architectural Drawings	Lake | Flato Architects					
	Construction Drawings	Lake | Flato Architects					
	As Built Drawings	Lake | Flato Architects					
9 Work coordination	Type of Management Organization	The integrated design team					
	Coordination	The integrated design team					
	Time Control	The integrated design team					
	Cost Control	The integrated design team					
	Quality Control	The integrated design team					
	Auditing/Certification Agency	Not required					
10 Contractual relations	Contract Type	Direct agreement					
	Contract Compliance	Yes					
	Contract Termination	None					
	Contract Renewal	None					

			Competence Creating	Competence Destroying	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	No environmental change	Knowledge acquisition	Sustainability achievement	Technological advancement	Resources generation	Social problems generation	No social changes	Knowledge acquisition	Social objectives achievement	Social Improvement	Extra benefit generation	Economic Loss	No economic change	Saving achievement	New jobs creation	Increased revenue	Market expansion
11 **Maintenance/Building Use**	**Maintenance Plan**	Defined tests after completion																											
	Building Use	Education																											
	Defined Maintenance	As per maintenance plan																											
	Actual Maintenance	After completion and over a year of occupancy, daylight measurements confirmed that the spaces were bright and visually comfortable, wind metering and occupant surveys confirmed our wind blocking/inviting strategies were successful, and air quality testing confirmed that the air inside the space is just as fresh and clean as the air outside. Our energy monitoring allowed us to adjust equipment such as the thermostat for the emergency heater in the water system equipment room so that the building could perform more efficiently than was predicted.																											

Newbern Library
Auburn, AL, USA
Rural Studio
2013 - 2015

Context Characteristics:	Rural
Concpet Characteristics:	Library as social center, providing such resources as after-school programming, computer access, and the first public internet point in the community. The reuse of building materials and the retaining of the original facade contributed to define the aesthetic approach of the project
Orientation:	North/South - East/West
Dimension:	148 msq
Shape:	Parallelepiped shape with a cubic extension of the back of the existing building
Floor number:	1 Floor
Access and circulation:	Linear circulation and access to the courtyard
Structure:	Masonry shell and glass storefront were preserved and refurbished. A simple metal canopy extends from the front facade and shelters the entrance
Construction systems:	In the rear of the building, the team added a 700-square-foot (65-square-metre) cubic addition clad in cypress, which contrasts with the white brickwork. Inside, the team installed bookshelves made of birch plywood, which were milled using computer numerical control (CNC) techniques and assembled on site. Birch was also used for the patterned ceiling panels
Evironmanetal control systems:	Fan assisted natural ventilation with openable windows, and natural lighting with addition of spotlights
Water treatment:	Standard existing system

1_Building			INNOVATION	DECISION-MAKER	SUSTAINABILITY		
					ENVIRONMENTAL	SOCIAL	ECONOMIC
CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	Type	Decision-maker	Results	Results	Results
1 Context Characteristics	Urban						
	Rural	Newbern is a rural town in Alabama					
2 Concept	Characteristics	Library as social center					
3 Orientation	Emisphere	North					
	Axes	North/South - East/West					
4 Architectural Characteristics	Aesthetic Approach	Retaining of existing building and re-use of materials					
5 Dimension		145 msq					
6 Shape	Typology	Library					
	Geometry	Rectangular layout					
	Volume Shape	Parallelepiped with cubic extension at the rare					
	Symmetry	Symmetric					
7 Floor number and height		One Floor					
8 Access and circulation	Main access	Main entrance from old building facade					
	Pedestrian access	From main road and circulation at the rear					
	Circulation characteristics	Open plan and free pedestrian circulation in the backyard					
	Circulation within the building	Open plan					
9 Structure		Masonry shell and glass storefront were preserved and refurbished. A simple metal canopy extends from the front facade and shelters the entrance					
10 Construction systems	Envelope	Cubic addition clad in cypress, which contrasts with the white brickwork.					
	Roof	Flat roof					
	Foundation System	Existing concrete slab					
	Other						
11 Internal partition and non-strcutural elements	Vertical (walls)	Bookshelves made of birch plywood					
	Horizontal (ceilings/floors)	Patterned ceiling panels in birch					
12 Doors and windows		Windows designed as nieche opening to frame the outdoor area					
13 Construction details	Characteristics if innovative	birch internal bookshelves designed using computer numerical (CNC) techniques and assembled on site					
14 Environmental control systems	Water system	Standard					
	Lighting system	Natural light and spotlight					
	Heating/cooling system	Fan assisted natural ventilation					
	Fire control system	Standard					
	Communication system	Not required					
	Energy generation	Standard					
	Buildign Control System	Not required					

				Incremental	Modular	Architectural	System	Radical	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	No environmental change	Knowledge acquisition	Sustainability achievement	Technological advancement	Resources generation	Social problems generation	No social changes	Knowledge acquisition	Social objectives achievement	Social Improvement	Extra benefit generation	Economic Loss	No economic change	Saving achievement	New jobs creation	Increased revenue	Market expansion
		Ventilation system (mechanical, natural or hybrid)	Fan assisted natural ventilation				■				■	■			■			■						■									
15	**Sewage connectionn and water treatment**		Standard	■							■	■			■			■						■						■			

2_Process			INNOVATION	DECISION-MAKER	SUSTAINABILITY		
					ENVIRONMENTAL	SOCIAL	ECONOMIC
CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	Type	Decision-maker	Results	Results	Results
1 Commissioning	Promoter	Local community					
	Land owner	Family owner of the existing Old Bank building					
	Client	Local community					
	Designer	Rural studio					
	Builder	Fifth-year architecture students at Auburn University's Rural Studio					
	Type of bid	Internal agreement - student design studio					
	Final building property	Local community					
	Building Manager	Not required					
2 Financing	Financing actors	Various donators from local community to local suppliers					
	Financing type	Donations					
	Entity	$63,000-worth of donated materials					
	Percentage of the total						
3 Program (brief)	Site characteristics	Old Bank building in Newbern					
	Project scope	Library					
	Architectural characteristics	Material re-use and library as a social gathering place for the local community					
	Timeline	About two years					
4 Component Production	Production place	Local					
	Production type	Resuse of most of the materials					
	Producer/Supplier	Local suppliers and students					
	Production time	Two years					
5 Worksite/Construction/Assembly	Worksite Organization	Fifth-year architecture students at Auburn University's Rural Studio					
	Construction Methods	Computer numerical (CNC) techniques and assembled on site and other standard methods perfomed by the students					
	Worksite Timing	About one year					
	Changes during Construction	None					
	Work coordination	Rural studio					
	Duration	About one year					
	Contingecies/Problems	None					
6 Tests	Management	Fifth-year architecture students at Auburn University's Rural Studio and local suppliers					
	Structure	Fifth-year architecture students at Auburn University's Rural Studio and local suppliers					
	Services	Fifth-year architecture students at Auburn University's Rural Studio and local suppliers					
	Materials	Fifth-year architecture students at Auburn University's Rural Studio and local suppliers					
	Forniture	Fifth-year architecture students at Auburn University's Rural Studio and local suppliers					
	Trades	Fifth-year architecture students at Auburn University's Rural Studio and local suppliers					
	Construction Systems	Fifth-year architecture students at Auburn University's Rural Studio and local suppliers					
7 Project Management/Control		Fifth-year architecture students at Auburn University's Rural Studio					
8 Drawing development	Preliminary Drawings	Fifth-year architecture students at Auburn University's Rural Studio					
	Architectural Drawings	Fifth-year architecture students at Auburn University's Rural Studio					

No.	Category	Item	Description	Competence Creating	Competence Destroying	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	No environmental change	Knowledge acquisition	Sustainability achievement	Technological advancement	Resources generation	Social problems generation	No social changes	Knowledge acquisition	Social objectives achievement	Social Improvement	Extra benefit generation	Economic Loss	No economic change	Saving achievement	New jobs creation	Increased revenue	Market expansion
		Construction Drawings	Fifth-year architecture students at Auburn University's Rural Studio		■			■	■					■							■	■	■				■	■		
		As Built Drawings	Fifth-year architecture students at Auburn University's Rural Studio		■			■	■					■							■	■	■				■	■		
9	**Work coordination**	**Type of Management Organization**	Fifth-year architecture students at Auburn University's Rural Studio		■			■	■					■							■	■	■				■	■		
		Coordination	Fifth-year architecture students at Auburn University's Rural Studio		■			■	■					■							■	■	■				■	■		
		Time Control	Fifth-year architecture students at Auburn University's Rural Studio		■			■	■					■							■	■	■				■	■		
		Cost Control	Fifth-year architecture students at Auburn University's Rural Studio		■			■	■					■							■	■	■				■	■		
		Quality Control	Fifth-year architecture students at Auburn University's Rural Studio		■			■	■					■							■	■	■				■	■		
		Auditing/Certification Agency	Not required	■			■							■							■	■	■				■	■		
10	**Contractual relations**	**Contract Type**	Internal agreement - student design studio	■			■	■						■							■						■			
		Contract Compliance	Yes	■				■						■							■						■			
		Contract Termination	None	■				■						■						■							■			
		Contract Renewal	None	■				■						■						■							■			
11	**Maintenance/Building Use**	**Maintenance Plan**	Local community	■			■				■			■							■	■	■				■	■		
		Building Use	Library used by the local community	■			■				■			■							■	■	■				■	■		
		Defined Maintenance	Local community	■			■				■			■							■	■	■				■	■		
		Actual Maintenance	Local community	■			■				■			■							■	■	■				■	■		

Albion Public Library
Toronto, Canada
Perkins+Will
2017

Context Characteristics:	Urban
Concpet Characteristics:	Reminiscent of a walled garden, the dynamic façade gives the illusion of a front porch trellis – its privacy veil injecting colour into the street
Orientation:	North/South - East/west
Dimension:	2694 msq
Shape:	Block with façade that give the illusion of a front porch trellis – its privacy veil injecting colour into the street
Floor number:	One double height floor
Access and circulation:	The building is accessible with different medium of transport. Moreover, the adjunted site was transformed into lush public plaza with a landscaped parking lot and space for a market square. A community garden allows for food production and a habitat for butterflies and pollinators. All exterior lighting is directed down to provide safe, well-lit pedestrian routes and mitigate light pollution
Structure:	Steel frame and concrete
Construction systems:	50MM Square glazed terracotta extrusion hung from the steel frame
Evironmanetal control systems:	Daylight harvesting and a photovoltaic array located on portions of the sloping roof will target 5 percent renewable energy that will be sold back to the grid
Water treatment:	Storm water management strategies include a number of elements which contribute to the quality, quantity, balance and control of water leaving the site and entering municipal systems
Certification:	COTE top ten AIA Award 2018

1_Building			INNOVATION	DECISION-MAKER	SUSTAINABILITY		
					ENVIRONMENTAL	SOCIAL	ECONOMIC
CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	Type	Decision-maker	Results	Results	Results

CATEGORY	SUB-CATEGORY	DEFINITION Characteristics
1 **Context Characteristics**	**Urban**	In Albion townhall
	Rural	
2 **Concpet**	**Characteristics**	Reminiscent of a walled garden, the dynamic façade gives the illusion of a front porch trellis – its privacy veil injecting colour into the street
3 **Orientation**	**Hemisphere**	North
	Axes	North/South - East/west
4 **Architectural Characteristics**	**Aesthetic Approach**	The dynamic façade gives the illusion of a front porch trellis – its privacy veil injecting colour into the street
5 **Dimension**		2694 msq
6 **Shape**	**Typology**	Block
	Geometry	Square layout
	Volume Shape	Cubic
	Symmetry	Overall symmetric with some opening that break the symmetry
7 **Floor number and height**		One floor with full height
8 **Access and circulation**	**Main access**	Main access from North side opening of the building
	Pedestrian access	Yes
	Circulation characteristics	The building is accessible with different medium of transport. Moreover, the adjunted site was transformed into lush public plaza with a landscaped parking lot and space for a market square. A community garden allows for food production and a habitat for butterflies and pollinators. All exterior lighting is directed down to provide safe, well-lit pedestrian routes and mitigate light pollution.
	Circulation within the building	Open plan circulation
9 **Structure**		Steel frame and concrete
10 **Construction systems**	**Envelope**	50MM Square glazed terracotta extrusion hung from the steel frame
	Roof	rooftop photovoltaic array, sloping green roof
	Foundation System	Concrete slab
	Other	
11 **Internal partition and non-strcutural elements**	**Vertical (walls)**	Open plan and locally sourced materials
	Horizontal (ceilings/floors)	Locally sourced materials
12 **Doord and windows**		Glazing and steel frame
13 **Construction details**	**Characteristics if innovative**	Standard
14 **Evironmanetal control systems**	**Water system**	Storm water management strategies include a number of elements which contribute to the quality, quantity, balance and control of water leaving the site and entering municipal systems. The parking/market square is designed as a permeable paving system with storage beds and oil grit separator.
	Lighting system	Daylight harvesting
	Heating system	Mechanical system
	Building control system	None
	Energy production	a photovoltaic array located on portions of the sloping roof will target 5 percent renewable energy that will be sold back to the grid

			Incremental	Modular	Architectural	System	Radical	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	No environmental change	Knowledge acquisition	Sustainability achievement	Technological advancement	Resources generation	Social problems generation	No social changes	Knowledge acquisition	Social objectives achievement	Social Improvement	Extra benefit generation	Economic Loss	No economic change	Saving achievement	New jobs creation	Increased revenue	Market expansion
	Ventilation system (mechanical, natural or hybrid)	Mechanical system																														
15 **Sewage connectionn and water treatment**		The use of green roof surface, grassed swales and extensive soft landscaping provide water treatment and reduce the volume of runoff discharged from the new building and surrounding at grade surface.The site utilizes a retention/detention system capable of exfiltration into native soils located under the new parking /market square in order to provide control of run-off from impervious areas.																														

2_Process			INNOVATION	DECISION-MAKER	SUSTAINABILITY		
					ENVIRONMENTAL	SOCIAL	ECONOMIC
CATEGORY	SUB-CATEGORY	DEFINITION Characteristics	Type	Decision-maker	Results	Results	Results
1 Commissioning	Promoter	Albion Public Library					
	Land owner	Albion Public Library					
	Client	Albion Public Library					
	Designer	Perkins+Will					
	Builder	Acquicon Construction Ltd.					
	Type of bid	Public bid					
	Final building property	Albion Public Library					
	Building Manager	Albion Public Library					
2 Financing	Financing actors	Albion Public Library					
	Financing type	Public financing					
	Entity	$11.8 million					
	Percentage of the total	/					
3 Program (brief)	Site characteristics	Parking next to the existing library					
	Project scope	New public library for Albion Townhall					
	Architectural characteristics	Reminiscent of a walled garden, the dynamic façade gives the illusion of a front porch trellis – its privacy veil injecting colour into the street					
	Timeline	Two years					
4 Component Production	Production place	Local					
	Production type	Prefab					
	Producer/Supplier	Local					
	Production time	/					
5 Worksite/Construction/Assembly	Worksite Organization						
	Construction Methods	Strategic decision to build a new facility on the underutilized parking lot allowing branch operations to continue					
	Worksite Timing	Two years					
	Changes during Construction	None					
	Work coordination	Acquicon Construction Ltd.					
	Duration	Two years					
	Contingecies/Problems	None					
6 Tests	Management	/					
	Structure	WSP and Blackwell Engineering					
	Services	Hidi Rae (M,P), Mulvey Banani (E)					
	Materials	Acquicon Construction Ltd.					
	Trades	Acquicon Construction Ltd.					
	Construction Systems	Acquicon Construction Ltd.					
7 Project Management/Control		Construction management					
8 Drawing development	Preliminary Drawings	Perkins+Will					
	Architectural Drawings	Perkins+Will					
	Construction Drawings	Perkins+Will					
	As Built Drawings	Perkins+Will					
9 Work coordination	Type of Management Organization	Project and construction management					
	Coordination	Acquicon Construction Ltd.					
	Time Control	Acquicon Construction Ltd.					
	Cost Control	Acquicon Construction Ltd.					
	Quality Control	Acquicon Construction Ltd.					
	Auditing/Certification Agency	/					
10 Contractual relations	Contract Type	As per public projects					
	Contract Compliance	Yes					

			Competence Creating	Competence Destroying	Institutions	Client	Designer	Builder	Industry	Users	Other	Environmental problems	No environmental change	Knowledge acquisition	Sustainability achievement	Technological advancement	Resources generation	Social problems generation	No social changes	Knowledge acquisition	Social objectives achievement	Social Improvement	Extra benefit generation	Economic Loss	No economic change	Saving achievement	New jobs creation	Increased revenue	Market expansion
	Contract Termination	None																											
	Contract Renewal	None																											
11 **Maintenance/Building Use**	**Maintenance Plan**	Standards																											
	Building Use	The library addresses demographic vulnerabilities by providing family and senior-friendly services. It creates a place of social inclusion, providing equitable access to new immigrants for services. The distinct design of the library supports the development of a unique place with a strong sense of community identity and pride. The library builds a sense of place and belonging, a welcoming environment for cultural and artistic expression that supports collaboration and innovation.																											
	Defined Maintenance	Standards																											
	Actual Maintenance	/																											

Appendix D

Links between building characteristics, process, innovation types, innovation impact, actors role and economic, social, and environmental results

Building Characteristics	Delivery Process	Innovation Type	Innovation Impact	Actors	Eco-Innovation Model	Social Relevance	Environmental Relevance	Economic Relevance
Context: Micro climate, historical significance, natural resources availability, morphology, location, distance from major cities, presence of built structures, presence of trees, water and other natural elements	Programming phase Building use	Incremental System Radical	Competence destroying or competence enhancing	Public institutions Clients Designers Local Communities	Eco-ideation	The site characteristics may have significance for local communities in terms of identity, history, meaning, and resource availability.	Micro-climatic characteristics of the site can influence the environmental features of the building, as well as of the surrounding environment.	The land value may vary before and after project development. Moreover, a project development can trigger economic benefits for local communities, both during building construction and its life-cycle.
Design Concept: Early stage of idea generation during the preliminary phase of a project design, in which the overall project characteristics are defined	Programming Phase	System Radical	Competence destroying	Designers Users	Eco-ideation	The building design concept can address social meanings and objectives.	The building design concept can address environmental meanings and objectives.	The building design concept can address economic meanings and objectives.
Orientation: Position of a building in relation to the cardinal directions	Programming phase	Incremental System	Competence enhancing	Designers	Eco-innovation Eco-ideation	The orientation of a building may have social significance as it could be considered a strategy to communicate a specific meaning.	The building orientation can be crucial to the optimisation of the micro-climatic characteristics of a site.	The building orientation can generate a secondary impact on the use of environmental systems and therefore on their costs, both during building construction and its life-cycle.
Architectural Characteristics: Relationship between volumetric elements of a building, ratio of opaque and transparent elements, internal layout characteristics, presence of decoration or stylistics elements	Design phase	Architectural System	Competence enhancing	Client Designers Users	Eco-innovation Eco-ideation	The architectural characteristics of a building contribute to communicate the value and the design intent. These features are generally visible and therefore are the ones that establish a visual connection with the social context.	The volumetric organisation of a building, as well as the ratio of opaque and transparent surfaces, or the layout organisation contribute to the ability to optimise and control the environmental performance of a building.	The architectural characteristics can have an economic impact since they determine the quantity of material that will be required in the building, as well as the complexity of the production and construction processes.
Size: Overall useful building surface	Programming phase	Incremental Modular Architectural	Competence enhancing	Public institution Client Designers	Eco-ideation Eco-innovation	The building size can have a social impact through the way in which it relates to the existing context.	The building size can have an environmental impact due to the amount of space that needs to be designed, controlled, and defined in terms of environmental control systems, as well as in terms of use of resources.	The dimensions of a building generate economic impacts depending on the economy of scale that they trigger in relation to the production of the quantities and number of building components needed.
Shape: Geometric characteristics of the arrangement of building volumes	Programming phase Design phase	Architectural System Radical	Competence enhancing	Designers	Eco-innovation	The shape of a building contributes to communicate the value and the design intent. As these features are generally visible, they establish a visual connection with the social context.	The shape of a building contributes to the ability to optimise and control the environmental performance of a building.	The shape of a building has an economic impact because it influences the optimisation of quantity of materials, as well as the ease of production and construction.
Number of floors	Programming phase	Incremental	Competence enhancing	Public institution Client Designers	Eco-innovation	The number of floors, similarly to the building size, can have a social impact through the way in which it relates to the existing context.	The number of floors can have an environmental impact due to the amount of space that needs to be designed, controlled, and defined in terms of environmental control systems, as well as in terms of use of resources. Moreover, the relation with the micro-climatic characteristics varies with the building height (e.g.	The number of floors generates economic impacts depending on the economy of scale that it triggers in relation to the production of the quantities and number of building components needed on a project.

							wind pressure).	
Access and circulation: Indoor and outdoor circulation; access on foot, on bike or by vehicles; internal circulation layout; number and types of entrances to the building.	Design phase Building use	Incremental Architectural	Competence enhancing	Designers Users	Eco-innovation	The access and circulation in a building can have social relevance by contributing to the perception of the space by the users, as well as in establishing a relation with the surroundings (e.g. permeability, closeness, etc.).	The accesses and circulation can have an environmental impact in relation to the number of openings and transparent surfaces as well as in the internal layout organisation. These aspects can contribute to the ability to control the environmental performance of a building.	The accesses and circulation in a building can influence the type of materials utilised and therefore their quantities and costs.
Structure: type of structure, visibility or not of the structure, shape of the structure, optimisation of the structural elements	Design phase Construction phase	Incremental Modular	Competence enhancing	Designers Builders Industry	Eco-innovation	The type of structural elements can contribute to the visible feature of a building and therefore be part of the elements that influence the perception of the space by their users.	The type and material of the structural elements can contribute to the definition of the environmental control systems due to their thermal behaviour characteristics.	The structural optimisation can have an economic relevance in terms of quantity of materials required and therefore their costs.
Construction Systems: Types of materials, wall stratigraphy, roof materials, roof stratigraphy, foundation types	Design phase Construction phase	Incremental Modular Architectural	Competence destroying	Designers Builders Industry Users/Local Community	Eco-innovation	The construction systems, and in particular the type of materials, can contribute to creating a specific identity of a building and therefore affecting the users' perception and generating social relevance.	The construction systems play a crucial role in the environmental control of the indoor and outdoor spaces. They also have a strong impact in terms of use of natural resources.	The construction systems are critical to the cost of a building in terms of material selection, quantity, material availability, logistics, and construction site sequencing and organisation.
Construction Details: Manners in which construction systems are joined together; these can be classified for example as exposed joints and hidden joints	Design phase Construction phase	Incremental Modular Architectural	Competence destroying	Designers Builders Industry	Eco-innovation	The construction details, if visible, can contribute to creating a specific identity of a building and therefore affect the users' perception and generate social relevance.	The type of construction details can play an important role in the thermal control of a building, for example, by avoiding the creation of thermal bridges.	The construction details are critical to the cost of a building in terms of material selection, quantity and availability.
Internal Partitions: Internal walls, movable walls, elements to separate or organise the internal space	Design phase Construction phase Building use	Incremental Modular Architectural	Competence enhancing	Designers Builders Industry	Eco-innovation	The internal partitions in a building can have a social relevance by contributing to the perception of the space by the users.	The internal partition may contribute to the definition of environmental control systems in a building.	The internal partitions influence the cost of a building in terms of material selection, quantity and availability.
Doors and Windows: type and number	Design phase Construction phase Building use	Incremental Modular Architectural System	Competence enhancing	Designers Builders Industry Users	Eco-innovation	The doors and windows in a building can have a social relevance by contributing to the perception of the space by the users.	The type of doors and windows contributes to the ability to control the thermal and lighting performance of the building, as well as indoor air quality.	The type of doors and windows influences the cost of a building in terms of material selection, quantity and availability.
Environmental control systems: passive ventilation systems, mechanical ventilation systems, geothermal pumps, hot-water solar panels, photovoltaic panels, heating systems, energy-saving lighting systems, and other	Programming Design phase Building use	System Radical	Competence destroying	Client Designers Builders Industry Users	Eco-innovation	The environmental control systems contribute to the users' physical comfort and therefore to their experience of spaces. Moreover, the awareness of those systems can promote a more environmentally responsible behaviour.	The environmental control systems aim to provide the required indoor and outdoor environmental quality, based on a sustainable use of natural resources, throughout the life of a building.	The environmental control systems can have a significant economic impact both during the building construction and its life-cycle.
Water treatment: rain water collection, grey water re-use, water storage, and other	Programming phase Design phase Building use	Incremental System Radical	Competence enhancing or competence destroying	Public institutions Designers	Eco-innovation	Water treatment systems can contribute to promoting a more environmentally responsible behaviour on the part of users.	Water treatment systems enable sustainable use of natural resources throughout the life of a building.	Water treatment systems can have an economic impact both during the building construction and its life-cycle.