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Leveraging Technology for Value Creation in the Context of Smart Sustainable Cities: Five Potential Approaches | Biophilic Design

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Abstract

This master thesis report investigates the potential of five different innovations for value creation in the context of Smart Sustainable Cities by 2050, applying the research question "How to create value by entrepreneurially using innovations in Smart Sustainable Cities?". Primary (interviews with experts) and secondary research was conducted. In-depth analyses and assessments of value creation and sustainability; critical examinations of the five innovations' challenges, interconnections, and potential are performed, concluding that by applying disruptive technology that surpass the requirements of the Smart City Canvas, leverage environmental sustainability without sacrificing price, quality or other advantages, value creation is ensured.

Keywords: Digital Business, Technology Strategy, Smart Cities, Sustainability, Technology, Entrepreneurship, Innovation, Value Creation, Digital Transformation, Business Model, Technology Adoption, Technological Innovation, Sustainability Assessment, Sustainable Development Goals, Biophilic Design, Green Buildings, Sustainable Architecture.

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1. General Introduction

"If we could build an economy that would use things rather than use them up, we could build a future. There is a massive economic opportunity out there to be taken without waiting for government legislation. When you start, you're trying to achieve staying alive and getting home."

– Ellen MacArthur

How will we live in 30 years? The answers to this question can be very diverging, but one thing is certain - the world will change dramatically. In the context of digitalization, Smart Cities is a concept that is constantly being discussed. New urban projects offer their inhabitants a vast amount of possibilities, of which many are still undiscovered and there is much to understand still. The state of affairs regarding this topic is constantly shifting and incorporating innovations and concepts that until very recently would have been considered futuristic but now are a reality.

Added to this is the growing importance of sustainability since issues such as the climate change, increasing scarcity of raw materials, and lack of urban space will be decisive not only for the coming years but for the future generations that are yet to come. It is the responsibility of companies and innovators to entrepreneurially tackle problems that now urge to be solved, as the consequences of ignoring them can be disastrous.

Therefore, the question which needs to be answered is: How to create value by entrepreneurially using innovations in Smart Sustainable Cities?

1.1. Previous research

"Smart city concept enjoys different aspects and a variety of definitions" (Mohseni 2021), meaning there is no unambiguous way to describe them in a sizable pool of research.

According to Anand Prakash (2019), the concept of Smart Cities was invented by an information technology firm, the International Business Machines (IBM) Corporation. First, the words "smart" and "cities" were separated, and several definitions analysed. It is then concluded that a Smart City is a city in which many essential business problems – such as "organized power supply, provision of clean water, strong civic infrastructure, sewage, and waste treatment plant, rainwater harvesting and solar energy through advanced connectivity" – are tackled. Often a Smart City is also defined as a city "that monitors and integrates conditions of all of its critical infrastructures, […] can better optimize its resources, plan its preventive maintenance activities, and monitor security aspects while maximizing services to its citizens" (Hall, 2008).

Research about Smart Cities has suggested various components and features that also range between many different areas, such as infrastructures, buildings, transportation, energy, health care, financials, governance or education (Mohseni 2021). Other definitions include other "aspects of urban life, such as urban planning, sustainable development, environment, energy grid, economic development, (…), social participation and so on" (Prakash 2019).

While discussing these components that compromise Smart Cities, the concept of sustainability becomes increasingly relevant. According to Virtanen (Virtanen, Siragusa, and Guttorm 2020), "the Brundtland Commission initially provided the notion of 'sustainable development' with its three intersecting and ranked hierarchically pillars (social, economic, environmental)".

To achieve the functioning and building of Smart Cities with sustainable methods, a modern and technology-driven approach (Prakash 2019), meaning technological and digital innovation, needs to be involved. So, the concept of 'Smart City' is outlined by its technical core, which, in turn, is inspired by advances in computer science and engineering field (Prakash 2019).

1.2. Research Gap and Aim of the Work Project

This work project considers the existing research and focuses rather on the exploration of innovative methods to make cities smarter and more sustainable through technological or digital innovation. A preliminary analysis of several innovations will be performed, which allows a scoping of five approaches that were selected due to their high potential for value creation and contribution towards sustainability.

The objective is to get insight into different, individual dimensions within Smart Cities, that are backed up by an innovative technology or digital platform. Within these individual dimensions, it will be determined how value is created and its impact on the environment, economy and society. In this way, a better impression can be created of what our lives will look like in 30 years from now. To delimit the analyses, it will be geographically focused on Europe, and the timeframe will be set until 2050.

1.3. Research Question

The above-described gap and research objective lead to the following defined Research Question (RQ) that will be explored throughout this paper: How to create value by entrepreneurially using sustainable innovations in Smart Sustainable Cities?

This question is separated into three main topics: technological innovation, sustainability assessment, and value creation. The first topic, technological innovation, will be tackled by defining five key areas of focus of this research. The work project aims to analyse the value these innovations create in this setting of cities of the future. After analysing the current state of affairs for each specific case, the second and third topic will be tackled by performing a value creation and sustainability assessment must. Theses assessments will be conducted through several formats, resulting in a critical discussion on the connection between these two dimensions.

Therefore, value creation must be defined in a specific way to understand better the question at hand. This can give us insights into the structure and analysis of this work project. Value Creation is achieved when a company generates added benefits for its customers through its work and resources. It can be assessed through different approaches. One way to validate it is to understand if the solution generates benefits of any kind for all the stakeholders involved. At the same time, it is important to assess what is the extent of these benefits. Another methodology is to assess the financial viability of the company business model, thus proving that financial value is created. Throughout this work project, the five different innovations presented will assess value creation using different methods.

This work project aims to answer the RQ on the ground of these dimensions of value creation on each of the subtopics and through a comprehension at the end. As mentioned in Chapter 1.1., sustainability comprises a social, economic, and an environmental dimension and will be explained in the later chapters. Each one of these can be tested and validated in different ways, ranging from gathering of primary data to question how citizens and other stakeholders are impacted to thorough research of available data to validate whether all of the dimensions are met, or even through a quantitative analysis of potential environmentally sustainable impact that an innovation can bring.

To thoroughly answer the RQ, it is additionally essential that a future outlook is provided to give a clear understanding of the state-of-the-art, potential, and associated implications of the innovation at the moment and in the future.

1.4. Supporting Questions

To answer the RQ as precisely and accurately as possible, it is necessary to define supporting questions first, which lead to the overall RQ, to ensure a clear understanding of every individual aspects. These questions will be answered in the General Conclusion, functioning as a final

validation framework of the conclusions that were the product of each of the innovations analysed.

For what do sustainable innovations create value?

To analyse and explain how to create value by entrepreneurially using sustainable innovations in smart sustainable cities, the output that the sustainable innovations lead to must be defined. Additionally, the stakeholders or key areas affected must be defined.

Are current Smart Cities already applying/adopting these technologies/digital services?

The willingness to implement and adopt new technologies and digital services is fundamental for possible value creation. If this willingness does not exist, value creation is not even possible from the start. Therefore, the prerequisite for answering the RQ is to consider the readiness of Smart Cities to adopt and implement the technologies and digital services.

What are the key challenges of the innovation?

In addition to the state of affairs, the challenges that may arise are also considered. The extent to which each challenge can be posed as a barrier to entry can depend on micro and macroenvironmental factors. Still, an assessment of each challenge and understanding of the level of risk towards implementation that it poses is key to a critical analysis.

Are these innovations in these Smart Cities truly sustainable?

Another very important point, after analysing the possible value creation, implementation and risks, is to assess whether the listed innovations have a positive environmentally sustainable effect on Smart Cities.

After answering these supporting questions, based on the detailed analysis of the possible value creation of the different sustainable innovations in sustainable Smart Cities, the RQs of this

master thesis can be answered successfully.

1.5. Relevance of Research Question

Despite occupying only 2% of the world's surface, cities have a disproportionate climatic impact and energy footprint, according to C40, a network of megacities committed to tackling climate change. Cities consume more than two-thirds of the world's energy and produce over 70% of global emissions (‘Beyond Smart Cities: Why Smart and Sustainable Cities Are the Way Forward’ n.d.). Environmental externalities - primarily resulting from population growth, rapid urbanization, high private motor vehicle dependency, the deregulated market, mass livestock production, and excessive consumerism - have raised serious concerns about the future of natural ecosystems in which we are a part of. Global climate change, one of the most significant problems humanity has ever faced, directly influences people's well-being and, in the long term, on humanity's existence (‘Climate Effects on Health | CDC’ 2021). In the past two decades, the concept of Smart City, especially the sustainable development of Smart Cities, has increasingly become the focus of attention in the fields of technology, science, urban and environmental planning, development and management, as well as for urban decision makers and practitioners. This was caused by digital technologies being a key enabler in stimulating paradigmatic transformations in visions, strategies, execution, and learning connected to urban development.. The combination of technocentric and environmentalist views is a path to the ideal urban form of the 21st century (Ahad et al. 2020).

1.6. Organization of Work Project and Delineation of Field of Study

In the following section, the structure of this paper and the procedure for answering the RQ will be explained. First, the basic building blocks for answering the question are laid in Chapter 2. For this purpose, a precise definition and literature review of Smart Sustainable Cities, along with an historical context and the analysis of existing Smart City business models will be performed. Furthermore, sustainable innovations in the context of Smart Cities will be defined.

The potentials, challenges, trends, and developments of these are examined in more detail. Next, the delimitation strategy is described by breaking down the general overarching theme of Smart Sustainable Cites to the focus of sustainable innovations within Smart Cites. After the basic building blocks have been laid, the methodology used in the further work for the analysis and application of the RQ is discussed in Chapter 3. For this purpose, the used data sources are listed, and the methodology used to define the five key innovations chosen is explained. The analytical methods to assess entrepreneurial and sustainable value are outlined in each individual part. In the following chapters, five different sustainable innovation areas within Smart Sustainable Cities are discussed in detail, ranging from smart sustainable mobility, vertical farming, and biophilic design to Fintech and blockchain in the energy market. Thereby, an analysis will be carried out on how and to what extent these sustainable innovations create value in Smart Cities. In Chapter 3, a general discussion of the research project will be conducted. Finally, the limitations of the RQs are discussed, and a look into the future of sustainable innovations in Smart Cities is ventured.

The RQ will be elaborated in the field lab “Technology Strategy” focusing on sustainability. The question was derived by breaking down this defined topic area into various possible application areas. The choice fell on the application area Smart City since, within a Smart City, multiple stakeholders and dimensions are affected by the implementation of new technologies. To create a link to sustainability, it was decided to limit the topic to innovations , that make cities smarter and more sustainable, as this topic is of significant relevance today, as explained in Chapter 1.2.

2. General Literature review

2.1. Delimitation Strategy of the Literature Review

As previously demonstrated, Sustainable Smart Cities contain a wide range of cross-cutting

topics that can be evaluated within an in-depth analysis. Although this type of analysis would enrich the research in terms of content, this work project will limit the focus of the research to sustainable innovations.

The urgency of adapting the traditional business models to preserve the human species and environment to guarantee a future for the new generations has never been higher. In many societies, the government is responsible and leading the innovation policy. These innovation processes are, however, often hindered by extreme bureaucracy. Therefore, innovations are typically tackled and achieved by entrepreneurs, adapting and creating new business models, in a faster and more efficient manner.

2.2. Smart Sustainable Cities

2.2.1. Definition

As previously established, the concept of Smart Sustainable Cities is very innovative and can have several definitions. To establish which new technologies can entrepreneurially create value for smart sustainable cities, a definition of "smart" and "sustainable" needs to be set up first. The UN in 1987 defined sustainability the following way: "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (Nations n.d.). United Nations Economic Commission For Europe (UNECE)'s definition distinguishes both parts of the concept of Smart Sustainable City very clearly, defining it as "an innovative city that uses ICTs and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, environmental as well as cultural aspects" ('Sustainable Smart Cities | UNECE' n.d.).

Dr. Rudolf Giffinger and the European Smart Cities research group at the Centre of Regional Science of Vienna University defined six Smart City areas of action (Giffinger 2015), which were later popularized in Dr. Boyd Cohen's "Smart Cities Wheel" (Cohen 2018). Although

these areas only refer to the sustainability dimension of Smart Sustainable Cities, they will be applied in the further work project to categorize the innovations assessed and to assess their sustainability according to the parameters defined in UNECE's definition.

The first area of action is "Smart Government", which includes creating synergies between the government and all stakeholders through the creation of policies, fostering transparency, and taking a digitally innovative approach. The second area, "Smart Economy", comprises the use of an entrepreneurial spirit and technology to create economic efficiencies, such as making a city more attractive for new businesses, and leading to local and global interconnectedness. Thirdly, "Smart Environment" relates to urban planning and the management of all key city infrastructures, ranging from waste management to the energy sources that are used. "Smart Living" also focuses on quality of life, but from a social standpoint. It relates to the access to basic services such as healthcare, housing, and the internet, and how access to these key infrastructures is enabled. "Smart Mobility" concerns the maximization of the efficiency of urban transports, making it more economically and environmentally sustainable through innovative and technological solutions. Finally, the sixth dimension – "Smart People" – focuses on the interaction with each other and with the public and private sectors. A Smart City should provide accessible and inclusive measures that foster the participation of all stakeholders in the city's matters through the implementation of intelligent solutions.

2.2.2. Historical Evolution of the Concept

As the definition of Smart Sustainable Cities has been established, taking into consideration the status quo for being "smart", "sustainable" and a "city", it is important to stress that this concept has evolved and changed over time, due to the constant development of society. In fact, Höjer and Wangel stated five key areas that ultimately led to the origin of research of the Smart Sustainable Cities concept (Höjer and Wangel 2014) – globalization of environmental problems and sustainable development, urbanization, and urban growth, sustainable urban

development and sustainable cities, information and communication technologies and Smart Cities. By understanding the latest developments within these five key areas, it is possible to trace the historical development of the Smart Sustainable Cities concept.

For a long time, environmental problems were perceived as local issues. In 1972, the Stockholm Conference – the first United Nations conference that focused on international environmental issues – these matters started to be perceived as a global concern, and the foundation for global environmental governance was set (United Nations n.d.). Later, in 1987, the concept of sustainable development appeared through the Brundtland Report (also known as "Our Common Future"), released by the World Commission on Environment and Development. In this report, sustainability was defined, as previously mentioned, as "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987). Additionally, among other results, the report set the grounds for the 1992 Rio Summit, in Rio de Janeiro, which ultimately led to the creation of the UN Commission on Sustainable Development in the same year. This commission was created with the purpose of tracking and implementing Agenda 21 – the output of the Rio Summit -, which was strongly reaffirmed at the World Summit on Sustainable Development held in 2002 in Johannesburg (United Nations n.d.). Other key events that were essential to international cooperation for environmental sustainability were the Kyoto Protocol in 1997, which consisted in a commitment to reduce GHG emissions through binding individual targets, requiring stronger efforts from developed nations (UNFCCC n.d.), and the Paris Agreement in 2015, which requires effort from all nations and introduces a higher level of flexibility and national ownership, allowing countries to set their own emission targets according to their development level (United Nations 2015). Even though the literal definition of "Smart Sustainable City" words has not been previously applied, the political, environmental, and economic factors that have been evolving over time lead to an update of past policies, adapting them to the current

state of affairs. Therefore, it is essential to mention the European Green Deal, which is a "new growth strategy that aims to transform the EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy where there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use" (European Comission 2019). It was proposed at the end of 2019, amidst a rise of global leaders that are considered to be hostile to the climate action cause, such as the former President of the USA, Donald Trump, and the current President of Brazil, Jair Bolsonaro. As so, it was not only a call for action for environmental purposes but also a political statement from the European Commission, presided by Ursula von der Leyen, as to what the priorities should be for the next decades, until at least 2050. It focuses on key areas of action, defining how to develop Smart City infrastructures and ultimately stating what factors need to be met to be considered as a sustainable city, and which policies and technologies should be developed to have a smarter path towards a more sustainable future.

It is expected that, as technology, policies, and cities evolve, the concept also shifts. To understand potential reasons for a transition and assess the value Smart Sustainable Cities can create, the City Model Canvas framework, introduced in the next chapter, will be used.

2.2.3. Key Concepts Related to Smart Sustainable Cities

The following concepts will be relevant for this work; Sustainable Development Goals (SDGs), the Three Principles of Sustainability, the ESGs, the Circular Economy, the Well-to-Wheel Analysis.

The Global Sustainable Development Goals (SDGs) ('THE 17 GOALS | Sustainable Development' n.d.). will be applied, which were created by the UN in 2016, as these can more distinctly describe the individual contributions of each innovation even though they might not be related. This helps to better frame and assess the innovations with regards to answering the RQ. In addition, the SDGs are very contemporary and are a global standard. Those define

sustainability goals in 17 areas, which bound every aspect together in one concept even though they do not seem related at first sight. This is the upside of applying the SDGs in the frame of this thesis as well. In the individual thesis report that tackles specific innovations, sustainability concepts are applied to assess and determine if the discussed innovation can be considered sustainable or not. For that, the definitions of sustainability (UN and SDGs) plus additional frameworks such as Circular Economy will be applied.

In connection to Smart Sustainable Cities, it is crucial to mention that sustainability can also be assessed by differentiating and analysing the technology at hand with the help of the three principles; environmental, social, and economic sustainability. Based on this dating definition, the concept of ESG emerged and became a standard in the financial world. Even though investing, transactions and loans might not be connected to sustainability, the history of sustainability concepts is linked. ESG stands for the pillars of sustainability: Environment, Social (Society), Governance (which stands for the governance of economic bodies). Nowadays, different standards of ESG are used to classify e.g. investment funds. For example, the higher the ESG standard, the more selective the screening process becomes for assets in one fund (eg. MCSI World (1601 Assets); MSCI World ESG Screened (1506 Assets); MSCI World ESG Enhanced Focus (1490 Assets); MSCI World SRI (386 Assets) (Zeiter 2021). Furthermore, banks, insurances, and other financial bodies express their contribution to sustainability in ESG terms.

Another concept that is more strictly bound to the concept of Smart Cities is Circular Economy (CE), which can be used to assess the environmental sustainability of an innovation. The advantage of the concept is that the Ellen MacArthur Foundation cooperates with firms that focus on Smart Cities. Often, it is required that autonomy in the food supply is needed for an urban population in a Smart City, which would mean that a working Circular Economy has to be applied. Looping back to the initial definition, a wasteless city is the goal also of the dating

definition from the UN, as waste necessarily harms future generations as even treated waste occupies space. If a working CE is applied, no waste is generated, all materials are resources, regardless of the state. This transformative approach has also the advantage as physical processes can be assessed based on their output of harmful material (e.g. CO_2) or waste created.

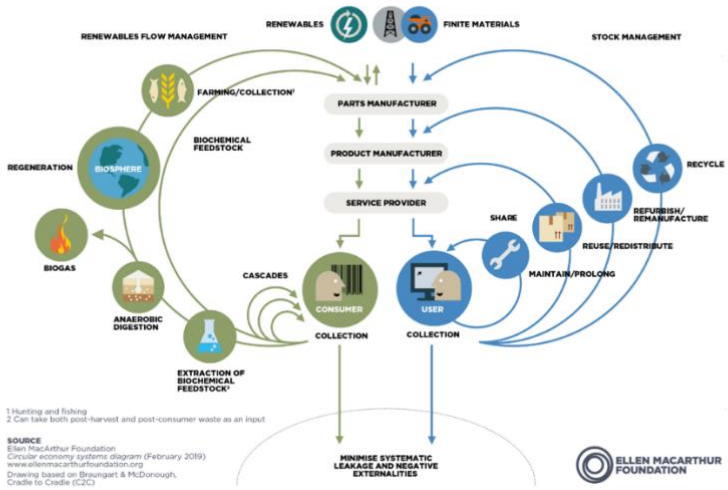

Figure 1: Circular Economy: Ellen MacArthur Foundation, SUN, and McKinsey Center for Business and Environment; Drawing from Braungart & McDonough, Cradle to Cradle (C2C) ('Intelligent Assets: Unlocking the Circular Economy Potential' n.d.)

Finally, a more quantitative concept is the Well-to-Wheel Analysis, which is a policy-neutral methodology that allows for the calculation of GHG emissions, energy efficiency, and industrial costs associated with several types of fuels, as well as respective technological implications. As shown in the figure below, this analysis focuses on the emissions exhausted from well to tank – meaning, from the moment these are produced to the moment these reach the fuel tank – and tank to wheel – meaning, the burning of the fuel. (Nieuweling 2016)

Those concepts are no definite answer to the question of what is and how to get to ultimate sustainability as there is no clear answer to it. Rather, those serve us as possible ways to assess the innovations presented in the context of Smart Cities, even though they seem unrelated. And the concepts show that those innovations are connected through the criteria posed.

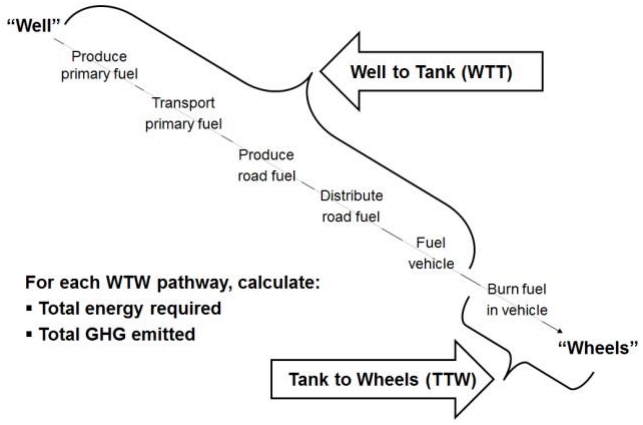

Figure 2: Graphic representation of the Well-to-Wheel Analysis

2.2.4. Smart Cities Business Model Canvas

To analyse sustainable value creation in depth the Business Model Canvas is applied. According to Alexander Osterwalder, creator of the Business Model Canvas "the Business Model describes the logic by which an organization creates, distributes and captures value" (Osterwalder, Pigneur, 2010). Essentially at the corporate level, the company creates value, markets it to the market, satisfying the desires of consumers, and obtains for itself a share of that generated value, i.e. profit. The Business Model is not a strategy, but a concrete and immediate tool, not based on the future but the action in the present (Magretta, 2002).

Humankind, who increasingly moving towards urban centers, representing a wide range of innovations and development to satisfy the daily needs, pushes the city apparatus to provide adequate services that can enhance the living experience within the social context. Thus, in recent years, cities have sought to accelerate the innovation process, using technologies that simplify citizens' lives such as the Internet of Things (IoT), Artificial Intelligence (AI), and Blockchain (BC). Population growth, largely due to the influx of people populating large urban centers for greater economic opportunities, has pushed cities to ensure an improved quality of life by focusing mainly on environmental impact, safety, mobility, and public and private health. Smart Cities are those that use new technologies to solve society's daily urgent tasks

such as housing, transport, and energy in urban planning and governance. To realize them, investments in Smart Cities are the result of complex relationships between the public sector and private leaders, who together contribute to the final result. Therefore, all these solutions need to be mapped correctly according to a business model that is fit for purpose. But how can we apply a Business Model to Smart Cities? As previously mentioned, the Business Model Canvas is one of the best tools to synthesize and analyse value creation through a business or technology. The canvas consists of nine building blocks divided into key partners, key activities, key resources, value proposition, customer relationships, channels, customer segmentation, cost structure and revenue streams (Timeus, Vinaixa & Pardo-Bosch, 2020).

It is a very useful tool to graphically represent all the fundamental components of a business model in a single image, while still being clear and useful to understand how the company works and how to create value or find new business opportunities. A more recent and extended version of the Business Model Canvas adapted to Smart Cities, proposed by Díaz-Díaz, Muñoz and Pérez-González called *City Model Canvas* (Timeus, Vinaixa & Pardo-Bosch, 2020). By adding an environmental dimension to the economic assessment of business models, it helps municipalities to deliver value sustainably, which will be used within the research.

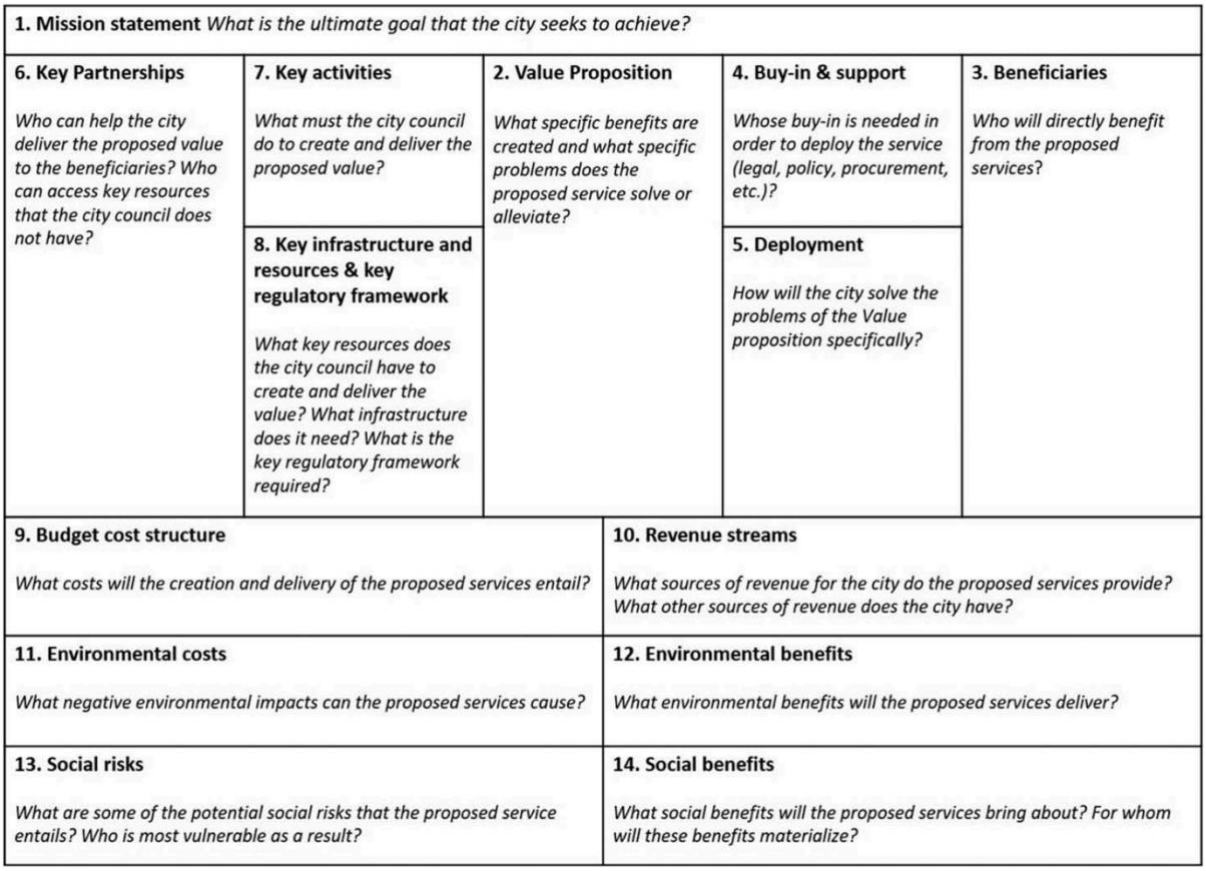

Figure 3: City Model Canvas

It consists of 14 blocks that are divided into four parts. The first part of the model concerns the presentation of the mission, i.e. the objective the city wants to achieve and the value proposition. The second part focuses on stakeholder action and the logistics of service delivery for citizens. The third part focuses on all aspects of value creation, in particular financial resources, infrastructure, and political resources. The fourth and final part consists of an assessment of the economic, social and environmental costs and benefits of the intelligent service to be proposed (Joyce and Paquin (2016). With this tool, not only the economic feasibility of the project is being assessed, but above all the sustainable impact it has on society and the environment.

2.3. Sustainable Innovations

2.3.1. Definition in the Context of Smart Cities

As previously established, sustainability is one of the requirements of Smart Cities, so innovations that benefit that pillar could already be regarded as sustainable innovations in the context of Smart Cities. However, sustainability in Smart Cities might have different definitions compared to e. g. sustainability in the context of Circular Economy or sustainable development. For this purpose, the definition of sustainability that was set in Chapter 2.2.1 - "meeting the needs of the present without compromising the ability of future generations to meet their own needs" – is relevant to define sustainable innovation.

To bring all relevant terms into context and provide consistency through the overall work project, a definition of innovation is necessary. As such, "Innovation is the creation and implementation of new processes, products, services, and methods of delivery which result in significant improvements in outcomes, efficiency, effectiveness or quality" (Eveleens 2010).

Finally, after defining the concepts of "sustainable" and "innovation", it is clear that the concept of sustainable innovation comprises the creation of a new tangible or intangible component that causes significant improvements in any area without harming others. This definition is in accordance with the definition given by Lee, who defines sustainable innovation as the creation of or adaption of existing products or services to achieve sustainable social, environmental, and ecological impact, while at the same time generating profits for the company. Through sustainable innovation, companies can create and deliver products or services that directly can contribute to sustainability (Lee n.d.).

In the context of this thesis, innovation has two major criteria: 1. It has to create value in the sense that it can be entrepreneurially harnessed and ultimately, profits can be achieved. 2. One aspect of sustainability has to be benefitted without harming another one. This is due to the complexity of sustainability (Tainter 2006), which implies potential downsides to every achieved progression. The most prominent example is that a more efficient technology (which could be beneficial e.g. carbon reduction due to more efficient usage) often leads to higher

consumption, which on the other hand has a negative influence on the absolute CO_2 emission balance. Therefore, this report aims at considering innovations that are not bound to this effect but are truly benefitting one area of sustainability (e.g. carbon reduction despite increased demand).

2.3.2. Potential for Sustainable Innovation

The biggest potential stems from the value created by sustainable innovations as a multitude of aspects are tackled at the same time. First, Smart Cities benefit from businesses that are successful and this can be the measured by the value generated for the inhabitants. Second, such an innovation would not only create value in terms of a service or product to the customers, but also leverage the sustainability of the service or product. For example, if the innovation creates a product that cuts 50% of the CO_2 emissions compared to its conventional counterpart and represents an integral part of a Smart City, then multiple desired outcomes for Smart Cities are pursued at the same time.

2.3.3. Challenges of Sustainable Innovation

The special context of Smart Cities, in which innovations should be integrated, poses a unique set of difficulties, that need to be overcome to foster value and succeed in such a market. A few findings are outlined:

1. The Articulation of technological innovation and change to the lifestyles of the individuals: Smart cities require a different lifestyle for the inhabitants compared to conventional cities. This inevitability becomes even more dominant when innovations are not only radical by the concept but also by implication. Therefore, if the implication of a disruptive technology offers or forces an adapting behaviour of a user, then resistance might be one of the reactions (Saujot & Erard 2021).
2. The complexity of intersectionality: Like the complexity of sustainability intersectionality can pose challenges to the interactivity of innovations and their users.

This is mainly an issue of infrastructure and data management and applies if the innovations are integrated in such a way that interdependency is the result (Saujot & Erard 2021).

3. The organisation of citizen participation: This point is highly business-model-specific and depends also on the innovation itself. For example, some business models require the users to be administers at the same time, which poses challenges in terms of communication misconduct questions and role issues. Furthermore, the business model identified (Saujot & Erard 2021)
4. The collaboration of public and private partners: What seems like a communication problem also is a funding problem and is, again, a specificity that arises from the applied business model (Saujot & Erard 2021)

3. General Methodology

3.1. Time Horizon and Geographical Delimitation

The time period and geographical area investigated are limited to answer the RQ in a more targeted and detailed manner. This paper examines only sustainable innovations in Smart Cities within Europe. Furthermore, the time horizon limitation is set to the year 2050. This determination was made based on the European Green Deal by the EU and following the EU's Paris Agreement commitment to global climate action. The key objective of the European Green Deal by the EU is to be climate-neutral by 2050, based on the fact that the targeted 1.5ºC to 2ºC increase in global warmth is the maximum that the planet can take without bearing uncontrollable consequences.

Furthermore, by 2050 the EU aims to become an economy with net-zero GHG emissions. To reach this goal, the EU aims to provide 100 climate-neutral and Smart Cities by 2030. Furthermore, according to the EU Commission, cities are a significant factor in achieving this mission of climate neutrality by 2050, as they account for only 4% of the EU's land area. Still,

the cities house 75% of EU citizens, using more than 65% of the world's energy, and produce more than 70% of CO_2 emissions ('EU Mission: Climate-Neutral and Smart Cities | European Commission' n.d.). Based on the EU's mission and the remarkable role of Smart Cities, the delimitation for this RQ was set.

3.2. Rationale of the Selection of the Innovations

Based on the previous chapter, recent trends were identified, which led to innovations commonly associated with Smart Cities in the context of sustainability. In addition, contemporary sources identify key technologies that were also considered in the frame of this report. For the selection of the five innovations further deepened in the subtopics a pool of 22 suitable and relevant innovations was selected and analysed through an Innovations Scorecard, presented in Appendix 1.1. The innovations are ranked based on the following criteria to assess their usefulness in this thesis and rated with a 3-point system.

The final score for each innovation results on the weighted average of the score attributed to the following variables:

Quality of life (15%). 3 points: An innovation has a significant positive impact on the quality of life throughout different areas of life; 1 point: No or negative effect on the quality of life through the innovation.

Efficiency of urban operation and services (15%). 3 points: A significant increase in efficiency in at least one of the mentioned areas (communication infrastructure, waste, energy and mobility); 1 point: No increase or a decrease in quality in urban operations and services.

Competitiveness (15%). 3 points: The innovation and its business model have a solid and differentiated value proposition compared to competitors; 1 point: Weak or common value proposition.

Economy (15%). 3 points: Long-term economic growth and profitability are expected for the innovations and its business model; 1 point: Long-term economic growth is not expected, or

decrease is expected.

Environment (15%). 3 points: The innovation (almost) causes no harm to the environment (e.g. air and material pollution/land usage/resource exploitation/biodiversity loss/biomass loss etc.) or even recovers prevalent environmental damage; 1 point: The innovation does not improve / not significantly improve environmental standards compared with the conventional counter technologies.

Society and Culture (15%). 3 points: A Life-changing positive impact in societal & cultural factors is expected through the implementation of the innovation; 1 point: No or a negative impact in societal & cultural factors is expected.

Own Interest/Experience (10%). This category is based on interest and experience. It is ranked from no (1 point) to strong interest (3 points).

The highest ranks are the innovations discussed in the individual chapters: Fintech (Ø 2,55), Blockchain in the Energy Market (Ø 2,55), Vertical Farming (Ø 2,4), Biophilic Design (Ø 2,4), Cooperation for Sustainable Mobility (Ø 2,7).

3.3. Resources and Data Sources

For the analysis of all sustainable innovations, both primary and secondary data were used for data collection. The primary data was generated using semi-structured interviews with experts and surveys. The secondary data was collected through in-depth analysis of contemporary sources, existing studies and academic papers, with a focus on the quality of these to ensure the highest academic quality of the work project. A detailed description of the resources used and the approach to data collection is provided in the individual sections of each innovation.

4. Motivation

The authors of this paper were driven by different motivations to contribute to the academic community with the analysis of each subtopic. The climate emergency is real. To achieve climate neutrality, a 90% reduction in transport emissions is needed until 2050 (European

Commission 2019). However, innovations and technology are the opportunities the world needs to exploit today to achieve sustainability goals. The cause of “technology for good” allowed to highlight the economic benefits of the sharing economy for cities in the branch of Smart Mobility. The reason for the focus on Biophilic Design, on the other hand, stems from the focus on a state of human well-being, a psycho-physical, mental, almost philosophical condition. The need for the human to live in a positive environment that can generate well-being and increase daily performance, using energy and hydraulic sustainability tools within the four walls. This fusion of art, design, and attention to future investments is the result of passion, academia, and the desire for a better quality of life. Vertical Farming represents an innovation that creates a value potentially recognized by every human being, since everyone has to eat, and this is an important driver for research. Furthermore, conventional agriculture needs to be revolutionized in terms of sustainability and indoor aquaponics represent a technology that leverages sustainability and has the potential to be economically scalable. VIF has the potential to become the new standard for growing leafy greens in urban areas in the next 10-30 years (Diaz, 2021), and can be used in a completely decentralized way, so with little initial capital an entrepreneur can grow the business from city to city, from a small scale to a larger one. Burning fossil fuels creates large amounts of carbon emissions and in addition in today's power grid due to long-distance transmission, there are significant energy losses. The idea of using Blockchain, a very recent technology with a large number of applications, to give the next generation a future with less inequality has motivated research to provide a timely and comprehensive review of possible solutions. Finally, coming back to everyday life, today Fintech has become an integral part of most people's daily lives. It facilitates human life every day, through the integration in various public services and easy usage through mobile devices. However, what needs to be considered about these opportunities are its sustainability and, above all, whether it can create long-term value.

5. Innovations Analysis

5.1. Biophilic Design

1. Introduction

The first section aims to introduce the following Research Question (RQ): “How to create value by entrepreneurially using innovations in Smart Sustainable Cities?”. This subtopic will focus on sustainable cities. This last can be found within the dimensions of “smart environment”' and “smart living”: Sustainable architecture and design. Consequently, there will be an analysis of the connection between nature-architecture and its benefits. The natural environment can reduce stress levels and increase subjective well-being, improving health and cognitive abilities (Oberti and Lecci n.d.). The first to study these benefits was Roger Ulrich in the early 1970s. He followed a hospital in Pennsylvania, whose patients had undergone a cholecystectomy in 1972. The test results showed that 23 of the patients with rooms facing a natural scenery, had shorter postoperative hospital stays. Findings showed that nurses left fewer negative comments in their notes, as well as having received fewer analgesics. In comparison to 23 of the patients assigned to rooms with windows facing a brick building (Ulrich 1984). This study pioneered Biophilia in the medical field and beyond, emphasizing the physical and psychological benefits. It will analyze the entrepreneurial potential of this innovation today and try to provide a guideline for the accessibility of this disruptive sustainable solution within the social fabric of smart cities.

2. Literature Review

2.1. Definition of Biophilic Design and Sustainable Architecture

Given that these concepts are recent, to understand their value we must first define the concepts "Biophilia & Biophilic Design" and "Sustainable Architecture".

Urbanization and crowding in cities have jeopardized the contact between man and nature. Key sustainability concepts such as energy - saving, and air pollution have been underestimated for

years. Today society is paying the price for it, and we need to rethink our interaction with nature. Therefore, within the theme of sustainable design, the study and application of BD will be explored. BD aims to ensure that places we live in, work in, and learn in include the vitality of nature, re-establishing the relationship between nature and man. (Oberti and Lecci n.d.). Edward O. Wilson and Stephen Kellert articulated extensively the concept of Biophilia introducing it as, " Biophilia is the inherent human inclination to affiliate with nature that even in the modern world continues to be critical to people's physical and mental health and wellbeing (S. Kellert n.d.). For 99% of their history, humans have evolved biologically by adapting to natural, not artificial, changes. (S. Kellert n.d.). BD is defined as "an innovative approach that emphasizes the need to maintain, enhance and restore the beneficial experience of nature in the built environment". (S. R. Kellert, Heerwagen, and Mador 2011). It encourages the use of natural elements and processes as design inspiration in the built environment. (S. Kellert n.d.). The challenge of BD is to address some of the most pressing issues of our time. (S. Kellert n.d.). It lies within the macro area of sustainable architecture., which is not easy to define. The struggle to find a definition was extensively discussed in a critical study completed in 1994 by Sara Cook and Bryn, stating that "disputes over nature and definition are unlikely to be resolved" (Donovan 2020). Provided by the World Green Building Council, an independent, non-profit organization working in the building and construction sector, provides us with a suitable definition of "Green Building". According to them, "A "green" building is a building that, in its design, construction or operation, reduces or eliminates negative impacts, whilst creating positive impacts, on our climate and natural environment. Green buildings preserve precious natural resources and improve our quality of life". ('What Is Green Building?' n.d.). Of course, these "green buildings'" have many defining characteristics, although they are not all the same. One must always consider the climatic conditions, economic and social differences, culture and tradition that shape the approach to this type of building.

2.2. Sustainable Architecture in Europe

Urbanization has created numerous threats to human's well-being in terms of environmental, air, water and noise pollution. In many cities this is cause for concern as highlighted by the health standards in the most troubled countries, as well as in Europe. The Commission of the European Communities (EC) launched its Green Paper on the Urban Environment (1990), the Organization for Economic Co-operation and Development (OECD) published its report on Environmental Policies for Cities in the 1990s (1990), and many other institutions (international, national, regional and local) have shown a strong interest in these causes by undertaking research projects on the urban environment and preparing quality of life programs. (Nijkamp and Perrels 2014). Europe's aspiration for competitiveness within world markets has generated contrasts in terms of environmental sustainability. However, this concept already came to life in Europe in the mid-19th century, as a requirement for the working classes within new industrial cities. In Paris, Napoleon III and Baron Haussmann created a green system to cleanse the city of pollution and dirt, similar to the English system in London (Willsher 2016), or the function of the Central Park in New York as a green lung within the city can be considered as the first attempts to research the relationship between man and nature within industrialized systems. Nowadays, there are already many examples of green buildings implemented in Europe, as well as of long-term sustainability and redevelopment projects. The case of the 'Bosco Verticale' in Milan, a current example of BD implementation, will be analyzed within the research**.**

2.3. Implementation in Smart Cities

The innovation brought by BD today is constantly evolving. This research aims to understand what value it can bring tomorrow within the Sustainable Smart Cities already defined in the previous chapters. Smart Cities are nowadays an extremely trendy topic, whose objective is precisely to use innovative means to improve the quality of life, the efficiency of the

functioning of urban services and the competitiveness for future generations. This all concerns the aspects that govern society, including the environment. Regarding this last aspect, incorporating BD and sustainable architecture seems to be necessary for the construction of an intelligent city. Within the built environment, BD can bring numerous benefits to the citizens of the future. We introduce three concepts that will help to understand this opportunity:

1. Nature in space: A direct form of nature, consisting of everything natural that surrounds us, from the sun's rays to the beneficial effects of water to animals.

2. Nature of space: Incorporation of indirect spatial elements of nature, such as expansive views, sensory refuges that generate tranquility and a feeling of risk.

3. Natural analogs: Anything that imitates nature, artificial elements. (smartcity 2021).

Within these categories are the projects of the future that will result from BD. The benefits that this innovation generates are not only psychological and cognitive. They have an impact on the environment, which benefits from them. A biophilic city can become a true ecosystem. Green Buildings can reduce carbon emissions to a large extent thanks to vegetation. They also increase the quality of life. In the next chapter, we will look at a practical case of the benefit of sustainable architecture for humanity, and whether this could be the beginning of a scalable model for future citizens to follow. (smartcity 2021)

3. Case Study: Bosco Verticale Roadmap

3.1. Presentation

After introducing the concepts of BD and Green Building, analyzing their advantages, their implementation today in Europe and, understanding how these innovations can bring value within Smart Cities, the research focuses on a specific case and in particular tries to answer to additional questions of the RQ. The case in question concerns the analysis of one of the most famous examples of biophilic buildings existing in the world today: The 'Bosco Verticale' by

‘Studio Boeri Architetti’ in Milan. This analysis will focus not only on understanding its qualities, and analyzing its sustainability, but will use the ‘Bosco Verticale’ as a starting point to draw guidelines for the implementation of biophilic architecture within Smart cities at more affordable prices and on a larger scale. There are many additional questions to the RQ that can be identified regarding the case at hand, but the goal in the next chapters will be to answer one question in particular: "How can BD create entrepreneurial value for smart cities in an affordable way on a large scale?"

3.2. Methodology

The first point of the research concerns the analysis of the characteristics of the ‘Bosco Verticale’ and the analysis of its sustainability, using as a method of evaluation the consideration of the SDGs. The final objective of the research is to try to create a roadmap for the implementation of the biophilic architecture within an entire smart village with time targets. The roadmap will be divided into phases based on a timeline according to the life stages of innovation in the market, from introduction to implementation following the model of the Gartner Hype Cycle (Appendix 3.1.). Different frameworks will be used depending on the type of result to be achieved to continue in the development phases of the roadmap. For a more effective analysis, it was necessary to compare with some experts in the field of design and architecture from which emerged several hints for the research and especially barriers for the realization of the objective. Through statistical research on demographics, ease of starting a new business, costs for launching a project and sustainability, the European country in which it would be advantageous to implement the final innovation will be identified. After the presentation of the Business Model Canvas of the biophilic village, in the development phase, analysis of the costs of implementation of ‘Bosco Verticale’ and especially of the monthly maintenance costs for the apartment blocks will be carried out to understand which costs are unnecessary for the implementation and maintenance of this type of architecture, trying to find

alternative solutions to the systems used in the case study. Finally, personal conclusions derived from the research and the ideas of the experts interviewed will be discussed also on social issues, providing further indications on the prospects of architecture and sustainability and giving opinions on the effectiveness of the proposed roadmap. The interviews were conducted with an Architect at BEHNISCH ARCHITEKTEN (App. 3.3, Vetrugno, interview), with a Fashion Designer at Altaroma (App. 3.4, Marseglia, interview) and with an Architect/Fashion Designer at Gaudiomonte Couture (App. 3.5, Gaudiomonte, interview).

3.3. Building Features

"The Bosco Verticale is the prototype building of a new architecture of biodiversity, which no longer focuses on man alone, but on the relationship between man and other living species". (‘Vertical Forest | Stefano Boeri Architetti’ n.d.). Designed by Boeri Studio, the ‘Bosco Verticale’ (Image of the building in Appendix 3.6.) is a model of a sustainable residential building, a metropolitan reforestation project contributing to the regeneration of the environment and urban biodiversity. The building consists of two towers, 80m and 112m high, on which a total of 800 trees (480 first and second size trees) lies. A vegetation equivalent to that of 30,000 square meters of forest, concentrated on 3,000 square meters of urban area. The feature that makes it not unique but also sustainable is the faces, which are covered with plants rather than "minerals", they do not reflect the sun's rays but filter them, generating a microclimate that reduces heat by about 2 degrees. Furthermore, the plant covering "regulates" humidity, produces oxygen and absorbs CO_2 and fine dust. Maintenance of the vegetation is entrusted to the "Flying Gardeners", a specialized team of arboriculturists who climb down from the roofs of the buildings to prune and check the condition of the plants. Irrigation is centralized, managed by a digitally controlled remote irrigation system, which draws its water largely from filtering the grey drains of the two buildings. In addition to the tenants, the building is currently home to numerous species of animals, including around 1600 bird species.

The combination of these features has earned the project important awards, including the International Highrise Award from the Deutschen Architekturmuseums in Frankfurt (2014) and the CTBUH Award for a best tall building in the world, from the Council for Tall Building and Urban Habitat of the IIT in Chicago (2015). (‘Vertical Forest | Stefano Boeri Architetti’ n.d.) (Image general building features are in Appendix 3.7.)

3.4. Sustainability Analysis

‘Bosco Verticale’ is a LEED Gold certified building. LEED (Leadership in Energy and Environmental Design) is the world's most widely used green building rating system. Available for virtually all building types, LEED provides a framework for healthy, highly efficient and, cost-effective green buildings. LEED certification is a globally recognized symbol of sustainability achievement and leadership. (‘What Is LEED? | U.S. Green Building Council’ n.d.). The building is equipped with four geothermal heat pumps and photovoltaic solar panels with 26 kilowatts of power. Another important sustainability advantage is the recycling of greywater for the irrigation system. As previously introduced, the building's sky garden helps to reduce heat by creating a plant microclimate of around 2 degrees. The building also helps to reduce air pollution through the plants, which help to absorb about 19,000 kg/year of CO_2. It also produces about 52 kilograms of oxygen per day. (‘Bosco Verticale (Vertical Forest), Milan’ n.d.). To assess sustainability, we also relate the characteristics of the innovation to the SDGs proposed by the United Nations. According to an order of compatibility, BD is very close to the achievement of Goal 7 - Affordable and Clean Energy, as innovation can ensure access to affordable, reliable, sustainable, and modern energy through the use of zero impact energy solutions such as the exploitation of rooftops for solar energy, ensuring self-production of energy (‘Goal 7 | Department of Economic and Social Affairs’ n.d., 7), Goal 9 - Industry, Innovation and Infrastructure, as building resilient infrastructure underpins sustainable architecture. Inclusive industrialization, derived from biophilic solutions, will create an

innovative, forward-looking and biodiversity-preserving environment (‘Goal 9 | Department of Economic and Social Affairs’ n.d., 9). And finally, Goal 11 - Sustainable Cities and Communities as making cities sustainable is the first goal of the research, through the use of biophilic architecture it will be possible to bring man and nature together in the city environment, favoring settlements that are inclusive in society, safe, resilient and sustainable (‘Goal 11 | Department of Economic and Social Affairs’ n.d., 11). However, the innovation under consideration also approaches SDG's compatible in a more general way, namely Goal 3 - Good Health and Well - being, because it guarantees a better quality of life for all citizens thanks to the psycho-physical benefits that BD generates through contact with nature (‘Goal 3 | Department of Economic and Social Affairs’ n.d., 3) and finally Goal 8 - Decent Work and Economic Growth because it promotes sustained economic growth through the increase of jobs related to construction and maintenance (‘Goal 8 | Department of Economic and Social Affairs’ n.d., 8).

3.5. Roadmap Development

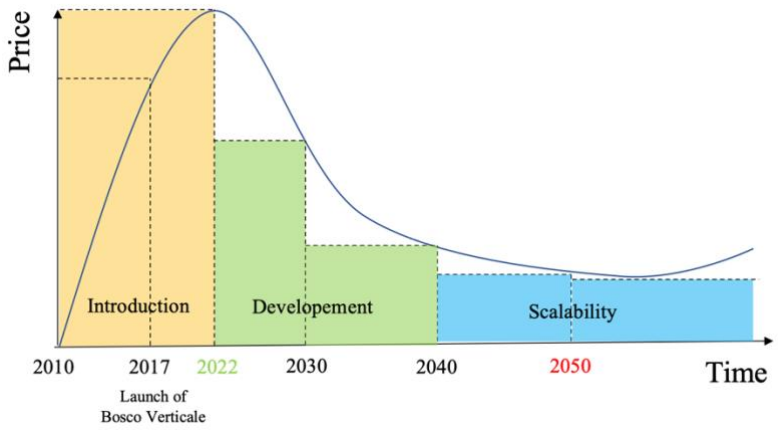

Figure 4 Own representation of the roadmap based on Gartner "Hype Cycle" model.

Having learned the technical characteristics and ascertained the sustainability of the building and the innovation it brings, at this point in the analysis a roadmap will be developed. The final objective of this is to try to implement the BD used by the ‘Bosco Verticale’ at an

entrepreneurial level throughout an entire village by 2050. Starting from the Gartner "Hype Cycle" model (App. 3.1.), this curve represents the roadmap to be followed for the implementation of innovation, where on the x-axis we find the time from 2010 to 2050, and on the y-axis the price of technological innovation. In detail, the Gartner model provides a graphical representation of the maturity and adoption of technologies and applications, and how they are potentially relevant to solving real business problems and exploiting new opportunities. (‘Gartner Hype Cycle Research Methodology’ n.d.). So, Gartner's Hype Cycle methodology gives us a view of how BD applied to architecture will evolve, providing information to manage its use within a business. On the model, in the year 2017, it is identified the launch of ‘Bosco Verticale’, the moment in which the point on the curve is very high due to the high hype of innovation, also demonstrated by the increase of searches of the term "Biophilic Design" on Google Trends. (‘Google Trends’ n.d.). Today, in 2021, innovation still has a lot of hype and consequently high prices, costs, and barriers to entry of various kinds in the market. Following the Innovation Adoption Curve theory of Everett Rogers (App. 3.2.) (Rogers 2003), individual users therefore still qualify as innovators. Assuming that the hype curve can be lowered over time, there will be an analysis of how these variables can be reduced to make innovation more accessible to early adopters or even an initial majority. Starting from the exposition of the main points of the Biophilic Village Business Model Canvas (App. 3.9.), it will be evident all the actors that revolve around the sustainable architecture chain.

Value Proposition. A new idea of sustainable living, the construction of a biophilic village to increase the psychophysical well-being of citizens, exploit renewable energy and reduce CO_2 emissions and pollution.

Key Partners. The design and architecture offices that are in charge of the creation of the project, the public administration dedicated to urban planning that, after its evaluations, decides whether to apply the project and, the construction companies dedicated to the construction.

Key Activities. To provide sustainable housing for the citizens capable of reducing CO_2 emissions through vegetation, to increase sustainable energy consumption with self-generation solutions using roofs, to recycle water, to exploit natural ventilation and to create areas for growing fruit and vegetables.

Revenue Streams. Project revenues will be mainly generated from the sale or rent of the village flats to the citizens, however, other revenues may be generated from the sale of natural products cultivated in the village, useful for the citizens' self-sustenance.

In the Appendix 3.9. all points of the BMC are listed. Through a direct comparison, consisting of interviews with experts in the field of architecture and design, the following obstacles emerged, which will be analyzed in detail, proposing alternative solutions to try to achieve the final objective and answer the RQ; Target Location and Costs and technical problems**.**

4. Challenges and Solutions

4.1. Target Locations

From the interviews carried, emerged the first concerns, that is where to implement this innovation. Michele Gaudiomonte, architect and fashion designer at Michele Gaudiomonte Couture, identified one of the main problems concerning the launch of this innovation on a large scale: the target location (App. 3.5, Gaudiomonte, interview). Carefully selecting the European city in which to realize the project will make it possible to limit various types of obstacles. ‘Bosco Verticale’ is located in Milan's Centro Direzionale on the edge of the 'Isola' district to redevelop the area around the building. However, Italy is not a suitable country for this type of implementation. Investments in start-ups in Italy are lower than in other European countries. Those who invest in Italy inevitably come up against a system that is not always up-to-date with the current needs of the business world (Ciaglia, Massimo 2020). In fact, in the seed capital phase, there has been a significant decrease in investments by venture capitalists

in recent years because it is very risky. Another barrier to investment in Italy is the high level of bureaucracy, as it is one of the countries with the highest governmental inefficiency (Cann 2016), and therefore there is an excess of administrative requirements. Using financial and environmental statistical filters, an analysis of European countries showed that there is a greater concentration of natural resources, sustainable energy use and economic health in Northern countries. As evidence of this, the ranking used highlighted Norway, Iceland, and Denmark as the most suitable countries for this type of implementation. (App. 3.10.). This is no accident. In the latest "Ease of Doing Business" ranking - drawn up annually by the World Bank to analyze the ease with which the average entrepreneur manages to set up his or her own business - Denmark and Norway were ranked 4th and 9th respectively, competing for the scepter of the best pro-business country in the world with the freest and best-regulated economies (Singapore, USA, UK) (App. 3.10). ('I Paesi Scandinavi: partner commerciali vincenti' 2020).

4.2. Costs and Technical Problems

The construction and, above all, maintenance costs of this type of architecture are very high and make the selling price equally high. Data from 'Bosco Verticale', identifies high expense maintenance costs, and services that guarantee the tenants both luxury and comfort. As wee as the technical upkeeping of the vegetation and irrigation system. In this way, we are going to understand which types of costs are superfluous and which can be current and future solutions that will allow us to save money.

- Average construction cost per sqm: 1,950 euro/sqm

- Average selling price per sqm: 9,500-10,000 euro/sqm

- Average maintenance costs: 63 euros/sqm/year, including heating, irrigation, 24/7 reception, 24/7 security, green maintenance, facade cleaning, CCTV system, air conditioning. ('Bosco Verticale (Vertical Forest), Milan' n.d.).

Alice Vetrugno is an architect at BEHNISCHER ARCHITEKTEN in Stuttgart and a specialist in sustainable architecture. The main focus of her interview is technical issues concerning sustainable architecture and what future solutions could combat the obstacles of the high costs. The architect blames one of the main causes of climate change on architecture itself. The constant demolition of buildings for reconstruction generates an enormous amount of CO_2 emissions. (App. 3.3, Vetrugno, interview). It is essential to consider the impact of producing or building things, without focusing directly on the result. (App. 3.4, Marseglia, interview). The importance of reusing rather than building emerges. Requalifying and making sustainable buildings that have already been implemented in cities, as well as saving CO_2 emissions, would not only allow us to redevelop buildings that are still perfectly usable, but also save on demolition and construction costs. Stating that costs vary according to geographical location, total square meters, type of finish (cheap standard or luxury) etc. (Madera Ing, Vincenzo 2021), in many buildings, the cost of the whole demolition work has to be calculated in a range between about 150€ per square meter and 200€ per square meter, even in the most favorable conditions (‘Demolire la casa e ricostruirla »Costi e esempio di prezzo’ 2021). For example, pure construction costs in Germany range from about 1,500 € per sqm to 2,500 € per sqm, and even higher for luxury buildings such as ‘Bosco Verticale’. In addition, there are about 15% to 20% of ancillary construction costs and after demolition, the property often has to be redesigned as well, which causes additional costs. In addition, Architects have shown how buildings could be built like nests, with zero impact, with local materials, which can then be biodegraded and disappear without a trace. About to the costs of maintenance, there are numerous solutions that the interviewee brought up for redevelopment. Some buildings can produce energy autonomously, exploiting roofs for solar energy as Energy Plus Architecture does. The ZEB Pilot House (2014) in Norway (our hypothetical country of reference for implementation), for example, is an experimental project that generated three times its energy

demand from renewable sources by combining different technologies such as a 150 m^2 photovoltaic array that was to generate 19,200 kWh per year, a 16 m^2 solar thermal array, a rainwater harvesting system, a heat exchanger that recovers excess heat and redirects it to heat tap water and a swimming pool that is heated using excess heat. (Bassas, Patterson, and Jones n.d.). Roofscape Urbanism can therefore be a viable solution to be exploited for energy, irrigation systems, vegetation, even zero-farming crops, as in many cities they remain unused space, but occupy 25% of a city (Voci 2021). Furthermore, for the irrigation systems of green areas, one could try to save on advanced remote-control technologies such as the drip system introduced earlier in the chapter on 'Bosco Verticale', collecting rainwater in tanks on roofs and filtering it to be reused for any domestic service.

5. Conclusion

The project work around the subtopic of BD sought to demonstrate the main challenges of the present and future of sustainable architecture. Sustainability must be a minimum and mandatory requirement for the cities of the future and any kind of business. (App. 3.4, Marseglia, interview). The following interviews, in particular the one with Michele Gaudiomonte (App. 3.5, Gaudiomonte, interview), brought up some important points about the social consequences that certain types of innovation, such as this, create and can create. When discussing sustainability, the concept of business should stray a little from its conception of profit derived from investments, because it is a subject that, above all, touches on a qualitatively delicate field for the health of future societies. An example such as the 'Bosco Verticale' perfectly represents the expression of implementable technology but is unethical for the meaning we want to give to the roadmap of the future. The fact of the matter is that sustainability in many circles today is seen only as a condition that adds value to a business or an innovation instead of being a necessary quality for the realization of any project. This characteristic of "added value" means that it is a factor that often impacts the benefit of only a

single target group of users who can afford the high maintenance and implementation costs we have analyzed above. The focus of the future must be to bring the benefits of these solutions to all members of society equally. A possible utopian solution to this obstacle could be to guarantee sustainable housing for the villagers, providing those who cannot afford to maintain the rental costs with employment within the village itself to maintain the vegetation, grow zero food for self-management of the town and sell it, creating a channel of self-financing and saving on the maintenance of the greenery and the town for each family. In addition, the slowness of certain project implementation processes due to the high level of bureaucracy in some countries must also be considered. The economies of Northern Europe, including Norway and Denmark, have a very free internal market, are extremely open to international trade, and are among the most innovative in the world, greatly facilitating all entrepreneurial activities as well as being rich in natural resources. Following the roadmap built based on the Gartner model and through interviews with experts in the field, we conclude that the project of implementing BD within an entire village by 2050 is a rather utopian condition at the moment if not organized consciously, with objectives and with an ethical purpose (App. 3.5, Gaudiomonte, interview). The curve will remain in its upward phase for many more years before falling and stabilizing mainly because of social inequality due to costs. However, the sound technical solutions that emerged in the development of the roadmap are likely to be the basis for large-scale investment in this area. The quality of life and the necessity for the health of the human species of the benefit of sustainability will one day in the not-too-distant future outweigh the simple business and exploitation 'fad' of being sustainable today and ensure a better future through the sustainable smart cities of the future.

6. Limitations

From an academic point of view, it was difficult, but at the same time stimulating to learn technical papers about architecture in depth. Furthermore, it was not easy to find articles about

the entrepreneurial aspect of such a young innovation. The interviews mainly yielded qualitative data, useful for our research but not enough to carry out detailed cost analyses or funding analyses in this type of project. However, it was easier to bring out the technical details concerning solutions to the challenges of today and the future of sustainable architecture.

6. General Discussion

While some conclusions in this report can be derived from the results of the research, another aspect might have multiple viewpoints to them.

In all the individual cases, presented sustainability can be leveraged compared to their conventional counterparts but often that cannot be stated with precision. Mobility, VIF or BC are examples of technology, which need some energy input to function. So, sustainability assessment results need to be taken cautiously as sustainability can only be levered if certain requirements apply. The energy source needs to be of renewable sources, otherwise, the lever to save e.g. CO_2 emissions is low. By presuming all of the technologies presented in this thesis report supplied with fossil energy, the innovation could not be considered sustainable.

However, if the energy sources would be 100% renewable, this thesis would be also pointless as one of the biggest problems would be solved, which is the global change of energy. Rather, the transition towards renewables and towards more impactful (in terms of sustainability) technical solutions that create value on multiple layers (e.g. the mobility case provides public transportation, CO_2 reduction and gamified user experience) is the true contribution despite the uncertainty of the energy supply.

But energy is not the only aspect, which is source-dependent. E.g., the packaging of the plants sold from VIF or the system on which a BC is applied are uncertainties that might limit the impact of the innovations discussed. This limitation is also a disadvantage that needs to be

considered along the way until 2050 in the sustainability assessment or the validation of value creation. However, this uncertainty might be a point that further leverages the impact of the innovation as uncertainty means that an entrepreneur can influence the development of the use of the sources. E.g., if the community of VIF-users agree to solely use paper wraps (or better no packaging at all) the impact would be increased.

Also, in all individual parts, the conclusion with regards to the sustainability assessment was positive and the innovation enhanced the status quo where applied. But that bettering the current state does not mean solving the problem entirely. In the introduction, the problem of climate change was addressed, and it is evident that this issue is among the most threatening problems we as humans face. Therefore, improving the status quo is not enough for the long run. The Paris Agreement states that CO_2 neutrality should be reached by 2050, which, in turn, mean for the innovations presented that CO_2 neutrality should be aspired. This does not necessarily mean that businesses that apply the innovations need to cut all the CO_2 polluters but to take the whole value chain into account and net around 0 (also after taking into account the biocapacity).

And here lies a big contrast: smart cities that use lots of technology to reach true interconnectivity, which supposedly should be sustainable might have worse CO_2 balances as the current best-performing country (and its cities) is Bhutan – an, according to western countries, poor country with less technology but committed efforts to reduce CO_2 emissions. This country is the only one to have reached CO_2 negativity (Munawar 2016) already and serves as a role model in terms of environmental sustainability. Therefore, the approach of using technology to solve CO_2 emissions is not wrong but not the only solution possible.

In the context of smart cities, it is important that the value of innovations can be increased by the interconnection with other technologies. Synergies in the case of this report might be

Fintech, BC and smart mobility but there come some downsides to it. Each innovation and each perspective of one technology or business can be embodied by stakeholders that all have interest, which consequently mean that the more perspectives on an innovation exist and the more interconnections are prevalent within smart cities, the more interests there are. This might sound positive as more perspectives enrich the diversity but also lead to an increase in the complexity and possibly conflicting interests. Therefore, it is important to agree on a consensus that supports an agenda that is suitable for all the entities of a network that decides to collaborate. Naturally, the more entities there are, the more difficult it becomes to set the specifics of a common agenda. This applies to business practices but also to technology, sustainability or social aspects. However, the complexity is not a problem that is not solvable as the network of Smart Sustainable Cities with its decentralized entities (VIF or mobility) and interconnections is part of the value created by such a system (Smart city canvas).

The scenario of a full Sustainable Smart City in 2050 serves as a canvas for the innovations to build beneficial use-case scenarios for the inhabitants of a potential city but also poses significant uncertainty as the scenario is 29 years in the future and the potential technical, social and regulatory developments are beyond grasp at the moment. So, the applicability of the innovations discussed might be as presented and would truly work in such a scenario, but they might also not. On the one hand, the individual parts deal with technologies that can be considered progressive, as they approach the challenge of sustainability (representing a future challenge), and transitioning as with them come new standards (at least technical or economically) – on the other hand, those might not be the technologies that will be adopted by the markets. In the early 2000s, only a handful of people could imagine how we now (20 years later) would communicate: via WhatsApp. Therefore, predicting the future is almost impossible and perhaps BC is a technology that will get disposed by something more advanced.

However, one of the most influencing factors is the aspect of regulation. In all the five

individual parts is concluded that regulation will influence the success of the innovation and represents one of the most relevant uncertainties. For example, the mobility case presumes that regulation will develop in favour of the idea (which is in the context of benefitting changes that promote sustainability to fight climate change, is rather likely in the next 10-30 years) meaning that subsidies benefit the shared use of EVs. The business model is based on the potential future development which poses some risks. In fact, the regulation might turn out to be sanctioning the business model (not likely but plausible) if priorities in a market are different than expected. The same happens for the application of BC to the EM. The key challenge that was tackled is outdated regulations, which prevent a tangible, city-scale, user-oriented application of this technology to this market. To base an enterprise on the hope of regulative improvements might not be the safest business idea but entails chances for future success, which, in contrast, is part of the purpose of this report. The business models of the other cases are not relying on the positive change of regulation but are susceptible to it. Especially the aspect of regionality in markets forces proper market analysis and negotiation with regulatory stakeholders to avoid too much uncertainty.

Some of the examples discussed revealed that regulation, in part, is behind the progression of the technology in terms of the benefits for positive change. In some cases, regulatory discrimination seems to slow down the development (Blockchain) and application of technology. This leads to the state where the market would be ready for adoption, but the incentives are missing. Therefore, it seems logical to invest in such technologies as an entrepreneur in the near future as it might turn out to benefit the business of the innovations. The problem is, however, that regulation often is not steered by one chancellor or president in terms of market condition as regionality plays a big role. Therefore, stakeholders of the regions are the important ones, and this poses a disadvantage for businesses as also the governance and regulation of Smart Sustainable Cities are complex. That means that a business based on a

technology, that has multiple entry points to a or multiple markets, might suffer from the bureaucracy of different regulatory entities such as different district laws, communities, communes, provinces, cities, etc. This might slow the process of market adoption and development down and decreases the attractiveness for entrepreneurs to launch their business.

Because the numbers of the business cases (except mobility) are based on the current prices and units, and because the regulation is not yet favouring the concepts, the prices might be higher (in some calculations - mainly VIF and Biophilic Design - it is questionable if the market would already positively respond to sustainability alternatives and pay more than the benchmark, but to provide the same value (in terms of quality, e.g. fresh VIF vegetables as good as conventional ones; biophilic buildings as good as conventional ones) – plus sustainability advantage, is a value proposition that stands out from the conventional counterparts. The problem, rather, is if the product or service would be below the quality of the competitors despite an environmental or social benefit. Then, adoption is less likely as clients would not adopt technology that is lower in value and cost more. But higher prices are in some cases inevitable (Biophilic Design) as it is the natural cycle of development and market adoption. The problem is that there are no alternatives to sustainable solutions as the threat of climate disasters poses too much danger to society (and all other beings). That means that some sustainable solutions will become the new benchmark with the openness to the kind of innovation.

6.1. Answering the Supporting Questions

As mentioned in the beginning of this report, to answer the Research Question as precisely and as accurately as possible, it is necessary to answer supporting questions first. The objective of the supporting questions is to ensure a clear understanding of the individual aspects/concepts presented. This methodology aims at summarizing and verifying the conclusions from each chapter before objectively answering the research question.

For what do sustainable innovations create value?

As previously shown, each individual innovation leads to its own singular output, and the key areas of focus are mobility, biophilic design, vertical farming, blockchain in the energy market and the fintech industry. It is interesting to notice that although these topics have such different final products, the stakeholders that each one of it affects are fairly the same – citizens, the city and governments are not only extremely affected by each innovation, but also essential for their existence.

Are current Smart Cities already applying/adopting these technologies/digital services?

The extent to which Smart Cities are already adopting the analyzed technologies varies. The cases of mobility and fintech are the most proven, meaning that there are several applications of the models proposed. Even so, these are two areas that are constantly growing in number, complexity and impact of applications. On the other hand, for biophilic design and vertical farming, the scenario is different. The technology already exists and several business models are available, but only for higher-level fringes of society. As so, the focus is on applying the innovations to people in medium to low class and to small-scale markets, respectively. Finally, Blockchain in the energy market has been theoretically proven and tested in real life with several B2B applications, but regulations prevent it from being tested at the necessary scale to allow individuals to become prosumers.

What are the key challenges of the innovation?

General challenges that affect all innovations are the complex governance models of key stakeholder entities that are required to be on board and regulations that prevent the innovations to be implemented with a higher level of flexibility. Even so, this paper assumes the necessary level of enablement of the innovations, as the focus is on the entrepreneurial and sustainable value rather than the legal ramifications. Depending on the implementation location or overall

context, other specific barriers to entry exist.

Are these innovations in these Smart Cities truly sustainable?

Another very important point, after analyzing the possible value creation, implementation and risks, is to assess whether the listed innovations really have a positive environmentally sustainable effect on Smart Cities.

The frameworks utilized to perform individual sustainability assessment ensure a minimum level of positive environmental impact. Even so, since this paper considers a time delimitation based on the European Green Deal's (2050), caution must be kept with regards to the long-term impact and the appearance of other solutions (that do not necessarily require a sophisticated technological level) that better meet sustainability requirements.

After this final validation through supporting questions, it is time to provide a definite answer to the research question.

6.2. Answering the Research Question

To answer the RQ "How to create value by entrepreneurially using sustainable innovations in Smart Cities?" in one sentence: by applying disruptive technology that leverage environmental sustainability without sacrificing price, value or other advantages and, if they surpass the requirements of the Smart City Canvas and the rating, which was part of the report (this would not exclude the ones below 5 but these are the ones selected as part of the report), by integrating them to Smart Cities. This way, value for the common key stakeholder can be assured: the citizens of Smart Cities represent the clients of the applied technologies presented which also benefits the entrepreneurs using the innovation to provide that value.

Because of the diversity of the innovations and the specificity and the multitude of the RQ the RQ will be answered in the sections Sustainability, Smart City and Value Creation.

Sustainability: Depending on the technology and its application a sustainability assessment (either based on CE, SDG or CO_2 emissions calculations) was performed to ensure a standard that significantly improves environmental or social concerns compared to the conventional counterparts that represent (for the majority of applications) the today's standard in 2021. The selection of the 5 innovations assessed is based on the (potential) environmental and social impact and the assessment for the innovation confirms that a significant value in terms of sustainability is guaranteed, given a correct integration of the technology. The methods led by the concepts of the innovations and its value propositions vary drastically. To exemplify: Fintechs can influence companies and policy makers to leverage financial inclusion and benefit the efficiency of economic operations, while the application of biophilic design leads to better mental health or passive heat regulation of buildings – the outcome, however remains the same. New standards are set and boundaries are relocated to a higher level (despite the acknowledgement that the innovations have different sustainability standards). Ultimately, this is a value created to the customer and to all the stakeholders, that suffer from the current climate disaster, which are all the organic entities in the biosphere.

Smart Cities: Also, in the category of Smart Cities it is important to note that a high standard to the preselection of the innovations (before the development of the thesis report), was set to guarantee that the technology fit the requirements of Smart Cities. As expected, different innovations have different focal areas, which, in the end leads to a portfolio of strengths when it comes to the integration of all the innovations. Still, common themes as decentralization, a benefit to the quality of life or interconnectivity are prevalent. To exemplify: the application of BC in the EM has the highest impact on the categories quality of life, effectiveness of urban services, competitiveness and especially interconnectivity due to the potential for integration with IoT/industry 4.0 and for automation and decentralization. This has a similar fit to Smart Cities as Fintechs benefit social sustainability, improved quality of life, interconnectivity,

automation and decentralization for autonomy, which, again, has a similar effect as vertical indoor farming.

Value creation: This aspect is the most uncertain of all researched areas as regulation until 2050 can drastically vary due to the time until 2050 but also due to regional effects and different markets. This has implications on the competitiveness and scalability of one innovation (e.g. BC, mobility, VIF). But as first regulators benefit more sustainable options, e.g. carbon tax, this uncertainty is expected to unveil to the favour of the innovations (besides that climate emergency and social movements e.g. Fridays for Future pressure policy makers and regulators into this direction).

As mentioned in the sustainability paragraph, the value is created by sustainability-related factors such as CO_2 emission reduction but also by the non-sustainability-related aspects (it remains questionable if the term is correct as every value that contributes to the thriving of humankind is somehow benefiting sustainability values.). The value provided are diverse, but through the interconnectivity of Smart Cities and through the frameworks used, related. To exemplify: Smart mobility concepts and Fintech could be improved by the application of BC. The same applies to potential synergies of VIF and biophilic design (e.g. potential to breed settlings at the same nursing station), which leads to the conclusion that in different values are lots of similarities.

7. Main General Conclusion

The initial goal of this research was to understand the potential that certain fields of innovation can have on cities, to make them smarter and more sustainable. For that, a broad initial exploration was done, and parameters for a preliminary potential assessment were defined. The chosen innovations focused on the following areas: Mobility, Vertical Farming, Biophilic Design, BC, and Fintechs. These concepts may sound like jargon, but after in-depth study, it is

clear that the benefit they bring to citizens can essentially change the way we live within cities in current and future days. After proving the entrepreneurial and environmentally sustainable value that these innovations generate and understanding the structural changes that would be required to implement these changes within a city, it is important to reflect upon the Sustainable Development Goals (SDGs) that will be affected by them, not only individually, but as a whole. In fact, out of the 17 SDGs, 15 of them are at least partly affected by at least one of the innovations, being Decent Work and Economic Growth (SDG 8) the one that is tackled by every analyzed innovation. This means that all of them contribute to promoting sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all (United Nations n.d.), which has been verified in the value creation analysis for each of the five innovations. By building a MaaS solution that fosters the use of the public and shared transport networks, it is not only the solution itself that is benefiting from growth, but also – and most importantly – the networks, which can then improve in qualitative and quantitative terms due to the success of this solution. Furthermore, enabling vertical farming for small-scale players means not only enabling every player to use more environmentally friendly solutions, but also giving the same opportunities for economic growth to all. The same happens with biophilic design architecture which, as previously explained, is a type of architecture from which only the most privileged fringes of society can benefit. But, at its core, the goal is to integrate nature and human beings and, through finding solutions on how to enable it for everyone, steps are being taken towards a more inclusive economic growth. On a more individual sense, Fintech solutions can increase financial inclusion through higher access to financial services, boosting SMEs and entrepreneurs' success enabling mobilization of domestic savings, allowing long-term investments and ultimately increasing economic growth. Finally, applying BC to the energy market not only opens space for more players in the sector, fostering competitiveness and growth, but also creates new opportunities for several players in

the city context, and even a potential new revenue source for citizens if they choose to become prosumers.

Although SDG 8 is touched upon by every subject approached in this research, it is not necessarily the key one for all of them. In fact, when talking about mobility, the main one is SDG 17 – Partnerships for the Goals, as enabling a MaaS solution in the city context requires a strong alignment between private and public players – not only in terms of transport modes but also, and mainly, with regards to technology, and a solid and flexible governance model. When talking about Vertical Farming, one of the main aspects is the fostering of Responsible Consumption and Production (SDG 2) – by enabling small business owners to use such technology in the sourcing of their products, production becomes sustainable (not only economically, but also environmentally), allowing a cycle of responsible consumption and production to be generated. For the application of biophilic architecture, the main focus is SDG 11 – Sustainable Cities and Communities, as it works towards making these types of buildings accessible to all, thereby aligning with "making cities and human settlements inclusive, safe, resilient and sustainable" (United Nations n.d.). Applying innovative Fintech solutions in the city context mainly contributes to SDG 1 – No Poverty as, as discussed during the in-depth analysis, reducing payment costs and enhancing access to capital and investments leads to higher financial inclusion and literacy. Finally, applying Blockchain technology to the energy sector mostly contributes to SDG 7 – Affordable and Clean Energy, as it leads to higher transparency of the energy infrastructure due to the decentralized nature and traceability of Blockchain.

Technology is constantly evolving. Ages ago, the fire appeared. Then, eventually, the Man invented the wheel. Later, the light bulb and the printer became part of our lives, and today we all live connected through the Internet. Things that we never thought could exist have much more than the direct application that can be initially assumed from it. As so, pursuing this kind

of exploratory research and potential assessment is key to ensure not only the cities' improvement but the evolution of mankind.

8. General Limitations

The limitations concerning research find some points in common and others of difference between the various subtopics. A group work articulated in five different areas that converge in a single objective leads to clashes with difficulties that are mainly technical and research-related, and with others that are consequences of the former. Sustainability is one of the most discussed and researched objectives of the last century and will be what mankind will have to achieve to survive. Smart Cities, on the other hand, represent the future starting from the small steps that man and technology take today, trying to build around it a welcoming and stimulating environment that reacts to human stimuli and guarantees a high quality of life. From this we can deduce that the topics dealt with are extremely topical and in particular, subtopics such as the Blockchain in the energy context or Biophilic Design from the point of view of cost analysis or the use of new architectural technologies lack numerous relevant academic articles that can provide further information as they are fields that are sometimes still unexplored. However, it is the future that will provide answers to our proposed solutions. In the course of the research, different frameworks were used, and sometimes it was not possible to obtain the desired results from them. From the point of view of Vertical Farming, we were not able to obtain a business plan and a real market research with real identification of the latter. The reason for this is purely due to the scarcity of quantitative data obtained and the large amount of qualitative information, which led to conclusions that were not based on numerical/analytical evidence. A similar problem was faced in the Fintech sub-topic where we have no information on the cost structure, in the Biophilic Design sub-topic where we have a qualitative analysis with some assumptions on the cost data due to the lack of architectural background and in the Smart Mobility sub-topic where we had to make assumptions on the public sector cooperation (even if its interest was

quite validated) and on the costs/demand. The Smart Mobility area also encountered some limitations in using a survey: closed-ended questions limit the person's opinion to the options proposed by the research, with a risk of leading to distortions due also to a word-of-mouth sample. On the other hand, the number of interviews was not high enough to get a complete picture of the experts' opinions, however, also due to the lack of response and not to the lack of research and as previously mentioned, they are purely qualitative, therefore they mainly provide opinions, validated however by the experience of the interviewees. It would also have been useful to be able to elaborate on many other points relevant to the research, such as regulatory frameworks for Blockchain in the energy market, the wide range of applications that Fintech provides today or quantitative analyses regarding the funding of this type of innovation.

9. General Future Research

According to Statista, the projected revenue generated by companies in a Smart City, offering products and services based on data technologies to increase the value creation, will rise to 241.02 billion U.S. dollars in 2025 (‘Global Smart City Revenue 2020-2025’ n.d.). Simultaneously, regulations and societal demand are increasingly pushing companies to focus on sustainability in their actions. These two developments show that in the future the topic of value creation through sustainable innovation in a Smart City will gain constantly importance and needs to be explored more deeply. This shows that this subject area must continue to be investigated.

To gain more insight into the value creation through innovations in sustainable Smart Cities, there are several options and approaches for future research.

The first option is to build on the limitations just listed. In the analysis of each innovation, some limitations limited the validity of the answer to the RQ. Future research could focus on these limitations and try to address them by collecting primary data. For example, focusing on the

missing information about the business cost structure and discovering it through data collection. Another limitation, which can be solved in future research, is the limitation of the validity due to the limited field of view. The present work focuses on the value creation of five innovations. To analyze the value added by innovations in a Smart Sustainable City in a more precise way, a wider range of innovations of different types must be considered. The second possibility for future research is to focus on the impact of the innovations on the three pillars of sustainability separately. In this way, the value creation through innovations in a Smart City can be divided into society, economy and environment. This helps to go into more detail about the impact of a single innovation on a specific target group and to better understand how value is created. The third possibility would be to support the existing findings with primary data by conducting a long-term experiment to truly analysze whether the innovations lead to sustainable value creation in reality. Since the results will be depending on the micro and macro-environmental circumstances, the experiment needs to be conducted in different cultural areas, to be able to deliver independent research results.

In conclusion, there is still a great deal of research potential in this area and, given its enormous relevance, the study should continue to be carried out from various perspectives and with different approaches.

10. Review of the collaboration and motivation of this work

The theme of sustainability, assigned at the beginning of this course, was not only a motive for academic research but above all a way of making everyone feel part of a group that wants to have objectives to change the world in its small way, improving it, looking towards the future. So, research after research, providing ideas to our teammates and working on what seemed to be suitable with our profile, the structure of the project became increasingly clear. Collaboration was the main driver of the research. It led to a general knowledge of the drafting process in a homogeneous way, with each component being interested in all subtopics. The

initial motivations were different for each of the team members. They reflected interests, passions, character and academic backgrounds related to the underlying topic. However, it was not easy to link interests to knowledge to keep the research business-oriented. Learning from areas completely outside the comfort zone has been challenging but at the same time interesting and educational. We achieved new knowledge, that have never before been explored in fields such as engineering, architecture, or agriculture. The greatest success is to see what in the beginning was just an idea born from a theme, that of sustainability, become a working project full of passion, creativity, and research. Through the choice of these solutions presented, it was a challenge to try to get to the heart of the matter: Can we create value? Can we in this way achieve sustainability goals linked to the SDGs that can one day give a better future to new generations, as the previous ones did not? This question was the driving force behind the research, which passionately tried to provide all the necessary points for as detailed an understanding as possible, albeit with significant limitations. All the subtopics could be explored in more detail. However, each of these innovations is more or less unexplored territory and this generated curiosity among the members throughout the drafting of the research. In the end, many points of initial prediction were mitigated by barriers that still drive society and governments. Personal motivations remain almost the same as at the beginning, albeit with much more awareness and knowledge of how processes work that are often taken for granted.

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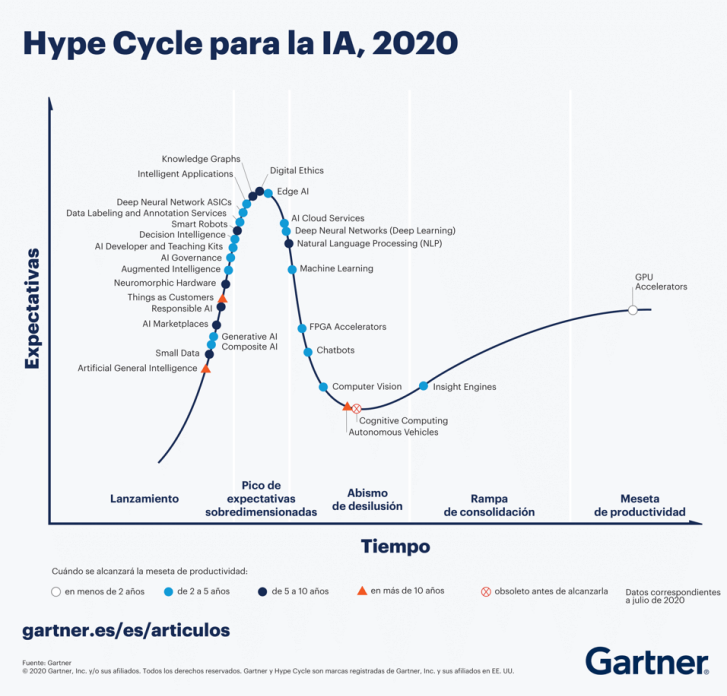
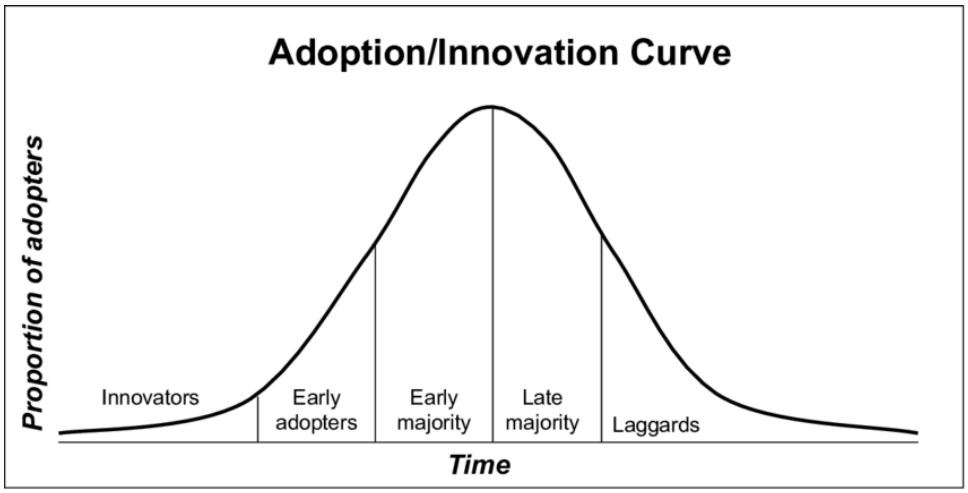
Appendix

Appendix 3.1. Gartner Hype Cycle Model



Source: (‘2 Megatendencias Dominan El Hype Cycle de Gartner de 2020 En El Campo de La Inteligencia Artificial’ n.d.)

Appendix 3.2. Roger’s Curve



Source: (Hovav, Page, and Schuff 2003)

Appendix 3.3. Interview with Alice Vetrugno, architect at BEHNISCH

ARCHITEKTEN (Stuttgart).

Key Takeaways:

Sustainable architecture: "Nowadays, those who commission projects from us from a sustainable point of view are always trying to increase the quality of life, or at least that is the goal. That's why we try to use natural ventilation systems, Soral Panels, and sustainable energy production to reduce emissions to zero and lower the cost of the energy the building produces.

Technical problems: "It sounds strange to say but the problem at the moment with this climate change is mainly architecture, because there is this turnover every year of billions of buildings being built and torn down, and the destruction of buildings creates more CO_2 than you can imagine. I recently read a theory of architecture about these buildings that should be built like nests. You know when a bird has to create a house, a nest, it has to create it with the materials of the place, so what it finds. This place that only serves him for this specific period of time that he has to live in there then it has to disintegrate at the end of his life. So you have to create these zero-impact buildings, with local materials that can be biodegradable or disappear without a trace. Another idea would be to reduce and use less and less energy. Another idea would be to reduce and use less and less energy. When you build a building you consume a lot of energy, also because of the fact that you take for example materials from another city, maybe take them to another country. For example, taking wood from Norway or palm trees from another type of ecosystem on another continent. In short, if I want to build a house and I want to respect sustainability, it is essential to always use local materials and create buildings that are sustainable, but that also produce a lot of energy themselves. So the goal is not to use as little energy as possible, but to create a building that produces more energy than you consumed to build the building,"; "You can use turbines on the roofs, so you can use the roofs for solar energy or for vegetation, improve the ventilation by using natural ventilation, or reuse rainwater, so that the building can create so much energy that it doesn't take it from these fossil products of the city, but it can manage itself in a certain way."

New technologies: "On the basis of Passivhaus, you create walls, which are so thick that they keep the heat in the winter and the cool in the summer, so you can save on heating, or even use natural ventilation instead of mechanical ventilation and be sustainable, or use a double façade that allows you to keep the sunlight off the main façade, making it warmer. A geothermal heating system is nowadays widely used to heat a building. That is, with a cistern 50/60 metres underground you can use the heat for your building"; "Now there is always this problem of collecting rainwater as much as possible, because there is water now and it costs a lot of money, so you create these cisterns or these viaducts on the roof that collect all the rainwater and you can reuse it for anything. It's also used as water for the toilets, for the bathroom. There is also grey water in that sense that can also be reused. Maybe it's used for vegetation, because you can't use it for anything else."; "Some even put pools, tubs that collect water on balconies and roofs. and not just the building. There are a lot of techniques for re-building such as creating zero-mile Urban Farms for self-management."

Redeveloping buildings: "Ideally, in my opinion, you should reuse what you have. Because unless it's really decaying, there are buildings that were built 10 years ago that are new and simply need to be renovated or made sustainable. In Germany they made a law that buildings that were built in the 60s now have to be torn down, but the buildings could simply be improved, through what we have said so far, roofs, vegetation, irrigation systems, city parks. There really could be a lot of innovation".

Interview held online on November 12th, 2021. Full transcript can be provided upon request.

Appendix 3.4. Interview with Italo Marseglia, Fashion Sustainable Designer and Consultant

Key Takeaways:

Sustainability in fashion: "My current occupation is still to lend my professionalism as a designer to different realities ranging from public institutions to multinationals such as Pfizer for which I am a consultant. I propose to them sustainable solutions to their needs, which align with the SDG's, environmental sustainability and ethical fashion."; "I believe that sustainability is a fundamental requirement today for any kind of project, but not only for green washing. Kofi Annan wondered back in 2000 what a company must do to be cosmopolitan and in step with the times. I like to think that the answer today is to be aware of the impact it has on environmental sustainability. Every business model should have this fundamental requirement at its core, to which a precise answer should be given, because as Greenpeace says "The time is now". It is absolutely necessary to take action,

because in such an interconnected world it is our duty to be respectful of the environment in which we find ourselves"; "It is important to think that not all things created from scratch are sustainable. You have to consider the environmental impact of producing these things and often we don't care. We just think from a product point of view. This is part of the short-, medium- and long-term demands of a new project. We need to understand what this economy really needs again, and instead ask ourselves how we can extend the life cycle of an existing product. Returning to a circular economy model could be a solution for everyone. With my brand it has become an imperative to bring sustainability back from the point of view of up-cycling".

Digital pollution: "Another problem is digitial pollution. Why? The digital world creates waste not only in terms of discarded devices, but also the energy consumption of data and clouds. Migrating towards a path of converting technologies to renewable energy would be useful. Educating consumers on the awareness of their choices is fundamental, because sustainability cannot be considered in watertight compartments but must permeate all aspects of our daily life and our social and economic life."

Smart City: "The 15-minute city is a very interesting concept that cities like Paris and Milan are working on. It consists of having a logistical elasticity where the citizen gets services (green areas, schools, banks) within fifteen minutes. By working on this model, we can achieve a stronger inclusiveness"; "Incorporating and involving nature in the urban space. Why? According to Greenpeace and the UN we will all be living in a big city in the future, converging towards large urban and housing centers. So, we need to find methods and solutions to accompany this urban and sociological transformation to a systemic sustainability of green environments and the cities themselves. 2050 is perhaps a somewhat utopian goal if we talk about total implementation, but it is certainly not so far away from what is already being created in anticipation of the future and the SDGs goals."

Interview held online on November 7th, 2021. Full transcript can be provided upon request.

Appendix 3.5. Interview with Michele Gaudiomonte, Architect and Fashion Designer at Gaudiomonte Couture (Italy)

Key Takeaways:

Reuse of materials and costs: "It is fundamental, as far as I am concerned, to reuse materials from the past that can become sustainable and environmentally friendly in order to give a higher quality to the article (thermal or livability characteristics for example). The main limitation of this reuse of sustainable materials is the cost. Many times, I have tried to use sustainable materials with people with a strong focus on not using synthetics and natural materials, but at the end of the day the costs were too high. Simple materials do not have great costs at the production level, but as a research product and a researched product, the added value is merely speculation. The question I very often ask myself is: How much should be done for the well-being of the planet out of necessity, and how much instead is a fashionable attitude on the part of those who speculate. Bosco Verticale' is a wonderful, dreamlike example of sustainability applied in a city, but it has management and maintenance costs that cannot be fully managed by the tenants. And these costs are so high because there is an added value of mere speculation. This is also the case in fashion. Nowadays we hear a lot of talk about sustainable materials, about eco-leather, but in reality not all the production chain is sustainable."

Target Location: "The problem is that today we are losing social and business opportunities because of high bureaucracy. This is something that some countries in particular, like Italy, should think about. It is important to have solid rules and regulations, but the process should be more streamlined. Today, too much time passes before any project is concluded and many clients prefer not to do anything at all, or worse, to circumvent the law and fall into abusive practices.

Biophilic Village: "I see it as possible to build such a village, with objectives. But we have to stop playing the role of those who advertise sustainability for fashion and not for purpose. Then take the lead on the importance of the issue. If a Grés floor at km0 costs you 20€ and a sustainable one costs 200€, the customer will always choose the 20€ one. So, you have to make customers aware of this, you have to change their perspective. Help must come from the top, from governments and global organizations. The village you have in mind should not be a happy island in the middle of decadent cities, but should be the example to be followed, the driver for future sustainable smart cities".

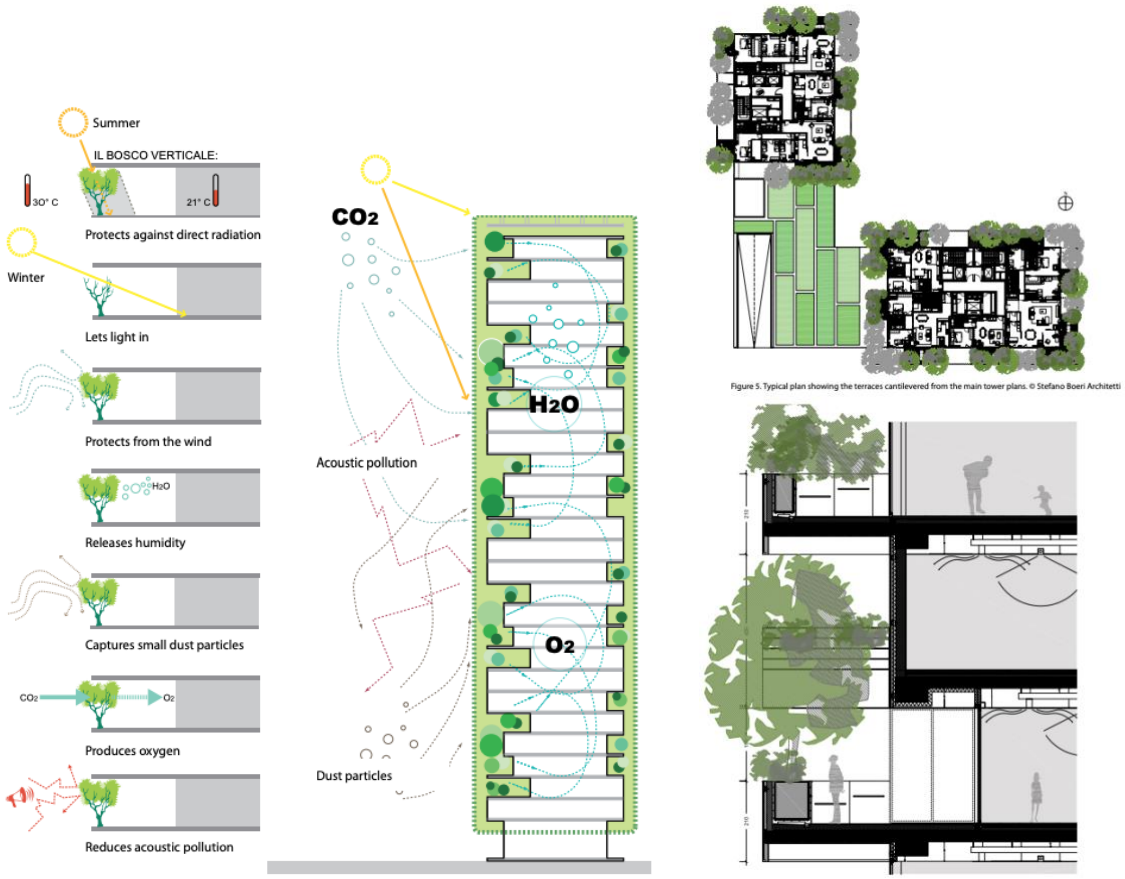
Social Issues: "It is fundamental that living in symbiosis with nature is for everyone, it cannot be a social status. If it were, it would remain just an advertising slogan. Increasing the quality of life is for the whole of society, not just for a select group of people living in the wonderful city and poorer people living in ghettos.

Interview held online on November 7th, 2021. Full transcript can be provided upon request.

Appendix 3.6. Image of Bosco Verticale

Source: (‘Vertical Forest | Stefano Boeri Architetti’ n.d.)

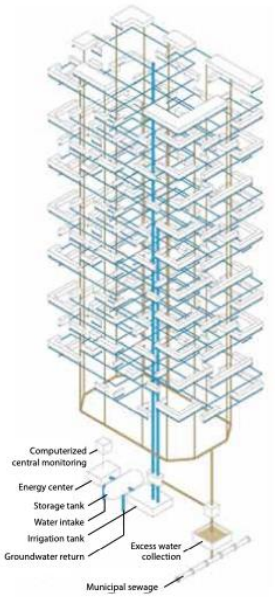
Appendix 3.7. Building Features



On the left: general, on the right: terraces

Source: (Forgemind ArchiMedia 2012)

Appendix 3.8. Irrigation System



Source: ('Il Bosco Verticale di Boeri: da fenomeno ad archetipo? | Inexhibit' n.d.)

Appendix 3.9. Business Model Canvas Bosco Verticale

<table>
<tr>
<td rowspan="2">Key Partners
• Construction Companies
• Design and architecture firms and studios
• Public administration, urban planning</td>
<td>Key Activities
• CO2 reduction
• Increase sustainable energy
• Self maintenance
• Water recycling
• Natural ventilation</td>
<td rowspan="2">Value Proposition
A new idea of sustainable living, the construction of a biophilic village to increase the psychophysical well-being of citizens, exploiting renewable energy and reducing CO2 emissions and pollution.</td>
<td>Customer Relationships
• Relationship with villagers building by guaranteeing their wellbeing and quality of life, collaborating to achieve objectives in sustainability and safeguarding the planet.</td>
<td rowspan="2">Customer Segments
• Citizens</td>
</tr>
<tr>
<td>Key Resources
• Funds
• Lands
• Non – viable buildings</td>
<td>Channels
• Internet
• Social media
• TV Channels
• Newspapers
• Magazines</td>
</tr>
<tr>
<td colspan="3">Revenue Streams
• Sale and rent of the houses
• Sale of product obtained from cultivation</td>
<td colspan="2">Cost Structure
• Construction costs
• Maintenance costs
• Village management costs</td>
</tr>
</table>

Value Proposition. A new idea of sustainable living, the construction of a biophilic village to increase the psychophysical well-being of citizens, exploiting renewable energy and reducing CO_2 emissions and pollution.

Key Partners. The design and architecture offices that are in charge of the creation of the project, the public administration dedicated to urban planning that, after its evaluations, decides whether to apply the project and the construction companies dedicated to the construction.

Key Activities. To provide sustainable housing for the citizens capable of reducing CO_2 emissions through

vegetation, to increase sustainable energy consumption with self-generation solutions using roofs, to recycle water, to exploit natural ventilation and to create areas for growing fruit and vegetables.

Key Resources. Funds to be used to finance the implementation of the project (e.g. European funds). In addition to the financial part, urban resources are needed, such as building land or non-viable buildings to be rehabilitated.

Customer Segments. Mainly the citizens of the Smart City where the village will be built, who will create the sustainable society of the future.

Customer Relationship. Building relationships with villagers by guaranteeing their wellbeing and quality of life, collaborating to achieve objectives in sustainability and safeguarding the planet.

Channels. Sponsor the Biophilic village project on all media and social channels, to raise awareness of other countries to achieve certain sustainability goals and to populate the flats with citizens.

Cost Structure. Costs are divided into 3 macro-categories: construction costs (including costs for design and construction management, materials, installations, foundations), maintenance costs for vegetation, irrigation and energy systems, and village management costs.

Revenue Streams. Project revenues will be mainly generated from the sale or rent of the village flats to the citizens, however other revenues may be generated from the sale of natural products cultivated in the village, useful for the citizens' self-sustenance.

Through a direct comparison, consisting of interviews, with experts in the field of architecture and design, the following obstacles emerged, which will be analysed in detail, proposing alternative solutions to try to achieve the final objective and answer the RQs.

Appendix 3.10. Country Analysis

Country Name	Ease of doing business rank (1=most business-friendly regulations)	GDP per capita growth (annual %)	Land area (sq. km)	Renewable energy consumption (% of total final energy consumption)	Time required to start a business (days)	Urban population (% of total population)	Total tax and contribution rate (% of profit)	Plant Species	Population ages 15-64 (% of total population)	Score	Ranking
Denmark	100,0	65,15853661	1,24	44,3144	97	86,25	72,91	1,400809717	20,46697317	9,551	3
Iceland	75,3	36,75896697	1,61	100,0000	87	92,94	57,13	1	34,26860054	10,408	2
Norway	94,4	70,17764921	3,21	77,4066	96	80,31	48,75	5,008097166	36,85851872	10,491	1
Relative Wheight	2%	2%	1%	4%	2%	1%	2%	2%	1%		

Countries: All European Countries

Filters: Ease of doing business rank (1=most business-friendly regulations) (2% weight); GDP per capita growth (annual %) (2% weight); Land area (sq. km) (1% weight), Renewable energy consumption (% of total final energy consumption) (4% weight); Time required to start a business (days) (2% weight), Urban population (% of total population) (1% weight); Total tax and contribution rate (% of profit) (2% weight), Plant Species, Population ages 15-64 (% of total population) (1% weight).

Source: WorldBank