DE MONTFORT UNIVERSITY

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GOVERNANCE FOR SUSTAINABLE SYSTEMS: THE DEVELOPMENT OF A PARTICIPATORY FRAMEWORK

PhD

Academic Year: 2010 – 2016

Supervisor: Prof. Mark Lemon, Dr. Richard Bull

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SCHOOL OF ENGINEERING, MEDIA AND SUSTAINABLE DEVELOPMENT

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Abstract

Despite an increasing recognition of the need for an integrative approach to sustainable development, there remains a tendency for this to be anthropocentric. Attempts to govern sustainability are invariably focused on the pre-eminence of the human perspective and social systems in the pursuit of human goals. This often means either excluding or attempting to control the external environment rather than understanding and responding to it.

This thesis explores more holistic approaches to governance that are based upon the need for an improved understanding about the interconnections between social, economic and ecological systems. It examines current literature on governance for sustainable development and systems thinking as applied to it, with specific reference to Socio-Technical Systems (STS), social learning about systems' interrelations and the nature of public goods. On the basis of this analysis, a systemic conception of governance for sustainability is developed and translated into a provisional framework that can aid participatory social learning relating to sustainable development.

Three initial Socio-Technical Systems (STS) case studies are drawn upon to populate the empty framework (the European Critical Electricity Infrastructure (ECEI), the Finnish security system and the transition of energy systems towards a post carbon society); these are then analysed thematically to derive common governance for sustainability criteria.

The final modified framework is then applied to an in depth, and on-going, case study of food systems' security and sustainability and a final discussion considers how this governance framework (GAME) might contribute to future holistic decision making for more sustainable Socio-Technical Systems. The multi-method GAME supports the generation of future scenarios and core sustainability criteria by multiple stakeholders; reflecting needs, capabilities and limits that can maintain systems' equilibrium. It also implies a more normative governance for sustainability and a commitment to improved evidence-based decision-making that reflects systems' complexity and contributes to bridging the gaps between science, policy and society. The GAME is currently being extended to incorporate the user-friendly geospatial representations of impacts.

Keywords: sustainability, governance, holistic framework, systemic approach.

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During the entire research project, I had the occasion to work within different environments, experiencing different cultural and research contexts and organisational peculiarities.

All the work carried out, independently or in cooperation with my colleagues, has contributed to discovering the winding path towards the research results. However, I have learnt that the conclusions of a research project are not only the product of academic work. They are instead the product of studying, thinking slowly, experiencing life, getting acquainted with different cultures, listening to the words of people around and observing. A great deal of knowledge came from the voluntary work in a Namibian orphanage and the contact with different worlds and dimensions of life. That is the reason why I also want to thank Ms. Barbara Winterfeldt, who showed, by her dedication to voluntary work, how socially sustainable systems need the contribution and entitlement of the human factor that is a major element in socio-economic studies, and at the same time the core element in sustainable development. That is why I dedicate my work to the children of Dolam, and in particular to Charlett, whose human rights of well-being and security were denied.

Charlett

I don't want back home,

Let me play with the sand, climb

over the trees, run on the grass,

where birds sing and no snakes bite.

Let me enjoy the sun of this beautiful day,

which will never come back

for me,

little Princess of Dolam

(Sajeva, 2009)

Freedom is living without walls (Sajeva, 2009)

BIOGRAPHY

Maurizio Sajeva is a social economist (University “La Sapienza” of Rome, 1999) and a Ph.D. student at De Montfort University of Leicester (UK), School of Engineering, Media and Sustainable Development, Institute of Energy and Sustainable Development (IESD). Since 2011, he has been working as a Scientific Liaison Officer at Natural Resources Institute Finland Luke, where his main responsibilities cover participation in international research agendas related to natural resources and conception of related research projects, some of them in the areas of food security and cooperation for development.

He has previously worked as a Project Manager at Finland Futures Research Centre of the University of Turku (2008-2011) and as a Scientific Officer at the European Commission, DG Joint Research Centre (2003-2008), where he worked on socio-economic research, with a particular focus on governance for security and sustainability of Socio-Technical Systems and qualitative assessment methodologies. He has pursued his Ph.D. studies by integrating research aimed at supporting European Commission policies with more academic research approaches.

LIST OF PUBLICATIONS

Sajeva, M., P. Singh Sahota and M. Lemon (2016). *A Vision and a Framework of Governance for Sustainability: Assuring Food Security within Natural Systems.* Paper presented at the 158th Seminar *"Euro-Mediterranean Cooperation in Sustainable Agriculture and Food Security: Policies, Sustainability, Marketing and Trade"*, organised by the European Association of Agricultural Economists (EAAE), at the Mediterranean Agronomic Institute of Chania (CIHEAM-MAICH) in Greece, 8-9 September 2016

Singh Sahota, P., M. Sajeva, M. Lemon, M. Brar (2016). *Learning from the Sikh Gurus: Improved Decision Making for More Sustainable Futures.* Springer, Philosophy of Management, February 2016, Volume 15, Issue 1, pp 21-34.

Sajeva, M., P. Singh Sahota and M. Lemon (2015). *Giving Sustainability a Chance: a Participatory Framework for Choosing between Alternative Futures*. Journal of Organisational Transformation and Social Change (JOTSC), 12 (1), pp. 57–89

Sahota, P.S., Lemon M. Sajeva, M. (2016). *Transferable case based lessons from value chain development in Kenya.* Food Chain Journal.Vol.6 number1 February 2016

Sahota, Lemon and Sajeva (2014). *The Application of Supply Chain Principles to Knowledge Transfer (Knowledge Dynamics) and Sustainable Development* (article sent for publication)

Sajeva, M. P. Singh Sahota and M. Lemon (January 23-24, 2014). *Giving Sustainability a Chance: a Participatory Framework for Choosing between Alternative Futures.* Paper presented at Business Systems Laboratory - 2nd International Symposium "Systems Thinking for a Sustainable Economy. Advancements in Economic and Managerial Theory and Practice". Universitas Mercatorum, Roma, Italy

Singh Sahota, P., Mark Lemon and Maurizio Sajeva (2013). *The Application of Supply Chain Principles to Knowledge Transfer and Sustainable Development*. Poster presented at Business Systems Laboratory - 2nd International Symposium "Systems Thinking for a Sustainable Economy. Advancements in Economic and Managerial Theory and Practice". Universitas Mercatorum, Roma, Italy

Sajeva, M. (2012). *Security, quality of life and development. A holistic approach*. In "Quality of Life in Italy - Research and Reflections", Social Indicators Research, an International and Interdisciplinary Journal for Quality-of-Life Measurement, Springer Science+Business Media - Springer Dordrecht Heidelberg New York London

Sajeva, M. and J. Kaivo-oja (2010); "Framing Privacy and Data Protection Finnish report on Symbolic representation of Security Agencies" Deliverable D 4.2. - Seventh Framework Programme - Collaborative Project FP7-SCIENCE-IN-SOCIETY-2008-1; Privacy Awareness Through Security Branding (PATS) Project number 230473

Sajeva, M. and J. Kaivo-oja (2010); "Workshop Report - Privacy Awareness of Security Organisations in Finland" Deliverable D 3.3. - Seventh Framework Programme - Collaborative Project FP7-SCIENCE-IN-SOCIETY-2008-1; Privacy Awareness Through Security Branding (PATS) Project number 230473

Sajeva, M. and M. LaBelle (2010). *Risks and governance in the transition process towards post-carbon societies*. Deliverable 4.2 - Seventh Framework Programme - Collaborative Project "Pathways for carbon transitions (PACT)"- Project number 225503 - Workpackage 4 - Transition towards post-carbon society

Masera, M., Y. Wijnia, L. de Vries, C. Kuenzi., M. Sajeva, M. Wejnen (2006). Governing risks in the European electricity system" in "Critical Infrastructures at Risk - Securing the European Electric Power System, Springer Verlag

Sajeva, M. and M. Masera (2006). Risk Governance of Critical Infrastructures: Characterising Stakeholders and Defining a Decision–Making Process. International Journal of Critical Infrastructures (IJCIS)

Sajeva, M. and M. Masera (2006). *A strategic approach to risk governance of critical infrastructures.* International Journal of Critical Infrastructures (IJCIS)

Sajeva, M., A. Stefanini and M. Masera (2006). *Risk Governance of the Electric Power System in North America: New Strategies for Facing Technological and Economic Changes*. Technical EUR Report Nº 22288 EN; Ispra, Italy, European Commission JRC.

Sajeva, M. (2005); The Technological Risk and Uncertainty in Governance and Economic Development (EUR 21548 EN)

Sajeva, M., D. Gatelli, S. Tarantola and Hugo Hollanders (2005); Methodology Report on European Innovation Scoreboard 2005, European Trendchart on Innovation

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1.1 The research problem

Historically, human development has produced changes on the environment without acknowledging the related criticality, complexity and importance of those changes early enough (Vitousek at al., 1997). Vitousek et.al. (1997) continues that population growth and the increased use of Earth's resources have caused the transformation of landscapes, with a loss of biodiversity, changing ecosystems and the fragmentation of land, even beyond the directly altered area.

These changes have been so rapid that *«we are changing Earth more rapidly than we are understanding it»*; statistical analysis has indicated that the transformation or degradation of land by humanity has affected up to 50% of the total existing land (Vitousek et al., 1997). As reported by Lipschutz (1996: 4), *«rather than seeing environmental change as solely a biogeophysical phenomenon ... we should also think of it as a social phenomenon»*. According to Evans (2012: 1), the problem of sustainable development is a social one, as it concerns human beings and the rules set for their own development—i.e. the adequacy of the governance of society for its pursuit. These arguments offer a useful starting point for this thesis and the identification of the research problem, which is the failure of social systems to create governance structures, and supporting frameworks, that adequately address the issues associated with the delivery of sustainable development.

1.2 The complexity of sustainable development and the importance of participatory governance

On March 20, 1987, the Brundtland Commission of the United Nations provided a definition of sustainable development; this has been taken as a starting point for the formation of many international agendas: *«sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs»*. (WECD, United Nations General Assembly, 1987). Sustainable development can be also defined as development that would produce prosperity, for the present and the future (Jackson, 2009: 16).

Rapid technological development, and the liberalisation and deregulation of markets, extended at the global level, have increased uncertainty as the interdependency among infrastructures and the propagation of social and environmental impacts, crossing state borders, reached an extent that was earlier unknown. This has increased systems' vulnerability and highlighted the growing importance of risk governance (Georghe, Masera et *al.*, 2007). The lack of integration of economic, social and environmental objectives, in a holistic vision of sustainable development (Barnes and Hoerber, 2013) coupled with the existence of impacts and interests that are global, calls for new governance approaches that cross borders and cover different aspects of sustainability.

The concept of governance, in Evans' (2012: 4) understanding, constitutes a third way between market and state and incorporates them into a broader process for achieving common goals with the participation of actors and stakeholders. Setting these aims involves linking together two main concepts, 'needs' and 'limits' (Meadowcroft, 2013). For this purpose we can refer to Sen's argument that human development *«as an approach, is concerned with what I take to be the basic development idea: namely, advancing the richness of human life, rather than the richness of the economy in which human beings live, which is only a part of it»* (Sen, 1998). According to Mahbub ul Haq, founder of the Human Development Report, *«the basic purpose of development is to enlarge people's choices. ... The objective of development is to create an enabling environment for people to enjoy long, healthy and creative lives»* (UNDP website, consulted on 16.08.2013). Development has also been identified with *«a process of expanding the real freedoms that people enjoy»* and the *«promotion and expansion of valuable capabilities»* (Sen, 2000).

The goals of human development presented in Sen's vision identify a conception of development that is multi-dimensional; however, in the vision of development as freedom, human capabilities have to be enabled within the limits and constraints of a finite ecosystem on the one hand and of the world's population on the other hand. As Jackson argues (2009: 7), human freedoms should be seen as 'bounded capabilities'.

1.3 The need for improved governance tools

As previously discussed, in order to proceed in the direction of sustainable development, human societies require governance systems and structures that are designed for the achievement of prosperity through the enhancement of human capabilities within environmental limits (Jackson, 2009: 7). Griffin (2013) argues that current approaches for meeting human needs are invariably based on the growth in production capacity (and the free markets that build on it) and often ignore the evidence about the negative effects it produces. Above a given level, and particularly in mature economies, additional increments of economic growth and wealth do not necessarily produce better quality of life (Prieto and Slim, 2010: 53, as cited in Slim, 2013). As Schumacher (1973) reports, reliance on the sole methodology of economics invariably ignores the dependence of humans on the natural world.

Therefore, in order to reflect a concept of governance for sustainability, alternative approaches could help by building capabilities, according to Sen's vision of *«getting-by with a little assistance»* or 'GALA' (1997), within the boundaries of the environment, the social conditions and the resources available (Jackson, 2009: 35). In an attempt to overcome the gaps of current governance and related evaluation tools for addressing the 'holistic' nature of complex systems and environments, a concept of governance for sustainability will be outlined in the following thesis; this will be supported by a methodology of social learning that reflects its multiple dimensions and the interactions between them.

1.4 Governance for sustainability through social learning

Social learning has been defined as an emerging and multi-disciplinary concept, involving social psychology, adult education, as well as planning and international development (Johnson et. al., 2012). Johnson explains that social learning, starting from studies of individual cognition and learning, expanded to experiences of learning through interacting groups and organizations. The concept of social learning is given strategic importance for the sustainable management of complex social-ecological systems, in order to understand the mechanisms that are at the basis of effective participatory environmental management processes (Steyaert and Jiggins, 2007). Examples of investigation on social learning can be found, among the others, in fields such as community forest management, water resources, use of natural resources, wildlife management and environmental risk assessment (Johnson et. al., 2012). This is because, as Johnson continues, learning among groups fosters adaptive capacity to cope with social-ecological complexity and to respond to an uncertain future. Therefore, social learning has a central role in adaptive management (Holling, 1978) and occurs when group interactions are able to change individual knowledge and understanding; individual learning however influences and informs knowledge and actions at the level of the group (Reed et al., 2010). This concept is useful to address the issue of systems' uncertainty discussed below (sub-section 2.4) in relation to subjectivity and objectivity. As social learning emerges among groups of individuals sharing differing knowledge and experiences, it involves the revelation and integration of often contrasting viewpoints (Mostert et al. 2007) for the construction of shared and informed visions (possible and more objective future scenarios), as well as the understanding of the diverging views (subjective perspectives). Social learning is both input and outcome of effective cooperation (Berkes 2009), through which individuals build awareness of others' understanding of the reality, and are enabled to evaluate alternative ideas and experiences (Johnson, 2012). Social learning transforms individuals into a community, sharing a common goal (Webler et al. 1995), in order to undertake collective action (Wenger 1998, Röling 2002). This is why, throughout this thesis, participatory social learning will be considered to be of major importance for the development of a methodology that can reflect a more holistic and systemic vision of governance for sustainability through an enhanced understanding of possible and desirable alternative futures. This will be pursued through the definition of policy actions or operational measures that are designed for specific contexts, and, following Bell's concept of Information System Design (2014), for *«facilitating the accommodation of multiperspectives»*. According to Bull (2013), the complexity of matters concerning sustainable development makes the multi-actor learning process a core insight for its governance.

Three case studies of different Socio-Technical Systems (STS) will be presented and sustainability criteria for each case will be identified to demonstrate the high level of complexity and interconnectivity within and between systems. This will align with a concept of governance for sustainability that is based on the generation of a phronetic view, as further treated in sub-section 5.2. (Flyvbjerg, 2012). Phronesis, from the Greek language 'φρόνησις' translated as 'wisdom', is defined as that particular form of knowledge that is able to address choices. Indeed, the purpose of this research is to induce systemic, phronetic and holistic

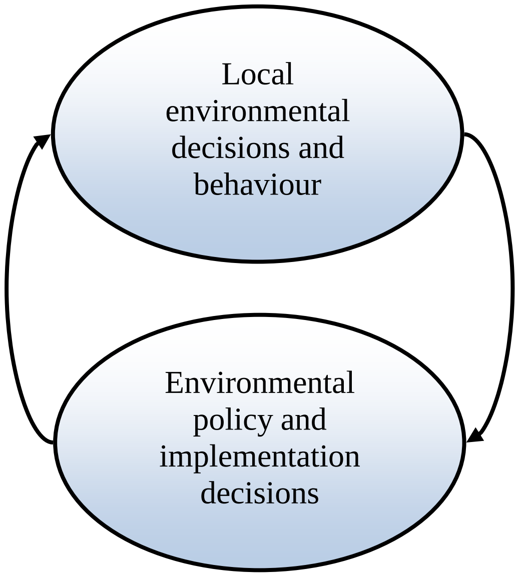


Figure 1. Learning from the "local": moving between policy and environmental decisions (Lemon et al., 2004.

thinking for making more informed choices about possible sustainable futures. This will be carried out through the development of a methodology and framework (Governance Assessment Matrix Exercise (GAME) that will support governance and decision-making about Socio-Technical Systems (STS), by helping stakeholders identify and choose between more sustainable futures and the standards or policy measures that can contribute to their achievement. The tool could help to clarify the contextual objectives and operational actions that are needed to improve the performance of social structures in pursuit of more sustainable development, according to the phronetic research planning approach (Flyvbjerg, 2004). Environmental decision-making, for example, is highly dependent on contexts and cultures (Green and Lemon, 1996); conversely, effective policies, even if not appropriate, can influence local contexts (Lemon et al., 2004). Such debate and interaction, represented in Figure 1 (page 5), is not always able to facilitate learning about how much human behaviour and cultural environments interact with, and affect one another (Lemon et al., 2004).

Moreover, gaps may arise between the understanding of scientists and the recognition of the usefulness of scientific knowledge by its users, often decision-makers, and proposals of dynamic conceptual modelling of knowledge transfer, from mere scientific information to its usability to reduce climate-related risks (Lemos et al., 2012).

Acknowledging the importance of the debate and interaction just described, the GAME is not focused on its potential use within governance meetings. The thesis does not aim to analyse how the social interactions between different stakeholders take place, from an organisational perspective; neither is it oriented to the use of thinking tools to engender sustainable thinking within governance systems. Rather it is intended to provide a tool that can induce a process of social learning about Socio-Technical Systems (STS)' sustainability and can support a governance approach that is holistic and systemic. The focus of the study is more on the adequacy of the tool to evaluate sustainability than on the way this is used by participants in practice—i.e. how the interaction between stakeholders takes place in a context.

1.5 The research approach

From a methodological perspective, the following research has been designed to reflect systems' complexity, according to the concept of Requisite Variety (2014) and the need for a *«repertoire of responses which is (at least) as nuanced as the problems you face»* in order to deal with complex and multifaceted issues. It is argued that evaluation models should adequately reflect and represent the diversity of the issues being treated, (Türke, 2008), in line with the concept that *«every good regulator of a system must be a model of that system»* (Conant and Ashby, 1970). Therefore, the methodology has been built in order to be systemic and holistic, based on the experiences of existing methodologies and able to make use of multiple data-types and collection methods.

According to Maxwell (2005), research questions are the *«heart of research design»* and indicate what the researcher wants to understand in relation to what is already known and why the study is initiated; they help to clarify the goals of the researcher. Maxwell continues, qualitative research implies starting with some preliminary questions that can induce findings arising throughout the research process. *«These early, provisional questions frame the study in important ways, guide decisions about methods, and influence (and are influenced by) the conceptual framework, preliminary results, and potential validity concerns.»* (Maxwell, 2005: 65-66).

According to Maxwell (2005), some preliminary questions can help in the design of a preliminary plan. As described in Figure 2 (page 10), a preliminary idea about the analysis of the literature of Chapter 3 and 4 is formulated. As Maxwell (2005) argues, research questions refer to what the researcher wants to learn; tentative answers, or hypotheses can be drawn from experience, and need to be confirmed and validated. This is why Chapters 3 and 4 are respectively an analysis of the effectiveness of existing governance for sustainability, related evaluation methods and the proposal of a holistic and systemic concept of 'governance for sustainable development'.

1.6 The aim and objectives of the thesis

In light of the previous discussion , the aim of this thesis is

> *to develop a governance for sustainability framework for the social learning and facilitation of more sustainable decision making in Socio-Technical Systems (STS).*

This framework aims to reflect the complexity of the issue at hand and support social learning process according to a more sustainable approach of governance. The intention is to base the framework onto a conceptual framework of governance for sustainability that is systemic and holistic—i.e. is able to represent the sustainability dimensions and their interactions within and between systems.

To meet this aim, the following objectives will be addressed:

a) To examine the literature on systems thinking, sustainable development and governance in order to identify synergies between them and develop a theoretical basis for the framework;

b) To apply an abductive multi-method data collection approach, with reference to three case studies of Socio-Technical Systems (STS) (i.e., the European Critical Electricity Infrastructure (ECEI), the Finnish security system, and the transition pathways towards a post-carbon society within Europe), in order;

c) To derive governance for sustainability criteria from a synthesis of the literature reviewed and case study analysis;

d) To incorporate the sustainability criteria into a generic participatory framework and toolkit; i.e., the Governance Assessment Matrix Exercise (GAME);

e) To undertake a final case study on food security in order to test and modify the GAME framework and method.

1.7 The purpose of the study

The aim described above is linked to the realisation of a framework, one of the many possible, that incorporates important aspects of governance for sustainability. It is intended to contribute to a process of social learning for the pursuit of sustainability and to help overcome some of the issues linking existing social structures and governance initiatives. The main purpose of the study is however not related to the practical issues of stakeholder participation or the interactions between them, nor is it to directly influence decision-making or the organisational and institutional operational activities within formal governance structures. Instead, the thesis proposes an approach to, and framework for, social learning that can facilitate an improved systemic understanding about more sustainable pathways and is rooted in a holistic concept of governance. The aim is to develop a tool that incorporates in itself the insights of sustainable development, and is built upon a concept of governance for sustainability for supporting decision-makers with an evaluation which is multi-dimensional and able to represent the multifaceted issue of systems' sustainability. This is why the design of the framework, although realised through the contribution and the participation of a large number of actors and stakeholders (the empirical case studies), is founded on a robust concept of governance for sustainability that derives from in-depth and multi-disciplinary literature analysis on socio-economics and sustainable development.

The final result, the GAME framework, will have to be implemented within formal institutional activities and with the participation of wide communities of stakeholders. However, the analysis of the possible institutional arrangements and the interactions between the participants within them is a further development that goes beyond the aim of this thesis.

1.8 Designing the thesis structure for the aim of the research

As mentioned above, the development of the participatory framework is based upon an approach to governance for sustainability that is holistic and attempts to represent system complexity. The purpose of this study, as represented by the aim is therefore two fold; firstly to combine the literature on systems, sustainability and governance in order to identify those attributes that influence decision making with regard to sustainable development and secondly, to generate a framework (GAME) that might enable decision-makers to incorporate these attributes into their deliberations. While it is recognised that this is one of many such tools, all with their respective merits and problems, the GAME is intended to build upon, and enhance, the social learning of participants through an appreciation of complexity and uncertainty.

In order to pursue its aim and objectives, the thesis will be structured as described in Figure 2 (page 10). First, the literature analysis will investigate the most critical aspects of Socio-Technical Systems (STS) and the adequacy of current more conventional social structures and arrangements (i.e. mainly legislative systems and markets) for pursuing their sustainability and whether possible gaps arise (Chapter 2). In relation to widely advocated governance approaches for pursuing STSs' sustainability, the adequacy of current initiatives and evaluation schemes are discussed in Chapter 3. In Chapter 4 the identification of key gaps in legislation, markets and governance initiatives will support a conceptual framework of 'governance for sustainability' that could better reflect the complexity of STSs. The methodological approach is then described in Chapter 5 with three exploratory case studies of very different socio-technical systems presented in Chapter 6.

The participatory framework is then modified through a synthesis of the literature and case study analyses in Chapter 7 and tested and validated in Chapter 8 through an additional in depth case study of food sustainability and security. The final chapter will discuss the contribution to knowledge and impact of the research, as well as future challenges and research arising from the study.

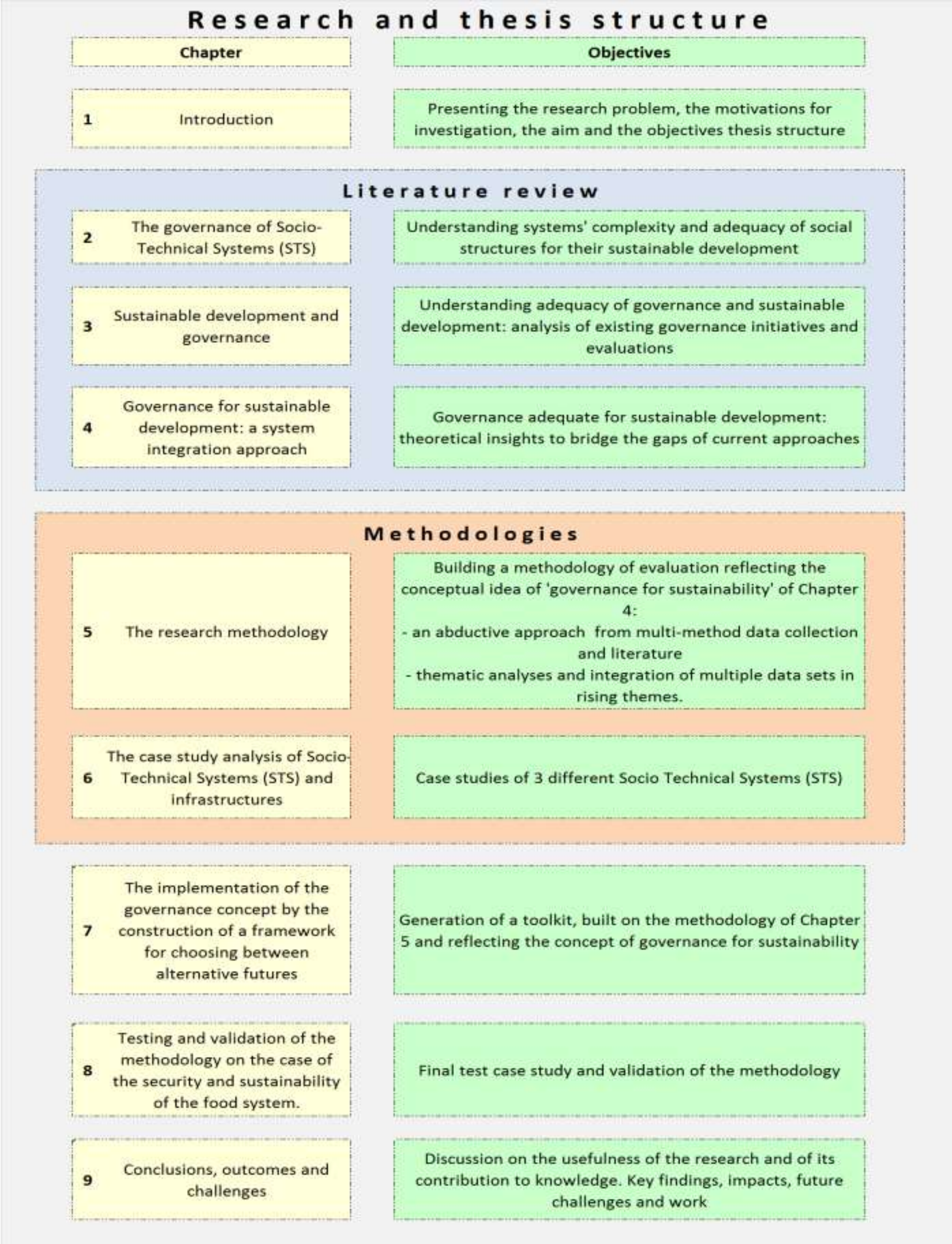


Figure 2. The research and thesis structure.

2 Social structures and the sustainability of Socio-Technical Systems (STS)

Objective	To provide an analysis of the critical factors that influence how social structures address the sustainability of Socio-Technical Systems (STS).
Content	2.1. Literature analysis for the development of an evaluation framework 2.2.The systemic approach 2.3. The complexity of Socio-Technical Systems (STS) 2.4. The uncertainty of Socio-Technical Systems (STS) 2.5. Public goods and sustainable Socio-Technical Systems (STS) 2.6. The adequacy of social structures in pursuing sustainable development

2.1 Literature analysis for the development of an evaluation framework

In the following three chapters (Figure 3, page 12) a range of literature is considered to identify the conceptual gaps that might constrain more sustainable decision making in, and enhance the social learning relating to, Socio-Technical Systems (STS).

This chapter will analyse some of the critical aspects of modern STS's and the ability of more traditional social structures—i.e. legislative, regulatory and market structures—to assure their sustainability. It describes the importance of a systemic understanding and how that influences social learning and attitudes to risk and uncertainty. Chapter 3 will investigate the effectiveness of governance policies and some provide examples of where they are more or less successful. Chapter 4 then pulls together the findings of the previous chapters to generate a provisional conceptual framework for 'governance for sustainability'.

2.2 The systemic approach

The literature presented in this Chapter is summarised in Figure 4 (page 14).

The governance of social systems can, in part, be explained by Giddens' social theory of structuration. Giddens describes social systems as constraints and enablers of resources and human agency (Giddens, 1984). Social structures are composed by the *«rules and resources»* in the subconscious of the agents, which determine social actions. These are performed on the basis of the "knowledgeability" of the agents—that is, *«what agents know about what they do, and why they do it»*—and on the constraints, which are the understanding of rules or boundaries of the actions (Giddens, 1984).

The lack of governance arrangements can be referred to as inadequate social structures organising human societies in order to achieve sustainable development goals. In this view,

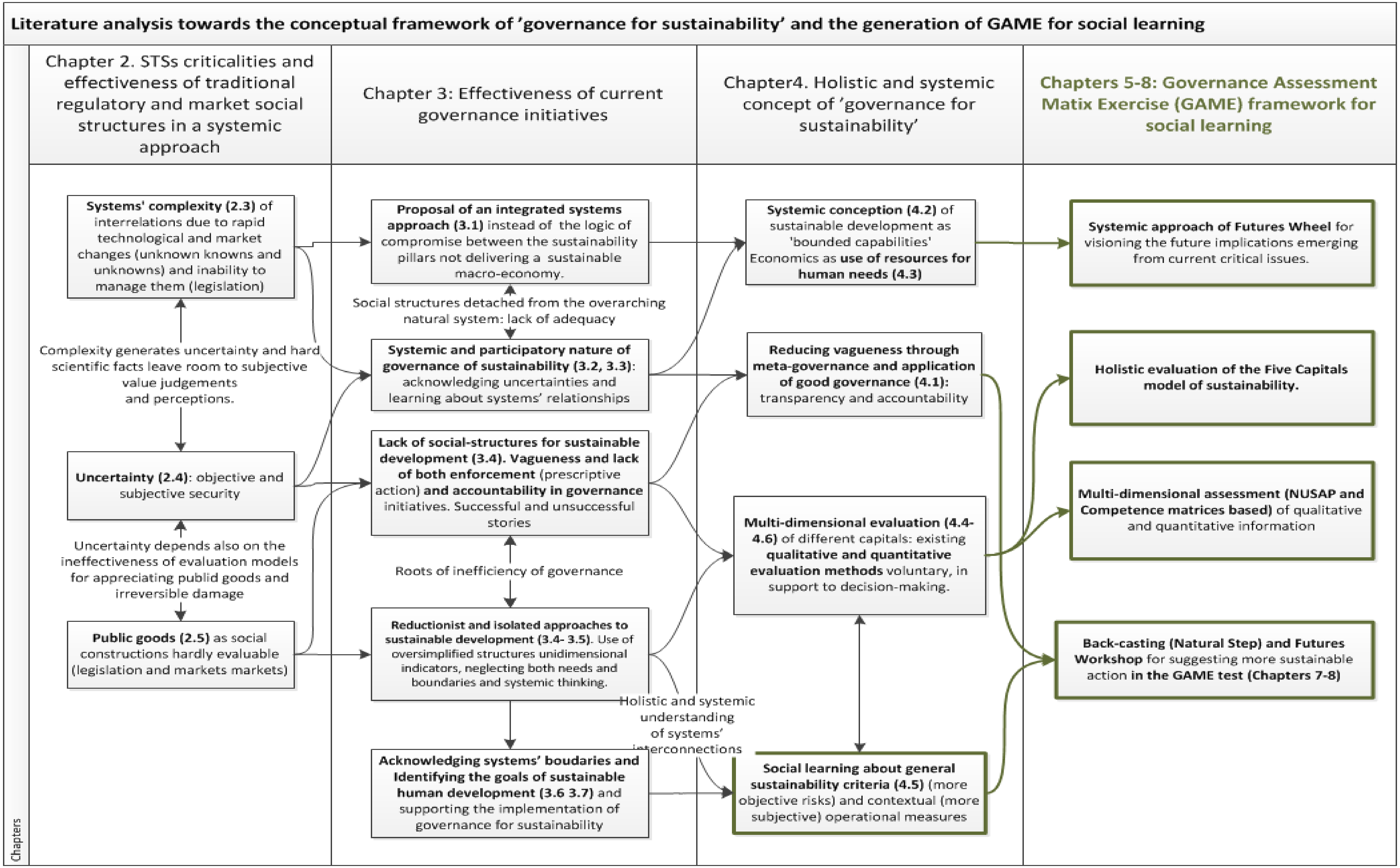


Figure 3. The design of literature analysis for the generation of the GAME evaluation framework

human agency has not taken the natural limits and constraints of environmental systems into due account, detaching from them, while relying on human-made social structures that are based on religious, cultural, socio-economic or legislative constraints. From an environmental perspective, according to Vitousek (1997), there is a need to reduce the impacts of human agency, according to the actual limits, which, in Giddens' terms, can be referred to as constraints imposed by natural systems.

According to Holling (2000), *«[s]ustainable development and management of global and regional resources is not an ecological problem, nor an economic one, nor a social one. It is a combination of all three. And yet actions to integrate all three typically have short-changed one or more»*. This statement can of course be supported by an idea of sustainability as composed by different dimensions and as a result of their mutual interaction. However, saying that sustainability is also an environmental problem may be interpreted in the sense that the sustainability problem is also caused by the environment, which looks questionable if, as Vitousek claims (1997), environmental issues are problems of the functioning of social structures.

In order to investigate the governance of sustainable development from a systemic perspective it is important to refer to literature of systems' theory. *«The basis for any natural law describing the evolution of social systems must be the physical laws governing open systems, i.e., systems embedded in their environment with which they exchange matter and energy»* (Prigogine et al., 1977: 2). This is why systems theory represents a useful approach for understanding the interrelations of human-made systems and structures within ecological systems (Laszlo and Krippner, 1998).

The systems concept identifies *«a group of interacting components that conserves some identifiable set of relations with the sum of the components plus their relations (i.e., the system itself) conserving some identifiable set of relations to other entities (including other systems)»* (Laszlo and Krippner, 1998). According to the same authors, in order to maintain these relations, a system has to be resilient to its entropy, which means developing forces of inertia opposing the increasing chaos. According to the second law of thermodynamics, *«entropy always increases in any closed system not in equilibrium, and remains constant for a system which is in equilibrium»*. (Bullock & Stallybrass, 1977: 634, as cited in Laszlo and Krippner, 1998).

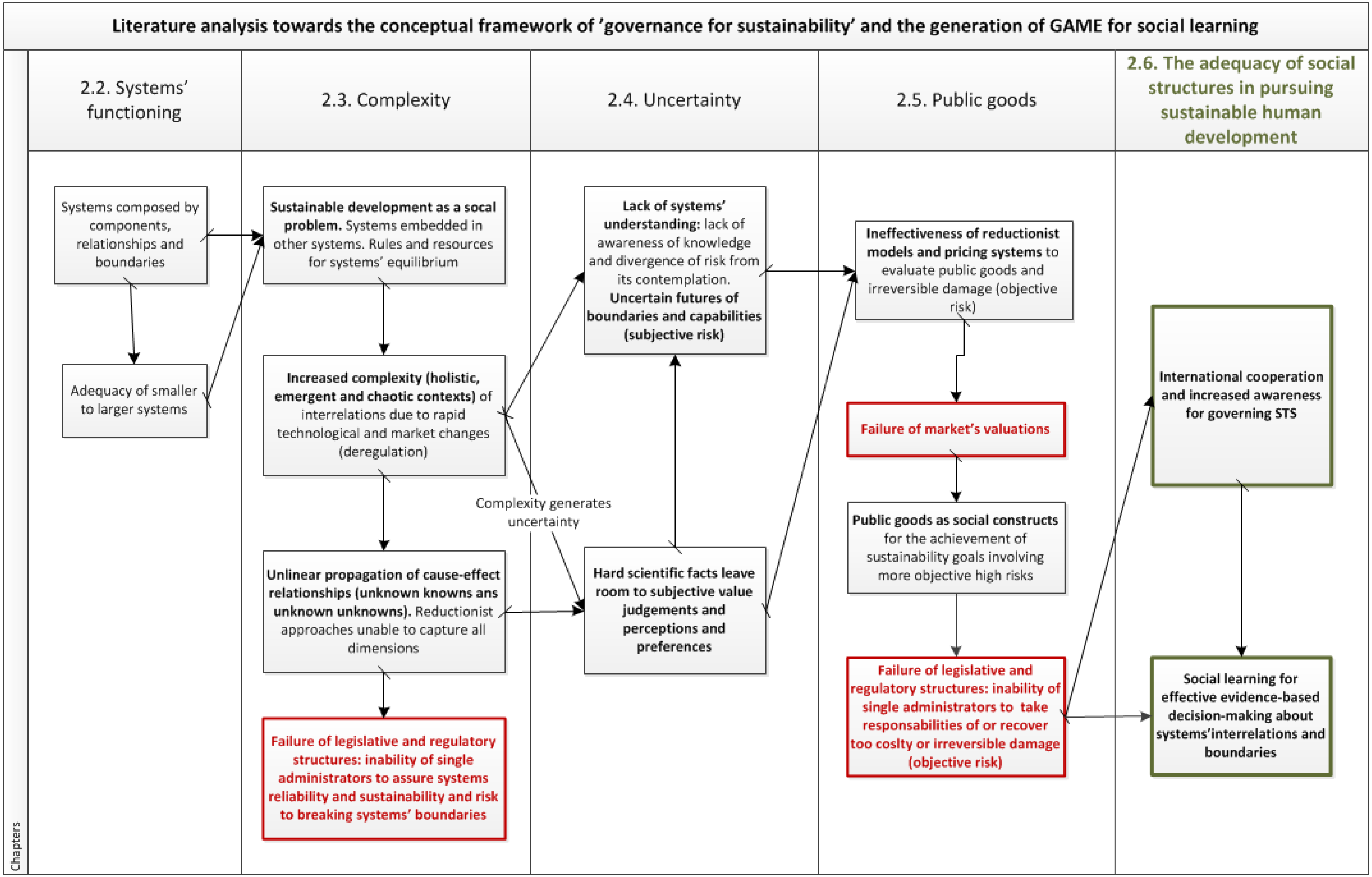


Figure 4. The traditional social structures and the sustainability of Socio-Technical Systems (STS)

In the lack of an external agency aiming at creating relations allowing the conservation of the systems' structures and functions, their energy will be dissipated. This means that whenever equilibrium forces are not present in a system, it will continue to degrade until a state of thermodynamic equilibrium is reached (Williams, 2011). Therefore, a system is by definition functioning within external boundaries. In a system, each of the components impacts the functioning of the whole and is affected by at least one other component (Laszlo and Krippner, 1998). When a system is closed and the internal forces maintain it in equilibrium, it is able to resist the natural tendency of systems towards the increasing chaos generated by entropy (ibid.). While this is only one of the existing definitions of a system, a general agreement exists around the presence of three main elements: the components, the relationships that keep the system together, and a boundary between the internal and the external environment (Williams, 2011: 26). The boundary identifies in a sense a purpose to be achieved (Senge et al., 1994: 90, as cited in Ricigliano and Chigas, 2011); that is, the equilibrium to be maintained.

The concept of the 'Socio-Technical System' was conceived by the labour studies of the Tavistock Institute in London (Emery and Trist, 1960). It focused on the adaptation of humans to the organizational and technical structures of production, according to the principles of Taylorism and Fordism. The human factor introduced by other researchers, such as Elton Mayo (1946), was suggested in individual psychology theories. Nevertheless, the idea of technological determinism, according to which technology is to be considered an autonomous variable, was not affected: industrial sociology held the conception that the mental and social conditions of human work had to adapt to the established technical structures. The Socio-Technical System (STS) identified the interrelations between humans and machines, in order to define the technical and social conditions of work that would make it possible to pursue suitable objectives of efficiency and humanity at the same time. Such an idea of adapting the social aspect to the technological one, in order to first and foremost meet the economic demands of single actors, cannot be supported without taking the consequences for other dimensions into account, especially according to the principle of adequacy of smaller to larger systems (Scott Cato, 2009). The exploitation of natural resources, as well as the need for humans to adapt to technical systems, responded to the logic of the traditional economic paradigm based on economic growth as able to solve all problems and work in all places and times. In this view, development has to go beyond the simplified models of supply and demand and to give answers to people's needs and concerns (Scott Cato, 2009: 2). The systemic element remains in the analysis of the complexity of the interrelations in their real and practical manifestations, rather than in the focus on different aspects as separate elements. A system therefore identifies a set of elements and the relations between them (Ropohl, 1999). The challenge in the study of such systems is the frequent lack of mutual understanding between social and technical aspects, because of the reluctance of sociologists to approach technical matters and the tendency of engineers to underestimate the social dimensions of technical issues. A system, integrating the different perspectives, should be better placed to produce the necessary actions for the transformation of the initial state (existing resources) into goals. Socio-Technical Systems (STS) are indeed characterised by a dynamic interaction of social and technological dimensions. While the technical aspect of a system, taken as a historical reference, is related to established (static) technical characteristics, a perspective of its development identifies dynamic processes towards new technological achievements and solutions, which are a source of uncertainty, subjective perceptions and value judgements about risk and opportunities. This is because, as Geels reports (2011), environmental problems such as climate change, loss of biodiversity or resource depletion, are very likely to trigger great societal challenges for a plurality of stakeholders; thereby, the consideration of the multi-level interactions between technology, social and cultural aspects, policies and economics becomes necessary. In order to analyse the adequacy of current social structures to address Socio-Technical Systems' (STS) sustainability according to this systemic perspective, it is necessary to understand the most critical elements of STS and to understand whether societies are able to guarantee the sustainability of Socio-Technical Systems (Evans, 2012).

2.3 The complexity of Socio-Technical Systems (STS)

According to Complex Systems Society (2014), a "complex system", in general terms, identifies any system that is composed of a large number of parts that are heterogeneous and interact to form multi-level collective structures. Natural systems are described as being complex as they are constituted by highly heterogeneous parts, such as bio-molecules, living cells, ecological systems as well as human social systems, and even advanced artificial systems built by humans themselves, such as critical infrastructures (e.g. large-scale information technology or electric power infrastructures) (ibid.). The characteristic of complexity manifests in the interconnection of systems with other systems or sub-systems at various levels (Gallopin et al. 2001, as cited in Funtowicz and Ravets, 2003) and in the non-linear unpredictable propagation of cascading cause-effect relationships between them, thereby generating intricate chains which can hardly be identified (Funtowicz and Ravets, 2003). Complicated systems are characterised by intricate and hidden relationships among their parts, as well as multiple 'right' solutions; however, the cause-effect relationships are perhaps difficult but known or knowable (Quinn Patton, 2011). On the other hand complex systems manifest high levels of uncertainty and a lack of agreement. As reported by Snowden and Boone (2007), complicated systems still remain in the domain of the 'unknown knowns' (we know that we do not know), while complex systems reveal the presence of 'unknown unknowns', meaning that we do not know that we do not know. *«While other large systems can be described as merely 'complicated', the reference to complexity identifies a context which is holistic (i.e., the whole cannot be understood by the mere accumulation of its parts), emergent (i.e., high level patterns derive from simpler rules at lower levels), and chaotic (i.e., nonlinear behaviour sensitive to initial conditions)»* (Kastenberg, 2005). The high complexity of a system therefore identifies elements of interconnectivity and/or interdependency among a plurality of contexts/actors, characterised by the absence of linear cause-effect relations and unmanageability at the individual level, due to the spreading of systems beyond the power of influence of the responsible actors.

This condition of complexity is particularly relevant due to rapid technological development, while social structures, which should keep systems in equilibrium, remain anchored to old patterns or develop at a much slower rate. The problems inherent in complex systems have mainly been represented by reductionist approaches in which phenomena are described as isolated occurrences, as detached from other parts (Morgan, 2005). This leads, according to Morgan (2005), to a separation of deterministic and predictable contexts, which ignores the most critical factors of human systems resulting from the interrelation between their components so that tracing back the changes in the composing parts and evaluating the sensitivity of a system to the changes in the initial conditions might become challenging. This systemic interconnection creates two-way impacts (Complex Systems Society, 2014): first, emergent features arise from the interactions that are produced at a lower level and global conditions impact the lower levels themselves (the so-called immergence). However, complex systems are often so robust as to absorb even large-scale and multi-dimensional perturbations, thanks to their inherent capacity to adapt and maintain their stability; i.e., their resilience (treated later in more detail in sub-section 3.2).

Secondly, a characteristic of complexity (Complex Systems Society, 2014) is the variability of impacts in relation to place and time, which increases the difficulty to determine theoretical models for describing their behaviour and for exerting control. The relevance and scope of systems may well be the concern of very different scientific fields that possess more or less divergent perspectives and also adopt different models of analysis, often limited to single components of the system. Interdisciplinary, integrated and participatory approaches, looking at contextual situations, are thus required. There is a need to understand and learn the relations between lower and higher levels, and between the individual components and the whole of the collective organisation, in order to design structures for their governance (ibid.). The case studies presented in Chapter 6 will focus on identifying examples of these components and their interaction at different scales.

As Laszlo and Krippner (1998) report, the General Evolutionary Systems Theory describes how human societies evolve by continuously converging at higher organisational levels, and, by intensifying their interactions, in terms of flow of people, energy or goods, transcending the formal boundaries of the social system itself. Historically, many STSs have been physically and logically isolated systems (often at a national or even sub-national level, e.g. the case studies described in Chapter 6) with limited interdependence but also limited vulnerability related to equipment failure, human error, weather and other natural causes. In many systems, technological advances and the development of information technologies in particular, as well as the deregulation and liberalisation of markets within open societies and economies, have generated great improvements in the efficiency and quality of services. However, these developments, constantly increasing the degree of interconnection within single systems and between systems, have also generated additional and more complex vulnerabilities (Sajeva and Masera, 2006). In particular, the rapid development of information and communication technologies and their influence on human societies have generated an incumbent need to develop appropriate solutions for facing the increased complexity (Complex Systems Society, 2014).

According to Morgan (2005), human systems become over time more open and interconnected, which can be a source of both support and threat. The author specifies that systems' improved development typically implies greater complexity, so that during the last fifty years, the health care, judiciary and education systems of most countries have growing problems relating to their management.

As mentioned in Chapter 1, the high complexity of a system may result in a situation where the plurality of contexts and/or actors as well as the absence of linear cause-effect relations between them causes the system to spread outside its boundaries and impact other systems. This high complexity compromises the responsibility and interventional power of single actors, private and public, because the impacts exceed their range of action or responsibility. Neither national states nor isolated administrators are entitled to intervene by setting policies or regulatory standards upon systems exceeding the national borders (i.e., involving seas, rivers, air or other kind of infrastructures); they neither have a comprehensive understanding nor can they effectively respond (Gheorghe at al., 2007).

As for the changes humans have caused on the environment, *«these related changes have locked the global economy and global ecology together in new ways. We have in the past been concerned about the impacts of economic growth upon the environment. We are now forced to concern ourselves with the impacts of ecological stress - degradation of soils, water regimes, atmosphere, and forests upon our economic prospects. We have in the more recent past been forced to face up to a sharp increase in economic interdependence among nations. We are now forced to accustom ourselves to an accelerating ecological interdependence among nations. Ecology and economy are becoming ever more interwoven locally, regionally, nationally, and globally into a seamless net of causes and effects»* (UN, 1987: 13).

This links the need for systemic thinking, to as a form of social learning, to sustainable development. Glasser (2007) mentions the existence of a gap between societies' aims of sustainable development and the actions realised for their pursuit in ordinary practices. He refers to the *«seduction of material affluence and the corresponding failure to recognise, appreciate, or effectively respond to the predicament of our seemingly interminable quest for ever greater consumption and its potential to undermine the ecological and social basis of our existence»*. Environmental concerns are not followed by effective actions affecting lifestyles, behaviours and decisions; reductionist views and models are invariably unsuited for representing complex systems as they remain unaware of important aspects and uncertainties (Glasser, 2007).

In a globalised, deregulated context, characterised by rapid technological development and continuously growing long-distance interactions through a variety of networks, an analysis taking into account the complexity of systems is required, especially when considering the relevance of these systems to sustainable development at different geographical, societal and environmental scales (Complex Systems Society, 2014).

Uncertainties are, in this vision, not elements to be avoided, but instead elements to be included in order to deliver information about the quality of scientific knowledge and the dependence on individual and contextual aspects. According to Morgan (2005: 6), *«[r]eductionism is fundamentally about exerting control over people and processes. But in applying these techniques to human systems, it can undermine the very objectives that participants are seeking ... The reliance on reductionism is creating the fiction that prediction and control are workable approaches to dealing with complex systems»*.

As described in the next sub-section, the characteristic of complexity of the cause-effect relationships typically generates such high uncertainty that cannot be captured or explained by oversimplified models, which merely try to explain problems once at a time and do not consider the multiple, delayed and often hardly acknowledgeable causalities. In order to survive in a complex environment, systems need to develop and change according to the changing conditions, as previously reported, and resist natural entropy forces by adapting to contextual places and times. The more uncertain the evaluation of the impacts in terms of probability and consequence, the more room it leaves to the subjective evaluation of risk (Sajeva and Masera, 2006; Morgan, 2005) as more specifically described in the next sub-section.

2.4 The uncertainty of Socio-Technical Systems (STS)

The high uncertainty that is evident in Socio-Technical Systems (STS) is mainly related to the absence of 'hard' scientific facts, which in turn lowers the quality of scientific information (Funtowicz and Ravetz 1990, 2003) and leaves room for 'soft' subjective value judgments according to the different perspectives of the stakeholders involved. These concern in particular individual perceptions about subjective risk valuations and individual security perceptions, as well as the valuations on the desirability of alternative futures. This lack of clear solutions for the functioning of systems decreases the quality of scientific information (Funtowicz and Ravetz 1990, 2003) because contextual, cultural and individual factors can hardly be grasped by deterministic and predictive rules.

Sustainability issues provide many examples in which science is not able to give certitude about possible future implications and risks (hard scientific facts) so that, all possible views represent legitimate preferences. However, risks associated to the sustainability of systems usually have a high relevance for the security and sustainable development of Socio-Technical Systems (STS), as well as for ecological systems, and include the possibility of producing irreversible impacts. For this reason understanding complexity, reducing uncertainty, and accommodating the preferences among a plurality of stakeholders (freedoms and capabilities), in consideration of the shared elements of objective risk (boundaries or constraints) assumes a particular relevance. Actually, the more technical and objective definition of risk as «*the combination of the probability of an event and its consequences*» (ISO and IEC 2002) is challenged by those subjective elements of perception defined by the psychometric approach (Slovic and Weber, 2002), as well as by the Cultural Theory of risk (Douglas, 1985). As Giddens holds (Linsley and Shrives, 2009), according to the deterministic notion of risk, the assessment of risks should be the prerogative of experts, who would be the only ones having the scientific knowledge to evaluate the related impacts. This rationalist view maintains that non-experts would base their choices only on the evaluations given by experts. As Wynne (1996) however reports, individuals typically construct their risk knowledges naturally, thereby rejecting Giddens' vision of trust and blind acceptance of experts' views. They create their risk vision through the experience of life without necessarily comparing the visions of different experts (Wynne, 1996) and often actively question experts' credibility (Lupton, 1999). Due to the stakeholders having multifaceted visions and belonging to different socio-economic contexts, their risk perspectives often diverge substantially, as treated in the Cultural Theory of Risk (Douglas, 1985) and put in the context of multi-stakeholder systems: «*risk perception depends on social structures ('ways of life') that generate attitudes towards the world ('cultural biases')*»; a concept supported by Dake (1992) as well.

As Slovic (1999) argues, a risk analysis involves both scientific and political factors as risk perception involves values, processes, powers and trust. As will be reported later from a stakeholder assessment performed in connection with the case study of the European Electric Power Infrastructure System (ECEI), the multiplicity of stakeholders generates a number of visions, concerns and risk perceptions, which depend on the backgrounds, interests and personal sensitivities of the said stakeholders. Perceptions of risk are in fact very influential in the decision-making of different individuals, so that conflicting ideas might easily rise between technical experts vs. the general public (Slovic, 1987), men vs. women (Finucane, Mertz, Flynn, & Satterfield, 2000; Flynn, Slovic, & Mertz, 1994; Weber, Blais, & Betz, 2002), as well as between single individuals with different cultural backgrounds (Weber & Hsee, 1998, 1999).

A common perception of risk for all human beings or social groups can therefore be questioned with stakeholders making their own choices about what represents a risk for them (Thompson, Ellis and Wildavskv, 1990). According to Slovic and Weber (2002), risk can be classified as a hazard, probability, consequence or potential adversity. For this reason, it is important to make the risk explicit by understanding it in its different contexts. For instance, in the debate about the risks of nuclear power, misunderstandings may arise between different stakeholders: while experts traditionally refer to the product of probability and consequence, the public rather focuses on the disaster potential (Perrow, 1984).

The probabilistic technical definition of risk, as the product of probability and consequence, defines an objective vision not adequately taking into account the question: 'risk for whom'? This is why the 'qualitative' contextualisation of the evaluations is important in order to understand the concrete potential of the harm to a given social context or individual. *«The purpose of risk characterization is to enhance practical understanding and to illuminate practical choices»* (National Research Council, 1996).

Part of social science, in light of the previous argument, rejects the notion of 'objective risk', by arguing that the objective characterisation of the distribution of possible risk effects is incomplete or even misleading. The nature of risk would indeed be subjective (Krimsky & Golding, 1992; Pidgeon et al., 1992; Slovic, 1992; Weber, 2001b; Wynne, 1992). As Slovic and Weber (2002) argue, risk *«does not exist "out there," independent of our minds and cultures, waiting to be measured»*. This interpretation is in total contraposition with those who consider risk to be a matter of measurable and empirical evidence (Lowrance, 1976: 95). The subjectivity or objectivity of risk is discussed by Campbell (2006), who argues that understanding risk depends upon an appreciation of culture and individual perception.

The notion of risk as a feeling of fear or anxiety is indeed important for the protection from harm (Loewenstein et al., 2001). Nevertheless, a high risk may well remain as such even if an individual perceives it as being unlikely or of a low magnitude; this may be due to (over)under estimation or lack of knowledge. This lack of awareness or knowledge determines, in Campbell's terms (2006: 231), a divergence of the risk from its *«contemplation»*. This availability of knowledge and its receptivity (ability and willingness to use) is important in the definition and exploration of sustainability pathways; social learning about the implications of future choices.

This argument is useful to inform two aspects related to systems' sustainability:

1. the contextual analysis and the interpretation of potential futures and decisions relating to them (subjective perspectives of security). This aspect, in relation to the notion of sustainable development as introduced in Chapter 1, links to the need to enable the agency and capabilities, for meeting contextual needs.
2. the more objective aspects about system thinking and multi-dimensional sustainability aspects that are less negotiable for their sustainability (objective security). This aspect is more related to the understanding and learning about the boundaries and the constraints to meet for assuring systems' sustainability, according to Jackson conception of 'bounded capabilities' (2009).

2.5 Public good and sustainable Socio-Technical Systems (STS)

The complexity of Socio-Technical Systems (STS) described in sub-section 2.3, implying increased propagation and entity of impacts involves aspects of security that are more objective, less negotiable and less dependent upon subjective value-judgements, because these refer to the well-being of whole societies and the health of ecosystems. The existence of more objective public interest in the governance of STSs' sustainability leads to the consideration, in the following sub-section, of relevant socio-economic literature on public goods on the adequacy of markets and legislation for their evaluation and their sustainability.

2.5.1 Public goods: valuing nature and market failures

From a traditional economic perspective, public goods refer to those goods that are non-rival on the side of consumption and have non-excludable benefits (Kaul and Mendoza, 2002: 80; Pearce, 1983). The non-rivalry of public goods implies that the use by a consumer does not diminish their utility for other consumers, for instance when breathing air or drinking water. Typically, these goods are not scarce, at least in the short run. The non-excludability implies that a consumer cannot exclude others from their use. The incentive for single actors to invest in the reduction of carbon emissions is low, as they can "free-ride" on the efforts made by other investors, a condition commonly described as spill-over (Graves, 2002). The same would hold for investments in pollution control, made by single countries. In these cases of public goods, according to the mainstream economic literature, a government intervention is justified, because the private equilibrium of price and quantity determined by the interplay of supply and demand diverges greatly from the social equilibrium, which would include all internal and external costs. Market failures also occur in the use of common resources, such as, for instance, fish stocks, water resources and grazing land; that is, resources that are relatively abundant and not privately owned (Graves, 2002). For this reason, the lack of a price and the low marginal cost of extraction for the private actor, often close to zero, generate phenomena of over-exploitation of public or natural goods, thereby reducing the possibility for their use by others. These conditions lead to a situation where the market cannot price the resources in an efficient way, resulting in market failures and thereby providing a clear rationale for policy intervention to improve efficiency. According to the mainstream economic approach, the intervention is only justified when the benefits exceed the costs, measured in monetary terms (Graves, 2002). As for activities directed at the reduction of pollution, they are rarely, if ever, cost-free processes; the question becomes one of public interest. Economic literature indeed assigns private goods to the market and public goods to the state, maintaining that the state should intervene only when markets fail (Kaul and Mendoza, 2002: 80). To make an example related to the case study of the electricity infrastructure, only in recent times the development of modern energy generation technologies has allowed to increase their efficiency so that public intervention, for an economic perspective, was no more needed and market were able to work efficiently. However, the sub-sections that follow will present other aspects that can determine the public nature of certain important goods, in force of evidence-based considerations (e.g. irreversibility of damage or important function for the life of ecosystems).

2.5.2 The pricing and valuation of public goods

A first consideration is that market failures are not only related to the market offer; individuals are not enabled to make choices on the use of public goods or natural resources, even when these could be evaluated, because their enjoyment cannot be separated and purchased in an exclusive way. These have to be delivered to the whole society. Even if some individuals would like to renounce their private goods in order to save species, preserve habitats or produce air quality improvements, their isolated decision would neither affect the actual consumption of these goods (Graves, 2002), nor produce any income. This is because the level of consumption of public goods is affected only by the common choices of larger social groups, local communities of individuals, or even global societies, which requires collective decision-making. This reveals a failure of the markets not only on the side of the offer (i.e. the convenience for the investor, the output market failure) but also on the side of demand (the input market failure) (Graves, 2002). In short, only collective demand can deal with collective public goods.

Another aspect that seems important is the valuation of public goods. As the UN reports (United Nations General Assembly, 1987), economic development should be based on the resources available. Today the cost of resource depletion is simply related to the cost for their extraction, excluding the cost for their regeneration and losses in terms of possible future revenue, for example due to the degradation of forests. At the UN level (1987), it was argued that these costs, yielded for instance by losses in air, forests or soil, should be internalised to the national accounts of all countries.

As for the valuation of public goods, and particularly nature, different schools of thought treat the problem. The most common valuation of ecosystems is through aggregative approaches which identify and estimate the value of natural systems by summing up the values of their single parts (Norton, 2012). However, there is seldom a common view on the units of measurement; mainstream environmental economists focus on the actual and possible units that can be used to measure consumption, whereas non-anthropocentric environmental ethicists concentrate on habitats and ecosystems. The approaches tend to conflict and a common methodology for valuing nature is missing.

Environmental economics and ecological economics both focus on analysing the interrelations between economics and the environment. Environmental economics (Van den Berg, 2001) focuses on externalities or external costs, considering the environmental degradation of free natural resources a negative effect that lies outside the market—an effect that is not compensated. Environmental problems are therefore seen from a human agency perspective of optimal allocation of scarce means and resources, including the externalities, according to the traditional Pareto efficiency (an improvement in the welfare of any individual cannot be achieved without a welfare loss for someone else). However, by merely focusing on allocation problems, the problem of dimensioning the scale of economy according to the maximum physical limits to growth has been neglected (Daly, 1992). The approach of environmental economists assigns value in terms of "commodities" that can be produced as ecosystem services and measures the preferences of individuals, their behaviour and *"willingness-to-pay"* (wtp). These costs are considered in the calculation of individual welfares, balancing them against other preferences (Norton, 2012). Even so, economists admit that many natural systems are rarely traded in markets, yet they conserve great value. These aspects are captured by stated preference methods (Krutilla, 1967), also called *"contingent valuation studies"*, to elicit estimates of individuals about the 'wtp' if goods were available through the market (Mitchell and Carson, 1993; Freeman, 2003). In order to evaluate a change in an ecosystem, an aggregation and comparison of the total commodity values available to humans before and after the change would be sufficient. This approach would encourage the use of "Cost-Benefit Analysis" (CBA), and the potential list of all possible commodities might grow significantly. However, as Norton (2012) argues, the method is not reliable for valuing the economic preference of many important aspects of life such as love and spiritual feelings; in consequence CBA has only provided an indication of the possible risks of loss (Freeman, 2003). Economists have attempted in this way to include the overarching environmental pillar into human-made economic conventions and models. So, as van den Berg (2001) argues, environmental economics have assimilated sustainable development to sustainable growth, approaching it by general and abstract models not contextualised according to time and place with their socio-ecological characteristics, which denotes an oversimplification of complex phenomena.

Noting how mainstream economists either took for granted or ignored the principles and the forces governing natural communities (Sagoff, 2012), and acknowledging the difficulties of traditional approaches in the evaluation of goods, during the 1980s, some economists and ecologists promoted a new field of ecological economics (Gomez-Baggethun et al., 2010). Ecological economics confronted sustainability from an interdisciplinary perspective, trying to address the interdependence of economies and ecosystems (Xepapadeas, 2008) by explicit modelling of the interrelations and cause-effect chains of systemic impacts between natural and human-economic dimensions, with the objective to reconcile ecology and economics, and *«"right size" the human economy for its natural infrastructure»* (Sagoff, 2012). Ecological economics therefore involved a wider understanding of ecosystems and focused on a stronger concept of sustainability aiming at preserving natural capital. Ecological economists rejected the idea of substitution of natural capital by human-made capital and considered the economy a sub-system of the ecosystem (van den Bergh, 2001). In theoretical terms, they considered the carrying capacity of the Earth a central issue, rejecting the neoclassical approach of considering the environment as part of the human economy. Ecological economics is concerned with renewable resources like fish, forests and water (Clark 1990; Neher 1990), and is thereby quite close to resource economics (Turner et al. 1997). Thus, this approach goes much beyond the narrow vision of environmental economics of pollution, considering the economic-ecological cause-effect relationships involving hydrological, chemical, physical and ecological dynamic processes within a longer time horizon (van den Bergh, 2001). In this way, ecological economists consider the absolute physical limits to growth, with particular attention to the situation of developing countries and their specific contexts. In contrast with the neo-Malthusian catastrophists, they focus on a systemic perspective, which does not simply consider food production or material resources, but instead rather looks at the risk of overloading ecological systems beyond their ecological thresholds, involving the risk of their consequent collapse. *«There may be close substitutes for conventional natural resources, such as timber and coal, but not for natural ecological systems»* (Costanza et al. 2002). Ecosystems were described as *«complex, adaptive systems [...] characterized by historical dependency, complex dynamics, and multiple basins of attraction»* (Levin, 1999).

Ecological economics is also closer to evolutionary economics than to neoclassical economics when referring to path dependence, i.e. the economics of scale, which can be reached through technological development, not necessarily corresponding to the optimal in neoclassical terms (van den Bergh, 2001). When historical accidents and irreversibility of changes are also considered, ecological economics looks at *«systems, including markets, as adaptive and coincidental rather than optimal»* (ibid.). While environmental economics are based on efficiency and cost-effectiveness, indicating that more is better, and considering distribution and equity as secondary criteria, ecological economics focuses on basic needs and on the complexity of the interrelations between environmental and social sustainability; i.e., poverty and environmental health. It sees technology as the main factor responsible for the risk of depletion of resources and gives therefore the main role to the precautionary principle and ethics in their evaluations, leaving efficiency in the second order and linking to the objective of distribution. Ecological economics was focused, in fact, on issues of intergenerational equity and irreversibility of environmental change so that the ideas of the uncertainty of long-term outcomes and sustainable development guided ecological economic analysis and valuation (Faber, 2008).

However, even while criticising its predecessors for ignoring the scale of impacts on ecosystems and the limits of the ecosystems, ecological economics was unable to raise awareness about the dynamics by which ecological systems support human well-being and about the ways natural regulatory functions can ensure systems' stability, suggesting how humans can adapt to them (Norton, 2012). Once again, in order to raise awareness about human dependencies on nature, it was chosen to analyse ecosystems' processes in their ability to provide human beings with ecosystem services (Daily, 1997; World Health Organization, 2005) so that ecological economists remained anchored to the standard economic methods of measuring market and non-market values. According to Norton (2012), these services cover three main domains: the provisioning of food and fibres; the regulation, in terms of maintenance of energy flows and systems' resilience; and cultural aspects, such as the values of places. The measurement of these values relies on certain methods, for instance the estimation of the total value that these ecosystem services deliver to human activities (Costanza et al., 1997). Nevertheless, the use of financial evaluations by ecological economists, when detached from the mainstream economic approach, generated confusion about the validity of the different measurements (Norton, 2012). In 1997, the neoclassical utility theory was used in order to calculate *"The Value of the World's Ecosystem Services and Natural Capital"* to be about $33 trillion, in contraposition to the global GDP of 27 trillion dollars (Costanza et al., 1998; Costanza, 1997). In this way, ecological economists joined the mainstream welfare economics in holding the view that «*protecting the environment is a matter of getting the prices right*» (Sagoff, 2012). Other articles later on criticised the analysis, even if the positive potential for making an economic valuation of the global ecosystem was acknowledged (Harris, 2006). Some ecological economists have attempted to consider economics a value-free 'hard science', holding positions of conservation on the basis of «*aesthetic and ethical arguments*» and by arguing that «*conservation must be framed as a moral issue*» (McCauley, 2006). This assumes that nature has an «*intrinsic value that makes it priceless, and this is reason enough to protect it*». For some other ecological economists, value-free economics is generally not a realistic approach (Soderbaum, 2004); Costanza and Daily again argue that the only instrument able to appeal to people and to influence public policies towards the protection of the environment is its economic valuation and pricing (Sagoff, 2012). We can see how, even when considering a systemic approach, orthodox economics remains a strong and implicit ideology (Spash, 2013) also in ecological economics, as they consider «*market-based systems as the best means for the delivery of democratic and free societies*», in combination with technology for problem-solving. According to Sagoff (2012), the political and academic decline of ecological economics, in common with classical economics, is the reliance on mathematical models, which has led to a failure to detach sustainability and an environmental perspective from market mechanisms.

The considerations above reveal some key aspects of public goods:

- Even if the offer of public goods is economically possible and market failures can be overcome, these goods are often collective while demand exists on individual basis, so that a consumer cannot choose alone and the decision becomes collective. In this case, markets fail, as they cannot manage collective transactions. In other cases offer is not existent, for instance of enjoyment of natural environments, which are free.

- There is much debate about how to price goods that are very important for human life and that cannot be produced or replaced once consumed.

For these reasons, in the sub-section that follows a different view on public goods is presented.

2.5.3 Public goods: social constructions upon objective needs

The arguments provided above about the valuation of the environment lead to more general considerations concerning public goods, with a particular reference to the conception of intrinsic value, and to the related social learning and decision-making for more sustainable futures. According to Kaul and Mendoza (2002), the characteristics of goods and resources do not always follow the traditional classification of being private or public, as argued by the economic justifications above. Goods can be private or public according to the characteristics of non-rivalry and non-excludability; however, the decision to assign them to the state or to the market cannot be made only in relation to these two qualities. Kaul and Mendoza (2002) use the example of land; in spite of being classifiable as a private good, land has been in the past and still is often an object of conflict. Regulatory mechanisms have been set up in order to discipline its ownership and reduce the related uncertainty, thereby assigning land to the category of private goods. However, land is often ruled in a different way than other private goods, because some of its uses and functions are non-exclusive, such as grazing and hunting. Very often land is a natural resource, which is in the category of commons, as it provides forests, water and plant and animal species (Barzel 1997; Bromley 1990; Demsetz 1967; Ostrom, 1990). Policy choices are made, for instance, in order to guarantee broad public access to public parks and natural reserves and the purchase of large areas of land, or land with particular value, is often prevented by government.

For the considerations above, private and public goods are often social constructs (Kaul and Mendoza, 2002), designed to regulate the functioning of social systems in pursuit of their sustainability. They thus represent a way to combine the actions of the environmental, economic and social pillars, towards goals of public relevance. So, goods such as security, health, freedom from violence and abuse can be considered public goods. A sketch of national and global public goods is represented in Figure 5 (page 30).

Nevertheless, too often the understanding of public goods relies on a passive approach, assuming that a non-rival and non-excludable good must be public, and that a rival and excludable good must be private even when non-excludable and should therefore be left to the

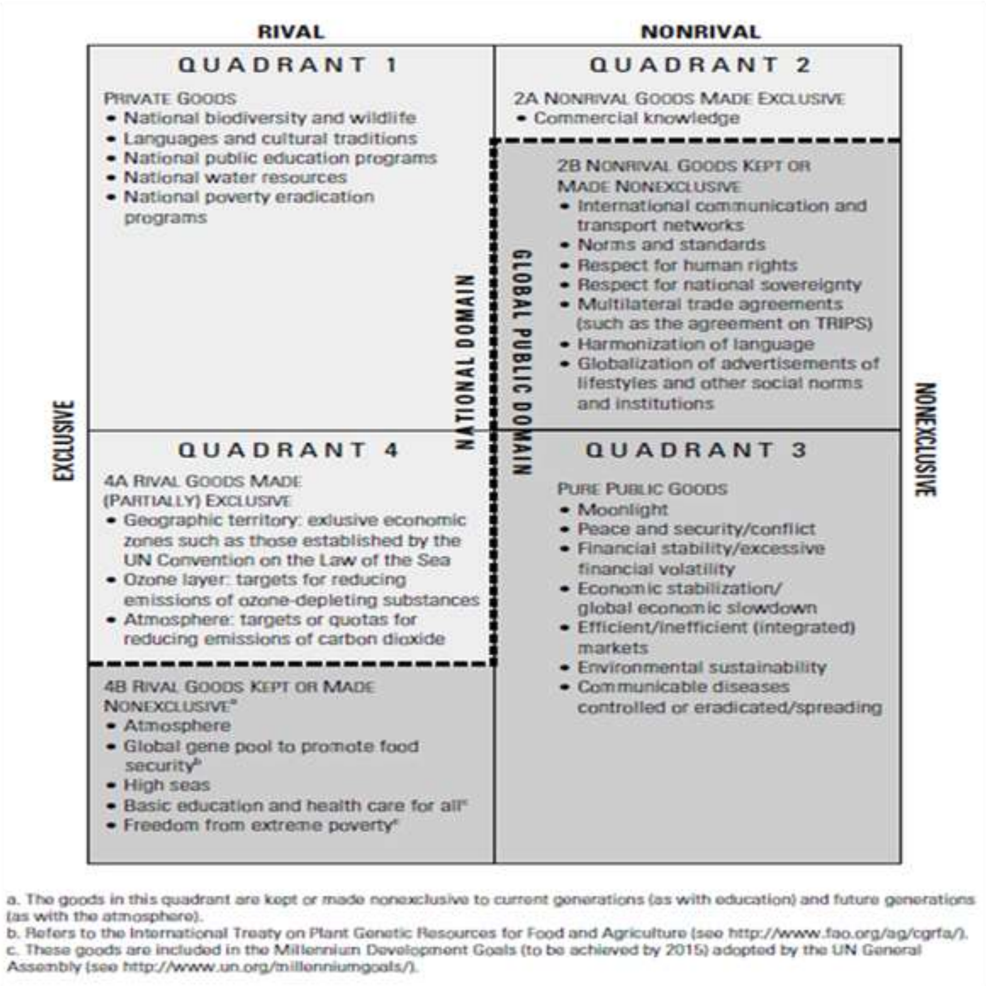


Figure 5. The de facto mix of national goods and global public goods (source Kaul and Mendoza, 2002)

market, thereby not considering the possibility to design them in force of social or cultural arrangements, on the basis of more concrete needs or functions for systems' sustainability. So, even if the provision of control and reduction of public bads (e.g. crime, violence, air pollution) are included in the category of public goods (Kaul and Mendoza, 2002), for example policies for greenhouse gas emissions trading have been put in place, thereby transforming the nature of atmosphere from public to private. In the same way, rapid technological development has allowed overcoming the market failures typical of the energy sector, as identified in the case study of the European Electric Critical Infrastructure (ECEI), by increasing the efficiency of production (Chapter 6).

Efforts are currently being made for the enforcement of effective social and economic governance arrangements. However, the current divisions of private and public domains are not efficient for that purpose. Policies and initiatives have been put in place by the private sector in the name of a sustainable environment, for instance Corporate Social Responsibility (CSR) approaches or initiatives of ethical branding. According to Evans (2012: 114), Corporate Social Responsibility strategies attempt to include sustainability goals into the objectives of enterprises, with the aim to get free from regulatory constraints concerning the assurance of public interest. Actually, market mechanisms, based on objectives of self-interest exclude actions driven by the common interest so that sustainability goals are pursued merely as means through which to build good reputation and achieve competitive advantage (Evans, 2012). Typically, market structures are not able to evaluate all needs or resources—those often very important aspects of human life—within the different pillars. They are simply not designed to manage systems that are too complex, uncertain and characterised by public relevance (often accompanied by the need to provide urgent solutions). As Evans argues, *«by definition markets lack a social conscience and are then incapable of self-regulation»* (2012).

Competitive advantage and capital remuneration are essential to the existence of private corporations operating in the free market. *«Becoming environment-friendly lowers costs because companies end up reducing the inputs they use. In addition, the process generates additional revenues from better products or enables companies to create new businesses. In fact, because those are the goals of corporate innovation, we find that smart companies now treat sustainability as innovation's new frontier»* (Nidumolu et al., 2009). Neoliberal approaches have delegated development goals to the mere functioning of the markets, as side effects of the economic growth itself. However, as Jackson reports (2009: 9) the ability of a privately owned company to survive market dynamics is to adapt by producing not only more efficiently but also by constantly introducing new innovative products. This means understanding the demand that is needed for their commercialisation, through the novelty of markets, individual choices often creating new needs and contributing to building a society that is dependent on consumerism Jackson (ibid.). This is also demonstrated by the ever-increasing advertising efforts, tending to influence people's behaviour towards consumption. In this context, Jackson (ibid.) admits that private companies *«must innovate or die»*—as must the economy as a whole, demonstrated by the need to keep up consumption growth; idea that Jackson (ibid.) defines as the *«iron cage of consumerism»*. In this way, market-related short-term objectives of capital remuneration rarely take into consideration long-term sustainability goals, thereby eventually putting them at risk, *«for the diversion of economic effort and enterprise towards making money out of money and away from providing useful goods and services»* (Scott Cato, 2009).

Private goods are currently used in to limit the damage generated by public bads, such as threats to human security and well-being (Cropper and Oates, 1992), in other words activities of avoidance of harm to basic conditions for human living. Such choices have been at the basis of the privatisation of security services, as treated in the case study of the Finnish socio-technical security system (see Chapter 6). Even if some individuals can, at a certain point, avoid a condition belonging to a public ‘bad’ by this kind of averting behaviour, for instance by buying locks or alarm systems, security remains a good belonging to the public domain and is strictly related to the concept of development (Sajeva, 2012). A common characteristic of many public bads is the inverse relation between the amount of the given service in quantitative terms and the positive utility provided for maintaining the well-being of the users. For instance, the existence of a high number of security services reveals an initial condition of insecurity due to the presence of threats; similarly, a high number of activities for environmental protection can indicate a situation of danger and overexploitation.

Kemp, Parto and Gibson (2005) discuss the unsustainability of current resource-intensive development structures and of market-based measurement models. This because current economic activities are threatening the natural capital and the functioning of ecosystems in an irreversible way (Jackson, 2009: 35), measuring only the value of the transformed goods, without being able to measure the losses in natural value. In fact, according to Kaul and Mendoza (2002), the public or private nature of goods can be planned by design in order to reflect their high or infinite intrinsic value. These authors remark that not all excludable resources are private or exclusive: they may assume public relevance, for instance, in order to ensure the sustainable use of resources. The respect for human rights is also a public good, which is expressly designed by social arrangements and laws. Policies can intervene on goods, which are private, and design them as public, by increasing their availability for all citizens. This is the case of basic education and health services, considered as having an intrinsic value for their relevance in terms of human rights and societal development. This is not just in the spirit of egalitarianism, but also for the private and public benefits that can be delivered by an educated and healthy population (Tobin, 1970).

The presented perspective of public goods as social constructs, to be designed according to their and intrinsic value and high relevance for human life, supports in a way the ethical approach put in evidence by Norton (2012), in contraposition to environmental and ecological economics. The ethical considerations regard the relationship between nature and human structures, as the economic valuation and the so-called commodification of ecosystem services might have long-term negative effects onto the conservation of the biodiversity and of the equity of access to the benefits they provide (Gómez-Baggethun and Ruiz-Pérez, 2011). The aggregation of commodity values introduced by ecological economists in order to value nature finds strong criticism by environmental ethicists, as economic valuation is judged as «*unacceptably anthropocentric*», and based only on the utilitarian view, i.e. the human welfare (Norton, 2012). Environmental ethicists claim that ecosystems have to be protected not because they are instruments for human well-being, because of their intrinsic natural value, in terms of organisms, ecosystems or species (Taylor, 1986; Rolston, III, 1988; Callicott, 1989). According to Norton (2012), the value of physical and living systems should be infinite, as they constitute the habitat supporting the very existence of life of plants and animals, group to which also humans belong. However, he argues, the many ways in which ecosystems contribute to our ordinary existence tend to be forgotten, also because the transformed products hardly remind consumers about what was the price in terms of environmental impact. Norton reminds us that, for instance, «*toilet tissue is transformed trees!*» Norton argues as well, a rational policy for protecting and sustaining the human environment requires our understanding about cause-effect relations. These includes those relations involving the more intangible values, such as those romantic, spiritual or non-instrumental: a walk in the forest, clean air for our health and free time, as well as the perpetuation of its biodiversity, which affects whole Earth ecosystems. This means understanding, learning and recognising the great contribution of ecological systems to human well-being, exceeding the mere production of commodities derived from those systems.

For environmental economics, the action of mitigation is a public good since the risks of climate change are both non-exclusive (climate mitigation provided to one does not reduce the level of mitigation that anyone else enjoys) and non-excludable (the global consequences will not exclude anyone). However, mitigation can be considered as a public good also because of the considerations as mentioned above, including the fact that pricing can be effective only for damage that is actually recoverable and not irreversible. A lost ecosystem or biodiversity could never be brought back again because it is not recoverable and there is no countermeasure able to restore the damage; or, even if there is a countermeasure available, it is not affordable or convenient for anyone, not even for national states or global communities, according to the utilitarian system. In short, the concept of public goods as social constructions can be related to Campbell's concept of a more objective dimension of risk (2006), suggesting more adequate evaluation of their dimensions and social learning about needs to accomplish and systems' boundaries, for informing a more evidence-based decision-making.

2.5.4 The failure of legislative systems

Besides markets, the dominant social structures determining sustainability are legislative and regulatory powers. The market-based valuation seems to be in a clear contrast with the US environmental legislation of the 1970s, which had abandoned market failures theories and embraced, as common law states, *«the belief that one person should not injure or invade the person or property of others without their consent»* (Sagoff, 2012). The Clean Air and Clean Water Acts were in fact promulgated having in mind the aim of protecting public safety and health against hazardous waste and emissions, which represent an invasion of person and property. The principle is clearly in contrast with that of ecological economists because it completely changes the perspective. The goal is the protection of citizens, and therefore their freedom to enjoy good, healthy and safe lives, instead of maximising their utility expressed in monetary terms. In this case, what is to be measured is the level of health and well-being, instead of the utility in neoclassical terms. Focusing on the freedoms that people enjoy, the environmental law is libertarian, as it treats pollution as a threat to be minimised and the health and safety of people as a goal (Sagoff, 2012). The attempt to embed nature into market systems according to utilitarian models fails, as it subordinates the health of nature and the well-being of citizens—namely the sustainability goals—to self-interested mechanisms for a maximisation of the utility expressed in economic evaluation—namely the means for development. According to the utilitarian view, a policy producing economic value but decreasing people's health might be preferable whenever justified in terms of the cost-benefit analysis. In contrast, the libertarian view denies a person the right to pollute and trespass on another person, even when efficient from a utilitarian perspective. As economists Maureen Cropper and Wallace Oates report, *«the cornerstones of federal environmental policy in the United States explicitly prohibited the weighing of benefits against costs in the setting of environmental standards»* (Cropper and Oates, 1992).

Nevertheless, legislative systems can lack adequacy from a dimensional perspective. In fact, a characteristic of many systems to spread beyond the sphere of influence of single administrators, sometimes producing global impacts. This aspect, due to technological and market developments, characterises an increasing number of systems, extending to larger and larger areas. This means that the dimensions of Socio-Technical Systems (STS) and the sustainability problems that are generated may well exceed the power of intervention and the responsibility of single stakeholder actors. Even when considering a good as public and keeping the responsibilities in public hands, risks are sometimes too high to be taken on behalf of entire populations (Masera et al., 2007). Whenever a public good or a natural resource cannot be recovered, nobody can take the responsibility to put it at risk, often because its value is simply infinite. This aspect of the increasing public relevance of systems would call for urgent decision-making in contexts that are deregulated, uncertain in the evaluation of their risk perspectives and complex in the definition of their impacts at a systemic level, whereby a clear contradiction arises. On the one hand, regulatory authorities do not have the power to impose regulation; on the other hand, private actors cannot take the responsibility for impacts that they could not compensate for or damage that they could not repair. These sustainability problems in turn bring to focus the matter of capability to confront and manage them, as neither market systems nor national legislations are able to deal with issues that exceed their sphere of influence. Kaul and Mendoza (2002 :80), specifically report that global public goods *«can be seen as national public goods plus international cooperation»*. In this view, these public goods are also outside the influence of single governments.

The tendency to operate in isolation within one sector, in negligence of economic and ecological interdependences, represents a weakness and reveals the interrelations between the criticality of uncertainty with those of complexity and public relevance. Sustainability in fact requires the enforcement of well-defined responsibilities, due to the great impacts of decisions and changes in the legal and institutional frameworks, for the achievement of the common interest (UN, 1987).

2.6 The adequacy of social structures in pursuing sustainable human development

It would appear from the arguments discussed above that the vulnerability of Socio-Technical Systems (STS) has greatly increased. The characteristics of systems’ complexity, uncertainty and public relevance determined the inability of free markets and national legislation systems to confront Socio-Technical Systems' (STS) sustainability and a need to face it through collective action (Evans, 2012: 6). Rapid technological development as well as market deregulation policies have continuously increased complexity and uncertainty, and in turn, the vulnerabilities of systems to threats not yet known. Objective risk is present, but as scientific evidence is often very complex, uncertain (Funtowicz and Ravetz, 1990; Evans, 2012) or unknown, they leave room to subjective perspectives, with the consequence of making the system unable to react and make decisions about countermeasures that might be urgently needed. STSs' reliability and efficiency levels do not only impact single stakeholders (operators, end users), but instead have a wider relevance for national security and economic development, potentially affecting the well-being of society as a whole in an irreversible way. These risks may compromise the existence of finite resources of infinite value, such as environment, air, water, energy and services necessary for the functioning of human societies, and consequently the sheer existence of human beings. These risks also concern the most basic human needs such as food, security, safety, health, shelter, education and capabilities. The previous discussion has highlighted the risk of environmental degradation caused by human activities and how this interpretation can be extended to the interaction of social systems and sub-systems, potentially also causing market failure. The legitimacy of the global system is put in doubt by the existence of socio-economic inequalities and international arrangements (i.e. deregulation and liberalisation of markets, instances of global governance), often exerted by the influence of restricted groups of players, thereby imposing global standards over goods that belong to the public domain (Kaul and Mendoza, 2002).

In summary, the literature presented has shown how market mechanisms fail in pursuing the sustainability of STSs from different perspectives. Firstly, market prices do not account for the externalities or the possible social costs deriving from the exploitation of natural resources. When this happens, controversies arise on evaluation methods and the selection of the different risk types. Second, even if they would consider externalities, they would not be able to objectively quantify the impacts of the damage produced, which might be significant, for instance in the case of nuclear disasters or diseases. Third, even when an objective evaluation could be provided, no single actor is able to take responsibility for possible damage or to restore it by returning to the initial conditions, because the cost could be unaffordable or the damage could be irreversible. Legislative systems, on the other hand cannot rule on Socio-

Technical Systems (STS) that spread cross-border and involve responsibilities that cannot be taken by single administrators.

This poses increasing challenges for the administration and regulation of STSs to provide solutions to the tension between human development and sustainability. Oversimplified traditional social structures are often not adequate for reflecting, measuring and learning about all the systemic interrelations between the dimensions involved and the limits of ecosystems, hardly providing effective decision-making for more sustainable Socio-Technical Systems (STS) (see Figure 4, page 14). This because they are often focused, culturally and economically, on one aim: that of increasing their own wealth, instead of pursuing the satisfaction of human needs according to the resources available, as it will be further discussed in Chapter 3.

The transboundary nature of environmental problems, as Evans reports (2012), calls for international cooperation, while current systems are instead often based on competition. This discourse leads to thoughts about what is the main problem in the current sustainable development paradigm.

The suggestion from the United Nations also indicates the need for alternative organisational and cooperative arrangements that would go beyond national regulation and market mechanisms, such as those introduced at the Rio conference in 1992 (UN, 1987). Cross-boundary and collaborative governance approaches are to be preferred, in order to fill the gaps of isolated policies or interventions (Sajeva and Masera, 2006). The principle of sustainability governance has also been included in the policies of many organisations, institutions, NGOs, businesses, and governments. A research question a) emerges naturally from this discussion and will be discussed in the next chapter:

'Is current governance adequate to harmonise the different components of social, economic and ecological systems?'

3 Sustainable development and governance

Objective	To explore the scientific field of sustainable development and to provide theoretical insights in order to understand about the adequacy of its current governance.
Content	3.1. Sustainable development 3.2 Sustainability as a development process 3.3.The importance of participatory governance for sustainable development 3.4. On the adequacy of current of governance 3.5. Neo-liberal approach to governance 3.6. Solving the conflict between the pillars of sustainability by the concept of ‘bounded capabilities’: learning about limits and needs

The analysis conducted in the previous chapter has considered the critical elements of Socio-Technical Systems (STS) and the related inadequacy of market and legislative structures for assuring their sustainability. In order to face these gaps instances of governance at regional and global level have been put in place. However, the persistence of the sustainability problems suggests that they have not led to a concrete change towards pathways of sustainable development. Therefore, the research question formulated about the adequacy of current governance to harmonise the different components of social, economic and ecological systems will be addressed in this chapter (see Figure 6, page 39).

3.1 Sustainable development

The hegemonic position of ‘industrialism’ in the 1950s and 60s led to an *«overarching commitment to growth in the quantities of goods and services and to the material well-being that growth brings»* (Dryzek, 2005: 13). Economic growth, believed to act as the driving force towards development, conversely initiated a process of ‘creative destruction’, in the terminology used by economist Joseph Schumpeter (Jackson, 2009: 9). Indeed the first concerns about sustainability arose in the 1950s and 1960s mainly in relation to its environmental dimension (Barnes and Hoerber, 2013: 1). The land transformation, described in Chapter 1, and the impact of these changes, have been described by Vitousek et al. (1997) in terms of biogeochemical cycles, possibly causing irreversible alterations in the climate or in the biological diversity and percentages of land surface transformed (Vitousek et al., 1997). Even while the last quarter of the last century has seen the global economy doubling, about 60% of the world’s ecosystems have degraded and carbon emissions have increased by 40% (Jackson, 2009: 6). As Jackson (ibid.) argues, we cannot afford to continue in the same way: if the entire world would consume as much as OECD countries, the global economy would be

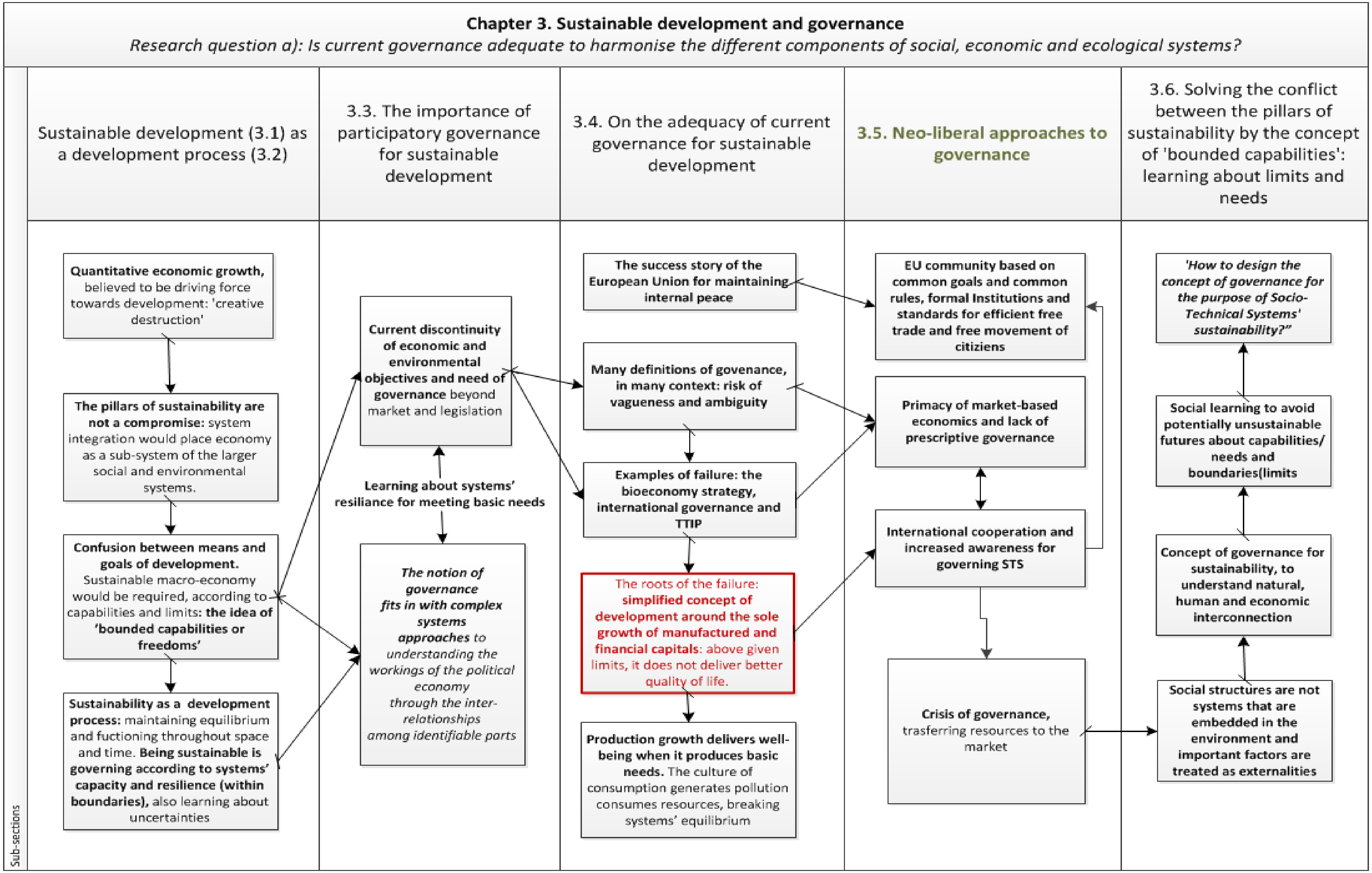


Figure 6. Sustainable development and governance

of fifteen larger than at present by the end of this century. The problem of sustainability was initially considered merely from an ecological viewpoint, referring to the maintenance of biodiversity and productivity over time, and only later on the considerations extended to economic and social dimensions, seeking for a reconciliation of economic development with environmental and social sustainability (Barnes and Hoerber 2013: 21). Thus, the well-known definition of the Brundtland Commission, as reported in the introduction, has spread globally.

At the 2005 World Summit on Social Development, reconciliation of environmental, social equity, and economic demands—the “three pillars”, or the three ‘E’s of sustainable development—was considered a necessary step. However, the oversimplification of the traditional economic model and the drive for economic growth has produced living standards beyond the ‘needs’ and developed production systems beyond the ecological limits, for instance in the use of energy (Meadowcroft, 2013) and in fact created a detachment of the economic models from the environmental and social dimensions. The problem of sustainability indeed stays in the anthropocentric vision of development, which, even according to the strong conception of development, considers environmental protection as subordinate to the pursuit of economic growth (Barnes and Hoerber, 2013: 25). The 1972 *‘Limits to Growth’* report clearly states the impossibility of society to continue in the way of continuous growth. In fact, it has been pointed out how pathways towards sustainable development have slowed down due to the consideration of development as economic growth, held mainly by developed countries and focused on the primary goal of growing levels of wealth (Drexhage and Murphy, 2010: 6). Economy-centred human development has underestimated or neglected the consequences of human action onto the rest of the ecosystem, forcing the environment to adapt to humans rather than searching for ways to adapt economy and society to the constraints imposed by environmental limits (Scott Cato, 2009). According to green economics (Porrit, 2006: 46) *«the economy is, in the first instance, a subsystem of human society ... which is itself, in the second instance, a subsystem of the totality of life on Earth (the biosphere). And no subsystem can expand beyond the capacity of the total system of which it is a part».* As was observed previously in sub-section 2.6, Socio-Technical Systems (STS) are naturally interrelated with the systems in which they are embedded (WCED, 1987), especially current technological development trends. This concept is also hold by Scott Cato (2009) in relation to the paradigm of sustainability that she proposes (Figure 7, page 41) so that any attempts to consider them detached entities, overlapping only for a small portion, cannot be supported. This would mean that, in order to integrate the pillars, economic activities should be designed according to biophysical and social environments. The traditional conception of compromise between interacting and overlapping sustainability pillars does not consider them as interdependent. This leads, in turn to confusion between means and goals of development (Sen, 1989), meaning that the goals of development should be pursued quasi exclusively by quantitative growth.

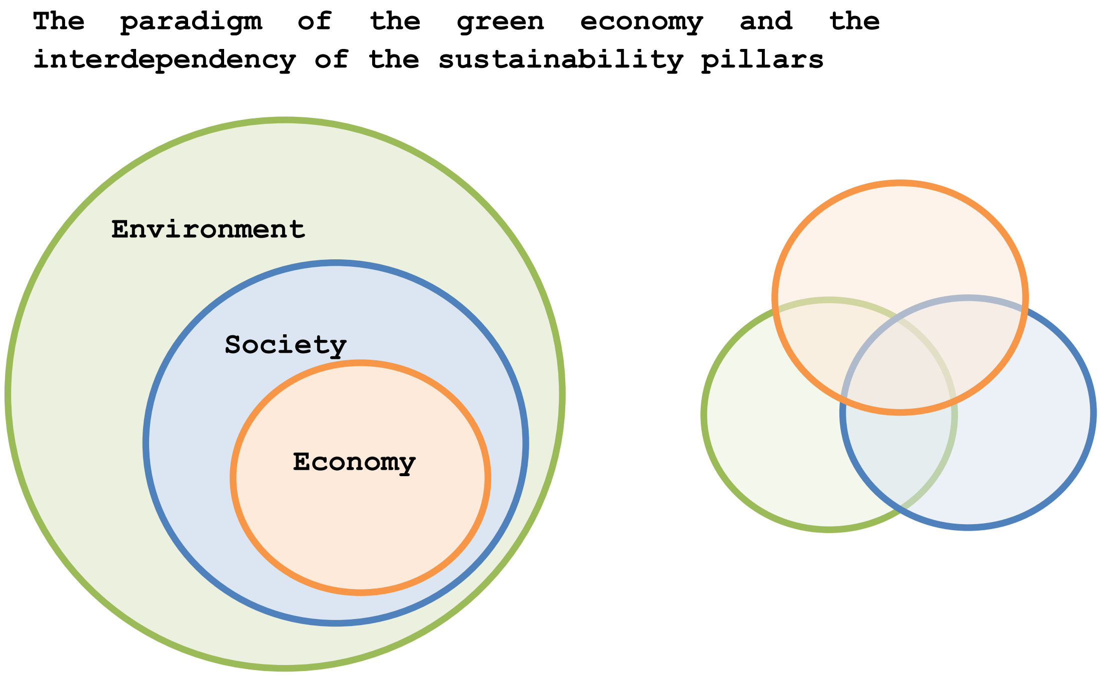


Figure 7. The three pillars of sustainability in the green economics paradigm vs. the conventional view (Scott Cato, 2009)

According to this systemic perspective, in which human systems are within ecological systems, shaping the former in relation to the constraints imposed by the environmental pillar would be feasible. However, as Glasser (2007) argues, *«many of today's interconnected environmental and social problems [...] are the unintended, unforeseen (but not necessarily unforeseen or unforeseeable) consequences of a failure to recognise, adequately appreciate, or effectively respond to the reciprocal character of humankind's relationship with nature».* This means that even when scientific knowledge continuously increases much remains unknown about possible future consequences. In such a situation of uncertainty, the main problem is how to act on the social and economic pillars, i.e. the human social structures that are most suitable to the overarching environmental pillar (Jackson, 2009: 35). According to Jackson (2009: 12), a sustainable economy would require *«building a sustainable macro-economy, protecting capabilities of flourishing and respecting ecological limits»*. Sustainable development is defined therefore as development that is able to produce prosperity in the long run, including concepts of care for the future and for the others (Jackson, 2009: 16). In a vision of development as freedom, indicated by Nobel Laureate Amartya Sen, human capabilities should be enabled within the limits and constraints represented by the finite ecosystem of the planet on the one hand and by the population on the other hand. In this view, as Jackson argues (2009: 7), human freedoms should be seen as 'bounded capabilities'.

From the discourse above, the problems of sustainability derive from the lack of awareness of the mentioned boundaries, as the reliance on social structures as isolated and detached from the overarching natural systems has indeed determined a problem of their adequacy. In a similar way, social sustainability problems derive from the inability of social and economic structures and arrangements to generate security and well-being for all human beings. It is the relation between the different sub-systems that determines their sustainability in relation to the upper-level systems, social and human, and in relation to the overarching ecological system. In this view, systems' functioning would include the consideration of all sustainability factors, and constraints, in relation to the needs and goals to be accomplished. Sustainability, as highlighted in Chapter 2, cannot be pursued by means of isolated and oversimplified structures (i.e. free market or national legislation in the case of social systems) without considering the systemic and multiple interaction of all its dimensions. About the adequacy of current governance arrangements, it is necessary to consider whether these have succeeded in the task of systems' integration and harmonisation.

3.2 Sustainability as a development process

Recalling the Brundtland definition of sustainability reported in sub-section 1.2, the long-term perspective, previously considered an important element in the conception of economics, is particularly relevant. The verb 'to sustain' has Latin roots, originating in *sustinēre*, and it can be translated as 'to up *(sus)* hold *(tinēre)*' (dictionary.reference.com; the freedictionary.com) or 'to endure', 'to support', 'to maintain or prolong'. The element that plays an important role in such definitions is time. Sustainability thus concerns the maintaining of a condition throughout time, so that it assumes a dynamic connotation of adaptive capability, in relation to changes in space and time. The approach followed in this research is based on such a dynamic vision of sustainability in which it is not seen as an outcome but as an ongoing process. Such a vision is corroborated by the concept of 'reduction to dynamics' (Laszlo and Krippner, 1998) between the components of a system in conditions of complexity. Indeed, the sustainability of social systems would better be associated to the process of development, which has to create the adaptive and resilient conditions for their self-maintenance.

Resilience is formally defined *«as the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure and feedbacks - and therefore the same identity»* (Resilience Alliance, 2014). The resilience of an entire socio-ecological system, therefore, is related to its ability to provide resources through time and to be able to balance the occurring disturbances or changes. Resilience and sustainability are therefore two sides of the same coin: sustainable development is that development and those related changes that remain beyond the limits of the resilience of the system in which they are produced, maintaining its equilibrium. In other words, sustainable development is firstly composed by a pro-active development action, i.e. enablers acting on contexts, and secondly by a reactive resilience, i.e. the resistance limits which define the sustainability constraints (the rules), according to the systemic approach presented in sub-section 2.1. Indeed, sustainable development involves taking into account the relative resilience or ability to adapt of the system to which it applies. Governing sustainability means acquiring the ability and knowledge to understand about the characteristics of resilience of systems and adapt sub-systems to the functioning of larger ones, as well as understanding the interrelations between them. Governing sustainability means also acknowledging uncertainties and act according to a precautionary principle, according to which in presence of uncertainty doing nothing is also an option. Participation in governance is a key aspect, as more objective beliefs can be questioned by the contribution of more subjective perspectives helping to reduce the gap between them and understand contextual diversity (as discussed in sub-section 2.4). In this way, a process of social learning can be useful for increasing knowledge, as it will be described later in Chapter 4.

3.3 The importance of participatory governance for sustainable development

According to Jackson's vision of sustainable development as bounded capabilities, the importance of participatory governance is related to the reduction of uncertainty between subjective and objective perspective through processes of learning about the resilience of systems and the boundaries within inner systems can act. In consideration of basic human needs to be satisfied by the use of resources of the Brundtland definition, the idea of sustainability is systemic, as it would be difficult to be obliged to make a choice between health, education, freedom, security and clean air (IISD, 2013). This means that sustainable development involves integration of needs according to a systemic perspective.

The discontinuity of economic and environmental objectives, not integrated in a holistic vision of sustainable development (Barnes and Hoerber, 2013), calls for participatory governance approaches that go beyond the mechanisms of the markets and the isolated management and legislative actions, to form a harmonised socio-ecological system, involving interrelations between the different dimensions of sustainability. Where traditional social structures seem to be unable to grasp systems' criticalities, governance arrangements can more flexibly adapt to local contexts and confront the complexity of systems. Again, following the vision of the bounded capabilities (Jackson, 2009), participatory governance, enabling to build capabilities and meet needs, would set as well the limits within those can develop. The aim is indeed to be able to take into account the systemic interrelations between systems and their sub-systems. *«The notion of governance fits in with complex systems approaches to understanding the workings of the political economy through the inter-relationships among identifiable parts (e.g., social, economic and ecological), rather than just the parts themselves»* (Kemp, Parto and Gibson, 2005: 17).

Koimaan (1993: 2), separating the notion of governance from the act of governing, understands the notion of governance as a mode of social coordination. Kemp, Parto and Gibson (2005: 17) talk about the convergence towards collective decision-making.

3.4 On the adequacy of current governance for sustainable development

While acknowledging a main role of governance initiatives for addressing issues related with sustainable development, however, as Jordan (2008: 18) reports, there is a risk that the increasing reference to governance and sustainable development in many different contexts and the different meanings might result in an ambiguous and politically driven approach Jordan (2008: 18).

Environmental governance has been defined in different ways:

- *«the whole range of rules, practices and institutions related to the management of the environment in its different forms (conservation, protection, exploitation of natural resources, etc.»* (Fontaine, 2007)

- *«Global Environmental Governance (GEG) as the sum of organizations, policy instruments, financing mechanisms, rules, procedures and norms that regulate the processes of global environmental protection»* (Najam, Papa and Taiyab, 2006: 1)
- *«the formal and informal institutions, rules, mechanisms and processes of collective decision-making that enable stakeholders to influence and coordinate their interdependent needs and interests and their interactions with the environment at the relevant scales»* Tacconi (2011: 240).

The definitions of governance as the *«range of rules, practices and institutions»* (Fontaine) or *«the sum of organizations, policy instruments, financing mechanisms, rules, procedures and norms»* (Najam, Papa and Taiyab) lack the systemic component of the concept that identifies the interactions and interrelations between the factors themselves; in other words, the integrated effort of rules and practices, which is not the same as their sum. The integrated approach is included in the third definition, enabling stakeholders to participate in collective decision-making. The dynamic element, which is required in order to be able to respond and affect a changing environment, is also considered. According to Kemp, Parto and Gibson (2005), in the implementation of governance, a number of instruments can be used, such as multi-stakeholders deliberations, indicators, and regulatory instruments. However, these are often in the hands of single, central governments for their legitimisation.

The definitions of governance proposed above do not include the enforcement of measures—the commitment in joint deliberation for the actual achievement of the final goals—in other words, the monitoring of the effectiveness of governance procedures. The lack of a systemic approach, involving more dimensions than those captured by the market and the regulatory ones, has been one of the reasons why processes of concrete action directed towards enhanced sustainability have been missing. In the same way, the Brundtland report, even while recognising the need of governance systems, did not specify in which way societies should govern themselves in order to achieve human development in a sustainable manner (Jordan, 2008: 17). The Brundtland definition is often not analysed in its content, but instead used to support restricted political aims (Baker, 2005: 22; Dryzek, 2005: 146–147). Jordan (2008: 17–18) recognises that this definition, by enlarging the notion of sustainability to many different aspects (Pierre and Peters, 2005) and thus including everything, risked to lose its potential, and actually, after the publication of the report, things went worse and not better (Jordan, 2008: 17). The problem is how the notion of sustainability is defined and translated into principles, as well as how these principles are put into practice (Barnes and Hoerber, 2013). The many different definitions of sustainability often lack concreteness, and thereby leave room for ambiguity, instead of providing strategies for its actual achievement (Drexhage and Murphy, 2010: 10).

Some sustainability values are reported as being able to generate harmony and balance between economics and ecosystems (Porrit, 2006):

> *«Recognition of interdependence*
> *Self-determination*
> *Diversity and tolerance*
> *Compassion for others*
> *Upholding the principle of equity*
> *Recognition of the rights and interests of non-humans*
> *Respect for the integrity of natural systems*
> *Respect for the interests of future generations»*

According to Jordan (2008: 20), the analysis of the concept of sustainable development has developed by setting a number of subprinciples:

- Intergenerational and intragenerational equity
- Alleviation of chronic poverty
- Public participation in decision-making
- Observance of important environmental limits to growth
- Integration of the environmental dimension into policy making

These principles have been revised and further developed in major events, such as the 1992 Rio Declaration, Agenda 21 (United Nations, 1992), and the Report of the World Summit on Sustainable Development (United Nations, 2002). According to Jordan (2008), as these principles might often enter into conflict, governance is called forth to resolve them. However, governance should not simply achieve compromises between the three pillars, but realise social learning about the overarching systems' constraints and the behaviours that allow the pursuit of pathways of sustainable development Meadowcrofts (2005) argues that the new governance strategies adopted by governments are often more 'cosmetic' than 'ideal'. Different, society-centric and state-centric, approaches are often adopted (Jordan, 2008).

While the preferred governance model saw the predominance of a networked approach at an empirical level (Treib et al., 2007), a comprehensive notion and interpretation of governance is missing (Flinders, 2002: 52); a theory for governance remains in an embryonic form.

A clear example of successful governance has been the process of integration of the European Union. In 1951, in the aftermath of World War II, six countries—Belgium, the Federal Republic of Germany, France, Italy, Luxembourg, and the Netherlands—took the decision to establish the European Coal and Steel Community (ECSC), as a first step of a project for European integration, in order to realise long-term peace and stability, and create a favourable environment for economic recovery (Archick, 2016). Archik reports how, in the mind of the funders, binding economies and controlling together the raw materials would have promoted political reconciliation and reduced the risk of possible future conflicts in Europe. According to the same author, the European Union (EU), the latest stage of the European integration, *«is a unique partnership in which member states have pooled sovereignty in certain policy areas and harmonized laws on a wide range of economic, social, and political issues»*. Thinking in terms of governance, it has realised therefore a good governance of international security in Europe, because by creating a customs union, a single market in which goods, people, and capital can move freely, common trade and agricultural policies, and a common agricultural policy, and a common currency, it has impacted on some of the most recurrent causes of war in history, which are economic and political interests.

Even if, as Archick reports (2016), the EU has taken only steps to develop common foreign and security policies, *«the EU is largely viewed as a success story and as a cornerstone of European stability and prosperity»*. Thinking about governance, the EU has represented indeed a good example of governance of security because it has been based on real institutional efforts and arrangements, concrete agreements, regulatory measures and enablers for European citizens. Nevertheless, a number of problems have recently come up, in relation to the ability to remain united in relation to external and internal pressures, and to develop the integration further. If the socio-economic success might be questioned, the aim of avoiding conflicts has been (until now) successfully achieved, by developing capabilities and by developing regulatory social-structures. Further examples of governance are provided in the next sub-sections.

3.4.1 The bio-economy strategy of the European Union

As Barnes and Hoerber (2013: 23) report, the European Union has a long-term and ambitious strategy of economic, social and environmental development, aimed at eradicating poverty. According to Griffin (2013: 41), while the official strategies of the European Union put environmental sustainability at the core of their Sixth Environmental Action Plan, implying that economic development should not compromise environmental health, the actual economic development policy sticks with *«old-style approaches of growth based on economic expansion at all costs»* (Pepper, 1999, as cited in Griffin, 2012: 41). The EU's economic governance (EC, 2013a) is built upon the Europe 2020 ten-year growth strategy (EC website, 2013b), with the aim of bridging the current gaps by *«a model of growth»* that aims at becoming *«smarter, more sustainable and more inclusive»*. 'Smart' growth, in terms of real GDP, emerged as a concept at the 1992 Rio United Nation's Agenda 21, with the aim to strengthen economic activities; to increase income and wealth, as well as the quality and accessibility of education; and to improve the living environments, while preserving physical resources. The European Union strategy includes the definition of long-term growth priorities for the realisation of a regulatory environment assuring effectiveness and security of financial markets and innovative instruments (e.g. public-private partnerships) to finance the necessary investments. New governance structures and processes have been planned by the European Commission since 2010 and they cover the key targets of employment, education, research and innovation, social inclusion, poverty reduction and climate/energy issues, as further specified in Table 1 (page 49). The Europe 2020 strategy aims at addressing the economic crisis by the construction of a more competitive economy, increased employment and investment in education, research and innovation. All this should be achieved with a particular attention to sustainability (low-carbon energy sources), social inclusion and poverty reduction. However, recent initiatives for the strengthening of the bio-economy in Europe still do not clarify their conception of sustainability and the priorities involved in it: the European Commission Bioeconomy Observatory, for instance, bases its concept of bio-economy on the idea of innovating towards sustainable growth (EC, DG Research, 2012).

Being involved as a stakeholder in the bioeconomy observatory roundtable (Bioeconomy Observatory Roundtable, DG Research, Brussels, 26.11.2013), the researcher had occasion to ask the responsible officers whether a priority among the pillars had been or will be established, and could not get a clear answer. The answer of EU officers repeated that sustainability is the integration/compromise of the three pillars. With reference to the Holling statement reported in sub-section 2.1, the three pillars approach did not consider the priority that should be given to the different dimensions.

Table 1. The five 2020 objectives for the EU (EC, 2013)

Area	Goal
Employment	75% of the 20-to-64-year-olds to be employed
Research and Development	3% of the EU's GDP to be invested in R&D
Climate change and energy sustainability	Greenhouse gas emissions 20% (30% if possible) lower than in 1990
	20% of energy from renewable resources
	20% increase in energy efficiency
Education	Reducing the rate of early school leaving below 10%
	At least 40% of 30-to-34-year-olds completing third level education
Fighting poverty and social exclusion	At least 20 million fewer people in or at risk of poverty and social exclusion

The Europe 2020 strategy of smart growth, coupled with the objective of harmonisation with the environment, again falls in the same problem: What is the goal of development? What does the economic pillar of Brundtland Commission represent? The question is whether there are non-negotiable conditions and what those are e.g. should economic growth occur on the condition that it is environmentally and/or socially sustainable? Alternatively, can environmental or social sustainability be pursued only on the condition that it realises economic growth? In case of conflict, which is the primary goal among the three? Indeed, these questions that were formulated by the researcher at the Bioeconomy Observatory roundtable, did not receive an answer.

3.4.2 International governance approaches

Sustainable development was presented in 'Our Common Future' (WCED, 1987) as a philosophical idea, supported by the principles for its realisation, as summarised in Table 2 (page 50).

These principles have been updated or revised by international, national, and sub-national actors, including the Rio Declaration and Agenda 21 (United Nations, 1992), which was considered the final programme for the pursuit of sustainable development. Again, the Declaration on Sustainable Development's Plan of implementation presented at Johannesburg

2002 World Summit states that *«good governance within each country and at the international level is essential for sustainable development»* (United Nations, 2002).

Table 2. Proposal of a common action for institutional and legal change made by the Brundtland Commission (Source: WCED, 1987: 308-347) and related questions posed by the researcher

Proposal of a common action by the Brundtland Commission	***Questions by the researcher concerning the common action proposed by the Brundtland Commission***
Supporting development in an economically and ecologically sustainable manner	*In case of a conflict between the two, which is the non-negotiable constraint? Should economic development be pursued at any price and on any condition?*
Environmental protection and sustainable development integrated into all sectors and levels of government	*Should human systems not be integrated into ecological systems?*
Ensuring that national and international regulation and legislation keeps up with the scale of environmental and human development	*How to ensure that regulatory and social norms are produced in relation to the scale of environment?*
Enforcing measures for environmental protection and resource management; strengthening the United Nations Environmental Programme (UNDP)	*Is the UNDP to become a governance entity able to enforce and assure the respect of protection measures and social systems based on the resources available?*
Identification, assessment and reporting of risks of irreversible damage to natural systems and threats to human well-being	*Is human agency then planned in relation to risk avoidance?*
Participation of informed public, non-governmental organisations and the scientific community, increasing cooperation with industry for making sustainable choices	*Is this participation aimed at generating good practices and actions towards sustainable development, and cooperation for the common good?*
Investments in the future by multilateral financial institutions, through fundamental commitment to sustainable development; new and additional sources of revenue to support development in the South	*How to ensure their commitment, also when revenue cannot be guaranteed? How to evaluate irreversible damage or qualitative well-being? Should sustainable development in any case effect the functioning of human systems? Alternatively, should human systems adapt to the overarching systems?*

In relation to the good plans presented in Table 2 (page 50), the researcher attempts to pose some governance-related questions in connection with the UN proposals, with the aim to adopt more precise determination of actions to be carried out.

Table 3. The OECD checklist of questions for each theme for improving governance for sustainable development (Source: OECD, 2002).

Theme	Questions
A common understanding of sustainable development (SD)	Is the concept of SD sufficiently clear and understood by the public?
	Is it well understood by public organisations and across all levels of government?
Clear commitment and leadership	Is there clear commitment at the highest level to the formulation and implementation of SD objectives and strategies?
	Is this commitment effectively communicated across all sectors of government?
Specific institutional mechanisms to steer integration	Is there an institutional 'catalyst' in charge of enforcing SD strategies?
	Are there specific reviews of laws and regulations to check whether they conflict with sustainable development?
	Is SD integrated into budgeting, appraisal, and evaluation activities?
Effective stakeholder involvement	Do mechanisms exist with government or independent organisations to ensure that consumers are informed about the consequences of their consumption decisions?
	Are there guidelines on when, with whom, and how consultations should be carried out?
	Are transparency mechanisms being reinforced at different levels of government?
Efficient knowledge management	Are there transparent mechanisms in place for managing conflictual knowledge?
	Is the flow of information between the scientific community and decision makers efficient and effective?

In order to put principles of governance, and their interconnections for sustainable development into practice, the Organisation for Economic Cooperation and Development (OECD) produced a checklist (see Table 3, page 51) in 2002 for 'Improving Policy Coherence and Integration for Sustainable Development (OECD, 2002)', even if the OECD expressly specify that this is not *«a compilation of 'quick fix' solutions or 'recipes'»* (2002: 1). However, the idea that human systems should be integrated into the ecological ones is not taken into consideration and all is measured by traditional budgeting and evaluations. A question asking whether human systems are designed according to the constraints and limits imposed by the ecological systems is not formulated; neither is there a question about whether economic systems are adequate in terms of guaranteeing social development. A question whether the interaction between systems' components is adequate in terms of maintaining the equilibrium in the overarching systems is also missing. The consideration of development as economic growth, together with the primary objective of generating increasing levels of wealth, mainly promoted by developed countries, has slowed down the progress towards sustainable development (Drexhage and Murphy, 2010: 6).

3.5 Neo-liberal approaches to governance

Dominant political trends clearly go in the direction of neo-liberal approaches of governance, based on the primacy of market-based economics and excluding state intervention. Nevertheless, a *«paradoxical increase in [state] intervention»* (Jessop, 2002) is made for maintaining the neo-liberal order, typically by privatisation and liberalisation policies (Peck and Tickell, 2002). While delegating the allocation of resources to the free market, the state renounces the function of holding social accountability towards citizens and engages in the *«purposeful construction and consolidation of neoliberalized state forms, modes of governance, and regulatory relations»* (Peck and Tickell, 2002). Examples of neoliberal governance, such as the recent multilateral trade agreements (e.g. North American Free Trade Agreement or the proposed Transatlantic Trade and Investment Partnership (TTIP)), aimed at including neoliberal approaches (e.g. the protection of the individual property rights of the investors) into environmental governance (Stiglitz, 2014). The TTIP, Stiglitz continues, is about dumping environmental, safety and work regulations by means of the 'Investor state dispute settlement' (ISDS), that is not actually meant to protect investors, and instead recognises corporations the right to sue sovereign governments in arbitration tribunals when national regulations would cause a reduction of their profits. This constitutes a permit to undermine environmental rights and citizens' protection (Stiglitz, 2014). These governance frameworks transfer public resources to the free market, hoping to increase efficiency and optimal return on investments, realising *de facto* the privatisation of increasing areas of nature (Swyngedouw, 2005) and subordinating the achievement of environmental sustainability to the realisation of economic returns. Bakker (2004) talks about the privatisation of water supply and sewage treatment in England and Wales, as well as the debated carbon market, as strategies to *«deploy markets as the solution to environmental problems»*, which allows users to *«right the wrong»* and to postpone the problem of the pollution of the atmosphere to the future. This may create barriers to the transition towards a post-carbon society rather than support the rebuilding of infrastructural systems, especially in light of sustainable development goals in developing countries (Page, 2011: 267).

According to Griffin (2013), governance for environmental sustainability fails to overcome tensions and dilemmas, as it programs reforms along the functioning of free markets, ignoring the evidence of the negative effects of economic growth on sustainable development. The United Nations Conference on Sustainable Development held in Rio de Janeiro in 2012, for instance, produced a nonbinding document, *'The Future We Want'*. While accepted by all participant governments, the document merely committed to strengthen the role of the United Nations Environmental Programme (UNEP) in setting the international agenda, and was described, under US request, as 'an authoritative advocate' and not as 'the authoritative advocate' (Bierman, 2013). As Bierman (ibid.) reports, the permanent Global Environmental Assessment Commission, established to represent an independent and autonomous entity assigned to warn about stability and security issues in the world, was given a mere advisory role on the scientific knowledge about planetary boundaries. The lack of prescriptive policy advice and the separation of scientific evidence from decision-making actions, maintained in the hands of national states, determine a lack of the necessary strength that would allow governance to be effective. Unfortunately, current governance initiatives have not led to the solution of the problem, mainly because, in the same way as legislation, they are focused on maintaining the conditions that allow markets to operate and GDPs to endlessly grow, while neglecting the remaining dimensions of sustainable development (Jackson, 2009: 11). Mike Hulme, (2009: 310), author of the Intergovernmental Panel on Climate Change (IPCC) Third Assessment Report in 2001, reported that the environmental problem is a *«crisis of governance… [not] a crisis of the environment or a failure of the market»*.

3.5.1 The roots behind the inadequacy of current governance of sustainability

One main problem of current governance is that sustainable development is associated to the pursuit of economic growth and the contextual achievement of environmental and social sustainability, at the same time resolving the problems of poverty and environmental protection through markets and technology (Hopwood et al., 2005, as cited in Drexhage and Murphy, 2010: 10). Contradictions still exist, according to Griffin (2013), when pursuing objectives of environmental sustainability by business-as-usual strategies and this recalls the problem of integration and harmonisation of the sustainability pillars described in sub-section 3.1. The way some have tried to justify growth theories relies on the expectations about technological development, allowing dematerialisation of economies and an increase in the efficiency of production processes, using, in aggregate, fewer materials (Haberl et al., 2004). This vision of a more intangible economy is supported by the idea of 'decoupling', meaning the disconnection of economic and social well-being from the use of biophysical resources. Economic growth (measured by GDP) may be decoupled from material and energy use, through increasing efficiency, till dematerialisation, while material and energy can also be decoupled from social well-being, in terms of sufficiency and social well-being can be decoupled from economic growth, in terms of equity (Haberl et al., 2004).

When we look to microeconomics, according to the principle of 'diminishing marginal benefits', growth should be pursued until marginal benefits remain greater than marginal costs (Lawn, 2007a). This principle is not being followed at the macroeconomic level, where continuous growth is pursued. As mentioned in the introduction, the social pillar is influenced positively and negatively by economic growth, which produces wealth on the one side but does not assure its redistribution. Even recognising the ability of GDP growth as a mean able to induce well-being, above certain limits of growth, *«additional increments of wealth do not generate better quality of life»* (Prieto and Slim, 2010: 53, as cited in Slim, 2013), so that, especially in mature economies, they diminish or cease their capability to induce well-being. As Vitali (2013) holds, the production growth results in more well-being when it allows meeting basic needs, maintaining of creation of jobs or conservation of a level of income that can guarantee human security. When instead production growth results in an increase of available objects, the author admits, it does not proportionally involve a greater well-being as its actual level is perhaps much lower than we are induced to think by the constant pressure to consumption. As Vitali argues, consuming more in order to grow GDP, even when this does not really deliver well-being, seems a paradox. As Jackson reports (2009: 11, 16) governments insist on the culture of consumption, influencing citizens' behaviours and creating social structures fully based on free markets, and in this way delegating the function of managing public goods and generating in many cases unevenly distributed benefits, which are also a source of social conflict and unsustainable societies, in turn one of the major causes of missing environmental sustainability.

Vitali (2013) reports how increasing production means also increasing pollution and consumption of resources, thereby reducing their availability, and this cannot continue endlessly, without taking the risk of destroying the planet. On the other hand, the author continues, sustainability problems seem not to be related to the satisfaction of basic needs, but to the induction to higher levels of consumption: while at the beginning of the last century a family of four people owned about 150- 200 items, including clothes, today it owns about 2500-3000 products (excluding books), many more than those needed to live a full life. It is estimated that an individual may be exposed in the course of his life to about 20,000 objects. As Vitali (2013) reports, the possession of too many objects does not make appreciating them, and the need to continuously produce novel products, in order to stimulate continuous consumption, *«creates anxiety that can undermine social well-being»* (Jackson, 2009: 9). As Vitali (2013) argues, often worries are raised just by saying that incomes are back to the level of the eighties. However, Vitali continues, the memories of those years may just remind us how we were better off if compared to present times, when there was still free public healthcare, people was more serene, the unemployment rate was smaller than now, the poor were less poor and the rich were less rich. This arguments are supported as well by Huesemann and Huesemann (2011), when they report about the pervasive belief that the current lifestyle can be indefinitely supported by technological innovation. They argue how this techno-optimism about the ability of technology to prevent social, economic and environmental collapse, as well as its inherent and predictable negative unintended consequences, is completely unjustified. According to this idea, in the presence of continued economic growth, technological solutions to social and technology-created problems are ineffective do not promote sustainability, instead hasten collapse.

As Jackson maintains (2009: 10), *«there is no macroeconomics for sustainability and there is an urgent need for one»*. The main inadequacies in the current macroeconomics can be referred to the anthropocentric perspective, maintaining that all goods are evaluated exclusively for their utility to human aims (Norton, 2012) and second, the consequent conception of macroeconomic theories and of the social structures based on them, as independent and detached for the overarching systems (Scott Cato, 2009).

On the basis of this, the sustainability pillars, traditionally considered, are conflicting because endless and uncontrolled economic growth requires systematic use of resources, while environmental sustainability requires lowering the use of these resources and the priority of the environmental pillar over the economic one. In the 'axiomatic basis of green economics' of Lawson (2007), the continuous expansion in a finite space is simply impossible as long as it requires systematic uptake of finite resources. From a biophysical point of view, the economic dimension is a subsystem of a finite ecological system—that is, the Earth. According to Hazel Henderson (1988, as cited in Scott Cato 2009), *«GDP is a narrow, economistic, patriarchal measure of the economy that fails to take into account the most important aspects of productive life, such as caring and the environment itself»*. According to Scott Cato (2009), the idea of Earth as a sacred entity and source of our life is a very recent belief, in contraposition to the traditional behaviour, which instead treats it, in Scott Cato's words, as a *«larder»*, a pool from which to take resources and to which to toss all that has become useless for human activities.

Solving the conflict between the pillars of sustainability by the concept of 'bounded capabilities': learning about limits and needs. In order to face the deficiencies of GDP to measure well-being and development, some ecological economists have suggested alternative measurement approaches, for instance with the intention to measure national progress by evaluating the efficiency of economic growth by the Index of Sustainable Economic Welfare (Daly and Cobb, 1989), or the Genuine Progress Indicator (GPI) (Lawn, 2007b), which covers 25 benefits and costs, including economic, social, and environmental dimensions. Some further analysis of the GPI revealed, for the majority of developed nations, a direct relation with GDP until 1970s or 1980s (Lawn and Clarke, 2008). After that, a further increase in the GDP has in fact corresponded to the decrease of the GPI, indicating economic inefficiency of growth. In this case, while GDP growth generates benefits in terms of consumption, it also produces much higher growth rates in social and environmental costs, thereby creating a need for defensive policies for the recovery from the negative impacts.

3.5.2 The aim of governance for sustainability

Summarising the analysis undertaken in this sub-section, the problem is that when focusing just on growth in production, the conflict between indicators of growth (GDP) and the needs of sustainable development emerges. The way out from the conflicts between the sustainability pillars can be represented by a vision of 'economics' as the use of limited resources for meeting human needs, as discussed in the following Chapter 4. Current governance approaches often focus on the quality of life of the present and future generations, but they do not really address the concepts of 'limits' and 'needs', which determine the interactions between ecological and human systems (Meadowcroft, 2013). According to Stern (2014), mainstream growth models do not take into consideration any natural resources in terms of flows or stocks, including non-renewable ones; such considerations challenge the idea of indefinite economic growth. The focus on production growth makes so that limits are broken and, on the other hand, human needs are not met.

The discussion in this chapter suggests that inclusive and participatory processes can still fail and lead to unsustainable futures, and introduces to a vision of 'bounded capabilities' of governance (Jackson, 2009). This is particularly relevant to the aim of the thesis, to develop an alternative and holistic framework that would help in this task through a process of social of learning about Socio-Technological Systems' (STS) limits and needs (or entitlements), inducing ability to think and act within a systemic perspective. The aim of governance is therefore:

a. To achieve an holistic and systemic understanding of human, natural and economic interconnection—i.e. the conceptual framework of governance for sustainability

b. To reflect this understanding about how the different capitals interlink in social, and formal, learning and, through this, supporting adaptive responses to uncertainty and avoid potentially unsustainable futures—i.e. supporting the implementation of governance for sustainability

With reference to the uncertainty of complex systems exposed in sub-section 2.4, the first aim is related to the understanding of more objective aspects of systems' interaction and reduce the level of uncertainty related non-negotiable systems' boundaries. On the other hand, the second aim is to understand and communicate the uncertainties that relate to the subjective and contextual visions of sustainability, that also refer to the construction of the capabilities of the agents within the boundaries of the systems.

This conceptual interpretation of governance will now underpin the construction of an alternative methodological approach to address research question b) that is treated in the following chapter:

'How to design the concept of governance for the purpose of Socio-Technical Systems' sustainability?

This links to the following Chapter, in which a proposal of designing governance for the specific purpose of sustainability is made.

4 Building governance for the purpose of sustainable development: a system integration approach

Objective	To present governance as an approach and a process of cooperation and systemic social learning for pursuing the sustainability of systems having public relevance
Content	4.1. Towards an effective 'governance for sustainability' framework 4.2. Human sustainable development: developing capabilities within boundaries 4.3. Sustainability as inherent in the definition of economics: meeting human needs (social pillar) by rational use of scarce resources (environmental pillar) 4.4. Understanding systems' interaction through social learning 4.5. Towards a concept of 'governance for sustainability' 4.6. Existing methodologies for sustainability evaluation and communication

This chapter draws on the governance issues investigated in Chapters 2 and 3 to generate a 'governance for sustainability' conceptual framework. The following sub-sections will analyse the key aspects of such concept, which will serve as basis for the development of the evaluation framework for social learning, aim of this thesis (see Figure 8, page 59). These are:

- An approach that would reduce the vagueness of governance and would be effective in pursuing Socio-Technical Systems (STS) sustainability. This could be a more normative and structured approach based on a concept of meta-governance (see sub-section 4.1)
- Reference to a systemic approach of sustainability, that is based on the two characteristics of enabling actors within the systems constraints (objective and non-negotiable factors), referring to the vision of 'bounded capabilities' (see sub-section 4.2). This refers also to a conception of economics as meeting human needs by use of scarce and limited resources, resolving the conflict between the sustainability pillars (see sub-section 4.3).
- A shift from unidimensional evaluations towards multi-dimensional impact analysis that balances different capitals (see sub-section 4.4).
- The social learning process for understanding systemic interactions within and between different capitals, to identify general and more objective sustainability criteria and more context based operational measures (see sub-section 4.5).
- A review of existing methodologies for sustainability assessment and/or communication (see sub-section 4.6).

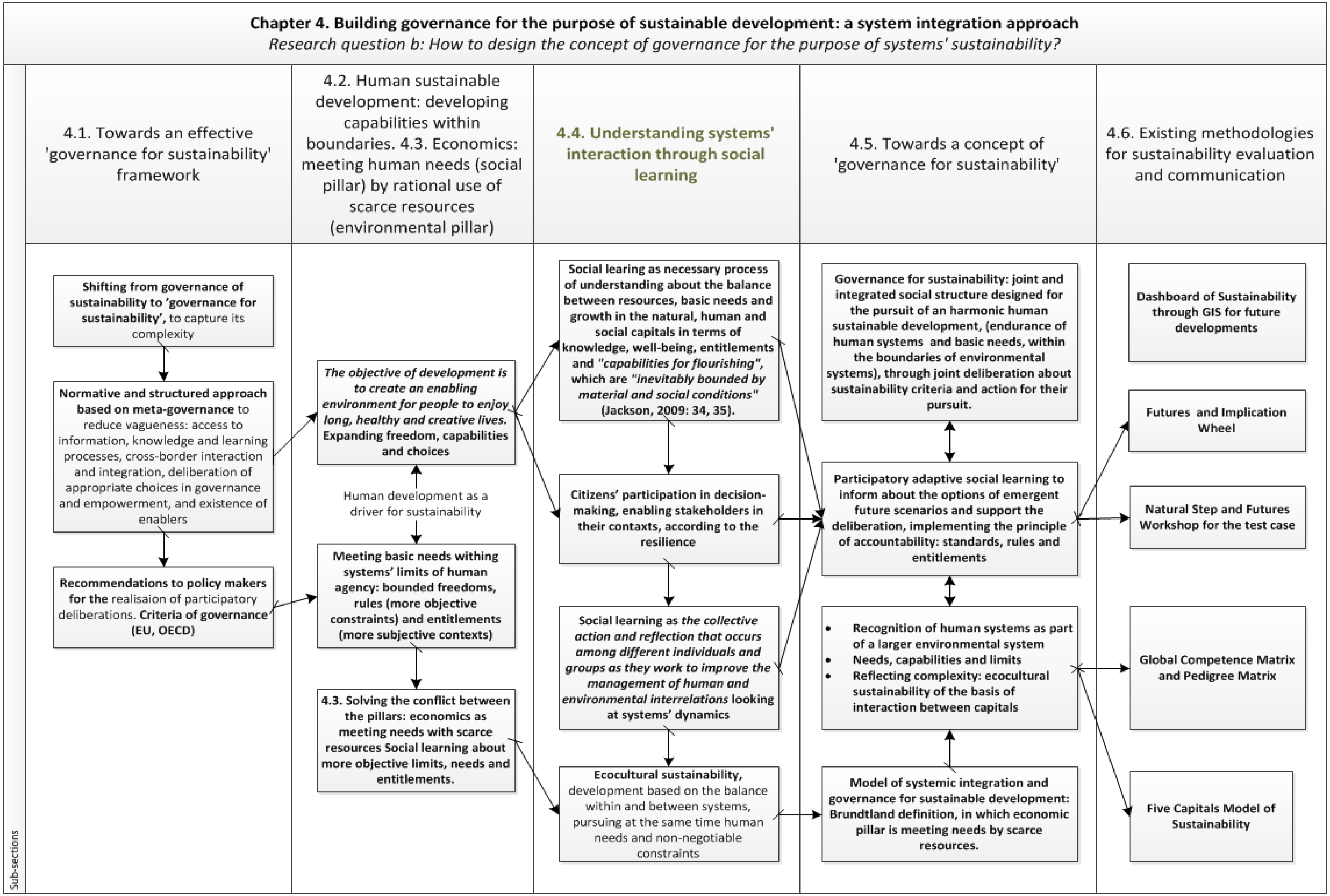


Figure 8. Building a 'governance for sustainability' conceptual framework

4.1 Towards an effective 'governance for sustainability framework'

As discussed in sub-section 2.6, current development pathways and governance schemes have not been able to cope with systems' criticalities, mainly because of the adoption of sectorial approaches and the lack of a systemic and holistic view of sustainability. In spite of the many attempts to discuss the role of the state at the political level, the efforts made for studying governance for sustainable development have neither produced dedicated theories nor described which theories can be useful for the purpose (Jordan, 2008).

Among the various approaches adopted, as treated in the previous chapter, governance has been interpreted in a more prescriptive and normative way, in order to achieve a desired objective (Kohler-Koch and Rittemberg, 2006: 29). According to this latter conception, adopted by the World Bank (2002), governance is considered as an *«efficient public service, an independent judiciary, a publicly accountable system for collecting and allocating funds, a respect for law and order, as well as human rights»* (Jordan, 2008: 22). The 'OECD technique' (Lehtonen, 2007) is based on a particular network-based governance approach, involving benchmarking and sharing of best practices, case studies, OECD performance reviews and checklists, with reference to the ability of administrations to achieve sustainability (OECD, 2001).

In the vision of sustainable development as a 'fundamental normative idea' (Meadowcroft, 2000: 371), it seems very important to identify the necessary governance changes. For instance, the EU Consultative Forum on Environment and Sustainable Development has advocated 'sustainable governance' on the basis of *«full information, an open public discourse and stakeholder dialogues at all levels [and] [m]otivating rather than prescriptive measures»* (ECFESD, 2000: 6, 8). Sustainability governance has been defined as *«the deliberate adjustment of practices of governance in order to ensure that society eventually proceeds along a sustainable trajectory»* (Meadowcroft et al., 2005: 5). Some authors make a distinction between 'governance and sustainable development'—focused on the interpretations provided by different approaches—and the concept of 'governance for sustainable development'—a concept that involves a more prescriptive and normative approach (Farrell et al., 2005: 127). This latter one (2005: 130) enhances the role of governance as an alternative arrangement through which sustainable development can become possible and actually achievable (or approachable), and therefore able to capture its true complexity.

Some authors, in order to reduce the vagueness of the concept of governance, focus on the concept of meta-governance as a process — the *«governing of governing»* (Kooiman, 2003), *«reducing the vagueness of the sustainable development concept and the complexity of its implementation»* (Christopoulos et al., 2012). Other authors define meta-governance as a *«way of enhancing coordination of governance in a fragmented political system based on a high degree of autonomy for networks and institutions»* (Sørensen, 2005) or as *«an approach, which aims to design and manage sets of situational preferences for a mix of institutions, consisting of elements, from the main modes of hierarchical, market, network governance and sometimes self-governance»* (Meuleman, 2008). In particular, the meta-governance approach involves access to information, knowledge and learning processes, cross-border interaction and integration, deliberation of appropriate choices in governance and empowerment, and existence of enablers (Christo et al., 2013). Meta-governance would be intended to produce recommendations to policy makers about the need for accessing information and knowledge, mediating between regulatory and administrative levels, empowering citizens in terms of instruments and capabilities, and participatory deliberation and common cross-border practices. Such meta-governance approaches have been realised, for instance, through the creation of a World Governance Index (WGI) (Forum on a new World Governance, 2013), containing the dimensions of peace and security, rule of law, human rights and participation, and sustainable and human development. Other indicators were developed in 2009 by the Bertelsmann Foundation that published the Sustainable Governance Indicators (SGI), with the aim of measuring the capacity for reform within OECD countries (Empter and Janning, 2009).

The concept of governance has also been related to the need to respond to given criteria, such as the European Commission principles of good governance (EC, 2001) of openness, participation, accountability, effectiveness, coherence or the criteria of the United Nations Development Programme (1997):

- Participation: providing all actors with a voice in decision-making
- Transparency: built on the free flow of information
- Responsiveness: of institutions and processes to stakeholders
- Consensus orientation: differing interests are mediated to reach a broad consensus on what is in the general interest
- Equity: all actors have opportunities to become involved

- Effectiveness and efficiency: processes and institutions produce results that meet needs while making the best use of resources
- Accountability: of decision-makers to stakeholders
- Strategic vision: broad and long-term perspective on good governance and human development of leaders and the public sector, and the perspective of what is needed for such development. Understanding of the historical, cultural and social complexities in which those perspectives are based.

The OECD principles of corporate governance can also be taken into consideration (OECD, 2004):

- Ensuring the basis for an effective corporate governance framework: the corporate governance framework should promote transparent and efficient markets, be consistent with the rule of law, and clearly articulate the division of responsibilities among different supervisory, regulatory and enforcement authorities.
- The rights of shareholders and key ownership functions: the corporate governance framework should protect and facilitate the exercise of shareholders' rights.
- The equitable treatment of shareholders: the corporate governance framework should ensure the equitable treatment of all shareholders, including minority and foreign shareholders. All shareholders should have the opportunity to obtain effective redress for violation of their rights.
- The role of stakeholders in corporate governance: the corporate governance framework should recognise the rights of stakeholders established by law or through mutual agreements, and encourage active cooperation between corporations and stakeholders in creating wealth, jobs, and the sustainability of financially sound enterprises.
- Disclosure and transparency: the corporate governance framework should ensure that timely and accurate disclosure is made on all material matters regarding the corporation, including the financial situation, performance, ownership, and governance of the company.
- The responsibilities of the board: the corporate governance framework should ensure the strategic guidance of the company, the effective monitoring of management by the board, and the board's accountability to the company and the shareholders.

In order to construct a concept of governance for sustainability and widen the scope to other types of capital that are important for life on the Earth, it is important to make a deeper analysis the concept of sustainable development and the dimensions it includes.

4.2 Human sustainable development: developing capabilities within boundaries

Mahbub ul Haq, Founder of the Human Development Report, states that *«[t]he basic purpose of development is to enlarge people's choices. In principle, these choices can be infinite and can change over time»*. He reports that many valuable achievements are not represented at all in growth measurements, or the visible measured impact is delayed. These are typically an enhanced access to knowledge, better nutrition and healthcare, security in all its different manifestations, leisure time, political and cultural freedoms, as well as inclusion and participation in community activities. This is why, Mahbub ul Haq, holds, *«the objective of development is to create an enabling environment for people to enjoy long, healthy and creative lives»*. (UNDP website, consulted on 16.08.2013).

UNDP also defines *«human development as expanding the choices for all people in society. This means that men and women—particularly the poor and vulnerable—are at the centre of the development process»* (Speth, 2005), referring to the *«protection of the life opportunities of future generations [...] and [...] the natural systems on which all life depends»* (UNDP, Human Development Report 1996 as cited by Speth, 2005).

The definition of sustainable development formulated in the Brundtland Commission Report (1987), as mentioned in the introduction, makes a particular reference to the priority of the basic needs of the world's poor and to an idea of limitation to present social systems, which would ensure their ability to meet also future needs (WCED, 1987: 43). *«Sustainability is an injunction not to satisfy ourselves by impoverishing our successors»* (Solow 1991: 3). In other words, it is an obligation to preserve our productive capacity by maintaining the total stock inherited from past generations, not with the aim to assure equal well-being but to maintain the resources that are essential to build future well-being. In this sense, human development is a driver for sustainability: besides the importance of promoting it in order to enhance people's capabilities to improve their life conditions, it is also important to increase the future human capital and to protect the environment, as the World Bank (1992: 30) suggests: *«The poor are both victims and agents of environmental damage»*. This is because, the World Bank continues, about half of the world's poor live in environmentally fragile rural areas and rely on natural resources without legitimation nor entitlements. These are steeply sloped areas, erosion-prone hillsides, semiarid lands subject to rapid soil degradation, cleared tropical forests where crop yields often drop suddenly after some years (ibid.). The same source reports that for the very poor it is often impossible to avoid degrading their environment, as they struggle for subsistence, and day-to-day survival. The World Bank reports how poor communities often owe strong ethics of stewardship in land management and therefore the matter is not of having short horizons; however, the limited resources, the often unclear property rights, and the limited access to credit and insurance markets are responsible of the lack of care and investment for environmental protection. Human and socio-economic development generates in fact the resources that can be employed for achieving sustainability. According to Anand and Sen (1994), human development gives families the freedom to have fewer children, because the availability of healthcare allows abandoning the logic of giving birth to many children to make sure that some of them survive. In the same way, the expansion of basic and advanced female education gives women the opportunity to better understand the social values of having a smaller family. The expansion of capabilities and the enabling of human agency happen through the participation of larger communities of stakeholders and the activation of resources, by extending the rights for basic education and improving health conditions, thus also contributing to solve the population problem. Human development is a goal, as it directly increases people's *«basic capability to lead worthwhile lives»* (Anand and Sen, 2000) in the short run.

The argument above demonstrated how, the goal of sustainable development involves a more objective goal of meeting basic needs. Sachs also reminds us the concept of 'structural violence', meant as those unjust social, economic and political structures that limit the access to basic needs and reduce people's life expectancy (Sachs, 2003).

On the other hand, human agency requires the support of a social structure of resources and constraints (i.e. rules). According to Anand and Sen (2000: 2030), the core concept of sustainability in the Brundtland theory clearly refers to the ideas of needs and limitations: *«we cannot abuse and plunder our common stock of natural assets and resources leaving the future generations unable to enjoy the opportunities we take for granted today. We cannot use up, or contaminate, our environment as we wish, violating the rights and the interests of the future generations»*. The authors, citing Mary Wollstonecraft (2000: 2029–2030), state that *«it is justice, not charity that is wanting in the world»*, in terms of entitlements, human capabilities and development for all, so that *«ethical universalism is an elementary demand of impartiality»*. The authors claim that sustainable development does not mean present deprivation or renouncement of present enjoyments, especially for the less privileged classes; however, mainstream economic sciences have often focused on commodity production and material success more than on the need to address deprivation and present human development. The arguments presented above are important to understand that human enablers also have limitations: according to Sardar (2007), *«prosperity can only be conceived as a condition that includes obligations and responsibilities to others»*; a view that is consistent with Jackson's (2009) concept of bounded freedom. In the definition of sustainability, human development and capabilities are key factors, and institutional arrangements have the role of empowering and enabling human agency through efficient use of resources. However, human agency also influences social structures, as it defines, through decision-making, the required institutional arrangements and the constraints for keeping within the boundaries of the systems. This involves learning about the limits of that human agency and offers one reason why currently its lack and limiting social structures can determine a situation of non-sustainability. The focus on the combination of opportunities and limits of human lives can confront challenges that are often underestimated by oversimplified and isolated approaches and structures. The ability to scrutinize and re-examine values and priorities makes the two dimensions of human agency and social structures strictly interrelated in the construction of sustainability (UNDP, 1993).

The concepts of 'rules' and 'entitlements' can be found in the literature from different perspectives (see Table 4, page 66). As Evans (2012: 1) argues, sustainability problems are inherent in human beings and in the rules they have set for their own development. In other words, it could be argued that the failure stays in the current attempts to build self-discipline upon the economic and social pillars. Giddens' social theory of structuration (Giddens, 1984) specifically refers to the components of a social system: social structures (rules, constraints and resources) and human agency. Giddens focuses on the action of individuals as part of social structures. Social structures are the *«rules and resources»* embedded in the subconscious of the agents who act according to them. Individuals are not completely free to act: they are subjected to the rules; however, they are also enabled to make changes, according to the rules themselves. This so-called *«duality of structure»* cannot function in an isolated manner, because structures are created, maintained and changed by human agency. However, human agency can be produced only by the rules of the structure itself; that is, the rules that enable it. The learning about the enablers and constraints, empowering and limiting systems along their different dimensions, allows for correcting the direction towards sustainable development and contributing to reduce the uncertainty that derives from the gap between subjective and objective visions related to subjective views, thereby supporting conflict resolution. In Giddens' terms, adequate social structures able to manage entire systems are missing and isolated attempts that are focused on single components or sub-systems do not allow a harmonious development within and between human and ecological systems. Enablers of human agency for the purposes of decision-making, as well as sustainability constraints ruling the agency itself, are currently missing and need to be built.

Table 4. Key authors: Governing complex systems: the 'rules', 'boundaries' and 'capabilities', or 'contextual entitlements'.

Brundtland Commission (1987)	Satisfaction of current and future needs
Sen (1997)	Capabilities and freedom, consideration of real goals of development and entitlement
Jackson (2009)	Bounded capabilities (freedoms)
Campbell (2006)	Subjective preferences about objective facts (systems' boundaries)
Giddens' theory of structuration (1984)	Enablers and constraints of social structures
Laszlo (1991)	Evolutionary systems design: *«If we so willed it, the next leap in the development of human society can be intentionally guided»* by a *«holarchic path where individuals and communities collaborate of their own accord in flexible social systems»*.
Kaul and Mendoza (2002)	Public goods and social constructions depending on more complex factors than the simplistic economic consideration
Flyvbjerg (2001)	The rules (the objective side) are not the 'game' (the contextual aspects). Learning the rules to play the game
Ashby (2014)	Requisite variety: reflecting complexity by multi-method approaches
Morgan (2005)	The problem is in the reductionist approach: impossibility to control systems by prediction approaches
Norton's pluralism (2012)	In the presence of uncertainty and controversy among singular measurements by economic theory, a plural approach of scenario building could be preferred
Glasser (2007)	Social learning for the definition of desirable futures, involving «*a process of acquiring knowledge, skills, norms, values, or understanding through experience, imitation, observation, modelling, practice or study*»
Porrit (2006)	*«[T]he economy is, in the first instance, a subsystem of human society [...] which is itself, in the second instance, a subsystem of the totality of life on Earth (the biosphere). And no subsystem can expand beyond the capacity of the total system of which it is a part»*
Meadowcroft, (2013).	Current governance approaches often focus on the quality of life of the present and future generations, but they not really address concepts of 'limits' and 'needs', which determine the interactions between ecological and human systems

From another perspective, Campbell (2006) talks about subjective perceptions of objective facts that cannot be controlled by reductionist approaches (Morgan, 2005). In this situation, it is important to set participatory approaches that enhance the processes of learning that would reduce the distance between more objective constraints, problem contexts and subjective perceptions.

This theoretical discussion has highlighted a need for more modern and flexible social structures that would support a process of self-learning about the increased complexity and uncertainty of systems (Table 4, page 66). In particular, Flyvbjerg (2001) analyses the characteristics of learners in relation to experts: the first ones have to use rules in order to be effective. Experts instead, even knowing the rules, are able to understand when they should not be applied, in consideration of the contextual factors. At more advanced stages, experts can understand by intuition, based on experience, what might be the best course of action to follow. In this view, expert judgement is based on tacit and assimilated rules. However, experts do not necessarily possess the contextual knowledge of local actors who learn from practice about the adequacy of general and theoretical 'rules', adapting them through an iterative process (Flyvbjerg, 2001).

4.3 Sustainability as inherent in the definition of economics: meeting human needs (social pillar) by rational use of scarce resources (environmental pillar)

According to the view presented in the previous sub-section, market and government policies should therefore be evaluated in terms of human ends, taking into account the existing limits imposed by the systems. Sen's (1998) definition of human development, mentioned in the introduction, describes it as an advancement in the *«richness of human life»* and not in the partial vision given by the richness of the economy (UNDP website, consulted on 16.08.2013). In order to approach the aim of building a concept of governance it is important to understand the original meaning of economics and attempting to solve the conflict with the social and environmental pillars of sustainability.

As Scott Cato (2009: 5) maintains, the so-called 'green economics' has emerged from environmental political movements. This is because too often the reference to the economic pillar refers to the possibility to increase well-being, interpreted as mere material growth and measured in monetary terms (typically material ownership and income). However, green economy, by claiming to differentiate itself from traditional economic approaches, has created a contraposition. But when considering economics in terms of satisfaction of needs, the idea that 'greens' could be identified as a some kind of an extremist political party falls. When Scott Cato (2009) calls for an "ecological development", the first reaction is to think that human development is instead "ecological" by definition. This is because humans are part of the natural environment, *«connected in a web of life»,* according to the ancient Greek conception of *'oikonomia',* from οἶκος (oikos, "house") and νόμος (nomos, "custom" or "law") meaning the 'laws of the household, administration' (Douglas Harper dictionary, 2014). Economics refers in fact to *«the study of people in the ordinary business of life»* (Marshall, 1890 as cited on the AEA website, 2013), *«the science which studies human behaviour as a relationship between given ends and scarce means which have alternative uses»* (Robbins, 1932 as cited on the AEA website, 2013), and *«the study of how societies use scarce resources to produce valuable commodities and distribute them among different people»* (Samuelson, 1948 as cited on the AEA website, 2013). Economists are particularly interested in the measurement of well-being and the possibilities to improve it (AEA website, 2013). According to the American Economic Association, *«[e]conomics is the study of how people choose to use resources. Resources include the time and talent people have available, the land, buildings, equipment, and other tools on hand, and the knowledge of how to combine them to create useful products and services. Important choices involve how much time to devote to work, to school, and to leisure, how many dollars to spend and how many to save, how to combine resources to produce goods and services, and how to vote and shape the level of taxes and the role of government. Often, people appear to use their resources to improve their well-being. Well-being includes the satisfaction people gain from the products and services they choose to consume, from their time spent in leisure and with family and community as well as in jobs, and the security and services provided by effective governments. Sometimes, however, people appear to use their resources in ways that don't improve their well-being»* (AEA website, 2013). According to Sen, the purpose of the economic science is to deal with real life conditions of well-being, thereby highlighting the limitations of traditional approaches that are focused on considering self-interested utility maximisation as the sole driver of human behaviour (ODI, 2001). The UNDP's Human Development Reports consider human development an expansion of valuable human capabilities, in line with Sen's perspective (ibid.). In defining poverty, three main human capabilities are considered particularly critical: knowledge, longevity and a decent standard of living. The Gender-Related Development Index (ibid.) is focused on capturing the inequalities in the achievement of these capabilities from the gender perspective, while the Human Poverty Index focuses on deprivations, assessing standards of living on the basis of the safety of water, quality of health services and newborns' birth-weight. In a similar way, the World Bank's World Development Report 2000-01 also bases it concept of poverty on the multi-dimensional impact of some main factors, trying to add to the achieved functioning (inadequate income and human development) also components of individual agency and rights, in terms of vulnerability and lack of voice, power and representation (ibid.).

In Samuelson's definition we can find the limitation of the scarce resources, as well as their distribution. Considering that definition in the light of the Brundtland concept of sustainable development, particularly referred to as the priority of meeting the basic needs of the world's poor and the essential needs for people's lives in general (IISD, 2013), we can better define the meaning of the economic pillar. The economic dimension would indeed refer to the rational and efficient use of resources, directed to satisfy human needs from a long-term and dynamic perspective and in the consideration of their scarcity.

4.3.1 Identifying the goals of sustainable development: needs and capabilities

As Schumacher (1973) refers, *«it is inherent in the methodology of economics to ignore man's dependence on the natural world»*. This is because the growth in production capacity is seen as the sole driver by which human needs can be satisfied and conditions of well-being can be generated. In this view, the primary goals of human development, freedom, well-being, security and sustainability are merely secondary effects that can be achieved only on the condition that some economic return is produced. The improvements in prosperity and well-being may not have regard to mere capital growth, when financially measured, as they also refer to psychological dimensions, for instance to active participation to social life (Jackson, 2009). Prosperity, as Jackson (2009) reports, rather refers to reduction of adversity and not simply to economic growth, which, beyond certain limits, can even be an obstacle to human happiness, deplete natural resources or cause environmental degradation. The concept of economics as suggested above would rather focus on meeting human needs. Maslow identifies most important measurable biological and psychological needs:

«1. Biological and Physiological needs - air, food, drink, shelter, warmth, sex, sleep.

2. Safety needs - protection from elements, security, order, law, stability, freedom from fear.

3. Love and belongingness needs - friendship, intimacy, affection and love, - from work group, family, friends, romantic relationships.

4. Esteem needs - achievement, mastery, independence, status, dominance, prestige, self-respect, respect from others.

5. Self-Actualization needs - realizing personal potential, self-fulfillment, seeking personal growth and peak experiences». (McLeod, 2014)

In this view, those needs are objective and not only a matter of social value or cultural beliefs. To exemplify this McLeod (2014) identifies additions that were proposed to the original five-stage model during the 1960's and 1970s:

«1. Biological and Physiological needs - air, food, drink, shelter, warmth, sex, sleep, etc.

2. Safety needs - protection from elements, security, order, law, stability, etc.

3. Love and belongingness needs - friendship, intimacy, affection and love, - from work group, family, friends, romantic relationships.

4. Esteem needs - self-esteem, achievement, mastery, independence, status, dominance, prestige, managerial responsibility, etc.

5. Cognitive needs - knowledge, meaning, etc.

6. Aesthetic needs - appreciation and search for beauty, balance, form, etc.

7. Self-Actualization needs - realizing personal potential, self-fulfillment, seeking personal growth and peak experiences

8. Transcendence needs - helping others to achieve self-actualization».

4.3.2 Understanding more objective limits

This condition of scarcity of resources, considered in the long run, also identifies the ‘limits’ imposed on social structures in order to maintain the ability of the environment to also meet the future needs, according to its characteristics of resilience. Economics, as the human and social well-being and improvement of life conditions, within natural ecosystems, would not necessarily involve an endless accumulation of material goods. Among the needs, the material ones form only a limited part. In order to pursue the goal of the maximization of well-being of a socio-ecological system, growing all the way until the biophysical limits of an ecosystem are reached is not necessary, let alone exceed them (Lawn, 2001). Lawn (2001) reports that there is a need to recognise the limits to growth, for the reason that the part of it that exceeds the economy’s optimal scale and the biophysical limits results in the reduction of well-being, because it goes to touch and modify natural and also social equilibriums, thereby determining unrecoverable damage. We have learned from natural sciences that ecological systems are based on laws of equilibrium and balance. That is why a subsystem, such as the economic one, should reach an “about optimal” dimension, an ability to live within the larger system in a balanced relationship. Usually, the dimension of the inner system should be much smaller than the maximum sustainable potential (Lawn, 2001). However, studies on ecological footprint demonstrate how more than half of national economies, as well as the entire global economy, exceed the limits of sustainability (Global Footprint Network, 2008).

The difficulty of putting a value on nature, public goods and market failures (see Chapter 2) suggests the need for integrated social structures that are appropriate to the nature of the goals to be reached: thus, complex collective matters would require collective action, adequate to the importance of natural goods being essential to the existence of humans and the environment, and often impossible to be valuated. It is also important to recognise the scale issues in valuation and the fact that many 'goods' cross social and ecological boundaries. *«Global public goods are an often ignored but enormously important aspect of multilateralism. Whether we are talking about preserving biodiversity, preventing climate change, fighting the spread of communicable diseases, establishing rules for trade and aviation, or setting global standards of human rights, it is impossible for any single state to secure such goods on its own. Quite the contrary, global public goods can only be attained if countries work together, and globalization has only increased this fundamental interdependence. [...] [S]uggestions for improving the way in which the community of nations addresses common vulnerabilities and seizes common opportunities, [...] a basic truth about our times: global problems require global action»* (Annan, United Nations General Secretary, July 2002). When the resource is a collective public good, it requires the evaluation of the collective benefit (i.e. basic needs and well-being), which include also the availability of the resource itself for present and future generations.

The benefit of biodiversity for the health ecological systems is also acknowledged and expanded upon by the 'Natural Step' with its definition of sustainable society, as that in which «*nature is not subject to systematically increasing (1) concentrations of substances extracted from the earth's crust, (2) concentrations of substances produced by society, or (3) degradation by physical means; and, in that society, (4) human needs are met worldwide»* (Nattrass and Altomare, 1999). These have in fact been considered in the case study analysis in the form of data to be included in the empty framework for data analysis. In the same way, according to the concept of Ecological Footprint, sustainability is defined as *«living within the regenerative capacity of the biosphere»* (Rees and Wackernagel, 1994; Wackernagel et al., 2002). This definition would indicate the need to compare the amount of land that is needed for food and non-food production, together with its capacity to absorb waste from human activities, with the total amount of available land (Koshel and McAllister, 2010). When other kind of evaluations seems not reliable enough, a more objective evaluation of sustainability that is based on physical measurements (Koshel and McAllister, 2010) could be of a help, such for instance the Ecological Footprint and Gradel and Klee's Sustainable Emissions and Resource Usage model that are applicable to single or multiple resources or products. The Marshall-Toffel Sustainability Hierarchy (Marshall and Toffel, 2005) has attempted to review the previous models, by prioritising sustainability goals into a four-level hierarchy, inspired by the well-known Maslow Pyramid (see Figure 9):

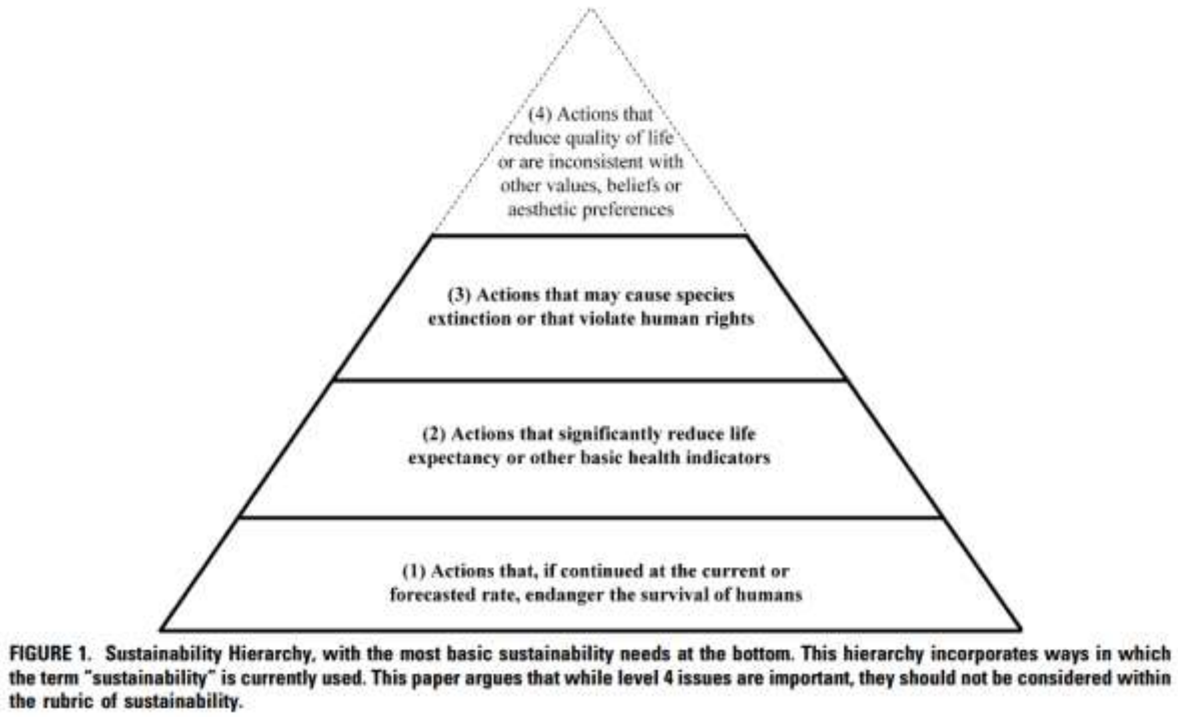


Figure 9. The sustainability hierarchy (source: Marshall and Toffel, 2005).

«Level 1: Actions that, if continued at the current or forecasted rate, endanger the survival of humans.

Level 2: Actions that significantly reduce life expectancy or other basic health indicators.

Level 3: Actions that may cause species extinction or that violate human rights.

Level 4: Actions that reduce quality of life or are inconsistent with other values, beliefs, or aesthetic preferences».

4.4 Understanding systems' interactions through social learning

According to the UN, (United Nations General Assembly, 1987), strategic actions for shifting from the present growth and development approaches towards a more sustainable way of development are imperative, in the consideration of the impacts that will affect other nations.

Some critical objectives have been indicated in the renewing of the conception of growth, more addressed to enhance its qualitative dimension, together with the need to meet the essential needs (jobs, food, water, health, security, sanitation). The criticalities of uncertainty, complexity and public relevance treated in Chapter 2 lead to the argument for a more integrated approach of governance. In evolutionary systems design, Laszlo and Krippner (1998) state: *«Having become conscious of evolution, we must now make evolution itself conscious. If we so willed it, the next leap in the development of human society can be intentionally guided»* by a *«holarchic path where individuals and communities collaborate of their own accord in flexible social systems»*. (Laszlo, 1991: 104).

Stiglitz et al. (as cited in Slim, 2013: 57), consider other forms of capital, which can produce positive effects on people's lives—such as human capital, natural capital and social capital—even if they are not exchanged on the markets or valuated in terms of GDP growth. According to the U.S. Environmental Protection Agency (2013), "smart growth" is the *«development that serves the economy, the community, and the environment. It changes the terms of the development debate away from the traditional growth/no growth question to 'how and where should new development be accommodated»*.

In order to move from the general view about the need to build sustainable development to the understanding about its concrete implementation through a more effective governance for sustainability—i.e. the definition of the policies and the actions needed for its achievement—the role of social learning and phronesis about sustainable development becomes an important and relevant goal of governance processes (Jordan, 2008: 18). According to Sterling (2007), the urgency and complexity of the issue of sustainable development requires processes of social learning, in order to build awareness about that complexity and the need to think systemically, analyse ethical contexts and question assumptions, and visualise alternative futures. This is introduced by Jordan (2008) as necessary process of understanding about the balance between resources, needs (interpreted as basic human needs) and growth in the natural, human and social capitals in terms of knowledge, well-being, entitlements and *«capabilities for flourishing»*, which are *«inevitably bounded by material and social conditions»* (Jackson, 2009: 34, 35).

The social learning process involves the participation of citizens in decision-making and in designing social structures by looking at systems' dynamics rather than their single isolated components. In other words, social structures shall be designed according to the participatory action of larger communities, enabling stakeholders' agency in the contextualised environments, and according to the characteristic of resilience of the systems in which they are inserted (Sterling, 2007).

As Carter reports (2007: 224), the road towards sustainable development has to be discussed, debated and planned and the meaning of sustainable development would emerge through an *«interactive process of social dialogue and reflection»* (Jordan, 2008). In order to bring societies towards their sustainable development the knowledge about its dynamic evolution cannot be ignored (Jordan, 2008). This suggests a need to build what Glasser (2007, 2004: 134) calls 'ecocultural sustainability', *«a dynamic equilibrium and a social process that is desirable and ecologically sound»*. This concept involves, according to Glasser (2007), a society that is able to renew itself and the individuals it embeds, by the promotion of cultural and biological diversity, participatory, equitable and transparent forms of governance and accountable and ecologically sound economies. These involve in turn the adoption of models of consumption and production, which are harmonised with the systems they are built in. Social learning has been defined by Keen et al. (2005: 4, as cited in Wals and van der Leij, 2007: 18) as *« ... the collective action and reflection that occurs among different individuals and groups as they work to improve the management of human and environmental interrelations»*. Wals and van der Leij (2007) report how the sustainability can be considered an emergent and evolving phenomenon and more a social learning process rather than an *«expert pre-determined transferable product»*. As they continue, social learning goals are partly determined by the learners themselves. On the other hand, a reference to more objective factors has to be acknowledged: according to Jackson, 'western' lifestyles based on possession and material values and the consequent *«symbolic role of material commodities»* in determining the social position of individuals are also strongly influencing developing societies. In such situations, a cultural shift from dependency on material growth and consumption, towards a focus on basic needs and a non-material conception of well-being, seen as happiness and health, seems necessary. The idea of ecocultural sustainability represents a development, which is based on the balance within systems and between systems, pursuing at the same time human needs and often non-negotiable constraints (Glasser, 2007: 36). Glasser continues that self-learning processes about needs and enablers, including subjective and contextual factors, and the overarching and more objective constraints, are required in order to realise anticipatory decision-making and adaptive learning about the possible future development. Sustainability is an open-ended process (Kemp, Parto and

Gibson, 2005), which represents the basis for the theorisation of participatory governance approaches of continuous learning. That is why sustainability is also about awareness and people's behaviour, confrontation of mindsets, as diversity gives contribution for understanding local problems, perspectives, behaviours, public engagement. Governance, in this view, is seen as a process of social learning about the systemic interaction between the parts of the systems and sub-systems, in order to design social structures, which are adaptive and more sustainable.

In a complex and uncertain environment a systems design approach has to recognise the interconnected and interdependent processes problems according to a holistic vision, designing future solutions *«through an informed understanding of the dynamics governing evolutionary systems»*.. *«This is based on the belief that we can shape our future on the one hand through the power of understanding the characteristics and requirements of the environment, and on the other through our aspirations and expectations»* (Laszlo and Krippner, 1998). The authors report on the inherent participatory nature of systems design because, in societal systems, humans represent naturally a critical component, and change cannot happen without their contribution. The participatory approach in governing systems represents therefore an *«anticipatory democracy, where people actively apply their skills to the analysis and design of socially and ecologically sustainable systems by becoming active participants in shaping their future»* (Laszlo and Krippner, 1998). In such a vision, social structures could engage people in a community for evolutionary social learning addressed at the design of systems, especially for the purpose of sustainable development. According to Goldstein (1981), social learning represents a higher form of learning, which takes place in specific social contexts with aims of social adaptation. Glasser (2007) considers social learning as being related to the participation and interdependence of stakeholders for the definition of desirable futures, involving *«a process of acquiring knowledge, skills, norms, values, or understanding through experience, imitation, observation, modelling, practice or study»*. Therefore, the evolutionary learning about systems design would involve an effort for raising a culture of participation and joint governance that is specifically addressed to initiate pathways towards sustainable development (Lazlo and Krippner, 1998). This includes a culture of responsibility within the social and physical systems, which recalls the idea of entitlements within rules (see sub-section 4.2).

Laszlo and Krippner (1998) hold that change cannot occur without incorporating the human dimension. In this view, the authors claim, systems design realises anticipatory democracy, as product of the enabling, entitlement and participatory active learning of people about systems which are socially and ecologically sustainable and contributing in this way to shape their future. In such a process of learning, the interpretation of current human social systems requires the integration of the different dimensions, in order to learn about the possible relationships. Understanding sustainability cannot neglect the increasing complexity of these interrelations when technological and social development has completely changed human systems' dynamics and detached them from the functioning of the natural world. In order to understand systems' sustainability and imagine desirable futures, and to adapt to change and survive, the integration of natural social and human sciences in a holistic interpretation is advocated.

The interrelated criticalities described in Chapter 2 are particularly relevant for the security of single systems and even more for wider sustainability issues, in accordance with von Bertalanffy's (1968) basic assumption that *«the whole is more than the sum of its parts»*. As Morgan (2005) states, in a system *«the behaviour of the parts depends more on how the parts are connected rather than on the nature of the parts»*. This leads to support the irreducibility of integrated systems (Laszlo and Krippner, 1998: 13).

'Adaptive management' or 'adaptive collaborative management', focuses on improved and processes of deliberation, designed to deliver the most rational decisions (Simon, 1979; O'Neill et al., 2008). Norton (2012) argues that aggregative analyses would like to present the best solution, for the use of political and social processes, and adapt them to the singular and best answer, even in conditions of high complexity and uncertainty. Alternatively innovative governance approaches can initiate processes of social learning about the opportunities for, and threats to, alternative solutions as well as stakeholders' value systems and desired futures. The consideration and awareness of what is to be considered as valuable and about the aspects of human dependency on nature can be an important aspect of learning and adapting to the ecological system, allowing for a detachment from the anthropocentric conception of development.

Laszlo and Krippner (1998) suggest the concept of 'evolutionary competence'. This refers to the self-actualisation of individual people and communities or groups, which is realised through the development of their knowledge, skills, attitudes, and which includes the evolutionary values required for their agency, for the *«pursuit of sustainable modes of being»*. These modes of being involve being aware about, and the simultaneous monitoring of: social desirability, cultural acceptability, psychological nurturing, economical sustainability, technological feasibility, operational viability, environmental friendliness and generational sensitivity.

Governance for sustainability is, in this light, a self-learning and self-regulation process, in a voluntary and/or mandatory form according to the specific issues, on the basis of both ethical (the relative harm produced) and precautionary principles, able to drive choices, by converging subjective and objective risks about systems' sustainability and in terms of entitlements and constraints (see sub-section 2.3).

4.5 Towards a concept of 'governance for sustainability'

Barnes and Hoerber (2013) report on the evolution of the sustainability discourse in Europe (see Table 5, page 79). According to the analysis previously described on the systemic conception and on the role of the economic pillar within the Brundtland definition of sustainable development it is possible envisage a model of systemic integration and governance for sustainable development, as reported in the last column. However, the systemic idea wants to enhance the fact that the models do not refer to 'deep ecology', as an extreme conception, far from Brundtland definition, but on the construction of social structures, which are adequate for the overarching systems and their resilience. According to Norton (2012), participatory approaches with individuals and groups will generate different development paths or scenarios to those which arise from an aggregation and or averaging process. This can happen by analysing given proposals for policy action according to desired expected outcomes and evaluating the changes, positive and negative, produced on ecosystems and societies. As Norton also suggests, the pluralism is expressed by a first identification of evaluative criteria representing important values shared by the participants, and then by the ranking of possible preferred solutions according to the chosen criteria (Norton, 2005).

It has been argued that the methodology and framework for the assessment of Social Technical Systems (STS) and sustainability evaluation should be able to reflect the concept of governance for sustainability based on participatory social learning about the complexity of multiple impacts within and between different STSs. Therefore, the principles driving the construction of such methodology are based on an idea of governance of sustainability based on:

1. Systems' adequacy: keep within the limits

2. Learning about (1) and building adaptive capacity
3. Creating entitlements for meeting basic needs and human rights
4. Governing systems by setting standards for systems' reliability and sustainability and entitlements for meeting needs: human-nature relationships balance and harmonisation

According to Evans (2012: 4), *«governance provides a third way between the two poles of market and state, incorporating both into a broader process of steering in order to achieve a common goal... governance operates by setting common goals or targets, which allow different actors to devise the most suitable ways to reach them»*. According to previous research conducted at European Commission level, governance has been defined as *«a conceptual construct dealing with societal sensitive and complex issues that can be translated in a decision-oriented process, inclusive of all concerned private and public stakeholders. The outcome of the process is based on participative deliberation, the informing of options, and commitment to the implementation of the joint deliverances. The governance process represents the interface with stakeholders, the source and support of strategic decisions and the instrument through which the principle of accountability can be properly implemented. Governance is a concept that expresses the aspiration for 'joint and integrated management' of affairs that cannot be handled by single stakeholders because of their multi impact effect and because of the complexity of relations between them»* (Sajeva and Masera, 2006: 8). These definitions suggest governance approaches that would be effective for the achievement of the final objective and serve as an approach for generating social learning. The main characteristic of such approaches is the enabling of social structures that would be flexible, self-learning, and able to change according to the specific characteristics of a complex system (Capra, 2007: 14). This involves the possibility that those structures would re-design themselves and enable the emergence of the necessary capabilities and the possible limits. Not all solutions are good; therefore, the process of social learning can identify alternative possibilities for change, while keeping in mind the non-negotiable constraints. Deterministic models, setting routines that are valid in all times and places, are destined to fail with a minimum of change in the initial conditions. In order to confront complexity, we indeed need an evolving and engaging process (Wals and van der Leij, 2007: 17) for a more systemic and reflexive thinking, to capture the sudden changes of an ecosystem. In this view, in relation to sustainable development goals, *«governance should have a role as a mean of persuasion and*

Table 5. The evolution of the discourse of sustainability in Europe and the systemic governance approach. Development of Pearce (1993: 18), Baker (2006:13) and Barnes and Hoerber (2013: 25)

Anthropocentric			Eco-centric	
POLLUTION CONTROL	'WEAK SUSTAINABLE DEVELOPMENT'	'STRONG SUSTAINABLE DEVELOPMENT'	DEEP ECOLOGY 'IDEAL' MODEL	SYSTEMS' INTEGRATION MODEL
Unlikely to lead to Brundtland model **(Barnes and Hoerber, 2013: 25)**	'No special place for environment' (Pearce, 1993: 16)	(Barnes and Hoerber, 2013: 25)	Unlikely to lead to Brundtland model (Barnes and Hoerber, 2013: 25)	Systemic governance for sustainable development
Focus on resource exploitation	Focus on economic growth	Focus on environmental protection as a precondition for growth	Focus on nature intrinsic value, no substitution is possible	Focus on the recognition of human systems as part of a larger environment systems
Effect: pragmatic market-led approach **'End of pipe' solution for pollution control** **Command and control regulation led by state action** **Inadequate**	Effect: Indifference to the form of capital left to future generations Rhetoric not action on environmental protection Some limited institutional reform introduced Some cross-sectorial policy coordination May address pollution at source	Effects: Ecological modernisation of production, mixed labour and capital intensive technology established as dominant technology Objective to maintain critical natural capital Integration of environmental concerns at sectorial level Partnership and shared responsibility across multi-levels of governance Democratic participation of civil society	Effects: Environment takes on a 'personality' to which moral obligations are owed. Strict limits on resource use De-centralisation of institutions, bottom-up community structures in place Labour intensive economic development	Effects: Participatory governance and social learning about economics composed of needs and resources available Use of resources in harmonic balance Knowledge intensive human development: enablers, entitlements and capabilities Abandon of economic (financial and material wealth) development focus: real capitals (natural, human, social). Ecocultural sustainability based on systemic interaction between capitals

education to overcome lock-in and trigger a process of self-learning and understanding about the general and non-negotiable sustainability constraints, going beyond formal regulatory provisions or market mechanisms (i.e. mandatory or voluntary standards)» (Sajeva, Sahota and Lemon, 2014: 11).

The assumption is indeed, as Barnes and Hoerber hold (2013: 30), that the multi-level governance action is brought to all societal dimensions—national, regional and local—and actually implemented in concrete and effective deliberations.

Biermann (2007: 335) advocates for an *«earth system governance»*, which is *«adaptive to changing circumstances, participatory through involving civil society at all levels, accountable and legitimate as part of new democratic governance beyond the nation state, and at the same time fair for all participants»*.

In light of the analysis of the idea of governance for sustainability would identify a concept of joint and integrated social structure designed for the pursuit of an harmonic human sustainable development, involving the endurance of human systems (basic needs) within the boundaries of environmental systems (ecological functions), through human agency—i.e. joint deliberation about sustainability criteria and action that is adequate for their pursuit. In order to be translated into practice, this concept of governance for sustainability requires a participatory process of adaptive social learning for evolutionary system design that can inform about the options of emergent future scenarios and support the deliberation about policies and actions for the sake of the futures identified, implementing in this way the principle of accountability.

4.6 Existing methodologies for sustainability evaluation and communication

Having addressed research the research question b) formulated in Chapter 3 in the previous sub-sections, it is now possible to approach the main research question, related to the aim of the thesis, about how to develop a governance for sustainability framework for the social learning and facilitation of more sustainable decision making in Socio-Technical Systems (STS).

In other words, how to build a methodology for social learning that can evaluate Socio-Technical Systems' (STS) sustainability that builds on the conceptual framework of the 'governance for sustainability' and incorporates the key insights and aim for a more sustainable future?

The inadequacies of the GDP index to capture all dimensions of well-being and to be reliable in the measurement of development and well-being, led to the conception of many other evaluation methodologies, both quantitative and qualitative. In the context of research that is aimed to generate a methodology for social learning and STSs' sustainability assessment, it is important to describe the state-of-the-art of existing approaches and their specific characteristics.

Many frameworks for qualitative evaluation of sustainability and their governance already exist, each of them with their own approaches and characteristics. For instance, Multiview for information systems, Triple Task for group work and Imagine (Bell, 2014; Bell and Coudert, 2005). The latter one, in particular, aims at providing a description of the context that would be as complete as possible—by utilizing indicators and providing a visual representation of sustainability, accompanied by Rich Pictures (RP) and metaphors that could easily be translated into activities to be performed (Bell and Coudert, 2005). In order to understand, assess and regulate a system the regulator needs to *«be a model of the system»*, reflecting its complexity (Bell et. al, 2016). Bell continues that the RP merges text and visual material representing complex stories and exploring different worldviews, encouraging discussion and contributing to reach an agreement.

According to OECD the essential characteristics of a sustainable impact assessment are the analysis of long-term flows, investments and effects, the equal measurement of economic, environmental and social impacts, the identification of synergies and trade-offs across domains, the transparency of processes (Stevens, 2015). The OECD (Stevens, 2015) identifies some key sustainability assessment tools:

- economic – cost/benefit analysis, modelling, regressions, scenarios
- environmental – life-cycle analysis
- material flows, resource accounting
- NAMEA, ecological footprint
- Social – sustainable livelihoods, human and social capital measurement, participatory processes.

It also reports on the modes by which synergies and trade-offs can be identified, through:

- *«comparative value analysis – impacts are scored according to pre-set values,*
- *utility analysis – impacts are rated on a uniform scale and weighted*
- *cost-benefit analysis – positive and negative impacts are assigned monetary values and compared*

- *multi-criteria analysis – both quantitative and qualitative impacts are ranked on pre-set criteria risk assessment – degrees of risk reduction identified with pre-set risk thresholds»*

and continues that long-term and intergenerational concerns can be identified by:

- *«Capital indicators – assess stocks and flows of economic, environmental, human and social capital according to discount rates*
- *Trend lines – identify positive, negative or constant*
- *Irreversibility – determine degree to which effects can be reversed*
- *Burden-shifting – determine degree to which negative impacts are shifted to future generations*
- *Cost of inaction – estimate long-term costs of failure to act at present»*

The OECD also considers the difficulties inherent in sustainability assessments (Stevens, 2015). Among these the issues of weighting the social environmental and economic pillars; giving adequate attention to the longer-term and the challenge of assigning monetary values to environmental and social assets are reported. These are reflected in the following steps for sustainability assessment (Stevens, 2015):

- *«identification of level and target (e.g. national policy, local project)*
- *establishment of sustainability relevance*
- *selection of quick scan vs. more detailed assessment*
- *identification of relevant tools (qualitative, quantitative)*
- *assessment of impacts, synergies and conflicts*
- *identification of alternative policy paths classified according to their sustainability level*
- *communication to policy-makers and stakeholders»*

Important procedural aspects of sustainability assessments are related to the identification of the agency or agencies involved in the assessment, the modalities of involvement and consultation of stakeholders and the society, the users of the assessment, the legal and political relevance of the assessment recommendations and the level of integration of sustainability assessments into existing procedures (Stevens, 2015).

4.6.1.1 The Global Competence Matrix (Edsteps, 2015)

The Global Competence Matrix (Edsteps, 2015) is aimed at constructing capacity, disposition to understand and consequently action on issues of global relevance, such as for instance climate change. Such Global Competence can be built within and across disciplines (Table 6). These matrices can be applied to either global or more localised issues with iterative and cumulative insight being generated from the local to the global and or vice versa.

Table 6. main Global Competence Matrix (source Edsteps, 2015)

INVESTIGATE THE WORLD	RECOGNIZE PERSPECTIVES	COMMUNICATE IDEAS	TAKE ACTION
Students investigate the world beyond their immediate environment.	Students recognize their own and others' perspectives.	Students communicate their ideas effectively with diverse audiences.	Students translate their ideas and findings into appropriate actions to improve conditions.

4.6.1.2 The NUSAP method for the qualitative assessment of scientific information (Funtowicz and Ravetz, 1990).

Funtowicz and Ravetz (2013) state that the notion of environment is specially challenging in policy making as it is composed by different specific issues that have to be considered in detail. Conversely, the environment involves broad strategic sustainability issues that have to be addressed by regulatory action. They argue that *«nothing can be managed in a convenient isolation»* as issues are mutually interconnected and spread across different levels of space and time. This complexity is accompanied, as also treated in Chapter 2, by uncertainties and value-loadings. Funtowicz and Ravetz recognise a role for 'Post-Normal Science' for managing complexity (Funtowicz and Ravetz 1992, 1993) that focuses on the aspects of problem solving that tend to be neglected in traditional accounts of scientific practice: uncertainty and value loading.

The rational of the NUSAP method is aimed to go beyond traditional science and acknowledge uncertainties and the relative quality of information, as part of the scientific process. Indeed NUSAP stands for Numeral, Unit, Spread, Assessment and Pedigree, that are meant to be added to the quantitative information in order to deliver its level of quality and uncertainty. The Pedigree, expressed by the use of a matrix, reveals the background meta-evaluation of the scientific information, through the translation of qualitative attributes into quantitative evaluation through a scoring system (see Table 7).

Table 7. Pedigree matrix for research (Funtowicz and Ravetz 1990)

Score	Theoretical Structure	Data input	Peer acceptance	Colleague consensus
4	Established theory	Review	Total	All but cranks
3	Theory-based model	Historic/Field data	High	All but rebels
2	Computational model	Extrapolated	Medium	Competing schools
1	Statistical processing	Calculated	Low	Embryonic field
0	Definitions	Expert guess	None	No opinion

When attributes of the matrix are chosen, they form a vector of four elements. These can be inputs for the generation of a spider diagram, showing the level of quality of the research done. When the evaluation is performed by more participants, it gives quantitative distributions of their qualitative evaluation, thereby providing a participatory evaluation of uncertainty.

4.6.1.3 The Natural Step (http://www.thenaturalstep.org/)

The Natural Step is a non-profit organization, for the achievement of long-term societal interests. It is oriented towards a critical future oriented analysis about improved options and concrete results, by inspiring management and helping people to the development of their skills. The Natural Step claims a *«different way of seeing and doing things»*, helping to change the perspective towards a more sustainable future, by challenging established assumptions, and helping to develop appropriate sustainability strategies.

The approach is based on the reliance to four main Sustainability Principles:

- *«… we cannot dig stuff up from the Earth at a rate faster than it naturally returns and replenishes.*
- *… we cannot make chemical stuff at a rate faster than it takes nature to break it down.*
- *… we cannot cause destruction to the planet at a rate faster than it takes to re-grow.*
- *… we cannot do things that cause others to not be able to fulfil their basic needs».*

These four sustainability principles identify a bottom line of basic conditions that are important to assure that society do not systematically destroy the social and ecological systems it depends on, thereby helping to build a more sustainable society. They are guidelines for current and future prosperity.

The Natural Step then suggests backcasting to help understanding future goals and the steps that are needed to reach them. This approach well reflects the governance for sustainability approach as earlier analysed, as, to be sustainable, the society needs some basic rules. However, looking at a more context-based specific challenge collaboration and participation, by workshops, in-depth interviews, mapping of existing information, can and bring value and identify different perspectives, or alternative future scenarios.

4.6.1.4 NAMEA

NAMEA (National Accounting Matrix with Environmental Accounts) is a tool developed by the European Commission's statistics service EUROSTAT for analysing economy-environment relationships. NAMEA is an integrated set of economic and environmental accounts, that cover important environmental themes and produces indicators of environmental performance. The linkage between economic and environmental indicators support the monitoring and analysis of a wide range of sustainability issues that are incorporated into a single accounting system that allows an integral policy analysis of sustainable development (de Haan and Kee, 2015). Currently, CIPEA (2015) reports, NAMEA analyses mainly pollutant emissions into air and water, as well as energy consumption. Further developments are being realised enlarge NAMEA coding to waste production and water abstraction (CITEPA, 2015). Therefore, NAMEA helps to understand the links between production activities and environmental impacts, identifying the respective contributions of the different economic agents to the specific environmental problems considered. This happens by cross-linking macro-economic indicators (GDP, net savings, exports, etc.) with environment data.

The atmospheric emissions are expressed by a NAMEA code (equivalent to NACE, the European Commission's statistical classification of economic activities in the EU), correspondent to different economic sectors, allowing to quantify the emissions produced for each of them. The eco-efficiency of each of the economic areas can monitor trends and benchmark performances in different countries (CITEPA, 2015).

The environmental and social externalities are captured by a broader approach of accounting than the conventional System of National Accounts (SNA) (United Nations et al., 1993) that includes physical flow accounts. The NAMEA environmental accounts are published by Statistics Netherlands every year, showing the interactions between the activities of production and consumption and comparing with the state of the natural environment (de Haan and Kee, 2015). This linking between environmental resources and human activities is used to generate environmental-economic performance indicators.

4.6.1.5 Dashboard of Sustainability Indicators (https://www.iisd.org/cgsdi/dashboard.asp)

The Dashboard of Sustainability is a non-commercial software that represents the complex relationships among economic, social and environmental dimensions. It is designed to be easily used by experts, policy-makers, the media, and the general public, by means of a metaphor – a vehicle's instrument panel – describing economic, environmental, social and institutional sustainability levels, specified for each country. The tool, developed by the Joint Research Centre of the European Commission, is being used to represent the United Nations' core set of sustainability indicators. At the World Summit on Sustainable Development in 2002, IISD expanded the Dashboard with a functionality that allows the comparison of environmental, social and economic data over a period of 10 years. The visual representation also informs decision-makers and stakeholders about the Millennium Development Goals (MDGs) indicators, with particular reference to developing countries, in order to support the definition of Poverty Reduction Strategies and monitor the related achievements. These indicators help define of the MDGs. Download the Dashboard.

In Figure 10, a map of Africa is represented by using a colour code from deep red ('critical situation') to deep green ('excellent'). It represents statistics such as 'Ratio of literate females to males', scoring maximum for Lesotho and minimum in the case of Niger. Among the 'good' countries Kenya scores 720 while Rwanda 693.

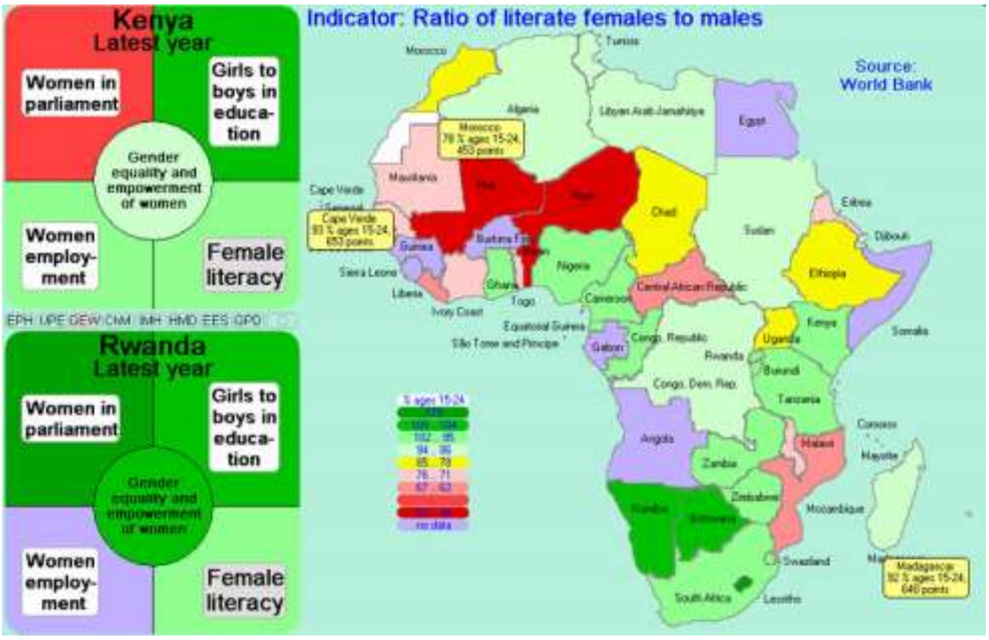


Figure 10. A view of the Dashboard of Sustainability Indicators (IISD, 2015)

The points are calculated as follows: 1000*(x-worst)/(best-worst). Example made by IISD: *«Best=119 (Lesotho), worst=44 (Niger); with 96 % ages 15-24, Rwanda receives 693 points: P=1000*(96-44)/(119-44)».*

As reported by IISD, the key features of the Dashboard are:

- Performance evaluation with individual indicators and aggregate indices.

- Country comparison with distribution curves and maps.
- Comparison within country groups.
- Linkage analysis and scatter plots.
- Multi-lingual functions.
- Internet connectivity.
- Extended help function.

4.6.1.6 The Futures Wheel for scenario building

The Futures Wheel is a means for visioning the future implications emerging from current critical issues, decisions or actions in order to assess impacts and inform strategic decision-making for more resilient planning (Emergent By Design, 2015, e.g. Figure 12). Futures Wheels have developed from the Implications Wheels (see Figure 11, page 87), developed in the 1970s by Joel Barker (Hines and Bishop, 2007).

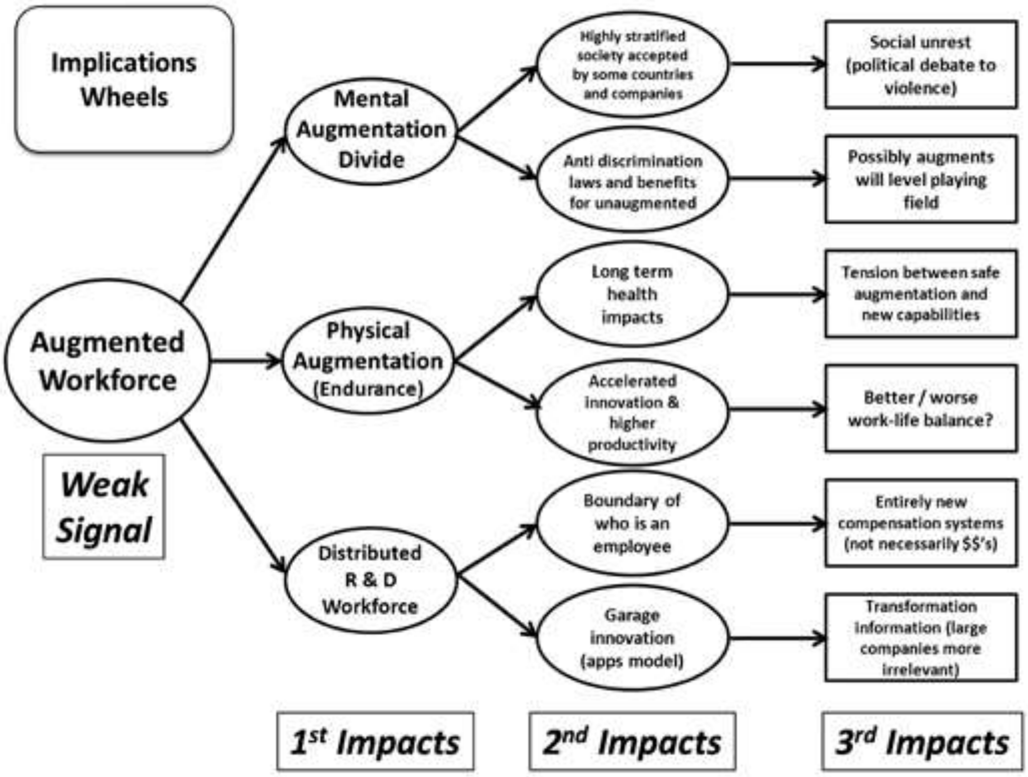


Figure 11. Example of Implication Wheel for augmented workforce (source Farrington *et. al.*, 2012)

The Futures Wheel is a structured brainstorming method to think and locate issues or strategic actions and their possible impacts or consequences that generate possible or desirable futures. The tool also allows to locate complex interrelationships. An event that already occurred, or a strategy to put in place, is first located in a central oval. Possible impacts or consequences of first order are reported in separate ovals around the central oval and connect it with a single line, to form a ring around the centre. The same is repeated for impacts of second order, for each one of the first order ovals with a double line, and for impacts of third order. This can go on until a the implications of the event provide a clear picture of possible futures (Emergent Futures, 2009).

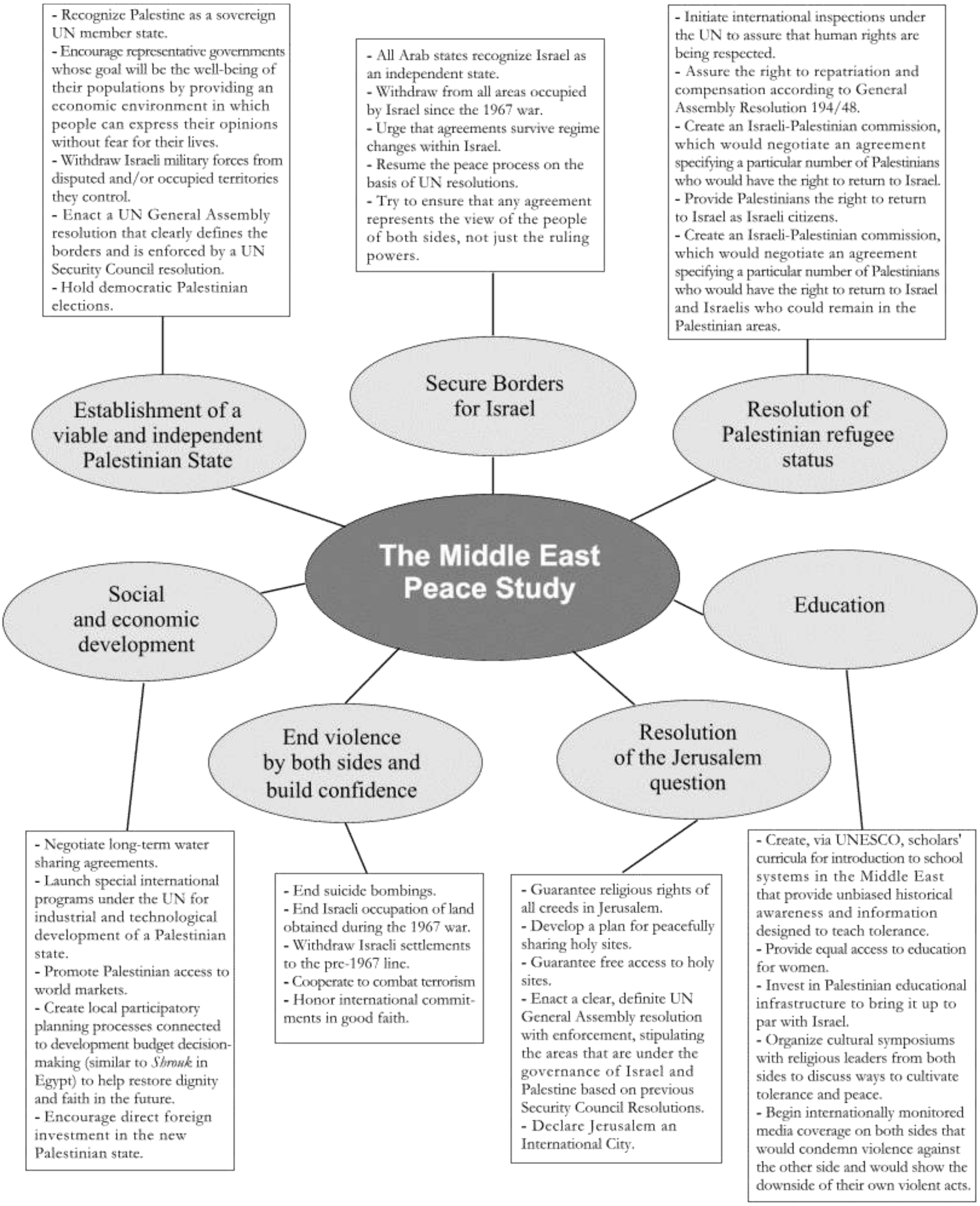


Figure 12. An example of Futures Wheel about Middle East Peace Scenarios (Millennium Project, 2009).

4.6.1.7 The characteristics of the exemplified methodologies according to the OECD classification

The methodologies described above are analysed in Table 8 (page 90), on the basis of the descriptions above, according to the OECD classification in order to have a vision of their applicability and different analytical approaches. This is done with the following objectives: to gain an understanding about the range of methodologies and their strengths and weaknesses, to identify where there is a need for complementary tools and thereby to support the construction of the proposed methodology.

A major problem in the area of governance for sustainability is that in spite of the range of measurement tools and scientific data available, these are not taken as basis for action or for designing social systems that are integrated with environmental processes and systems (László *et al.*, 2005)

Some of the exemplar methodologies are based on the traditional vision of compromise between the pillars of sustainability. The legal and political status of the recommendations is also often missing. Many of them, even if adopted by important international organisations and communicated to policy makers, do not really accomplish to the task of implementing the principle of accountability. It can be perhaps argued that by the calculation of physical flows, NEMEA realises a reconciliation of conflicts between the pillars. The Natural Step overcomes this compromise as well as it gives priority to established sustainability criteria and implements accountability in a way, but its scope is limited to the specific organisations that apply the method and, in any case, the criteria exposed are not mandatory. As also referred in Chapter 2, a main aspect that is responsible for the deficiencies of governance approaches is the reliance on markets and legislation for matters that are public, complex and exceed the responsibilities of single administrations. These methodologies have demonstrated their strength in making aspects not covered by traditional economic modelling emerge, however, the gaps in current governance approaches is not only related to the lack of evaluation methods in themselves but to the lack of governance for sustainability and adequate social structures for its pursuit. This in turn is translated into a lack of methods that are able to represent the complexity of sustainable development. These methods are not attached to theoretical concepts of governance for sustainability, made of more formal social structures and socio-economics for sustainability that would reflect systems complexity.

Table 8. Example of qualitative/quantitative methodologies for sustainability assessment

Characteristics according to the OECD dimensions	The Global Competence Matrix	NUSAP-pedigree matrix	The Natural Step	NAMEA	Dashboard of Sustainability Indicators
Identification of synergies and trade-offs					
Comparative value analysis	x		x	x	x
Utility analysis				x	
Cost-benefit analysis					x
Multi-criteria analysis	x	x	x	x	x
Risk assessment		x	x	x	x
Long-term and intergenerational concerns					
Capital indicators				x	x
Trend lines	x		x	x	
Irreversibility	x		x		
Burden-shifting				x	
Cost of inaction				x	
Procedural aspects of sustainability assessments					
Identification of agencies involved	x		x		x
Involvement of stakeholders and civil society	x	x	x		
Communication of assessment results	x	x	x	x	x
Legal and political status of recommendations					
Integration of sustainability assessment in existing procedures		x	x	x	
Challenges in sustainability assessment					
Equal attention to the three pillars					
Assignment of monetary values				x	x
Identification of trade offs	x		x	x	
Reconciliation of conflicts between the pillars				x	
General steps recommended					
Level and target coverage	x				x
Sustainability relevance	x	x	x	x	x
General or specific assessment	x	x	x	x	x
Relevant tools (quantitative, qualitative)		x	x	x	x
Impact, synergies and conflicts assessment	x		x		
Identification of alternative pathways and evaluation of their sustainability	x	x	x		
Communication to decision makers	x	x	x	x	x

As pointed out in sub-section 3.4, and reported verbally by a Scientific Officer of the European Commission, governance methods or indicators alternative to GDP have not been put in practice and have remained as isolated recommendations, often addressed to specific contexts and issues. They are often not integrated into the functioning of social structures, or designed to support an approach of governance for sustainability.

From the analysis undertaken so far, alternative governance arrangements could be designed as social structures that are able to address the sustainability goals. For example Scott Cato's (2009) inter-related sustainability pillars (see Figure 7, page 41) and the Five Capitals Model of Sustainability (Forum for the Future, 2013; see Figure 13, page 91) offer a potential basis for a framework from which the condition of well-being and human development can be evaluated.

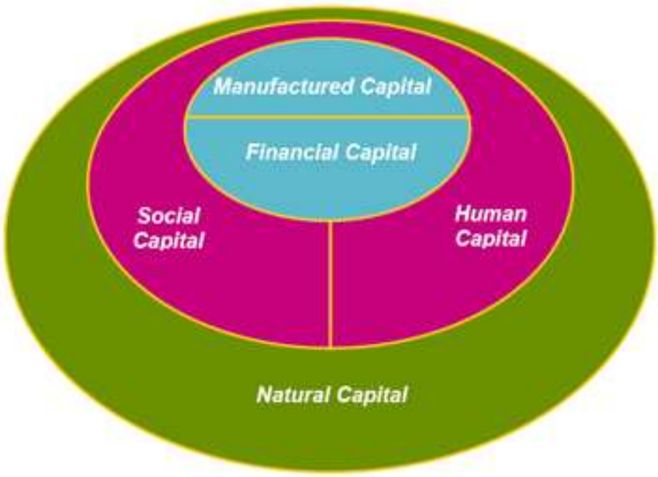


Figure 13. The five types of sustainable capital, Forum for the Future, 2013 (web source)

The Five Capitals Model of Sustainability (Forum for the Future, 2013) may support the approach of governance for sustainability through balancing different capitals and taking account of both contextual factors and the non-negotiable limits of systems. This may support a process of social learning and contextual, collective decision-making on the basis of sustainability criteria (Kemp, Parto and Gibson, 2005: 21) that are both quantitative (e.g. nutritional requirements, water, air and soil quality) and qualitative (e.g. social aspects).

The development made by the Forum of the Future represents an extrapolation, according to capitals of different nature. The composition of Scott Cato conception and the development of the concept by the Five Capitals model has been taken as a theoretical starting point for the analysis of the three STS case studies (see Chapter 6) and for the integration of their outcomes into the proposed method and subsequent framework (see Chapters 5 and 7).

Table 9 (page 92) describes the twelve features of a sustainable society (Forum for the Future, 2013). The Natural Capital is the most significant form of capital, in which all other capital types are embedded. This is defined as *"any stock or flow of energy and material that*

Table 9. The twelve features of a sustainable society (source Forum for the Future, 2013)

The dimensions of the Five Capital Model of Sustainability

Natural Capital	In their extraction and use, substances taken from the earth do not exceed the environment's capacity to disperse, absorb, recycle or otherwise neutralise their harmful effects (to humans and/or the environment)
	In their manufacture and use, artificial substances do not exceed the environment's capacity to disperse, absorb, recycle or otherwise neutralise their harmful effects (to humans and/or the environment)
	The capacity of the environment to provide ecological system integrity, biological diversity and productivity is protected or enhanced
Human Capital	At all ages, individuals enjoy a high standard of health
	Individuals are adept at relationships and social participation, and throughout life set and achieve high personal standards of their development and learning
	There is access to varied and satisfying opportunities for work, personal creativity, and recreation
Social Capital	There are trusted and accessible systems of governance and justice
	Communities and society at large share key positive values and a sense of purpose
	The structures and institutions of society promote stewardship of natural resources and development of people
	Homes, communities and society at large provide safe, supportive living and working environments
Manufactured Capital	All infrastructure, technologies and processes make minimum use of natural resources and maximum use of human innovation and skills
Financial Capital	Financial capital accurately represents the value of natural, human, social and manufactured capital

Table 10. The criteria for sustainability and the related constraints for Natural Capital (source Forum for the Future, 2013)

Natural Capital: Sustainability criteria	General constraints
"Substances taken from the earth do not exceed the environment's capacity to disperse, absorb, recycle or otherwise neutralise their harmful effects (to humans and/or the environment)".	Constant increases of substances taken from the earth's crust should be avoided.
"In their manufacture and use, artificial substances do not exceed the environment's capacity to disperse, absorb, recycle or otherwise neutralise their harmful effects (to humans and/or the environment)".	Constant increases of substances produced artificially by society (e.g. chemicals) should be avoided.
"The capacity of the environment to provide ecological system integrity, biological diversity and productivity is protected or enhanced".	Constant physical degradation should be avoided.

produces goods and services". It includes renewable and non-renewable resources, the Earth's inertia mechanisms for absorbing, neutralising or recycling wastes, as well as the natural processes and climatic cycles. However, Natural Capital is not only a means for production it represents the environment needed for the existence of life and also the element ensuring well-being, enjoyment and recreation. It is therefore a resource and a constraint at the same time (Table 10). Human Capital is represented by people's health, knowledge, skills and motivation, education and training, which are central elements for the efficiency and effectiveness of production and the more general economic prosperity. This has been treated in the previous sections by the analysis of Sen's literature, whose core point is the consideration of the human capital as not only a production factor or a means for economic development, but instead as a goal in itself and a source of well-being and human development. In a vision of bounded capabilities as previously described, human capital would include good health, well-being, education, professional learning and development, security, motivational, creativity and enjoyment standards to be ensured at all ages, throughout people's lives. Constraints could be found in the need for policies to reduce threats, increase the educational and professional levels and life-long learning and in guaranteeing efficient educational systems

Social Capital is constituted by the social infrastructure facilitating the integration, participation and development of the Human Capital into networks and social structures, such as families, communities, businesses, professional unions, associations, schools or other voluntary organisations. In terms of capabilities and constraints, the sustainability of this capital would involve high levels of trust in institutional social, security and justice systems at the same time, as well as mechanism of participation and social inclusion especially for weaker individuals or social groups. Communities and the society at large could share key cultural values, in order to motivate and combat psychological marginalisation. This means providing social structures for supporting governance of natural resources and human development for citizens, safe and secure working and living environments and support the positive right, enabling citizens to live free lives and increase own capabilities. The related constraints and enablers can consider increments in trust and both subjective and objective security as criteria to follow when adopting solutions. According to this conception, solutions or scenarios putting these aspects into danger are excluded.

Manufactured Capital refers to all the material goods or fixed assets used for the production process. According to the vision of bounded capabilities, the sustainability of the manufactured capital would involve technologies and production processes making minimum use of natural resources and maximum use of endless immaterial capital, such as human innovation and skills, excluding solutions that constantly increase of substances taken from the Earth's crust (see the Natural Step principles mentioned above), produced artificially by society (chemicals) or constantly produce physical degradation and waste. The Financial Capital (shares, bonds, credits or banknotes) is the circulating capital, which enables the trade and acquisition of the other types of capital. This is typically a mean, as it has not any value in itself, being only representative of the value of natural, human, social or manufactured capital. The function of the Financial Capital is to most accurately represent the value of natural, human, social and manufactured capital. In this view, the sustainability from a financial perspective would measure the capability of financial systems to capture the real value of goods with an acceptable level of accuracy. Criteria for the extraction and use of Natural Capital can be translated into some general constraints. In any case, as previously argued financial capital is not always able to represent public goods, whose value exceeds the simple utility for production purposes. This is because the Natural, the Human and the Social Capital are mostly goals to reach more than means of production. The confusion between means and goals (Sen, 1997) creates a sustainability issue because the consideration of these latter forms of capital as means of production can accelerate their depletion in favour of the production of financial capital, which is valued on the markets. The stocks of natural, human and social capital are consumed faster than they are being produced because they are not given a value in themselves, but only in function of the production of commodities. For example, water is a public good, which has an inestimable value for human and natural life (see the discussion on private and public goods in sub-section 2.4.3). However, it is commonly free and used for production purposes in great quantities. The goods produced get a value on the markets, while water remains a free or a very cheap good. The application of the Five Capitals Model of sustainability helps to develop a theoretical framework (see Figure 14, page 95) of 'governance for sustainability'; this will form the basis for the social learning methodology and framework for the evaluation of Socio-Technical Systems (STS)' sustainability that is the aim of this thesis.

This approach can be supported by Douthwaite's (1999) criteria for acceptable 'green' growth that is realised without reducing well-being in terms of other forms of capital.

«Growth is acceptable if it can be achieved without:

- *reducing the number of people employed*

- *increasing the amount of energy and raw materials used*
- *using more transport*
- *shifting the distribution of income in favour of the better off*
- *releasing genetically engineered organisms into the environment*
- *patenting life forms*
- *using technologies that make working less interesting and fulfilling*
- *increasing the amount of waste that goes into landfill or into the environment*
- *driving smaller firms out of business or damaging local economies*
- *allowing chemicals which are not quickly and harmlessly broken down into safe and stable constituents to leave factories*
- *purchasing from parts of the world where prices are subsidised because environmental, social or working conditions are significantly inferior to those in the countries they are supplying*
- *increasing human, animal or plant exposure to nuclear or electromagnetic radiation*
- *making production and supply systems less sustainable»*

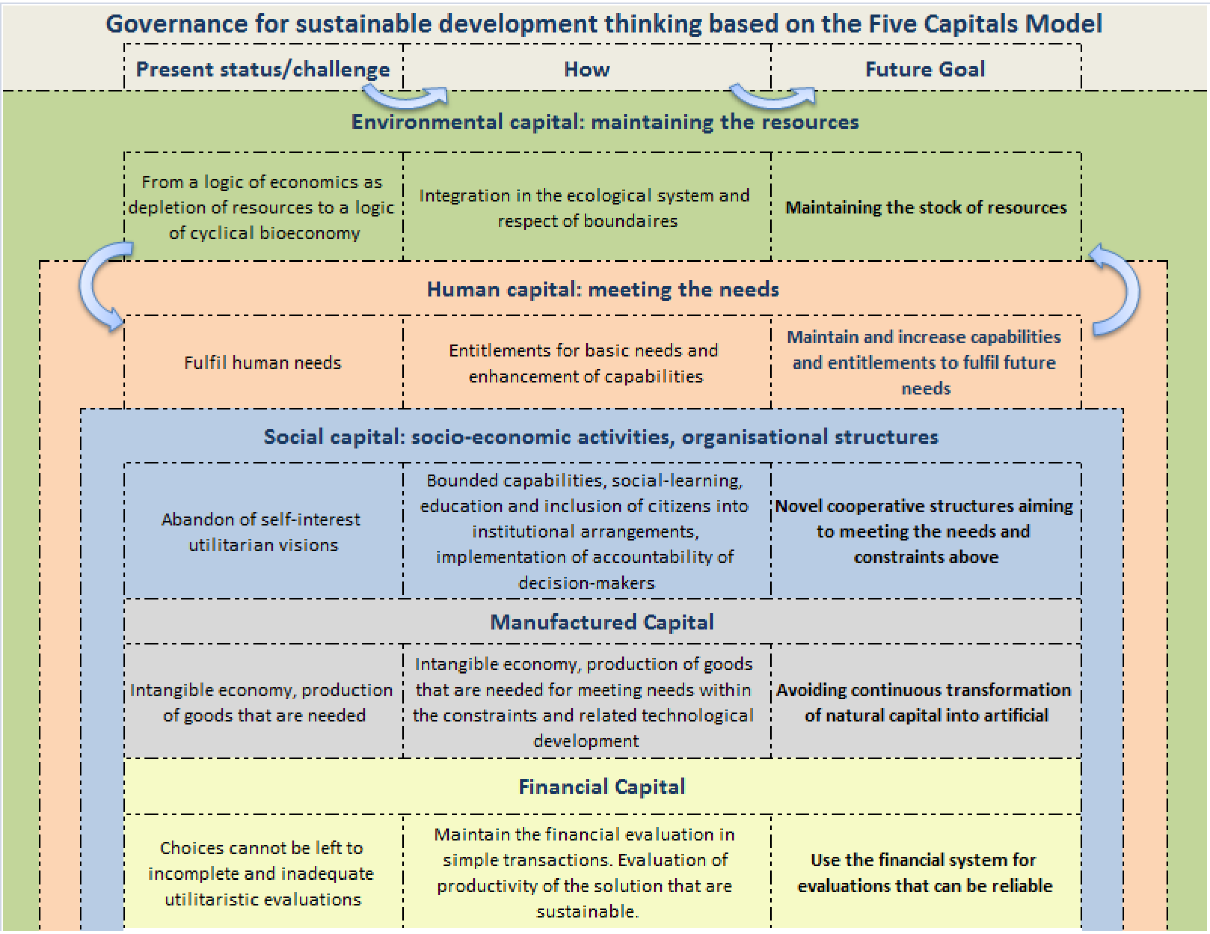


Figure 14. The conceptual vision of governance for sustainability

These criteria have been classified in Table 11 according to the Five Capitals Model of sustainability (Forum for the Future, 2013). They show the more complex and multifaceted vision of the possible constraints which have to be respected to maintain the capacity of systems to provide resources over time. The systemic approach adopted below aims at demonstrating that the economic pillar is not in contrast with the social and the environmental, when human needs are concerned, as pursued in harmony with social justice and environmental health.

Table 11. The classification of the criteria for green growth according to the Five Capitals Model: actions to avoid

Environmental Capital:	
-	Increase of transport, amount of energy or of raw materials or
-	Release of genetic engineered organisms into the environment or patenting of forms of life
-	Release of chemicals that are not broken down into safe a stable substances
-	Increase in the amount of waste accumulating in landfills or in the environment
Human capital:	
-	Reduction in the number of people employed or increase of income disparity
-	Increase of human, animal or plant exposure to electromagnetic radiation
Social capital:	
-	Purchase at lower prices from parts of the world where environmental, social or working conditions and standards are worse
-	Decrease of sustainability of production and supply systems
-	Closure of smaller companies or damage to local economies
Manufactured capital:	
-	Use of technologies diminishing motivation and interest in working activities

As Scott Cato argues, traditional economists do not deliberately leave the other forms of capital out of their economic models and ecological economists even try to include them. The reason why many variables are missing stays is the difficulty to provide scientific accuracy and in the need for simplifying assumptions for systems, which are complex. While in many cases these simplifications work quite well, contexts that are more critical and complex would require frameworks that are flexible enough to reflect that complexity (Douthwaite, 1996, as cited in Scott Cato, 2009: 43). The maximisation of marginal benefits needs to include those which are not valuable on the markets. This may require the compromise between different capitals and the need for temporary economic de-growth to enable, or pay for, growth in other capitals. The de-growth movement in order to face the global ecological emergency, hold the view that the promise of green technology could not be maintained.

> According to the Jevons Paradox, greater efficiency in the use of energy and resources, instead of generating conservation produces greater economic growth, and thereby still greater pressure on the environment (Foster, 2011; Foster, Clark, and York, 2010b).

As Foster (2011) continues, in many countries with very low per capita income de-growth might not be feasible; however, sustainable development could be focused on meeting real needs such as security and food security, health care, access to water, education (Foster, 2011). Cuba, for instance, is reported (WWF, 2006) as the only country with high levels of human development and a sustainable ecological footprint. De-growth is not a permanent solution but a way to reduce the size of the economy to a sustainable level Foster, 2011).

This research does not aim to search for accurate models and evaluation frameworks. The GAME is intended to support the social learning necessary to anticipate more, or less, sustainable pathways.

According to Laszlo and Krippner (1998: 20), «*the systems design approach seeks to understand a situation as a system of interconnected, interdependent, and interacting problems. Likewise, the solutions it seeks to create emerge from a vision of the entity taken as a whole. Such an orientation permits the design of the future through an informed understanding of the dynamics that govern evolutionary systems*». This means taking «*responsibility for the creation of our future in co-evolutionary interdependence with our social and physical environment*». The process of social learning that supports the governance for sustainability of Socio-Technical systems (STS) and has to be based, for that purpose, on participatory systems design and an understanding of systems' interdependencies. This is because «*social change can be brought about only if those who are most likely to be affected by it participate in soliciting it, and choose how it is to be implemented*» (Laszlo and Krippner, 1998).

The conception of a participatory and integrated evaluation framework supports the social learning for governance for sustainability and will be treated in the methodology chapter that follows, in order to answer to the research question c):

'How to apply the concept of governance identified through an innovative methodological framework'?

5 The research design: approach, methods and techniques

Objective	To describe the motivation for the choice of the research methodology
Content	5.1. The methodological approach 5.2. Planning the qualitative research 5.3. The selected case studies and research techniques to be used 5.4. Summary of the design of the research methodology for the aim of the thesis

This chapter describes the motivations for the choice of research method: this is important to justify and structure the thesis according to the aim and to provide it with the necessary robustness to validate the outcomes of the research (Coley, 2008).

The research method involves choices that have to be made on:

1. The general methodological approach, treated in sub-section 5.1, in relation to the object and aim of the thesis
2. The planning of the chosen qualitative research approach, described in sub-section 5.2, and including:
    a. The research method, among existing ones—i.e. ethnographic, grounded or case study (Coley, 2008), explaining the motivations for that choice
    b. The techniques for data collection that can be used in the framework of the selected method, which involves a preliminary analysis of the main existing techniques
3. A number of relevant case studies that are representative of the Socio-Technical Systems (STS) object of research (aspects of complexity, uncertainty and public relevance) and that can cover the dimensions of sustainability as described in Chapter 4 and the data collection techniques that are more appropriate for their representation, as described in sub-section 5.3
4. The methodology or methodologies for the analysis of the collected data, described in sub-section 5.4, with consideration about the quality of the research

5.1 The methodological approach

Traditionally, research methods are divided into quantitative and qualitative approaches (see Table 12, page 99). Quantitative approaches have the advantage of describing complicated phenomena and great amounts of data, logically interrelated by direct or indirect cause-effect relationships (Coley, 2008). This allows for accurate results and the replication of experiments within the theoretical boundaries from which the researcher can change one or more conditions and see how this change affects the result. According to a systems approach, the ‘reduction to dynamics’ is in contrast to ‘reduction to components,’ which is more typical of classical science. According to this classical view, phenomena as observed in practice are mostly so complex that science has tended to understand them by the simplified modelling of the interactions existing between their main components (Laszlo and Krippner, 1998) as isolated from all possible relations which are present between them and with the external environment.

Table 12. Comparison of Qualitative and Quantitative Research Strategies (Burns, 2000, p. 391, as cited in Coley, 2008)

Qualitative	Quantitative
Assumptions	
Reality socially constructed	Facts and data have an objective Reality
Variables complex and interwoven; difficult to measure	Variables can be measured and Identified
Events viewed from informant’s Perspective	Events viewed from outsider’s Perspective
Dynamic quality to life	Static reality to life
Purpose	
Interpretation	Prediction
Contextualisation	Generalisation
Understanding the perspectives of Others	Casual explanation
Method	
Data collection using participant observation, unstructured interviews	Testing and measuring
Concludes with hypothesis and grounded theory	Commences with hypothesis and Theory
Emergence and portrayal	Manipulation and control
Inductive and naturalistic	Deductive and experimental
Data analysis by themes from informants descriptions	Statistical analysis
Data reported in language of Informant	Statistical reporting
Descriptive write-up Abstract impersonal write-up	
Role of researcher	
Researcher as instrument	Researcher applies formal Instruments
Personal involvement	Detachment
Empathic understanding	Objective

The isolation of relations which can be represented by linear or circular cause-effect relationships has generated many practical benefits. However, the knowledge produced is often not able to disclose the impacts coming from the complexity of contextual environments, where more external influences are present. Qualitative research is usually employed to explore issues for which exact measurements and predictions are more difficult to be formulated, because of the particular complexity and the need to relate with the specific qualitative characteristics of the context being assessed (Coley, 2008). Robson (2002) talks about the need for a flexible research design that is able to adapt according to the emerging data and intermediate results. For this reason, observations, interviews and surveys are typical techniques used in qualitative research. Quantitative research is therefore more applicable for natural-science based approaches of investigation, which can provide measurement, predict results and evaluate uncertainties through the use of statistical techniques. In fact, natural-science quantitative models are typically epistemic; they often relate to generalised and therefore context-independent scientific knowledge, according to a normal and ideal conception of scientific theory as explicit, universal, abstract, discrete, complete and predictive (Flyvbjerg, 2001: 39). As Flyvbjerg remarks (2001: 45), the difference between natural sciences and social sciences is that the latter cannot be measured by physical facts. This implies that the level of uncertainty and complexity of the observation of the social world and of the cause-effect relationships limits the possibility to approach the analysis by natural-science based methods. Often these methods are adopted by the use of simplified models and assumptions, but this may undermine the reliability and objectivity of the results. When trying to approach social sciences using epistemic models from the natural sciences, in order to be considered as a scientific theory, a science studying social phenomena can exclude the societal context itself (Flyvbjerg, 2001: 40). The elimination of the object of scientific investigation i.e. the social world can mean the elements of predictability and detachment from contextual factors are missing. Testing a theory on a simplified social context, which actually does not exist in practice, would not be able to provide insights to contextual, complex problems.

This is why, in making the choice about possible methods, the major element to be considered is the object of analysis and the theoretical approach, which can best represent them. This thesis belongs to the field of social sciences and aims at understanding Socio-Technical Systems (STS), analysing their adequacy to deliver more sustainable development, and designing possible social arrangements, structures and participatory procedures for facilitating this.

In social and sustainability matters, the adoption of quantitative analysis would require to make ex-ante assumptions and value judgements about how to build the model and which parameters to include. These assumptions would mean making subjective judgements and influencing the results, instead of allowing them to emerge from the research. For instance, the economic dimension of sustainability is usually related to production growth, which is traditionally assessed by simplified economic models (Scott Cato, 2009: 43). In doing so, quantitative analysis does not consider other economic dimensions, for instance, whether the basic needs of a given context have been satisfied or, talking about sustainable development, how much that measurement can represent the actual condition of prosperity in the longer run. In conditions of high complexity and for socially sensitive issues, the choice of a simplified model or of a unique methodology might eventually represent arbitrary assumptions. This is why, for instance, many different statistical indicators are currently built in order to measure complex issues and multidimensional phenomena, as described in sub-sections 4.5.1.5 and 3.4. In their construction, the definition and the weighting of the different dimensions are key elements which have to be carefully considered in order to best reflect the phenomenon under analysis.

In order to explain complex phenomena, approaches of *«Post-Normal Science»* (Funtowicz and Ravetz, 2014) have been theorised. According to the authors, when a system is characterised by high complexity, (i.e. social systems, environmental policies and sustainability), this involves deep uncertainties and plurality of perspectives. In such conditions, they argue, methodologies, which are based on *«traditional laboratory-based science»* are not able to explain the issue at a hand. Often traditional methods start from assumptions which are just theoretical and do not take aspects of uncertainty and complexity into due account. In social sciences, it is important to enhance *«a socially relevant form of knowledge, that is 'phronesis'»*, defined as *«practical wisdom on how to address and act on social problems in a particular context»*. (Flyvbjerg, 2012: 1). In the present research, according to a view of 'reduction to dynamics' (see sub-section 5.1), social systems, structures and processes, technology, the environment and its sustainability have the following characteristics, as discussed in Chapter 2:

- Dynamic: the interactions change over time and space.

- Complex: systems and sub-systems affect each other in intricate and nonlinear cause-effect relationships, creating conditions which cannot be known beforehand and which go beyond the power of intervention of single actors; past relationships might not reproduced in the same exact way.
- Uncertain: impossible to forecast future states because unpredictable events will inevitably create unknowable future paths.
- Subject to a plurality of perspectives, perceptions (relative awareness) and interpretations between and within different stakeholder groups (what is relevant), through time and across space (e.g. political, technical and social cultures and sub cultures), which limits the technological determinism of technical failures.
- Involving multi-impact effects on larger social communities and need of urgent decision-making: multiplicity of possible responses to decision options possible and different responding behaviours from different people and in different cultures, which may also change over time.

In consideration of these aspects of complexity and uncertainty, in matters involving social aspects there is a need to better understand perceptions of individuals and their interaction with contextual environments (Lemon, 1999).

5.2 Planning the qualitative research

According to Maxwell (2005: 4), qualitative research can be planned according to a model that is interactive or systemic (see Figure 15, page 103) and includes:

- The goals—i.e. the reasons that justify the research.
- The conceptual framework—i.e. the theories, literature and preliminary key research findings guiding and supporting the research.
- The research questions—i.e. what the researcher wants to understand and learn in relation to what is already known and how these questions are linked to one another.
- The methods—i.e. the concrete actions that are employed in the investigation.
- The validity—i.e. the possibility that results and conclusions would be biased or wrong, and the alternatives that could challenge the validity of the research

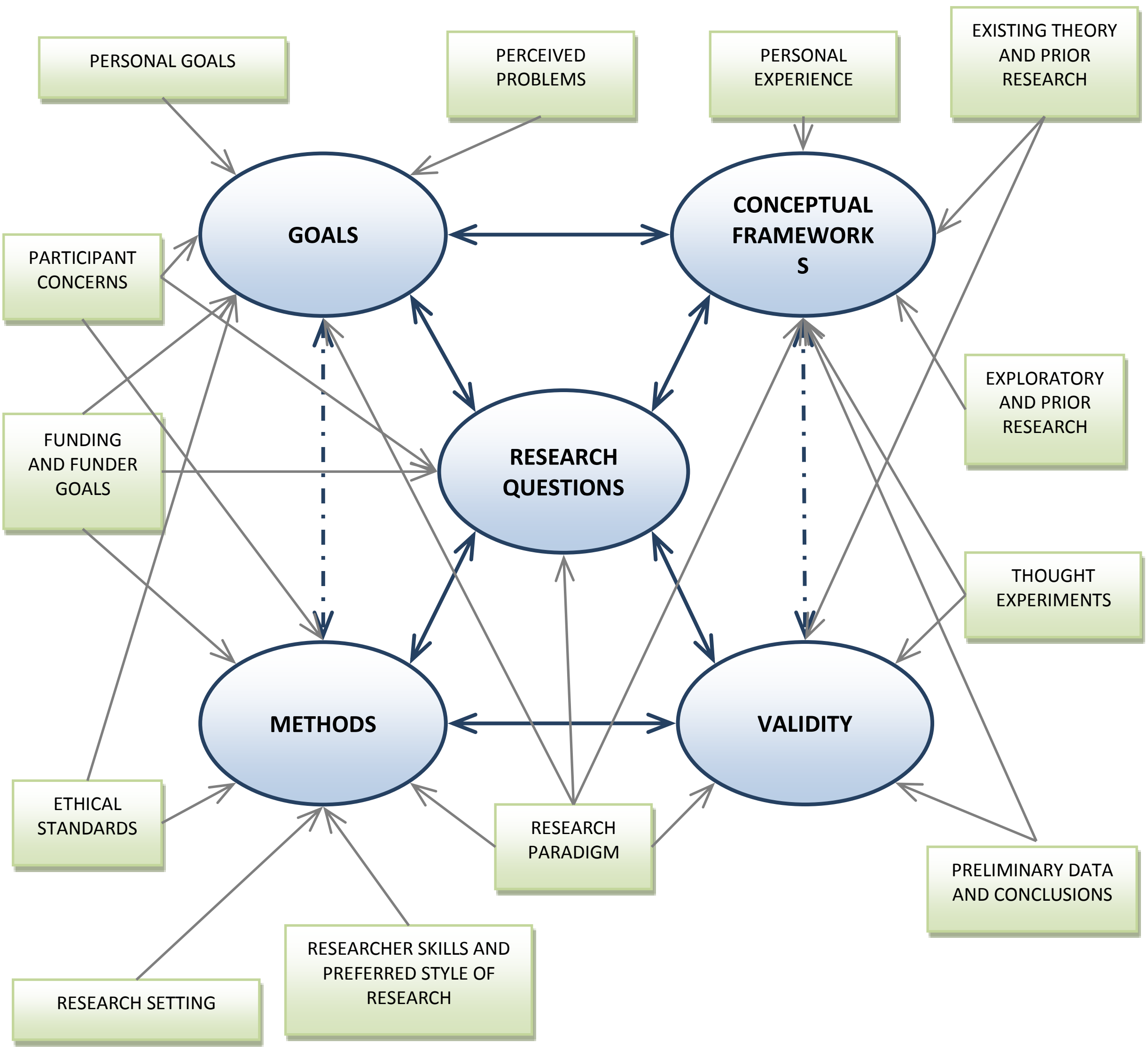


Figure 15. Maxwell Interactive Model of Research Design (2005: 6)

According to Maxwell's conception, the research questions are the means through which the validity of methods for achieving the goals can be demonstrated and reflect the related conceptual framework. The structure Maxwell presents can be considered as elastic in order to take all possible interacting factors into account (Maxwell, 2005: 6).

5.2.1 The choice of the research method

Once the general qualitative approach has been chosen for the study (see sub-section 5.1), a further selection has to be made in relation to the techniques for data collection. In the planning phase of the research, it is important to choose a structured approach, while providing justification, to guide the reader throughout the research process and validate it further (Coley, 2008). The appropriate documentation of the research methodology and the description of the rational for the choices made help others to understand and offers occasion for its repeatability.

Robson (2002) identifies three main methods—i.e. grounded theory, ethnography and case study, as represented in Table 13 (page 104).

Table 13. Comparing Research Traditions in Qualitative Research (Robson, 2002)

	Grounded Theory	Ethnography	Case Study
Focus	Developing a theory grounded in data from the field	Describing and interpreting a cultural and social group	Developing and in-depth of a single case or multiple cases
Discipline origin	Sociology	Cultural anthropology, sociology	Political science, sociology, evaluation, urban studies, many other social sciences
Data collection	Typically interviews with 20-30 individuals to 'saturate' categories and detail a theory	Primarily observation and interviews during extended time in the field	Multiple sources-documents, archival records, interviews, observations, physical artefacts
Data analysis	Open coding, axial coding, selective coding, conditional matrix	Description analysis, interpretation	Description, themes, assertions
Narrative form	Theory or theoretical model	Description of the cultural behaviour of the group	In-depth study of the 'case' or 'cases'

Ethnography (Surrey University, 2016) has a background in anthropology and means 'portrait of a people'. It consists in descriptive studies of cultures and people, looking for commonalities of shared experiences (Surrey University, 2015). The approach is based on *«...the production of highly detailed accounts of how people in a social setting lead their lives, based upon systematic and long-term observation of, and conversation with, informants»* (Payne and Payne, 2004). Strauss and Corbin (1998) report about Grounded Theory as an approach that enhances understanding of phenomena, provides a guide to action and uses induction and data to derive theory (Coley, 2008). A case study is *«an empirical inquiry that investigates a contemporary phenomenon within its real life context»* Yin (2003: 13, 14). As

Robson (2002) and Yin (2003: 13, 14) suggest that the case study method is useful to investigate real life contexts through multiple sources of empirical evidence. It is particularly relevant for combining research with practice in real world situations (Gill and Johnson, 1997) and, as Huberman and Miles (2002) report, its strategy specifically focuses on the analysis of systems' dynamics through the appropriate combination of data collection methods. Case studies employ data collection from multiple sources and perspectives and this triangulation can substantially reduce bias and increase validity (Coley, 2008). The case study method is not exempted from criticism, especially with regard to subjectivity, validity and verification. About validity, one criticism holds that the case under study may not be representative of a wider social setting and therefore it is argued that the results of the research cannot be used to make generalisations (Surrey University, 2016). This argument of lack of rigour that would undermine the possibility of scientific generalisation is contested by Yin (1994), stating that the case study method, adequate for business and management research, is able to face academic scrutiny and assimilable to quantitative research methods. According to John Hopkins University (2016), the purpose of case study research is to describe particular cases in detail, in order to learn and develop theoretical concepts. The same source reports how contextual information of multiple cases is analysed across case themes to identify similarities and/or differences, in order to make assertions and generalisations. This is why, for this study, STS case studies that are very different from one another will be considered, thereby providing the necessary robustness of the results (see sub-section 5.3).

Moreover, as one single discipline can hardly have *'the answer'* to the majority of complex 'real-world' problems (Requisite Variety website, 2014), the choice of the multi-method approach responds here to the idea that there is not 'a method' but a set of methods which can vary through space and time, according to contextual variation (see the choice of the techniques for data collection in sub-sections 5.2 and 5.3 and of the methodology for their analysis in sub-section 5.4). The robustness of outcomes consists in the achievement of convergence of the results, in terms of scale, coming from the interaction between phenomena and their contexts, in a systematic combining of theory and practice (Dubois and Gadde, 2002: 554). This identifies an abductive approach, which is composed by a greater inductive part, corroborated by a less extensive deductive analysis. As Laszlo and Krippner report (1998: 13), systems analysis would better start from the problem and not from a preconceived model. Abduction relates to contexts and embraces those hermeneutic and interpretative conceptions that Flyvbjerg talks about (2001: 35), which can better grasp the characteristics of local contexts. This integration of theory and practice allows for the directing and redirecting results (Dubois and Gadde, 2002: 556) in a dynamic and continuous social learning, which learns from the past and adapts to the future.

From the perspective of verification, criticism is reported by Diamond (1996) when he holds that the case study method does not apply scientific methods, thereby triggering a bias towards verification. Flyvbjerg (2001), on the other hand, does not support this view, as case study research experiences tend to produce bias mainly concerning falsification of preconceived notions rather than verification. The subjective views of the researcher, as Coley reports (2008), in case study investigation, tend to develop all throughout the process of combination of observation and empirical results and literature findings thereby limiting pre-existing visions and expectations. The triangulation of data from multiple case studies, multiple sources, with existing theoretical standpoints assures a more effective response to uncertainty and validity concerns if compared to experimental designs (Coley, 2008).

Therefore, the use and integration of multiple methods, able to triangulate and crosscheck from different perspectives (see sub-section 5.4) provides an appropriate approach as it increases the reliability and consistency of results and reduces the possible bias (Flick, 1992). *«Multiple triangulation exists when researchers combine in one investigation multiple observers, theoretical perspectives, sources of data, and methodologies»* (Denzin, 1978).

The argumentations mentioned support the adoption of a case study method, associated to a multi-method collection analysis (see Figure 16, page 111), for the purpose of this research and the analysis of the sustainability of Socio-Technical Systems (STS).

5.2.2 Case study tools and techniques

Within the qualitative case study method, a number of techniques can be used, as described below.

5.2.2.1 Interviews

Interviewing is a technique widely used in social research, however the researcher should be aware of the different types of unstructured, semi-structured and structured interviews (Robson, 2002). The choice among them is made according to their appropriateness in relation to the purpose of the case study and the knowledge to be produced (Coley, 2008).

According to Surrey University (2016), in structured interviews, a tight schedule is used and the same questions are posed to all respondents in the same way and this may not enable to explore the issue at hand in depth according to the answers provided. As Coley (2008) reports, fully-structured interviews are typically carried out in quantitative research, as data is usually analysed by proven statistical techniques.

If the purpose of the analysis is also to understand different stakeholder perceptions of different security operators, there is a need for interviews to have limited structure and able to elicit a broad response about a limited number of issues from the respondents. Open-ended questions encourage free expression and discussion that can go into greater detail and provide a rich form of descriptive data, with no expectations on the part of the researcher (McQueen and Knussen, 2002). Semi structured interviews include predetermined questions; however their order can be changed to be more appropriate for the interviewer and the interviewee (Coley, 2008). As Robson (2002) reports, additional questions can also be proposed in order to further explore responses to previous questions.

In relation to the freedom given for response, Lemon (1999), in Table 14 (page 107), identifies the advantages and disadvantages of less structured approaches.

Table 14. Formal and informal interviews. Advantages and disadvantages of less structured approach (Lemon, 1999)

Advantages	Disadvantages
Respondents can express themselves in their own language and according to their own classifications.	Time may be lost through the pursuit of irrelevant lines of enquiry and response.
The interviewer can 'clarify' responses when necessary.	Relevant issues may not arise in the course of the interview.
Important but unforeseen lines of questioning and response may emerge.	Analysis is complicated due to the variation of material covered or lack of commonality between responses.
The duration of interviews can be clearly determined. It is therefore easier to undertake a greater number within a specified time.	

In a structured type of interviewing, the interviewed asks the respondent the same questions in the same way (Surrey University, 2016). One reason for that is to be able to compare and analyse the results by a quantitative analysis (Lemon, 1999). The author, in Table 15 (page

108), offers a description of pros and cons of the structured format, highlighting for instance the advantage of being able to contact large amount of people scattered in very large areas.

Delphi types of surveys are examples of structured interviewing, as they have the characteristics of tackle issues by formulation of statements that are uncertain and that contain incomplete knowledge (Häder and Häder 1995). This is the case for studies that are future oriented and that aim at providing estimates for supporting decision-making.

Table 15. Advantages and disadvantages of structured format (Lemon, 1999)

General advantages	General disadvantages
Consistent wording	Procedures and questions are not adaptable if inappropriate
Directly comparable results	Loss of information which does not conform to predetermined format
Technical (third party) administration of the interview	Respondents may force responses into predetermined categories
Data analysis is clear, often quantitative, and designed in advance	If undertaken without exploratory phase the agenda will be that of the investigator rather than the respondent
	The language of the response is not necessarily that which the respondent would use
Self-completion advantages	Self-completion disadvantages
Enable contact with large numbers of people, this is particularly important when the sample is scattered geographically	When undertaken cold, without initial contact or the security of a common interest (i.e. a professional or interest grouping), the response rate can be very low or disproportionately high in favour of interested parties
They are cheaper to administer than interviews	In the light of the above any claim about random sampling (i.e. that in which each member of a specified population is equally likely to be chosen and to have responded) is questionable
They are cheaper to administer than interviews	Clarification and elaboration is difficult
Can ensure anonymity and as such may encourage more personal responses	Reading and comprehension difficulties cannot be catered for
Are free of interviewer bias	

5.2.2.2 Content analysis and observation

As Krippendorff (2004) argues, content analysis is potentially one of the most important research techniques in the social sciences and as Coley continues, it constitutes a powerful and non-obtrusive method that can be applied to understand and address the important issues that are contained in the process of mediation between people. Woodrum (1984) agrees on the potential of content analysis for studying attitudes, beliefs, and human relations, and reports that its application is underutilised. Weber (1995) defines content analysis as a technique that makes use of a set of procedures in order to make valid inferences on the content, the sender(s) and the audience of the message. Krippendorff (2004), confirming the previous argument, adds that these inferences should be replicable and valid.

As Neuendorf (2002) continues, when content analysis is used to analyse written text, it remains unnecessarily limiting, as it could be extended to transcribed speech, verbal interactions, visual images, non-verbal behaviours, and basically to any type of message. Krippendorf (2004) confirms that art, images, maps, sounds, symbols, and even numerical records may be considered as data, when able to deliver information about the phenomena being observed.

The advantages of content analysis for social science mentioned by Woodrum (1984) include the potential for summarising interviews, coding open-ended questionnaires, and conducting verbal evaluations. Content analysis, the author continues, is also a safe methodology that allows the researcher to check back to the original source, an operation that is not normally possible in experimental research. Again, Woodrum reports, the technique facilitates empirical studies because it does not react or enter in contact with research subjects, preventing bias of original measurements, and maintain ethics.

Table 16. Different types of observational study (Coley, 2008)

TECHNIQUE	FOCUS	RESEARCHER ROLE
Naturalistic Observation	Behaviour in its natural environment	The researcher does not attempt to interfere with what is being observed
Controlled Observation	Unlike natural observation the emphasis is not on the setting but on the natural occurrence of the event	The researcher attempts to structure or influence the behaviour or response to be observed
Participant Observation	Processes occurring in particular groups	The researcher becomes a part of the ‘thing’ that is being observed

Lofland and Lofland (1995) remark how observational research is prone to two types of bias that depend on the participant or the observer. When the observer is known, the observed people are aware of being observed and may alter their behaviour in response. Table 16 (page 109) describes different types of observations and related roles for the researcher (Coley, 2008). Gross and McIlveen (1998) report the best results are produced when people are not aware of being under observation.

Observation is important as it can give 'snap shot' of the bigger picture that captures the whole situation, so that the presence of possibly discrepant data that does not fit in that picture can be identified. In fact, observation can at times build reliable information about concrete facts or behaviours as they happen, even if we might be unaware about the reasons for that, which do not seem to be justified or justifiable in relation to the general view. In this latter case, explanation for the discrepancies is searched through other sources. As observation results in analysis and interpretation of the data collected (Robson, 2002), as Coley (2008) reports, even if elements of subjective judgement of the researcher may be present the presence of documentation and triangulation with other findings or interviews can provide validation, as it has been planned for this case study and for the whole research. In this way, observation can also be used to verify of refute information that was gathered by other means (Surrey University, 2016). This is why, in order to limit this risk, the data will be triangulated and compared to interviews, literature and documentary analysis. Relevant literature (Winterfeldt, 2007; Melber, 2007; Jauch, 2007) will also contribute to the methodological triangulation for case study II (Sajeva, 2012). As Denzin reports (1970), triangulation of data collection techniques and theory is superior to any single procedure or type of information. The specification about the data triangulation and integrated cross-analysis between the semi-structured interviews, the communication of the security organisations, the observation and the supporting literature is provided in sub-section 5.4.

Documentation and photographs may also be used to provide information (Surrey University, 2016). This will be used especially in case study II (see sub-section 5.3.2), in order to communicate both the policies of security organisations and the existing contextual situations. Coolican (1999) describes audio or video recording, still camera, or hand written notes, as means that can be used for capturing people behaviour or general contexts.

Historical analysis is a form of documentation analysis and has been defined as *«the systematic collection and objective evaluation of data related to past occurrences in order to* *test hypotheses concerning causes, effects or trends of these events that may help to explain present events and anticipate future events»* (Gay, 1996).

5.2.2.3 Summary of the methodology choices

The methodological choices made for project are summarised in Figure 16 (page 111) and discussed in more detail in sub-section 5.3 alongside the case studies of Socio-Technical Systems (STS).

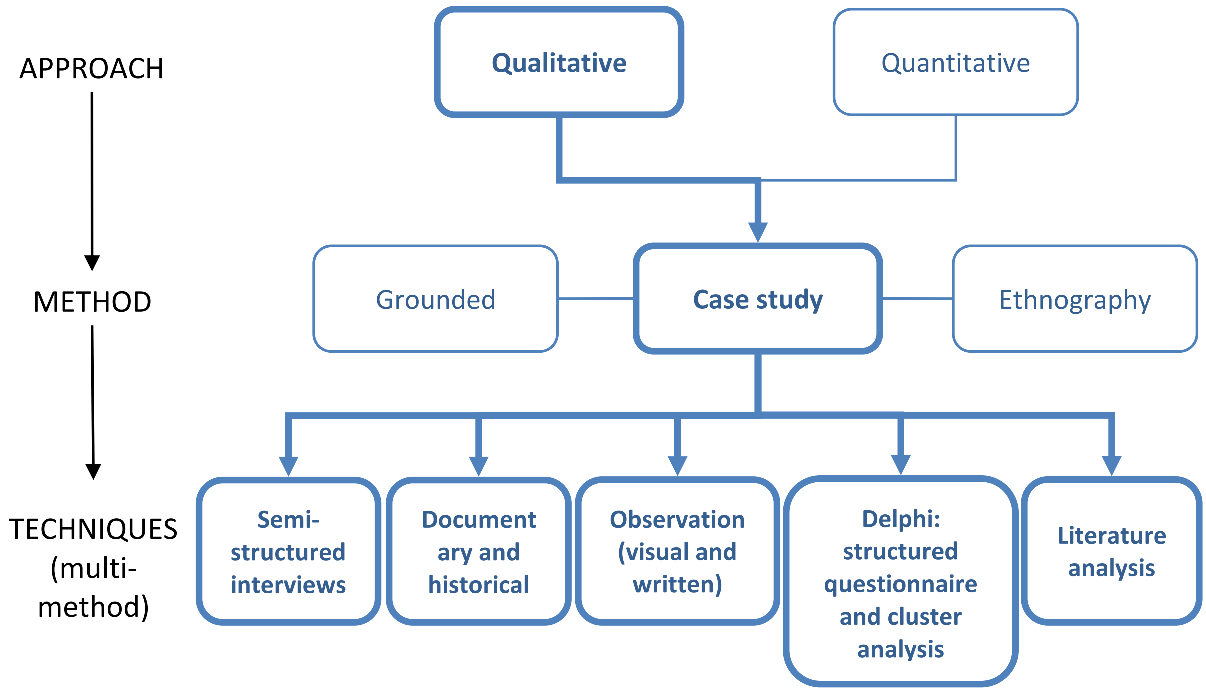


Figure 16. The methodology choices

5.3 The selected case studies and research techniques to be used

In this sub-section, the rational for the choice of case studies is provided (see Table 17, 112) alongside the choice of methods for collecting qualitative data. The choice of the case studies is made in order to reflect the Socio-Technical Systems (STS) as described in Chapter 2, with particular reference to the identified criticalities—i.e. complexity, uncertainty and public relevance. The STS cases represent socially sensitive and publicly relevant issues: infrastructures, energy and security with the food and agricultural sector being analysed in more depth in the final test case study. The case studies will represent different sustainability capitals and governance contexts that can cover the sustainability dimensions considered in the conceptual framework of governance for sustainability as described in Chapter 4.

The provisional framework will be built out of their analysis and the earlier literature survey and will then be trialled in case study IV.

Table 17. Techniques for case study analysis

Technique / Case studies	Observation	Documentary / historical analysis	Survey/ questionnaire	Interviews (historical, current and future visions)	Workshops
I: European Critical Electricity Infrastructure (ECEI)		The ECEI failure and lessons to be learnt	Frames of meaning applied to the risk of ECEI		
II: The security system in Finland compared with the Namibian.	Finnish and Namibian contexts photographs experiences, interviews with locals	Communication of security operators, photos and visual material		Interviews to security operators	
III: Pathways of transition towards post-carbon society		Reports	Stakeholders' assessment Delphi methodology: probability and desirability		Focus Group
IV: The security and sustainability of food systems (test case)		Previous futures studies and reports		Interviews	3 Workshops 1 Conference

5.3.1 Case Study I: the European Critical Electricity Infrastructure (ECEI)

The first case study of the European Critical Electricity Infrastructure (ECEI) was chosen as it presented an example of failure in a Socio-Technical System (STS). It provides an example of manufactured capital (a critical infrastructural system) having a significant impact on financial and social capital and to a lesser extent on natural and human capitals.

The case study of the ECEI will be conducted as an extension of an institutional research activity carried out at the European Commission – DG Joint Research Centre commissioned by the International Risk Governance Council (IRGC) The institutional activity conducted at the European Commission has been planned to look at the specific context of an accident on the Lukmanier line between Switzerland and Italy in 2003 that caused a blackout over the all Italian peninsula, analysing the general concept of governance of critical infrastructures in Europe and comparing it to similar cases in US. The analysis done for the European

Commission will widened for this study, by consulting additional documents and reports about failures across different European countries and consulting more material on the cases in US. The documentary analysis will also analyse possible lessons to be learnt for their avoidance. In this way, the analysis of data for the present case study, starting from results published for the European Commission (Sajeva and Masera, 2006; Sajeva, Stefanini and Masera, 2006; Masera, Sajeva et. al, 2006), will integrate that by additional data to build greater robustness.

5.3.1.1 Historical analysis

The case study will be carried out through a systematic historical analysis of reports and publications relating to the ECEI accident of 2003, and comparing these to similar failures in the US and throughout Europe. The choice for the historical analysis is made because of the need to refer to events that occurred far in the past and in different locations and for which a great number of studies and reports was already available. As already specified in the previous sub-section 5.3.1, the data collection focuses first on documentary evidence of the ECEI accident (Sajeva and Masera, 2006; Masera, Sajeva et. al, 2006), compared to the crisis of the electric power system in North America and the evolution of the US electric power infrastructure, both from technological and economic perspectives, with its main criticalities and gaps in the management of risk (Sajeva, Stefanini and Masera, 2006). In particular, this latter part describes the failure of the electric power infrastructure in the US, as well as the governance policies, which were put in place in order to confront reliability and security matters and face technological and economic changes. The data analysis extends beyond the results published for the purposes of the study of the European Commission and considers similar cases throughout Europe comparing failures and lessons to be learnt. This identifies an evolutionary approach that reflects the vision of sustainability of STSs as a development process that analyses gaps and learns for the future (see sub-section 3.2). The historical analysis of documentation about the power failures is complemented with a mapping and assessment of the ECEI stakeholders and operators, in order to evaluate their main risk perspectives, concerns and perceptions, by the use of 'frames of meaning' (Grin and Van der Graaf, 1996).

5.3.2 Case Study II: the security Socio-Technical System (STS) in Finland and Namibia

A second case study of the security Socio-Technical System (STS) expands upon the technical notions of security and system reliability presented in the ECEI to evaluate security systems from a wider cultural and socio-economic perspective that covers social and human capitals. Indeed, the contribution of this case study to the issue of governance for sustainability is important with regard to the social and human capitals, with some relevance for the environment. The case study will take advantage of an analysis realised for an EC FP7 research project on the Finnish security Socio-Technical System (STS) (Sajeva and Kaivo-oja, 2010a/2010b). This will be complemented by additional investigation on the same system, mainly consisting in contextual observation and photographing, content analysis of existing documentations and national policy strategies and re-analysis of original interviews for the purpose of this study. Moreover, the analysis extended to the Namibian security STS, already object of publication (Sajeva, 2012). The data collection for the Namibian context was performed in occasion of the personal commitment of the researcher in voluntary work at the Dolam orphanage in the Katutura slum of the Namibian capital city, Windhoek. The rationale of the analysis of two different contexts for the same STS, reported also in sub-section 6.3.6, is the consideration of two very different contexts that widens the perspective of analysis and build a more robust generalisation as John Hopkins University (2016) and Dubois and Gadde (2002: 554) previously argumented. In the context of this research, the use of two different contexts for the same case study provides robustness for the research methodology and for generating general sustainability criteria for STS that could be generalised and applicable throughout space and time.

5.3.2.1 Interviewing

Due to the main focus on the social and human capitals and the partially subjective nature of risk, the collection of different perspectives from security operators seemed necessary. The data collection methods for this case study includes a set of semi-structured face-to-face interviews undertaken by the researcher, with key security organisations, including both historical, current and future perspectives.

According to a conception of sustainability of the security STS as a development process (see sub-section 3.2), that includes historical perspectives, technological and societal changes that may represent challenges and the visions for the future, some main thematic areas are covered in this case study:

- National understanding of security and its historical development
- Security technologies: where is the limit? Debate on the use of technology (CCTV, biometrics)

- Security failures and main problems
- Vision of secure technology/services development in the nearest future.

These thematic areas relate to the analysis of current challenges or good practices, past failures and successful experiences, as well as future possible threats or sustainability pathways, that cover human, social and manufactured capital dimensions of the security STS. Semi-structured interviews are employed for this case based on these outline themes and more space is given to the natural development of the discussion according to the importance and value given by the interviewees on the specific issues at hand. This is felt to be important to understand the subjective component of security, as the social value of security problems may vary according to the social, historical, educational, professional or cultural background of the interviewees (see Table 28, page 151) and security organisations. Insight about the latter was also obtained through documentation analysis, and may depend as well on the nature and inclination of the single individual. Further detail is provided in sub-section 6.3).

For this case study, the experts and security organisations interviewed are carefully chosen according to a typology of security agencies (Table 18, page 115), with the intention to represent the range of actors and agencies in the security sector. Even if the interviews were made in connection with the EC FP7 research project on the Finnish security Socio-Technical System (STS), as mentioned above, they were carried out for the purpose of this thesis, by keeping in mind the governance and sustainability issues.

Table 18. The interview criteria for the security sector case

Type of organisation	Rational
Systems integrators and multinational corporations	Private integrated security services
High-tech industrial companies (also multinationals)	Technological development in security systems
Research institutions/experts	Academic security perspective
Specialised, local or very small companies	Vision from the perspective of small operators (for profit)
Public authorities (e.g. Ministry of Internal Affairs)	Public security
Associations, networks, funding agencies, including non-profit organisations	Non-profit security services for peace building, associations of stakeholders

In order to limit the disadvantages mentioned by Lemon in Table 14 (page 107), e.g. the lack of response on relevant issues, or the rising of irrelevant lines, the interviews are carried out by always keeping an eye to the themes and trying to recall the original discussion whenever it stray too far. The possible lack of commonality between responses might be present. In the same way, as the interview lasts just a limited time, problems of generalisability and reliability may arise (Huberman and Miles, 2002). These challenges will be faced, in the phase of analysis that is done in Chapter 6, by triangulating results and generating in this way more objective outcomes.

5.3.2.2 Content analysis and observation

The need to provide a more in-depth contextual understanding meant that the interviews will be triangulated with a content analysis of the communication and branding of security organisations, carried out both for the purposes of the EC FP7 project and then extended to further analysis. This involves a review of websites, reports, figures related to the communication of the security organisation, and by the observation and photographing of various situations that were able to communicate the security context in major cities. While the interviews will be designed to highlight the multitude of different individual perceptions and experiences of the interviewed people, the analysis of the information and communication at the level of the security organisations will provide information on the formal image they want to deliver outside.

The observation for case study II will involve the collection and use of visual material and written documentation (see content analysis in sub-section 5.2.2) collected in the Finnish and Namibian contexts, with regard to the situations being, in order to triangulate them with the information gathered by the other techniques and derive conclusions, and relevant themes (see sub-section 5.4).

5.3.3 Case study III: pathways towards a post-carbon society

The third case study, concerning the pathways towards a post-carbon society, is chosen for two main reasons—adding coverage to the natural capital and providing a future perspective on the analysis. The issue of energy sustainability has a plurality of stakeholders at all scales form the local to the global. This case study is taken into consideration to cover environmental, social and manufactured sustainability capital dimensions, as well as for the evaluation of alternative choices that are particularly uncertain as they regard future and uncertain choices. The data collection analysis for this case study takes advantage of an earlier

European FP7 project (Sajeva and LaBelle, 2010) and is then expanded through documentary analysis, to additional insights on future energy pathways.

5.3.3.1 About structured interviews and questionnaires

The analysis of case study III aims at performing a tentative participatory process among relevant stakeholders, for the definition of future scenarios of transition in the energy Socio-Technical System (STS) towards a post-carbon society. This exercise is intended to highlight the level of existing consensus about possibility and desirability of specific energy policies or operative measures that would proceed towards a post-carbon society, identifying in this way alternative future scenarios.

For this reason, the process is carried out through the use of a qualitative Delphi exercise (see sub-section 5.2.2), including a structured on-line survey about the desirability and probability of alternative options and a quantitative technique—i.e. a statistical cluster analysis applied to the questionnaire outcomes, to identify the main alternative orientations. This analysis, done for the European FP7 project, is contained in the related publication (Sajeva and LaBelle, 2010).

The general disadvantage of the predetermined format of a structured approach, as mentioned by Lemon (1999), has been addressed in the following ways:

- Firstly, the questionnaire will be planned by a Focus Group of relevant experts (see sub-section 6.3) the most important aspects to be covered

- Secondly, in order to give the possibility to participants to express own views, an open unstructured commentary will also be included

- Thirdly, an assessment of stakeholders for the evaluation of their risk perspectives and concerns will be included, in order to allow having a picture also about the distribution of the answers according to own interests or personal and professional background

This third consideration helps also to understand which type of respondents was participating, among those enquired, providing an evaluation on the level of reliability of the survey. About the risk of a very limited response, this is faced by involving over three thousand respondents, so that a satisfactory participation of about 150 people has been reported.

5.3.4 Case Study IV for testing and validation: the security and sustainability of the food system

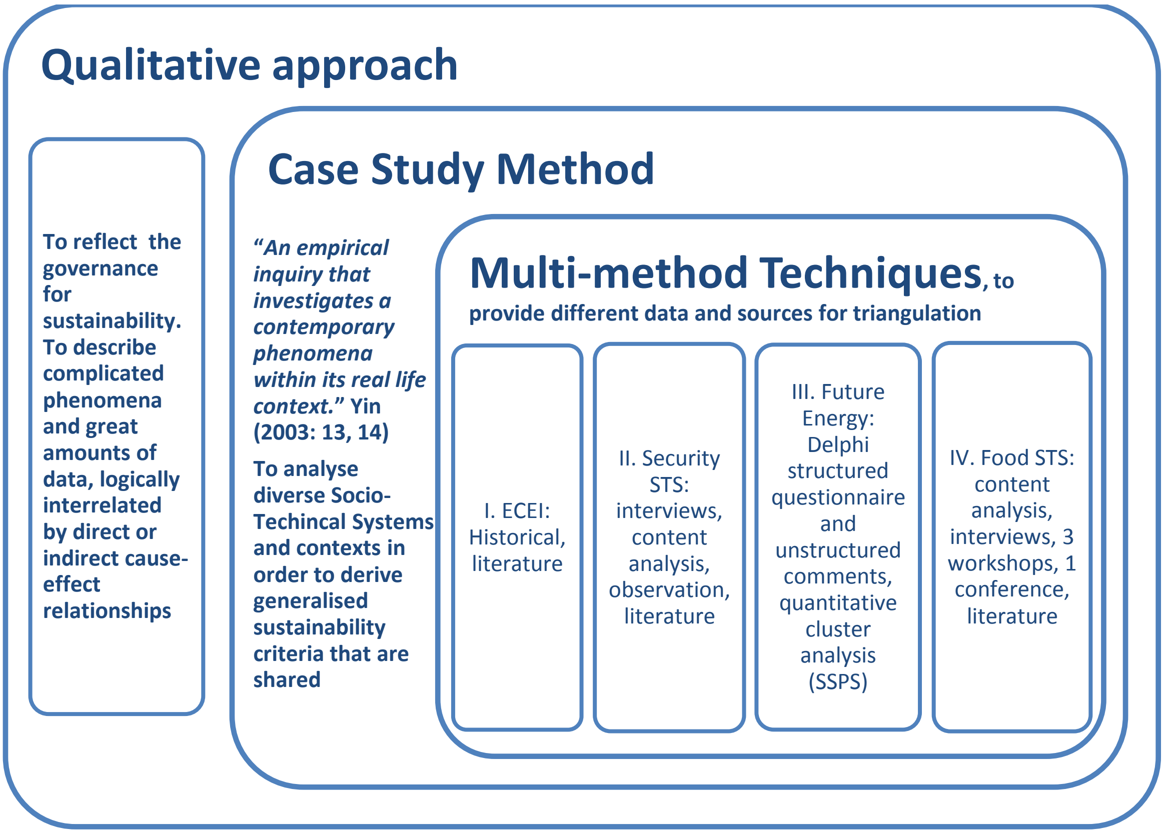
The previous case studies I, II and III, are carried out with the specific aim to generate the methodology and framework for the evaluation of Socio-technical Systems (STS)' sustainability, which is the aim of this thesis. The final case study will be performed for the purpose of the testing of the framework generated, as described in Chapter 8—i.e. the Governance Assessment Matrix Exercise or GAME. This is chosen in relation to one of the most socially sensitive Socio-Technical Systems (STS), and is related to the security and sustainability of the food system. The rational for the choice of case has been the on-going participation in a number of activities in European FP7 projects for the formation of strategic research agendas at Finnish national and European international level (including ERA-nets and other European and global forums). In fact, the food system has the very critical purpose of providing food security and safety, as well as attempting to assure different dimensions of sustainability. At the same time, the food system is a very complex context in which many national and supranational institutions, as well as private operators act through initiatives that are often isolated from one another. In this light, the testing of the GAME matrix will be directed to generate a more holistic understanding, through the cross-analysis and triangulation of data from multiple sources, initiatives and participating actors. This case study will be analysed, in section 8, in more depth than the previous cases because it is intended as the problem context to trial and evaluate the provisional participatory governance methodology and framework. It will therefore be analysed both for its substantive context (food security) and for its practical contribution (decision support framework).

The data collection for this case will also follow a multi-method approach, that is reported in Chapter 8. The need to refer to different sources and data-types is inherent in the GAME idea of making use of existing data that is gathered according to contextual situations and methodologies available, integrating and summarising it. A tool that would need for its own functioning to collect new data by a single method would not be effective, as too expensive and demanding for the user. The strength of the GAME is to be able to use different big data and realise a mind mapping that facilitates social learning.

The test consisted in the application of the GAME process to the food case and in the acknowledgment of its validity for the planned purpose of implementing governance through social learning for more sustainable futures. This has involved the application of key sustainability criteria in order to design policy actions at more practical level that would support decision-making for Socio-Technical Systems' (STS) sustainability. The test case has also contributed to evaluate the challenges for the future application of the GAME, as put in evidence by the conclusive considerations of Chapter 9. The methodology of analysis of the data collected

Summarising the choices that have been made for the research methodology, presented in sub-section 5.1-5.3, the research is conducted by a qualitative approach, a case study method and a multi-method data collection, as exemplified in Table 19 (page 119).

Table 19. Research approaches, methods and techniques and justification for their use



As is has been already described in sub-sections 5.3 and 5.4 a data triangulations is necessary to assure validity and to be able to generalise the research findings. Therefore, the methodology for implementing the triangulation analysis should be built while keeping in mind the aim of the research and the research questions that have been formulated in the literature section, with particular reference to the research question c that is here recalled:

'how to apply the concept of 'governance for sustainability' identified through an innovative methodological framework?'

This section explains the choice of the methodology employed in order to undertake the research—i.e. the approaches of analysis that can be adequate for the analysis of data in relation to the concept of governance for sustainability as described in Chapter 4. In other words, the theoretical approach and the definition of governance for sustainability of Chapter 4 can serve as basis to build the empty structure and process for data analysis. This can be done by applying Maxwell's Interactive Model of Research Design (see Figure 15 in sub-section 5.1, page 103), as shown in Figure 17 (page 121) is employed for this purpose.

In operating the choice for the methodology of analysis some guiding concepts of qualitative research (Lemon, 1999) are considered:

- Understanding of the subject's perspective.
- Placing actions and meanings in their social context.
- Emphasising time, space and process.
- Use of everyday contexts rather than experimental conditions.
- Adoption of a range of data collection techniques.

According to Blaikie (1993), social enquiry's purpose is to explore, describe, understand, explain, change and evaluate. The author holds that this requires a range of techniques and the investigation of not well understood phenomena, informing possibly further research. As Lemon argues (1999), the main objective of issue based research the primary is to determine perceptions and possibility of learning about a particular issue and identify possible futures, in terms of directions or change. In doing so, the author continues, in the strategic process of knowledge creation, it is important to establish the 'decision space' in which individuals operate, empowering them in a context of local participatory development. This includes goals of social justice, equity and democracy (Mikkelson, 1995). This approach, as Lemon continues, is focused to the provision of a range of possible responses incorporating physical and technical aspects as well as socio-cultural ones. In this way, the author holds, issue driven research can contribute to inform the options to be considered at the contextual level.

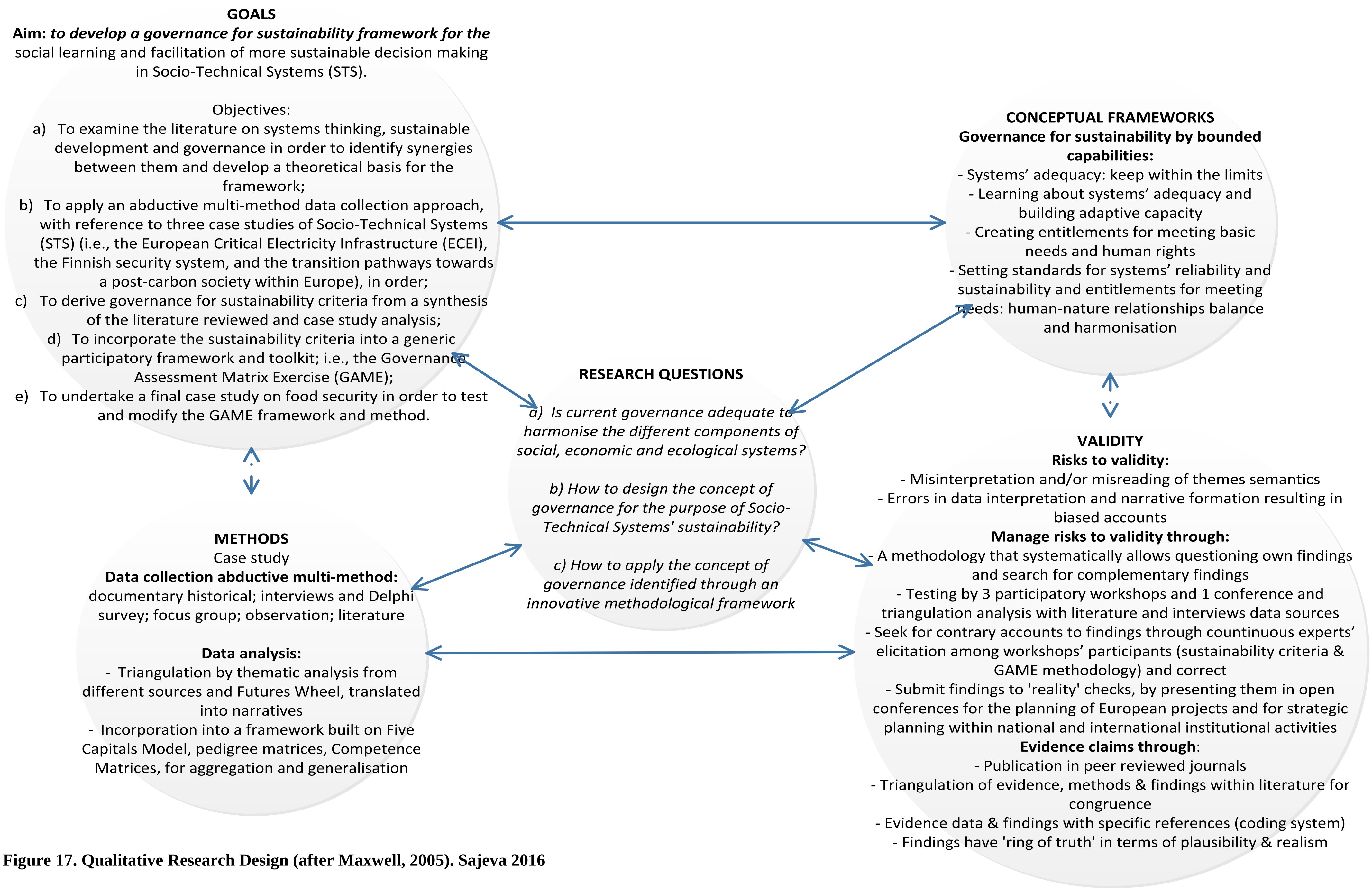


Figure 17. Qualitative Research Design (after Maxwell, 2005). Sajeva 2016

5.3.5 The construction of an empty framework for analysis of multiple data-types and the implementation of governance for sustainability

From a methodological perspective, the analysis of the case studies was planned to reflect the theoretical aspects of governance for sustainability as described in Chapter 4. In order to satisfy the requirements listed in Table 20, the methodology has taken advantage of conceptual insights that are typical of other evaluation methods, as already described and discussed in sub-section 4.6.

Table 20. The empty framework of evaluation reflecting the governance for sustainability conceptual idea

Governance for Sustainability requirements	Existing methodologies or conceptual frameworks
Allow the reporting of multiple data-types, realising social learning through generalisation of case study findings and re-application of generalised criteria to specific contexts.	Edsteps Global Competence Matrix concept. Encoding system for referencing different data. Analyse, integrate, and synthesize insights: clustering, integration and summary of homogeneous data (categorisation of Futures methodologies).
Allow a holistic evaluation of Socio-technical Systems' sustainability that is extended to different capital dimensions	Qualitative matricial structure of the pedigree matrix and scoring of attributes (Funtowicz and Ravetz, 1990) Five Capitals Model of sustainability.
Allow the visioning of future implications emerging from current actions for scenario building and the cross-impact analysis within and between systems.	Futures Wheel conceptual structure for analysing orders of impact

The concept of Edsteps (2014, 2015) has inspired the construction of the empty framework that analyses single case studies of different type and applied in different context in order to learn about general criteria, and then uses these criteria to assess other case studies related to different specific contexts. Global Competence Matrices are used in fact to analyse, integrate, and synthesise insights through categorising multiple perspectives, integrating and summarising homogeneous data in order to draw defensible conclusions in order to «*illuminate globally significant themes*» (Edsteps, 2015).

5.3.6 The empty matricial structure for data triangulation

In order to understand this complexity it appears necessary to move away from disciplines limited within strict boundaries and embrace a method that integrates different, yet relevant disciplines (Lemon, 1999). In a context characterised by continuous change, systems' interaction and interconnections of emerging relations, the empty structure for the analysis of case studies is built according to the conceptual idea of governance for sustainability as described in Chapter 4. The framework in intended to structure a process of social learning for more informed judgement about alternative futures. On the one hand, this can be done by extending the participation of stakeholders and by increasing knowledge, but on the other hand by providing a methodology that would allow the participants to analyse possible impacts, synthesise best practices, in this way supporting an informed, transparent and accountable decision-making, based on phronesis (Flyvbjerg, 2012). The framework is designed to structure and capture the mentioned social-learning process by facilitating the participation of a wider community of stakeholders (e.g. the interviewed actors or the respondents of the survey). The action of facilitation is aimed at structuring the process and enable the agency of the participating actors and the triangulation of their inputs. This means that the facilitator just proposes a structure on the basis of a conceptual and a methodological framework but does not influence in any way the participants. The information gathered may be triangulated with existing literature or documentary analysis. The methodological structure is intended to generate arguments of discussion and make the sustainability criteria arise, while the facilitator remains as a final observer.

For this purpose, some useful contributions can be derived from the techniques that are part of the existing evaluation methodologies. For instance, the approach of the Futures Wheel (2013) includes brainstorming that helps the participants to identify the potential consequences of changes, as expressed in terms of successive impacts of different order and to eventually choose between the possible options that can be pursued. However, these options need to reflect the concept of governance for sustainability identified, so that the data is classified according to the Five Capitals Model of Sustainability (Forum for the Future, 2013). In order to provide an evaluation method, a ranking of the options according to a scale of their performance has to be provided. Therefore, the first analysis performed by the Futures Wheel (with the help of the produced narratives) has been incorporated in an empty matricial framework built *ad hoc*, inspired by the existing example of the pedigree matrix for qualitative assessment that is a part of the NUSAP evaluation (Funtowicz and Ravetz, 1990). The aim is to incorporate the data, correlated by the cause-effect relationships that are reported in the sources, or that are emerging from the analysis by means of the Futures Wheel (2013), according to

- the capital dimensions of the Five Capitals Model of sustainability (x-axis), identified by coloured cells, or white cells for themes spreading across more than one capital to capture the interdependencies and multi-impact effects,

- the level of impact by a scoring system (y-axis). The sustainability level is represented by challenges, worsening situations, failures, goals and policies/actions for improvement.

The element of novelty of the composition of the Edsteps approach for learning, the Futures Wheel (2013) for determination of impacts and possible scenarios, and the pedigree matrix for evaluation stays in the analysis of impacts between the different types of capital, and in the determination of main sustainability criteria, valid for specific Socio-Technical Systems (STS) and contexts, as well as generalised for STSs. This way, the Five Capital Model is enhanced by a dynamic component of impact analysis according to the conceptual thinking of the Futures Wheel (2013), in order to identify the interconnections and the dynamic relations between the different capitals. The method of analysis just described is represented in Figure 18 (page 124).

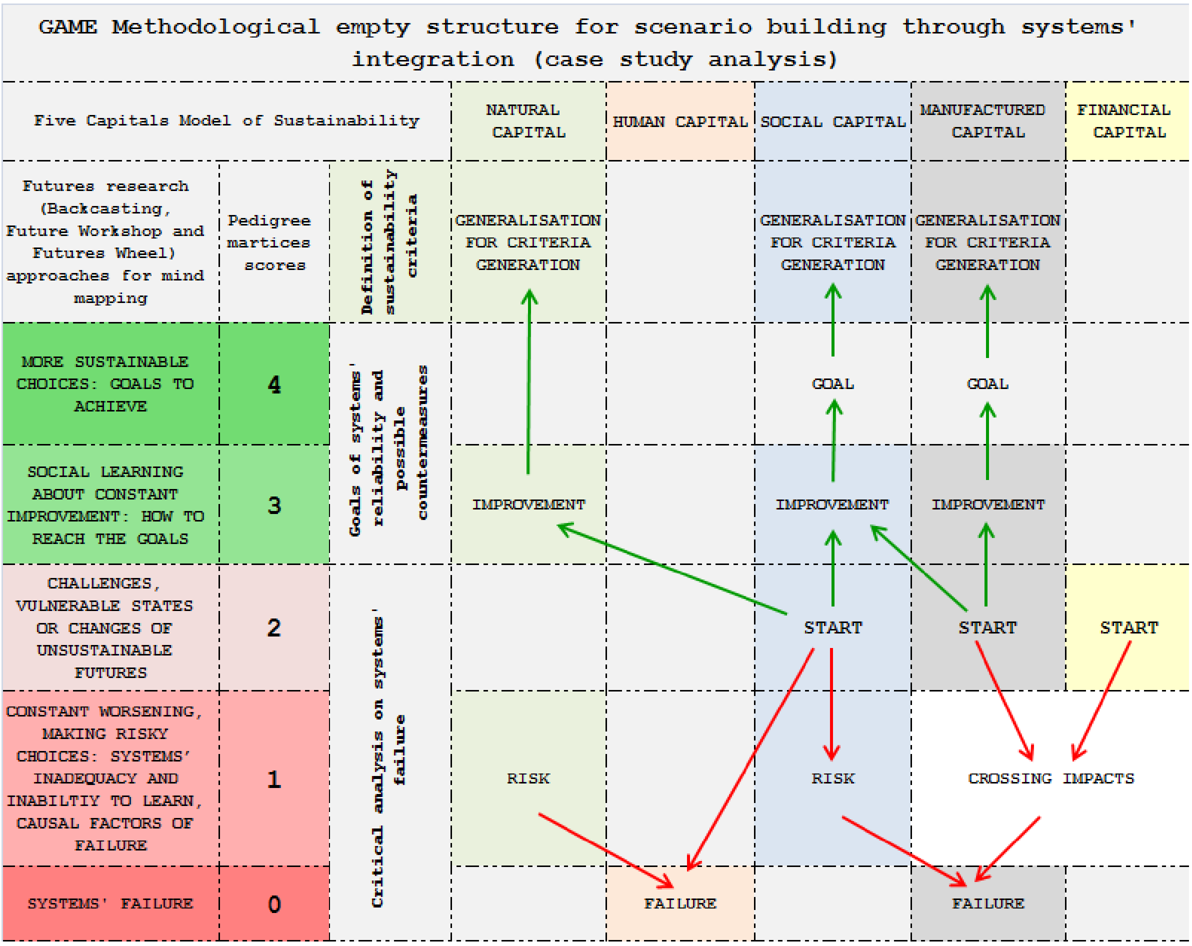


Figure 18. The GAME empty structure for data analysis across the Five Capitals Model (as published in Sajeva, Sahota and Lemon, 2015)

This procedure has allowed visualising the position of the data grouped according to the capital dimensions and impact produced in the past or that could be produced in the future, in terms of causes of systems' failures and lessons learned or improvements proposed in the case studies, and identify in the empty structure some main scenarios. As Dubois and Gadde reports (2002: 556), the data is not pushed into established clusters. Results in terms of combination of theory and contexts can be acknowledged when they naturally fit and are explained by existing theories or factual data, without distorting their meaning and nature. In order to convey the specific data and transform it into information, this is organised in common cells of the empty matricial structure in a synthetic way, in terms of straight citations, single or combined paraphrases, thereby realising a cross analysis between one or more sources, according to the traditional scientific method. According to the abductive approach, often the data is put in relation with existing conceptual frameworks, theories and literature at support.

5.3.6.1 Triangulating and integrating different data-type from different sources and methods

The matricial structure as described in sub-section 5.4.2 has been planned with the aim to incorporate and integrate multiple data sets of different types within and between the different cases and from a number of different sources—historical and content analysis, observation, interviews, workshops and questionnaires (see Figure 19, page 125).

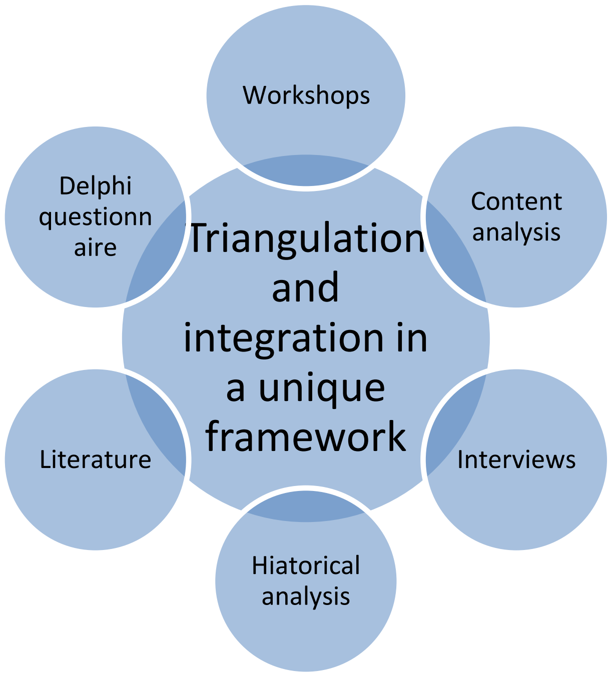


Figure 19. The data triangulation and integration

In order to analyse data it has been encoded by type of analysis (workshop, questionnaire or type of interviewee consulted), case study (I, II, III, or IV) and a specific number indicating the single contribution (typically from interviewees). The numbers in brackets refer to the analysis of reports or relevant literature undertaken for implementing the abductive approach (see Table 21, page 126). This allowed the researcher to keep track of the data source and the case study, as represented in Table 21 (page 126).

Table 21. The classification and encoding of data

Coding of data for the case studies					
Source		**System**			
		I	**II**	**III**	**IV**
		ECEI	**Security**	**Energy**	**Food**
Literature/Narrative	Reference code	[1..n]	[1..n]	[1..n]	[1..n]
Questionnaire	Q	Q.I (1..n)	Q.II (1..n)	Q.III (1..n)	Q.IV (1..n)
Workshop	W	W.I (1..n)	W.II (1..n)	W.III (1..n)	W.IV (1..n)
Direct observation	O	O.I (1..n)	O.II (1..n)	O.III (1..n)	O.IV (1..n)
Interviews					
Systems integrators and multinational corporations	MNC	MNC.I (1..n)	MNC.II (1..n)	MNC.III (1..n)	MNC.IV (1..n)
High-tech industrial companies (also multinationals)	Hi	Hi.I (1..n)	Hi.II (1..n)	Hi.III (1..n)	Hi.IV (1..n)
Research institutions/experts	R	R.I (1..n)	R.II (1..n)	R.III (1..n)	R.IV (1..n)
Specialised, local or very small companies	SME	SME.I (1..n)	SME.II (1..n)	SME.III (1..n)	SME.IV (1..n)
Public authorities (e.g. Ministry of Internal Affairs)	Pub	Pub.I (1..n)	Pub.II (1..n)	Pub.III (1..n)	Pub.IV (1..n)
Associations, networks, funding agencies, including non-profit organisations	A	AE.I (1..n)	A.II (1..n)	A.III (1..n)	A.IV (1..n)

Once encoded, the data a thematic analysis (see Figure 20, page 127) involved, for each of the case studies, the following procedures:

- Grouping of data from different source that are fully replicated, communicate similar messages, or complement one another, highlighting the triangulation process (see Figure 19, page 125; Table 22, page 128 and Table 23, page 129).
- Confronting data from different sources, supported by experts' contributions, especially in case of more uncertainty

- Analysing multiple cause-effect relationships within and between systems applying the Futures Wheel for the determination of successive order of impacts (see cause-effect relationships in Figure 24, page 141; Figure 27, page 153; Figure 28, page 154).
- Translating these multiple impacts into narratives that can explain the analysis undertaken, identifying ‘narrative scenarios’ (examples in sub-sections 6.2.1, 6.3.2-6.3.8, 8.2).

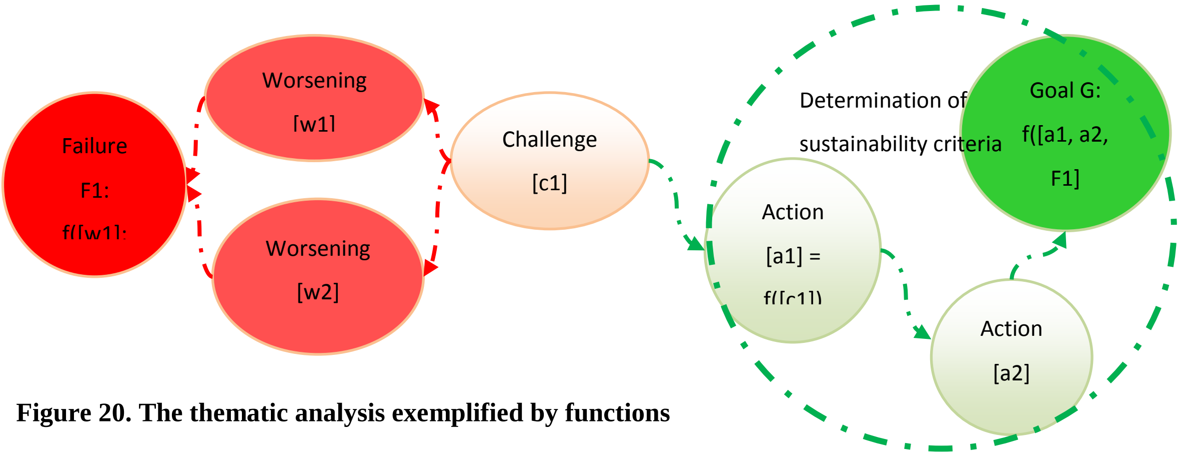


Figure 20. The thematic analysis exemplified by functions

In many cases, the nature of the data identifies different sub-dimensions within the capitals or separate groups of information going across them. For instance, in the case of the failures of European Electric Power Infrastructure (ECEI), an additional sub-dimension describing technical issues is generated; this is different from the other case studies. This ‘natural clustering’ of data within the empty structure for the construction of the GAME methodology realises a ‘mind mapping’ in the terminology of Valqui Vidal (2005), naturally identifying one or more scenarios, corresponding to the specific historical and societal developments, or choices made, across space or time. So, different scenarios can refer to different choices, that were made in different contexts or historical times.

Table 22. Structure of the methodological approach

Methodological approach of triangulation for knowledge generation and validation

Source code (see list of references)	Data collection within case studies
[xxx] [xxx] [xxx]	Documentary analysis
[xxx] [xxx] [xxx]	Delphi and on-line questionnaires
[xxx] [xxx] [xxx]	Interviews
[xxx] [xxx] [xxx]	Workshops
[xxx] [xxx] [xxx]	Direct observation
[xxx] [xxx] [xxx]	Literature analysis

Thematic analysis through triangulation for knowledge generation and validation: data aggregation and impact analysis	Empty framework for analysis (x axis: capitals; y axis: evaluation of performance)		General sustainability criteria
Decontextualised aggregated theme	System failure	0	Failure, system resilience broken
Decontextualised aggregated theme	Challenges or vulnerable states	2	! Warning!
Decontextualised aggregated theme	Constant worsening, possibly causing failure	1	Change direction
Decontextualised aggregated theme	Social learning and actions to reach the goals	3	Re-contextualised best practice
Decontextualised aggregated theme	More sustainable choices: goals to achieve	4	✓ Sustainability criterion
Decontextualised aggregated theme	Challenges or vulnerable states	2	! Warning!
Decontextualised aggregated theme	Social learning and actions to reach the goals	3	Re-contextualised best practice
Decontextualised aggregated theme	Challenges or vulnerable states	2	! Warning!
Decontextualised aggregated theme	System failure	0	Failure, system resilience broken

Table 23. Example of triangulation for the case study of the European Critical Electricity Infrastructure (ECEI)

Example of triangulation analysis for the case study of the European Critical Electricity Infrastructure (ECEI)

Source code (see list of references)	Data collection within case studies (see sub-section 5.2)	Thematic triangulation for knowledge generation and validation: data aggregation and impact analysis (see sub-section 5.3)	Empty framework for analysis (x axis: capitals; y axis: evaluation of performance; see sub-section 5.3)			Standards, actions and countermeasures
[310] [220]	Short-term blackouts or brownouts of few minutes causing some inconveniences Short term blackouts considered as physiological	Physiological short-term blackouts of few minutes disruptions causing inconveniences	**Challenges or vulnerable states**	2	!	Warning!
[310] [220] [310]	Increased dependency and vulnerability of modern societies on electricity Electricity is in fact a critical factor for the maintaining of all modern conveniences and standards of living of societies, including their security and safety Electricity the backbone of each industralised society and economy	Electricity the backbone of each industralised society and economy: increased dependency and vulnerability	**Challenges or vulnerable states**	2	!	Warning!
[310] [310]	Severe impacts represent great challenges for social structures Modern societies not used to face even short blackouts	Severe impacts represent great challenges for social structures, as modern societies are not used to face even short blackouts	**Challenges or vulnerable states**	2	!	Warning!
[314] [308] [320] [318] [220] [316]	The probability to produce correct outputs for a certain time period System performance in terms of delivering electricity in the amount of service required within given standards The degree of performance of the elements of the bulk electric system that results in the deliver of electricity within accepted standards and in the amount desired: frequency, duration and magnitude of adverse effects on consumer services Condition of correct activity over time. Acceptable level of power outages, in relation to the required cost 'Reliable operation': operating the elements of the power system within technical limits to avoid instability, uncontrolled separation, or cascading failuresfor sudden and unanticipated disturbances or failure of system elements	Reliability: continuous long-term functioning throughout time according to accepted quality and quantity standards of delivered service and possible failures	**More sustainable choices: goals to achieve**	4	✓	Sustainability criterion
[310] [325] [9][310]	Inadequate vegetation management (line contact by trees) Negligence in land management: power lines close to forested areas	Inadequate, negligent land management and lack of adequate interaction human-nature (power lines close to forested areas)	**Constant worsening, possibly causing failure**	1	↖	Change direction
[310] [323] [9]	The failure of the Italian power system of 28th September 2003, the worst in 50 years, impacted on 56 million people among Italy and Switzerland, where electricity was ripristinated after 1.5 hours (CH) and 18 hours (Italy). The blackout affected, besides Switzerland and Italy, also France, Slovenia, and Austria and the domino effect across the networks finally ended up with the separation of the Italian system from the European interconnected grid. Specific consequences concerned 30,000 people that were trapped on trains and other hundreds of passengers were stuck in underground transit paths. Underground transportation had to be evacuated. Domino effects were produced also across other critical infrastructures, affecting electricity users for 48 hours and causin, fro instance financial costs to restaurants and bars of about USD 139 m The shutdown of power plants in Italy provoked the simultaneous failure of voltage and frequency, which in turn generated a blackout throughout the entire Italian peninsula	High impact on human basic needs, security, safety and convenience [220]	**System failure**	0	⌫	Failure, system resilience broken
[311] [332] [311] [R.I.1]	End of monopoly: favorable conditions for solar energy producers, wind power generators and other kind of renewable energy technologies so that the generation industry flourished The extra production (of power) should have been achieved without affecting the environment Thanks to state incentives California was supplied with 85% of the world's wind power capacity and 95% of the world's solar power More local generators of renewable energy attached to micro smart grids	Spreading and isolating the risk: local self-sufficiency and local micro grids to break the complexity and reduce vulnerabilities [R.I.1] Systems kept well below their limits, avoiding to work under conditions of stress [347] [322]. Production achieved without affecting the environment [332]	**Social learning and actions to reach the goals**	3	→	Re-contextualised best practice

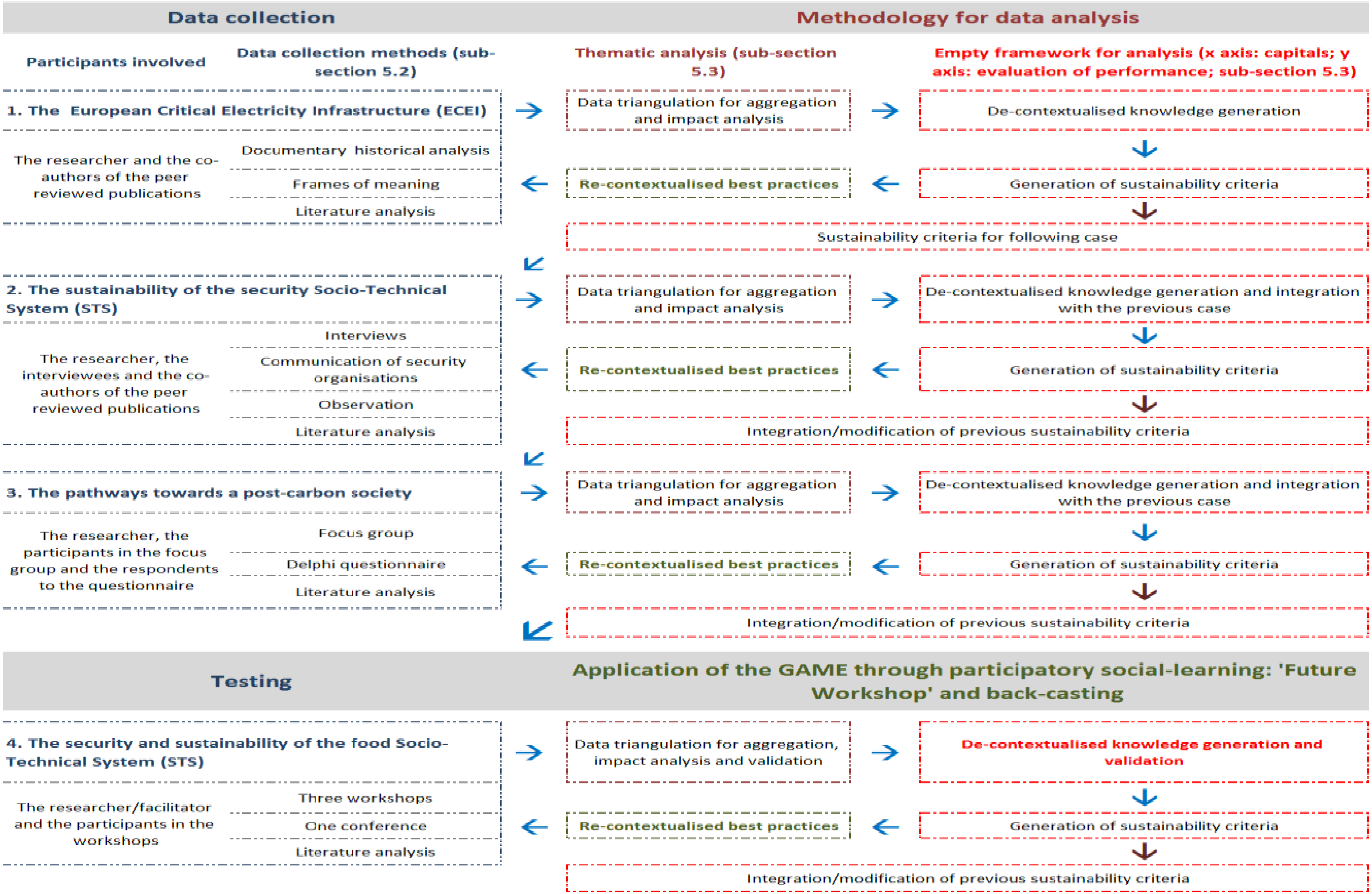


Figure 21. The case study analysis comprised of data collection (sub-section 5.2), thematic analysis (sub-section 5.3) and incorporation in a framework for criteria generation (sub-section 5.4) of successive case studies

The three case studies have been developed in order to identify the main critical elements that undermine sustainability of different Socio-Technical Systems (STS) and let the sustainability criteria emerge from each of them. The Futures Wheels has been able first introduced to understand, from the initial messy data, the propagation of impacts and the alternative scenarios that have been produced or could possibly be produced, as explained by the related narratives. The successive integration into a matricial structure has created knowledge, in terms of linked impacts between different capitals and stakeholder evaluation of the sustainability of the scenarios produced.

This procedure can realise the conceptual idea of Flyvberg (2001) about the need to develop general rules, that have to been applied to specific contexts, what Wilden calls 'games' (Flyvbjerg, 2001:43). This way, the data related to different case studies, both in space and time, is generalised, to find common principles or rules that are applicable in all systems but can be adopted or disregarded according to the contingencies of contextual situations. The determination of common and generalised core governance for sustainability criteria—the 'rules of the game'—resulting from the process of social learning about more objective and measurable evidence seems necessary in order to reduce the uncertainty that derives from more subjective visions, thereby reducing the vagueness of governance initiatives.

In other terms, the triangulation analysis within and between systems aims at integrating these multiple data sets to form the general 'rules' which in Wilden's terms, 'are not the game' but which have to be adapted to contextual factors at each successive application, (Flyvbjerg, 2001:43). These can be considered as guiding principles towards sustainability (see also the final GAME process in Chapter 8). The integration and generalisation of the sustainability requirements of 'the single games' (here represented by the case studies) determine the general sustainability criteria, 'the general rules' or the 'constraints', in Giddens' terms, which delimit Socio-Technical Systems (STS) (physically and conceptually). These core principles represent non-negotiable foundations of sustainable governance. However, the manner in which they are delivered may vary considerably, as subject to different perspectives on that delivery. Effective social structures can therefore develop according to such criteria at each successive application and new system, 'adjusting' the related actions and policies according to the contingent and contextual matter, or 'game' (Flyvbjerg, 2001). Governance for sustainability is therefore realised by making a distinction between a principle (that is non-negotiable) and its realisation (which is open to negotiation). The empty structure for data evaluation (see Figure 18, page 124) paves the way towards the final aim of the research—the realisation of tools that practically implements the concept of governance for sustainability and develops a methodology for governance deliberation, according to a vision of entitlements and capabilities for human agency within measurable and interpretive sustainability criteria (systems' constraints and boundaries).

5.4 Summary of the research methodology design for the aim of the thesis

In summary, in order to develop a participatory governance framework for more sustainable decision making in Socio-Technical Systems (STS), the research methodology and process is structured according to the following steps (Figure 22, page 133):

1. Choice about
   a. the qualitative approach (sub-section 5.1.1);
   b. the case study method (see sub-section 5.2.1);
   c. the identification of relevant case studies selected among socially sensitive and publicly relevant Socio-Technical Systems as those described in Chapter 2, (see sub-section 5.3) (STS)
   d. multi-method data collection (see sub-section 5.3), planned in order to align some, among existing qualitative and quantitative techniques, to case study contexts and specific characteristics. The data will be complemented with literature sources, according to an abductive approach, in order to allow a successive triangulation.
2. Development of an analytical protocol for the case studies that can support the generation of a provisional decision support framework through the incorporation and analysis of data from the selected case studies, inspired by existing methodologies (see sub-section 5.4). This aims at constructing the methodology for the implementation of the conceptual ideas underpinning the governance approach presented in Chapter 4—i.e. the harmonisation and integration of the sustainability pillars through the Five Capitals Model of Sustainability, the systemic and holistic analysis of impacts within and between systems, the reference to basic needs and bounded capabilities inherent in sustainable development and the search for related sustainability criteria, the implementation of the principle of accountability.
3. The incorporation of the data from the case studies into the empty framework (see Chapter 6), resulting in a Governance Assessment Matrix Exercise (GAME) (see Chapter 7). The GAME is tested in a final case study, in which the sustainability criteria are taken as guidelines for the determination of goals and contextual actions.

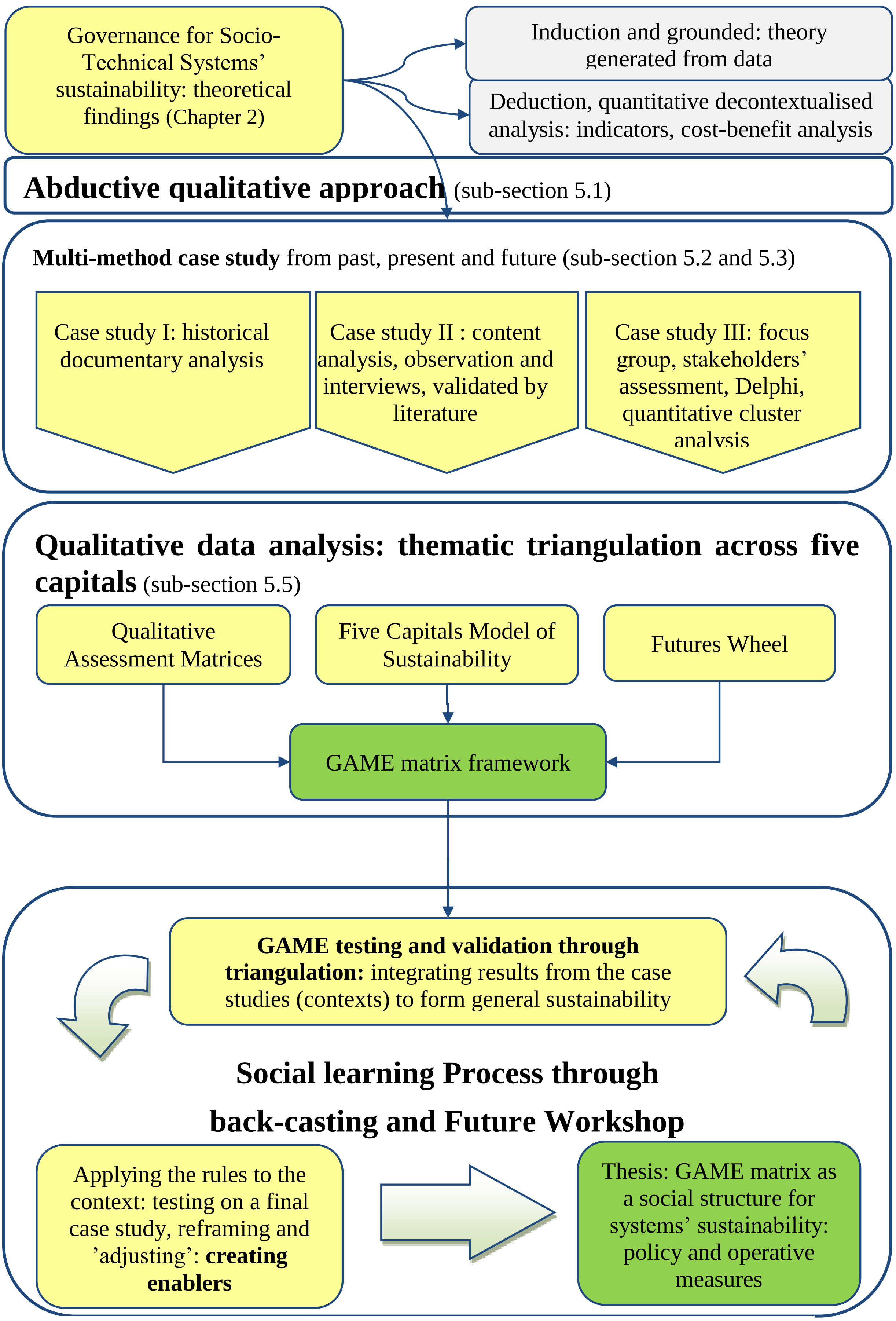


Figure 22. The methodology of the research process

6 The case study analysis of Socio-Technical Systems (STS) and infrastructures

Objective	To present the case studies of different Socio-Technical Systems (STS) and build the GAME structure and framework and the sustainability criteria by successive integrations
Content	6.1. The scientific role within the international contexts and the implementation of the thematic analysis 6.2. The case study of the European Critical Electricity Infrastructure (ECEI) 6.3. The case study of the Finnish Security Socio-Technical System (STS) 6.4. The evolution of the energy Socio-Technical System towards a post-carbon society

In this chapter, the case studies of Socio-Technical Systems (STS) are developed in order to represent different times, places, institutional cultures, system-types and sustainability dimensions.

STSs can involve the general aspects of security, energy or food systems, or then they can refer to more specific sub-systems, such as for instance critical infrastructures for the provision of health, water, electricity services, which are critical for the functioning of larger systems. The key aspect is that all systems are characterised by the criticalities of complexity, uncertainty and high public relevance (see sub-sections 2.2-2.4). Addressing the vulnerabilities of infrastructures, for instance, necessitates greater flexibility and an evolutionary approach that can span both public and private sectors, protecting both domestic and international interests. Every department and agency of federal, state and local governments is responsible for protecting their own infrastructure, however the single actions might not be effective in the context of enhanced complexity.

As already described in detail in sub-section 5.3, the rationale behind the choice of systems and sub-systems that are very different from one another is that the aim of the research is not to develop a methodology and framework for the determination of sustainability criteria that are specific to a particular system, context, country or region. Rather it is to develop a process for social learning that can be applied to different STSs.

In the context of this research, even when some general criteria—guidelines for systems' sustainability—are set, the realisation of specific policies and operative measures relate to the particular context they are applied to.

If specific cases demonstrate the invalidity of the criteria, a justified proposal for changing them, or making an exception could be made. For specific situations, laws often have exceptions, for instance whenever harm is caused out of self-defence. In the same way, scientific rules also allow exceptions, when this depends upon particular conditions. The case study analysis is indeed directed to study how systems, characterised by specific and contextual differences, share common principles and rules, which allows their smooth and integrated functioning, in the consideration of the relations between them and with the systems in which they are embedded. These rules mean that each system is not operated as a single entity, according to oversimplified models, but instead by taking into account of the complexity of existing interconnections. The case study analysis has therefore the aim to initiate a process of social learning about which the common sustainability criteria are, and how they can be applied to the different contexts, to give the direction towards more sustainable futures, searching for the 'sustainability rules' of the 'game' (Flyvbjerg, 2001).

6.1 The scientific role within the institutional contexts and the implementation of the thematic analysis

In the light of the rationale presented above, the case studies described in sub-section 5.3 are hereafter recalled, with particular reference to the institutional role covered and the achievements realised during the research journey.

The author started the research related to this study while working as a Scientific Officer at the European Commission, DG Joint Research Centre, Institute for the Protection and Security of the Citizen, Security of Critical Networked Infrastructure (SCNI) department. The case study of the European Critical Electricity Infrastructure (ECEI) was initially triggered by a very specific accident in a local context. Therefore, an institutional research activity was initially carried out for the International Risk Governance Council (IRGC) on the security and reliability of the ECEI.

After the experience at the European Commission, the researcher was enrolled as a Project Manager at Finland Futures Research Centre, spin-off special department of the University of Turku (Finland). Naturally, he transferred his Doctoral studies to the University of Turku, Department of Economic Sociology. In recovering that role, the researcher was in charge of three different projects, two of which he recognised as appropriate additional case studies. The second case study on the security Socio-Technical System (STS), has been initially carried out in Finland, in connection to the EC FP7 "*Privacy Awareness through Security*

Branding" (PATS) project. The project produced reports (Sajeva and Kaivo-oja, 2010 a/b, whose data and content was used for the analysis of the second case study. The project considered local culture and private and public organisations as well as experts, engaged with the security process. However, Finland is a small country with a very particular cultural context, even when compared to the other European countries. In order to provide a more robust analysis and comparison an additional observational study and documentation analysis has been focused on the Namibian security STS. The reason for choosing contexts that are so different is that the further two contexts are from each other, the greater the potential for identifying generic sustainability criteria. The analysis and observation from the author's personal experience in Namibia, as well as the related literature considered, highlighted the same key factors that are needed for the sustainability of the security STS. It is clear that the policies and the concrete actions that are needed to meet the sustainability criteria will be different and will have to take the local culture, habits, geographical conditions into account. Still, some general, more objective and less negotiable criteria, at a higher level of abstraction, can be defined as guiding principles.

The third case study on the future pathways towards a post-carbon society in Europe is carried out in order to complement the previous cases, that were based on the idea of learning from the past, with an approach that is more oriented to the choice among possible and desirable futures. Therefore it takes advantage of the results of a previous EC FP7 *"Pathways for carbon transition"* (PACT) project, which aimed at identifying future scenarios of transition towards a post-carbon society.

Table 24. The thematic analysis for the three case studies

Case study	Thematic triangulation (from data to information)		Incorporation in the empty matricial structure	Aggregation and generalisation of themes, to generate general sustainability criteria (from information to knowledge)
ECEI	Futures Wheel impact analysis and generation of narratives from qualitative data	Sub-section 6.2.1; Figure 24, page 141	Sub-section 6.2.2; Figure 25, page 143; Table 25, page 145	Table 26, page 146
Security		Sub-section 6.3.1 ; Figure 27, page 153 ; Figure 28, page 154	Figure 29, page 158; Figure 30, page 159	Table 31, page 157
Post-carbon society	Cluster analysis of quantitative data from Delphi survey	Appendix II, page 278; Table 57, page 287; Figure 48, page 293	Sub-section 6.4.2 (results of the scenario III.1 generated from the matrix)	Table 38, page 183

The past-present-future multi-method analysis (see Figure 22, page 133) puts the basis for the formation of the GAME methodology and framework that is presented in Chapter 7 and based on the analysis of present challenges, failures, future goals and actions to reach them.

The thematic analysis applied for the three case studies (see the examples in the following sub-sections for each case 6.2, 6.3 and 6.4) has been applied according to the methodology presented in sub-section 5.4 and has involved some steps, summarised in Table 24, page 136.

6.2 The case study of the European Critical Electricity Infrastructure (ECEI) system

The first case study of the European Critical Electricity Infrastructure (ECEI) is chosen according to the rational presented in sub-section 5.3.1. In this sub-section an example of the analysis performed for this case study, according to the methodological framework presented in Chapter 5, is presented. In particular, the case study has been developed through data concerning:

- The analysis of the occurrence of the incident, triggering the blackout of the entire Italian territory and an analysis of other similar incidents around the world, by the consultation of relevant reports and literature. The event and the sequence of cause effect relationships that triggered the development of the case study is represented in Figure 24 (page 141).
- A first mapping of the actors of the ECEI and an analysis of their risk management perspectives **[Q.I.1].**
- A comparative historical analysis of market failure in the American energy system by the analysis of relevant narratives.

6.2.1 Thematic triangulation: Futures Wheel impact analysis and generation of narratives

The first step involves the analysis of any relevant data collected and previously encoded in brackets [XX] (see Table 21, page 126) by the impact analysis of the Future Wheels and the contextual generation of narratives. In this way, the data is converted into information as it is aggregated and put in relation with other data by the Futures Wheel and scientific reasoning (see Figure 24, page 141).

6.2.1.1 An extract of the narrative material for the ECEI case study: the failures of the ECEI and the goals for the reliability of the system

In this sub-section, an example of the narrative generated by the data is provided.

Some challenges‒the changes occurring in the technological dimension—have been identified. One of these changes consisted in the greater efficiency of generation of electricity, due to the developments reached in gas-turbine technology, that made power cogeneration especially convenient (Smithsonian Institute, 2014) **[311]**, triggering the end of monopoly in the electricity market. From the human and social perspective, in absence of monopoly, the liberalised markets determined new challenges and risks, as they limited the responsibilities of single operators to isolated business interests, and to subjective evaluations of costs and

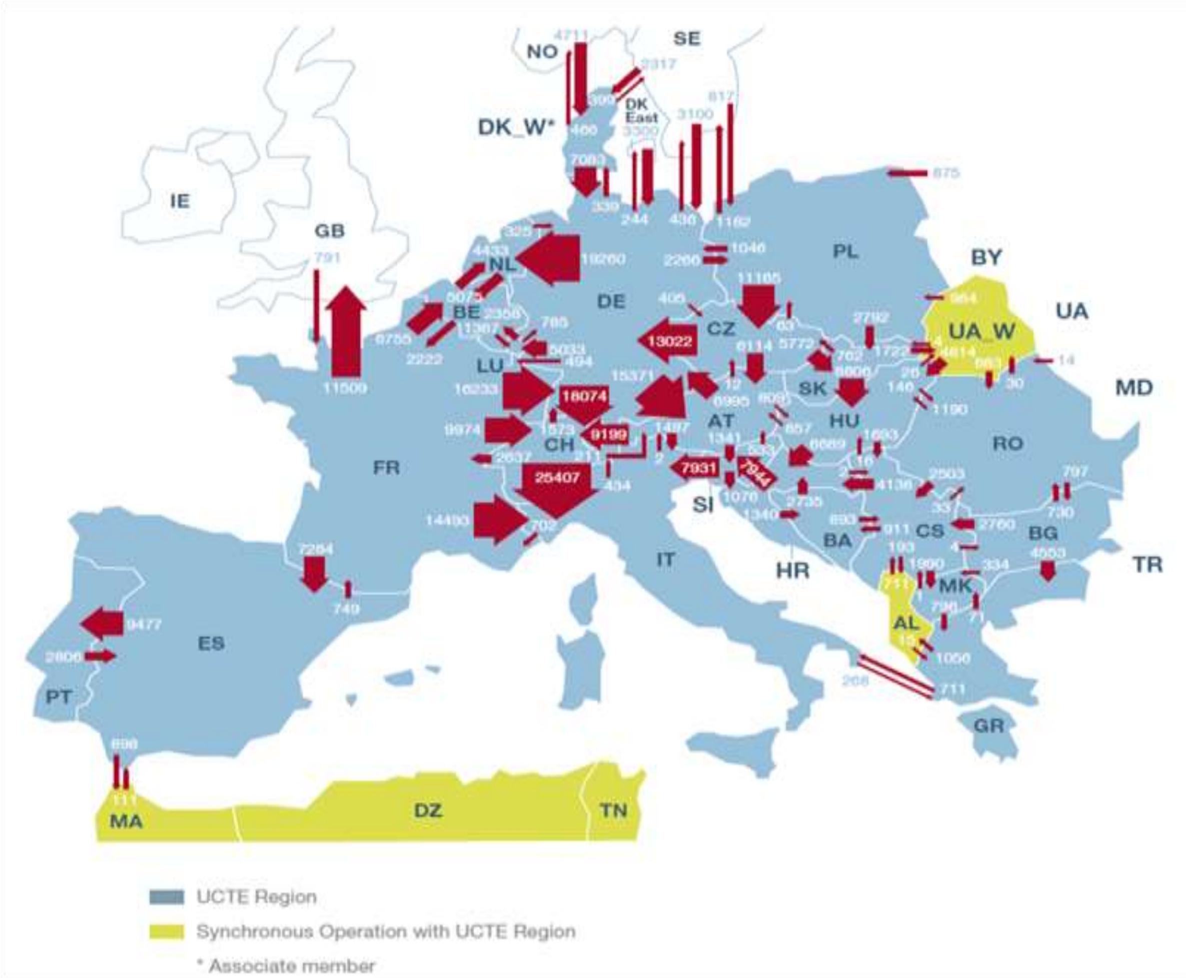


Figure 23. Trans-boundary physical energy exchanges in Europe in 2005 (UCTE, 2006, source: International Risk Governance Council, IRGC, 2006) [125]

benefits, losing the holistic vision of the potential effects on larger communities of stakeholders or entire societies (Gheorghe, Masera et al., 2007; Sajeva and Masera, 2006; Sajeva, 2012) **[102] [218] [210]**. What makes the situation critical is, as CRO reports (2011) **[310]**, the increasing dependency of societies on power supply for electronics, industrial production, and the majority of actions in daily life: *«electricity is the backbone of each industrialised society and economy»*. Electricity is in fact a critical factor for maintaining all modern conveniences and standards of living of societies, including their security and safety

(Sajeva, Stefanini and Masera, 2006) **[220]**. Considering that the ECEI is a socio-technical artefact, functioning as a unit, embedding administrations, operators and markets, connecting different regions but behaving as a unity **[102]**, as showed by the trans-boundary physical energy exchange in Europe in 2005 (see Figure 23, page 138) **[125]**. The increased system weaknesses and operational risks inherent in the recent developments of the European electricity market were found in the high level of cross-border exchanges **[322].** The worsening of the situation, in such conditions, can be explained by the impact onto the different capitals, and in turn, the following failure of the system, involving impacts on dimensions belonging to other systems. In short, the changes due to technological development have not been faced by the adaptation of both technological and social systems, producing a problem of inadequacy of the interconnected electric power system.

This has triggered failures in the physical and market systems, cascading onto other systems and affecting the social and human dimensions of sustainability. This analysis of the criticalities of the system puts in evidence a first scenario, identified by the red profile (see Table 25, page 145 and, in Appendix I, Table 55, page 276). According to this scenario, the logic of free markets has considered that an infrastructure, even when having great relevance for the well-being and security of the society, can be managed in a regime of free and unregulated markets by isolated approaches only because the economic justification of the monopoly has ceased to exist, without assessing all possible impacts within and across systems.

The inadequacy of the markets and of mechanisms for reliability assurance to control situations which are more risky and uncertain **[43]** than in the past**,** generated the urgent question of how to manage such complexity. One of the main problems is that the current trends toward privatisation of systems and management practices does not necessarily pursue common goals, and the sum of isolated actions does not constitute a proper integration towards the common objective of systems' reliability assurance. In fact, the change in the whole structure of the electric power system was not followed by adequate changes in the regulatory and legislative base **[322]**, determining a lack of coordination and control **[220] [311]**. However, the systems' failures have suggested alternative paths to respond to the changing situation **[102]** by authorities, such as, for instance, the North American Electric Reliability Corporation (NERC), researchers and stakeholders.

6.2.2 The analysis of the ECEI Socio-Technical System (STS) by incorporation into the empty framework

In this second phase, the data analysis realised by the use of the Futures Wheel and reported as narrative has been incorporated into the empty matricial structure, according to the methodology of analysis described in Chapter 5. The narratives, once populating the empty framework, have provided a general analysis (see the examples of Figure 25, page 143 and of Table 25, page 145, and the main analysis in Table 55 in the Appendix, at page 276), that describes the different scenarios represented by red and blue boxes classified per capital and according to their level of sustainability. The data contained in the narratives are located in the matrix where they naturally belong according to the source consulted, for instance if considered challenges or risks. Groups of similar data are therefore located in a same cell or cells close to one another. The data is then summarised and generalised by paraphrasing data and conserving the reference, in order to track the different sources. This procedure realises a mind mapping (Valqui Vidal, 2005), and identifies possible scenarios. The blue circles represent the aspects that are common to both scenarios (see Figure 26, page 148). In this case study, the human dimension of sustainability has been divided into two parts, the human security as absence of threats to humans and the threats of the human action. This is because in this specific case study, much of human insecurity is produced by humans themselves. In the same way it can produce harm on all other dimensions of sustainability. This division has been then maintained only for the human capital in the second case study of the security Socio-Technical System (STS), and abandoned for the third case study of future energy STS. The reason for this is that the division had no meaning for the type of information contained in the data.

Some themes concerning market and technological failures are reported in Figure 25 (page 143) and Table 25, page 145. They are marked by red and identify a red scenario, characterised, for instance, by:

- Lack of cooperation and insufficient coordination
- Market structures that allow for exceeding the technical capacity of other systems, and therefore
- Use of infrastructures in ways not contemplated in their original design, system operation too close to upper limits, generating their unpredictable behaviour
- Absence of systems' integration (in this case technical and market systems

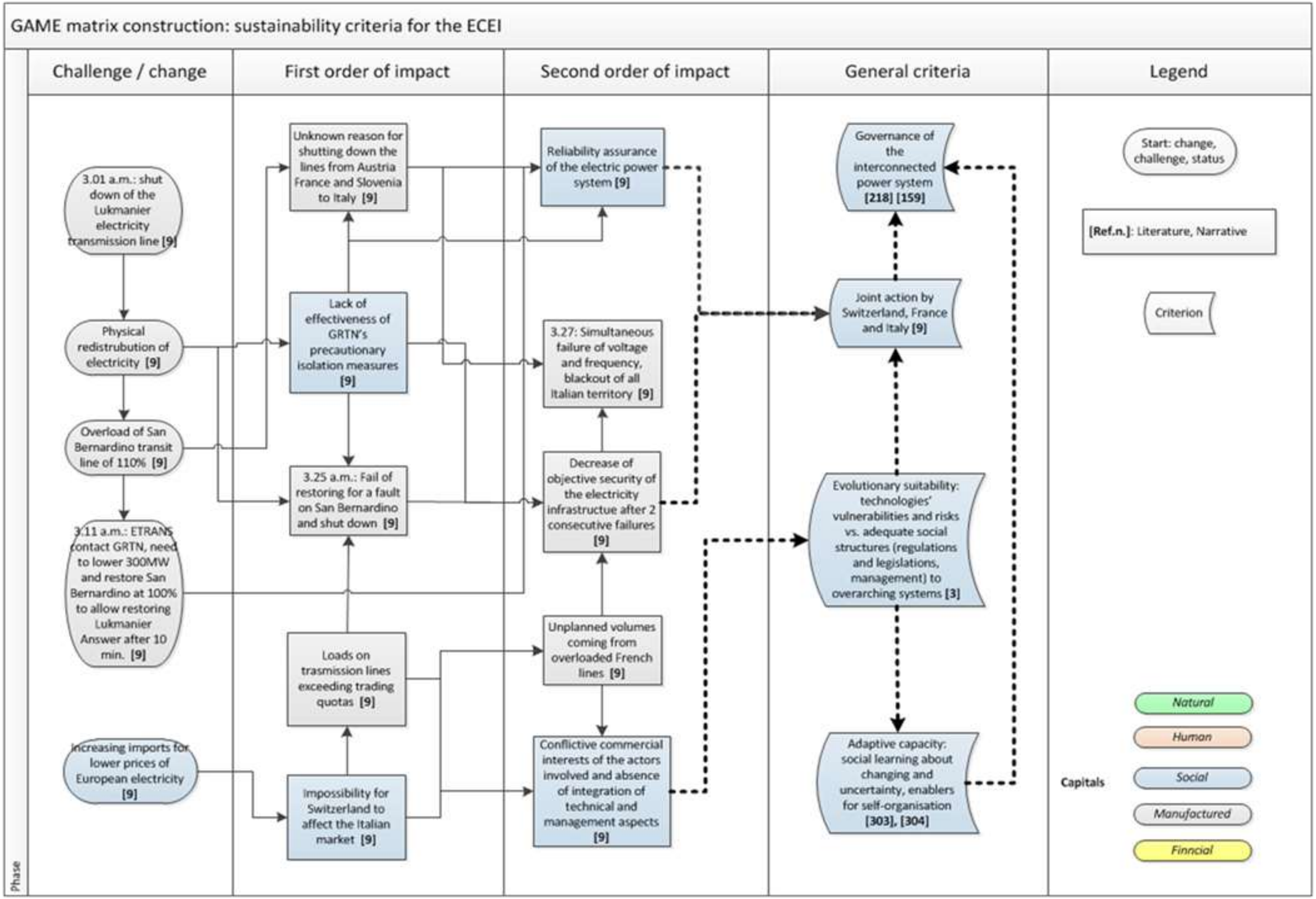


Figure 24. The cause-effect relationship of the event triggering the ECEI case study

The themes of this ECEI case study, that identify failures call in fact for solutions, and some lessons to be learnt are put in evidence by the blue cells scenario (see Table 25, page 145). For instance, the end of monopoly is not necessarily to be considered as negative, especially because it created the favourable conditions for solar energy producers, wind power generators and other kind of renewable energy technologies to make generation industry flourish (Smithsonian Institute, 2014) **[311]**, while producing extra power without impacting onto the environment **[332]**. Here, in the analysis, the blue circles identifies aspects that are common to the two scenarios (see Figure 26, page 148). Even acknowledging the improvements on the side of the environmental sustainability and on the social aspects of the new energy markets, the security of the systems cannot be left without control and alternative systems for security assurance have to be put in place. For instance the coordination of more local generators of renewable energy could be attached to micro smart grids that can be instantly disconnected in case of failure of one or more parts of the system; thereby guaranteeing the self-sufficiency of local areas **[R.I.1].** Moreover, interdependent systems cannot be operated as if they were independent and closer coordination is required **[337]**. Entities for cooperation and governance and mandatory standards should be put in place to deal with issues of public relevance **[218]**. From the point of view of the manufactured capital, short-term blackouts of a few minutes causing inconveniences can be considered as normal **[220] [310]** but in order to avoid irreversible or greater harm, systems should be kept well below their limits, avoiding work under conditions of stress **[347] [322]**.

These aspects mentioned above have been considered as possible goals, alongside the financial dimension, to raise awareness of the re-insurance industry about the possible risks and with the goals covering the human perspective, to raise awareness of major emerging risks relevant to society: standardising disclosure, stakeholder dialogue; knowledge sharing and developing best practice solutions **[310]**. These goals call for actions and policies adequately designed to achieve them. The failure of insurance mechanisms and financial evaluations, able to measure just 20-25% of supply chain disruptions, calls for actions of improving communication and transparency on the uncertainty of financial evaluation of risk and losses and perhaps of creation of alternative evaluation systems **[310]**. In order to raise awareness of the risk relevant to society, *«timely information to electricity customers about planned supply interruptions is decisive to keep damages within a limit»* **[322]**.

	Thematic analysis for Governance Assessment Matrix Exercise (GAME) fo			
Dimension	SOCIAL CAPITAL		MANUFACTURED CAPITAL	
Sub-dimensions	**Governance**	**The reliability of markets**	**Sustainability and reliability of infrasructures**	**Technical aspects of the ele infrastructure**
...SKY CHOICES: SYSTEMS' INADEQUACY AND INABILITY TO LEARN, CAUSAL FACTORS O... 1	Stakeholders having previously worked in cooperation have become competitors [43]. Conflicts in commercial relations and interests between the actors involved, absence of integration of technical and management aspects [310]	Export volumes allocated by producers exceeding the physical capacity available [9]	Unpredictable behaviour of the infrastructure, precarious situation [347] [322] [R.I.1]	Single outages and faults of parts of the s subsequant shut down of other parts, phy redistribution [9] [310]. «The cause was a coincidence of severe faults leading to a system far beyond the contingencies rega normal system design and operating secu standards» (Svenska Kraftnät, 2003) [322
	Lack of capacity of reaction of social structures for long-lasting blackouts [310]		Unknown reasons for shutting down international lines from Slovenia, Austria and France to Italy, and about the effectiveness of GRTN precautionary isolation measures [9]	Overloading over own capacities with unp volumes (e. g. Switzerland in the Italian ca Systems operated under conditions of st beyond the limits originally set. For instan power, today widely used, can lead to prob stability due to its rapid operational chang
	Slow and ineffective of communication in emergency situations [310]	«Insufficient coordination between the TSOs in case of a contingency actually propels the occurrence and spreading of a blackout» [322]. Fragmentation of the market and increased uncertainty and liberalisation processes at different speed [102].	Dysfunction of a control area's system and lack of adequate backup capability [325] [310]	Inadequate coordination of relays and oth devices or systems [310] [325]. Transmis closer to their limits, and more difficulty to blackouts confined within local areas [33 and protection systems are put under stre
	Lack of cooperation between neighbouring countries [347]. Lack of effective communication between the actors involved in a contingency (e.g. between the TSOs and the distribution system respectively for keeping the disruption within a limit and to restore the system as quickly as possible. [322]	Increasing imports of energy for prices divergences, exceeding trading-quotas (Italian blackout of 2003) [9]	Inadequate consideration of the risk situation by TSOs (e.g. inability of the Swiss operator to reclose the Lukmanier line) [310] [9]	Occurrence of a second outage and Impo control the infrastructure [310]
	Lack of reaction capacity of social structures [9]		«The TSOs operate the system closer and closer to its limits as allowed by the security criteria, which in essence have remained unchanged» [347] [322] «High system loadings increase the risk of cascading transmission line outages». [322]	Inadequate measures to maintain stability
	«Present-day standards and legal instruments are lagging well behind economic realities» (SFOE, 2003) [322].	insufficient co-ordination and communication of internal procedures between TSOs and lack of access to real-time data from the power units connected to the distribution grids [310]	Use of the grid in ways that are different from those expected in the original design (evolutionary suitability) [43]. «Today's market development with its high level of cross-border exchanges was out of the scope of the original system design» [347]. «It was as if we were caught	Instabilities in the network [310]

Figure 25. Example of thematic analysis by data aggregation in the empty matricial structure

In order to limit damage to few minutes disruptions, a logic of spreading and isolating the risk to break the complexity and reduce vulnerabilities could be adopted, for instance by assuring local self-sufficiency and local micro grids **[R.I.1]**.

These goals, appropriately generalised, have been translated into criteria grouped around some thematic areas, as reported in Table 26 (page 146), that can be applied to any system. For instance, as described in the first row, there is a need to focus on the prevention of harm for society and human security and designing systems that are adequate to maintain their functions throughout time. This implies the avoidance of systems to work under conditions of stress, too close to their limits or to the limits of connected systems. As we can see, many of them spread across different capitals and show the high complexity and uncertainty of systems. Even trying to classify the different issues according to capitals and sub-dimensions of these, and assign then the sustainability criteria to thematic areas, this can be done only with approximation. This demonstrates the need for a multidisciplinary and holistic approach. In dealing with complex systems, we can have only a rough picture of a situation and the impacts of actions, so that it becomes important to understand and learn about some strong yet general sustainability criteria that can be adapted contextually. The insertion of data in the empty framework also generates graphic representations of the scenarios that are presented on the right side of Table 55 (page 276 in Appendix I) and in Figure 26 (page 148).

The themes summarised above suggest the possibility for generalisation to other types of systems and infrastructures, and therefore will contribute to the formation of more general sustainability criteria. The question to be answered is: are these themes able to maintain the role of general criteria in the pursuit of sustainability? This question is answered by generalising the core sustainability criteria for the ECEI in a final matrix, presented at the bottom of Table 55 (page 276 in Appendix I) and in Table 26 (page 146), and applying them to a different case study, in order to build their robustness. In Table 27 (page 147), a summary of the sustainability criteria is presented, in order to test the validity of the sustainability criteria for other case studies and therefore to verify whether they can be considered as general criteria. In the following sub-sections which present the other case studies the scheme is developed to a) verify the validity of the generalised criteria for the new case and b) integrate further criteria that are considered relevant.

Table 25. Example of the thematic analysis for the ECEI (Sajeva, Sahota and Lemon, 2015)

Example: thematic analysis for Governance Assessment Matrix Exercise (GAME) for European Critical Electricity Infrastructure (ECEI)							
Capitals	**Scores**	**Phase**	**NATURAL CAPITAL**	**HUMAN CAPITAL**	**SOCIAL CAPITAL**	**MANUFACTURED CAPITAL**	**FINANCIAL CAPITAL**
MORE SUSTAINABLE CHOICES: GOALS TO ACHIEVE	**4**	Social learning and future vision	The extra production (of power) should have been achieved without affecting the environment [332]	Raise awareness of major emerging risks relevant to society: standardising disclosure, stakeholder dialogue; knowledge sharing and developing best practice solutions [310]	Interdependent systems can not be operated as if they were independent and closer coordination is required [337]. Entities for cooperation and governance and mandatory standards to deal with public relevance [218].	Physiological short-term blackouts of few minutes disruptions causing inconveniences [220][310]. Systems kept well below their limits, avoiding to work under conditions of stress [347] [322].	Raise awareness of risks for the (re)insurance industry [310]
SOCIAL LEARNING ABOUT CONSTANT IMPROVEMENT: HOW TO REACH THE GOALS	**3**		End of monopoly: favorable conditions for solar energy producers, wind power generators and other kind of renewable energy technologies so that the generation industry flourished [311]. More local generators of renewable energy attached to micro smart grids [R.I.1]	«Timely information to electricity customers about planned supply interruptions is decisive to keep damages within a limit» [322]	High responsibility of public institutions and private operators to assure security of supply and utilities' adaptive capabilities [220].	Spreading and isolating the risk: local self-sufficiency and local micro grids to break the complexity and reduce vulnerabilities [R.I.1]	Communication and transparency on the uncertainty of financial systems to valuate risk and losses: insurance mechanism measure 20-25% of supply chain disruptions [310]
CHALLENGES, VULNERABLE STATES OR CHANGES OF UNSUSTAINABLE FUTURES	**2**	Critical thinking ('critique phase')		Electricity critical factor for mainaining modern convenience and standards: high impact onto well-being, security and safety human basic needs [310] [220] [9] [323] ECEI Socio-technical artefact, functioning as a unit, but embedding more adminisrations, operators and markets, connecting different regions but behaving as a unity [102].		Liberalisation of markets and technological development: end of monolopy for a unique and integrated, ECEI, incorporating ICS [102].	
CONSTANT WORSENING, MAKING RISKY CHOICES: SYSTEMS' INADEQUACY AND INABILTIY TO LEARN, CAUSAL FACTORS OF FAILURE	**1**		Failure of prices in evaluating impacts on nature: «Why ride the bus to work when driving a powerful car to work was more convenient and when gasoline cost less than 30 cents per gallon? Why insulate your house when oil and electricity prices hit record lows?» [332]	Inadequate operator training, joint trainings and simulation exercises between transmission system operators [310] [325]	«The TSOs operate the system closer and closer to its limits as allowed by the security criteria, which in essence have remained unchanged» [347] [322] Use of the grid in ways that are different from those expected in the original design (evolutionary suitability) [43]with high level of cross-border exchanges [347]. «It was as if we were caught by surprise by the recognition of the fragility yielded by those changes» [102]. Increasing imports of energy for prices divergences, exceeding trading-quotas (Italian blackout of 2003) [9]		Inadequacy of the financial system to measure all losses [310]
SYSTEMS' FAILURE	**0**		Losses not covered by financial system for 75-80% [310] (possibly on the environment?)	4 deaths as a consequence of the Italian blackout [310]	Other non quantifiable and hardly predictable losses (unknown unknown) across larger geographical areas (e.g. impossibility for manufacturers to respect the delivery schedules for parts produced just-in-time (JIT) for supplying larger productions [310]	Unpredictable and uncontrollable exchanges along the cross-border lines: the Italian blackout and the Austrian near miss represent important signals of warning about the incumbent risk of supranational, wide-spreading cascading failures, in which a minor single event may snowball into very major accidents and impacts [322]	Losses not covered by financial system for 75-80% [310]
Generalisation							
Process of social learning and mind mapping		ECEI Sustainability criteria	Produce without affecting the environment [332]	Reduction of threats for well-being, standards of living, human safety [310] [220] [9] [323] [159] human rights and and human development [41] or irreversible harm [310]	Adequacy in relation to security: assuring the ability to maintain own functions in relation to the possible security threats and imminent disturbances [321] [308] [220]. Sustainability of systems as integrated mantaining and endurance of interdependent functions [337]. Systems kept well below their limits, avoiding to work under conditions of stress [347] [322].		Rising awareness on the uncertainty of financial systems: alternative evaluation systems [310]

Table 26. The GAME sustainability criteria for the ECEI

Sustainability criteria for the European Critical Electricity Infrastructure (ECEI)								
NATURAL CAPITAL		HUMAN CAPITAL	SOCIAL CAPITAL			MANUFACTURED CAPITAL	FINANCIAL CAPITAL	Criteria thematic areas
Environment produced change and challenges	Impact from humans	Impact on and from humans	Social sustainability: public	Governance	The reliability of markets	Sustainability and reliability of infrastructures	The reliability of the financial system	
Factors to be included in the decision-making process, from the larger to the smaller: security, sustainability, economic efficiency, reliability, technical performance. Security considered as the overarching concept [102], involving sustainable development [210]								Sustainability of systems and their priorities
System security gets priority on other trade objectives and personnel feel. System security as the overarching goal even when this implies smaller results and do not risk of being blamed [337]							Growing capital when security is met [102]	
Systems kept well below their limits, avoiding to work under conditions of stress [347].								Systems limits and adequacy
Adequacy in relation to security: assuring the ability to maintain own functions in relation to the possible security threats and imminent disturbances [321] [308] [220]. Systems reliability: continuous long-term functioning throughout time according to accepted quality and quantity standards of delivered service and possible failures [125] [316] [220] [320] [318] [308] [314]. Assurance of crucial functions of productivity, hydrological cycles, social relations and economic prosperity [202][321]. A good can be public in force of political considerations and social constructs [133]. Sustainability of systems as integrated mantaining and endurance of interdependent functions [337]								
Interdependent systems can not be operated as if they were independent and closer coordination is required [337]. Entities for cooperation and governance and mandatory standards to deal with public relevance [218]								Governance
Alternative evaluations for non valuable impacts and not accounted losses [310]				Application of principles of good governance: participation (a voice fro all in decision-making), transparency, responsiveness, consensus orientation and mediation of interests towards the general interest, equal opportunities of involvement, effectiveness and efficiency of result oriented processes (meeting needs with the best use of resources), accountability of decision-makers to stakeholders and strategic, long perspective vision, understanding complexity and heading to human development [41]. Definition of roles and responsibilities of public institutions and private operators to assure security and adaptive capabilities of systems [220].			Communicating uncertainty of financial evaluation systems and alternative evaluations [310] [332]	
	Favorable conditions, incentives and policies for the flourishing of renewable energy technologies [311]. Creating opportunity for self-organization towards social-ecological sustainability [304]. Localisation and flexibility for improving sustainability and reliability [R.I.1]			Cooperation and instant communication between contractors and adoption of common protocols and trading quotas and load control (for the non excludability of users) [R.I.1]. Reliability standard: a requirement approved by an authority for reliable operation of a system [316]				
Mitigate the environmental impact on humans by prevention action (precautionary principle) [322]	Produce without affecting the environment [332]	Reduction of threats for well-being, standards of living, human safety [310] [220] [9] [323] [159] human rights and and human development [41] or irreversible harm [310]	Reducing uncertainty and approaching subjective and objective risk [159]: raise awareness of major emerging risks relevant to society: standardising disclosure, stakeholder dialogue; knowledge sharing and developing best practice solutions [310]. Systematic and immediate communication about systems' interactions and failures [R.I.1]			Spreading the risk: local self-sufficiency to break the complexity and reduce vulnerabilities [R.I.1]	Limiting valuable losses [310]	Reduction of risk by reduction of threats
		«Learning to live with change and uncertainty» [304]				Flexibility and adaptive capacity of physical infrastructures		Adaptive capacity, communication, knowledge transfer and social learning
		Learning about systemic impacts by phronesis: becoming experts [90] Raise awareness of major emerging risks relevant to society: standardising disclosure, stakeholder dialogue; knowledge sharing and developing best practice solutions [310]. Long-term impact analysis for understanding institutional and operational changes required [322]. Promoting learning and continuous improvement of operations and adapt to lessons learned for improved (bulk power) system reliability [342]. Social learning for approaching science, policy and society and reducing uncertainty. Combining different types of knowledge for learning [304]						
Nurturing diversity for resilience [304]. It is not possible to know in advance all the possible ways the infrastructure could be used in the future, so that a so called 'Science and Art' issue requires continuous social learning on the complex systems' evolution [102].								

Table 27. A scheme for the analysis of sustainability criteria throughout the integration of more successive case studies: Case study I of ECEI.

<table>
<tr><th colspan="9">Integration scheme of themes from case studies: the sustainability criteria for the ECEI Socio-Technical System (STS)</th></tr>
<tr><th colspan="4">CASE STUDIES</th><th rowspan="2">NATURAL CAPITAL</th><th rowspan="2">HUMAN CAPITAL</th><th rowspan="2">SOCIAL CAPITAL</th><th rowspan="2">MANUFACTURED CAPITAL</th><th rowspan="2">FINANCIAL CAPITAL</th></tr>
<tr><th>IV</th><th>III</th><th>II</th><th>I</th></tr>
<tr><td rowspan="6">×</td><td rowspan="6">×</td><td rowspan="6">×</td><td rowspan="6">ECEI</td><td colspan="5">Priority of systems' security, systems kept below conditions of stress: risk awareness and learning of emergent risks. Systems' thinking: acting/producing without affecting greater systems</td></tr>
<tr><td colspan="5">Avoiding concentration of risk, spreading it to reduce complexity and vulnerability, systems' reliability and efficiency (local self-sufficiency and independency)</td></tr>
<tr><td colspan="5">Adequacy: assuring systems' ability to maintain own functions in relation to security threats and potential or actual disturbances or changes through space and time. Sustainability of systems as integrated mantaining and endurance of interdependent functions</td></tr>
<tr><td colspan="5">Cooperation, governance and mandatory standards on issues of public relevance. Knowledge sharing and developing best practice solutions</td></tr>
<tr><td colspan="3">Alternative evaluations for non-evaluable impacts and not accounted losses, precautionary principle about unknown unknowns, uncertainty assessment.</td><td>Governance and cooperation for systems' security and reliability</td><td>Rising awareness on the uncertainty of financial systems</td></tr>
<tr><td>Mitigation of environmental impact on humans and of human impact on nature: acting without breaking/impacting on other systems.</td><td colspan="2">Priority to well-being, security and safety, human basic needs. Minimisation of threats for well-being, standards of living, human safety, human rights and and human development or irreversible harm. Scurity focused on needs.</td><td>Adequacy of infrastructural systems to changes: use of smart grids to minimise risks</td><td>Adequacy of the financial system to measure the other capitals: growing capital when security is met. Communication and transparency on the reliability of financial system to measure different kind of losses</td></tr>
</table>

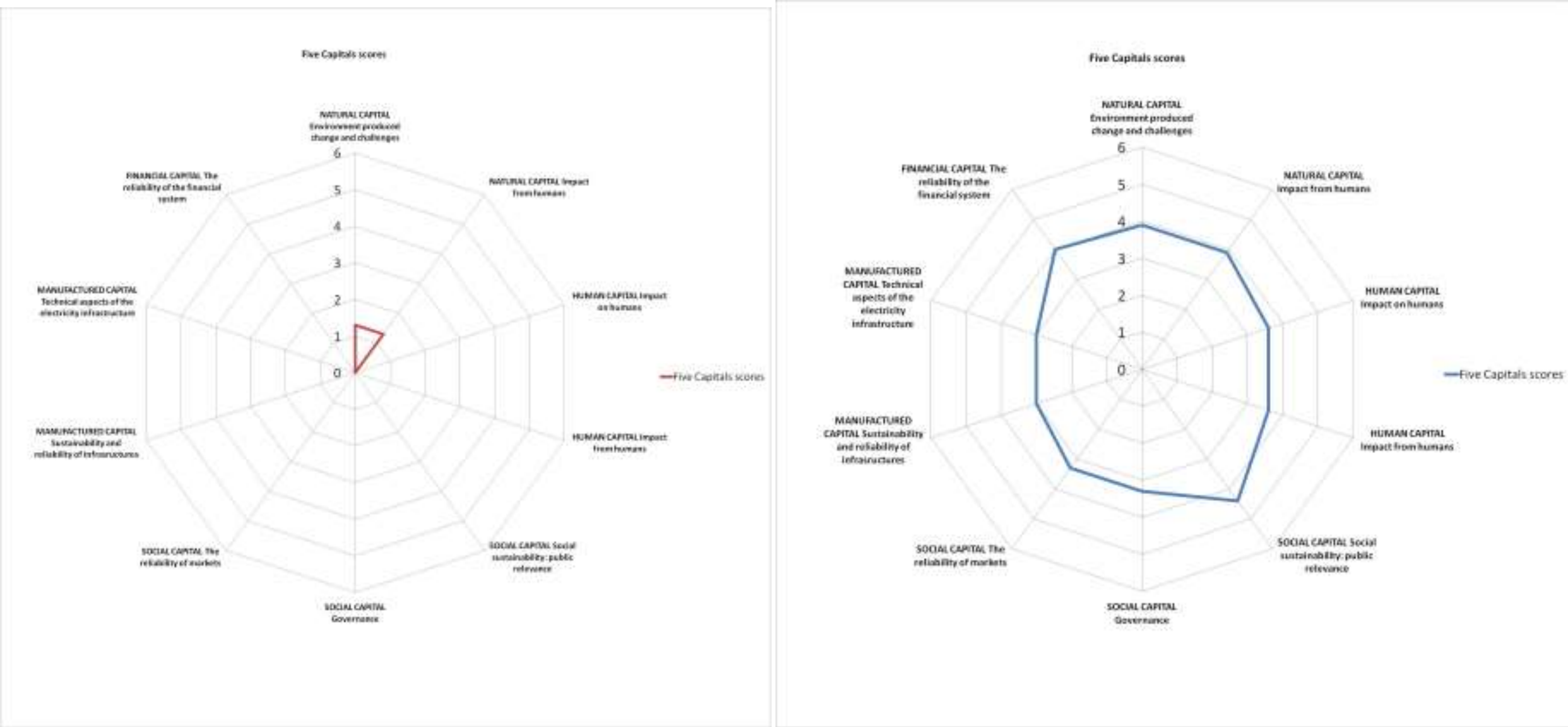


Figure 26. The red critical analysis and the possible blue future scenario towards the sustainability and reliability of the ECEI

6.3 The case study of the Finnish security Socio-Technical System (STS)

As mentioned in the previous sub-section, the analysis undertaken for this second case study builds upon the sustainability criteria generated for the first one. This will check their validity for a different system (STS) and context and identify sustainability dimensions not yet considered.

This second case study extends the security of infrastructures to human security, enlarging in this way the scope of the analysis for the generalisation of sustainability criteria. The rationale for the case study of the Finnish security STS, as mentioned in sub-section 5.3, is to describe the national understanding of security and the historical development that led to the rise of private security services and to an increasing adoption and use of security technologies (CCTV, biometrics). The analysis aims at understanding the opportunities, limits and threats of the changes that have emerged within the security system, possibly leading to failures. A futures research approach involving the visioning of the development of security technology and services in the nearest future is adopted in order to understand the pathways (goals and related actions) for building human security.

The analysis of the security STS is carried out according to the same procedure that was used for the first case study of the ECEI, as presented in Chapter 5. Narratives are produced by referring to the encoded data in brackets [XX], referring to the interviews (see Table 21, page 126), and to other relevant material (the encoded references listed at the end of the thesis). The methods of data collection included stakeholder interviews, integrated with an analysis of the communication by security organisations and by relevant literature. Meeting the participants has not always been easy and some of them have declined the invitation. Moreover, they preferred to keep their own and their organisations' identity confidential, so that all interviews were conducted with an assurance of anonymity and not recorded. However, in order to realise a reliable transcription, the interviewees were asked to speak clearly and where required repeat the important concepts. The organisations interviewed covered the following activities:

- *«Sales of professional services and consultancy on specific security issues*
- *Defence of the Finnish internal territory from security threats*
- *National and personal security, public security, internal security as a whole in relation to the principle according to which the security of the citizens is considered as a right*
- *Enhancement of well-being for the improvement of people's security*

- *Peace building for the resolution of crises, political conflicts or national rights*
- *Private surveillance, locking systems and transport of valuable goods*
- *Security protection, roles of security officers (in Finnish, “järjestyksenvalvoja”)*
- *Private investigation, resolving crimes and finding lost people*
- *Inspection of companies in the event of non-respect of contracts, for instance false declarations to insurance companies*
- *Development of special technologies, import and retail of security products (alarms, sensors)*
- *Representation, role of agents of banks and insurance companies, according to an integrated approach of security*
- *Combating against money laundering*
- *Security expertise and consultancy, also for privacy protection*
- *Corporate security and policy consultancy including support and assistance to clients for the development and implementation of business continuity plans, security strategies and risk management policies*
- *Export of security technology»*

The data was used then to populate the GAME empty structure (in relation to the thematic areas as presented in sub-section 5.3.2), and to produce three main scenarios, the first focused on the historical perspective of security in Finland, the second referred to the changes in international geopolitics and the third to the divergence of subjective from objective security and the widening of the market of private security. A fourth scenario has been hypothesised with reference to security systems in developing countries (i.e. the Namibian system), in order to make a comparison between contexts which are very far from each other and thereby reduce uncertainty and identify more general sustainability criteria for security systems. In the following sub-sections 6.3.2 − 6.3.5, the narrative realised for the case study, and the related scenarios, are reported.

Table 28. The Finnish security case interviews

Systems integrators, multinational corporations	High-tech companies	Research institutions/experts	Specialised, local or very small companies	Public institutions	Associations, non-profit organisations
[MNC.II.1] Multinational company of security services	**[Hi.II.1]** Multinational producer of security technologies	**[R.II.1]** Professor and Head of the Electronics and Information Technology Division at Finnish Defence Forces	**[SME.II.1]** Corporate security and policy consultancy company for business continuity plans, security strategies and risk management policies.	**[PUB.II.1]** Public Officer	**[A.II.1]** Finnish independent non-profit organisation for conflict resolution and sustainable peace
[MNC.II.2] Multinational company of security services	**[Hi.II.2]** Director of international sales of high security technology producer	**[R.II.2]** Security expert in the field of crises management, Military Officer, Ph.D. in Military Science and Arts, working in the academic, public and private sectors.	**[SME.II.2]** Agency of private investigation, patrol and integrated services and sale of security technologies	**[PUB.II.2]** Parliamentarian	**[A.II.2]** Security expert, director of an association 460 among banks and insurance companies
[MNC.II.3] Multinational company of security services, operators in the urban space	**[Hi.II.3]** Security wireless technology company	**[R.II.3]** Professor of Industrial Risk Management in an international and multitechnological applied research organization	**[SME.II.3]** Leading provider of open platform Video Management Systems (VMS) for IP and camera surveillance applications and systems	**[PUB.II/IV.3]** Ministerial research and development department for research and knowledge transfer on security	**[A.II.3]** Defence and Aerospace Industry Association
[MNC.II.4] Multinational company of security services	**[Hi.II.3]** Communications technology company, radio and telecommunications design and construction	**[R.II.4]** Security lecturer, former police	**[SME.II.4]** Director of a leading system supplier in the security sector	**[PUB.II/IV.4]** Expert in hygiene, food security and safety in developing countries	**[A.II.4]** Association of security organisations.
		[R.II/IV.5] Expert in regional development	**[SME.II.5]** Director of a SME international sales		
		[R.II/IV.6] Expert in political studies			
		[R.II.7] Professor of sociology			

6.3.1 The data analysis for the empty framework

The case study of security Socio-Technical System (STS) in Finland and the comparison with Namibia, is carried out, in a similar way as the first case study. The process of populating the framework and the construction of the matrix has analysed the cause-effect relationships generated by changes, events and choices, across the different capitals.

An example of the Finnish context is presented in Figure 26 (page 153), in contraposition to the Namibian context that, denying the basic security criteria reveals a situation of permanent insecurity (Figure 28, page 154). The different initial conditions are known and mentioned however, the important achievement of the case study is the determination of the criteria that are common to the different contexts, i.e. the causes of lack of insecurity and the conditions that are needed for the sustainability of the security Socio-Technical Systems (STS).

The narratives are not reported in depth as the procedure of triangulation, carried out for the analysis of the evolution of security scenarios, has been undertaken in the same way as for the previous case study (sub-section 6.2).

The narratives are used for populating the empty framework in the same way followed for the previous case, as represented in Table 56 (page 276 in Appendix I). The lower level, related to the failure of the security system, not included in Table 56, is extracted and presented separately in Table 29 (page 155). This is an example of the grouping of issues concerning situations of failure and highlights the intersections with the food system as it arises naturally from the case study on security and that will be further discussed in Chapter 8 (a scenario signified by boxes of different type and colour). The matrix of criteria derived from the case study of the European Critical Electricity Infrastructure (ECEI) (see Table 26, page 146) is used for the sustainability evaluation that is performed in this second case study, verified by the additional analysis (the data of the second case study is not in contrast with the criteria derived from the first case) and then complemented with additional criteria. Table 30 (page 156), extracted form the whole analysis of Table 56, is an example of the integration and generalisation of the results of the previously developed matrix of sustainability criteria for the ECEI case study with the new analysis of the security STS. The procedure generates a new matrix of sustainability criteria, integrating and generalising the previous ones, as represented in Table 31 (page 157).

In order to provide a clear example of the analysis that has been undertaken, the narratives relating to the generated scenarios of the Security Socio-Technical System (STS) are described in the following sub-sections 6.3.2 – 6.3.5.

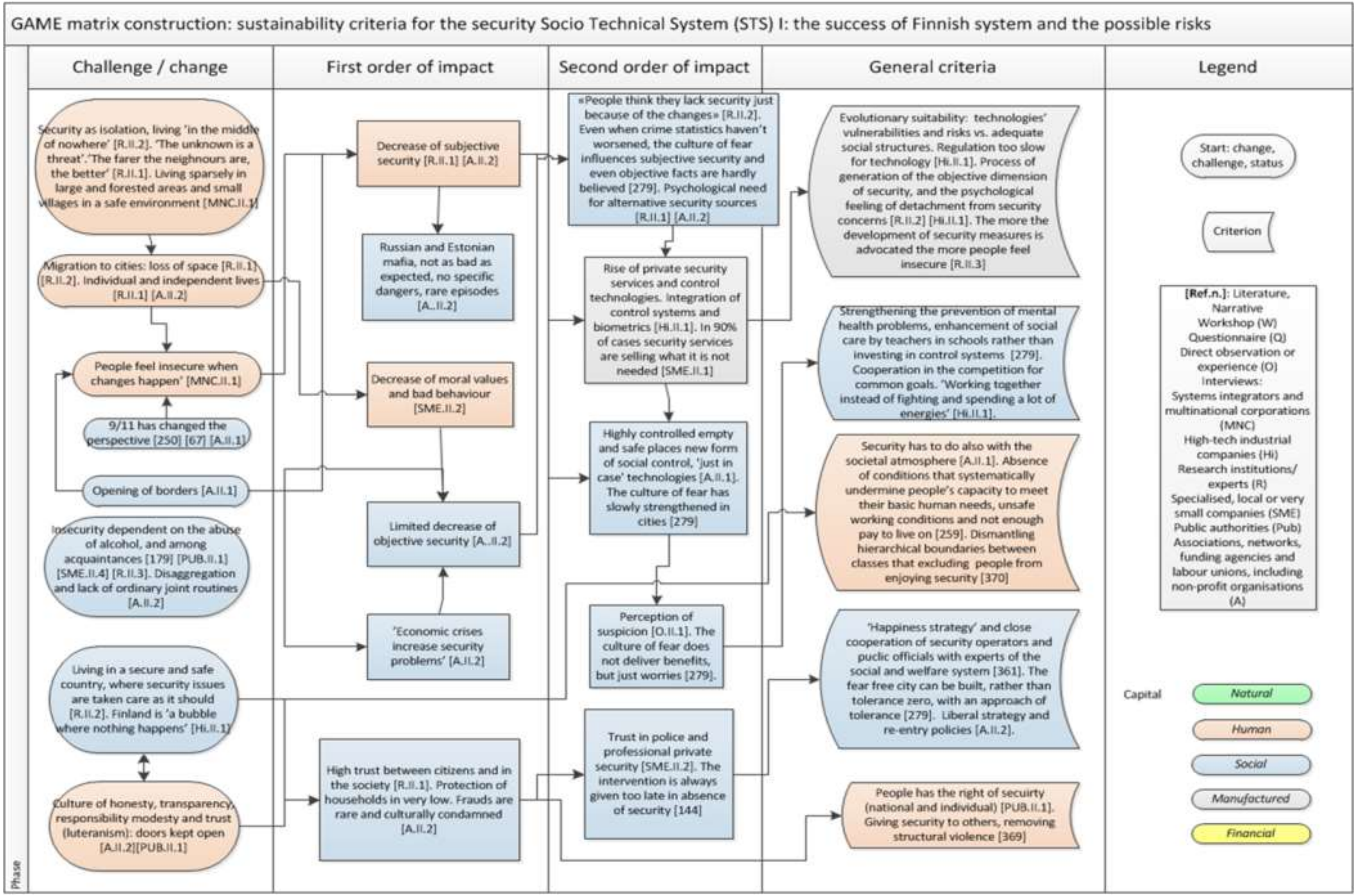


Figure 27. The cause-effect relationship in case study of security Socio-Technical Systems (STS): the Finnish context

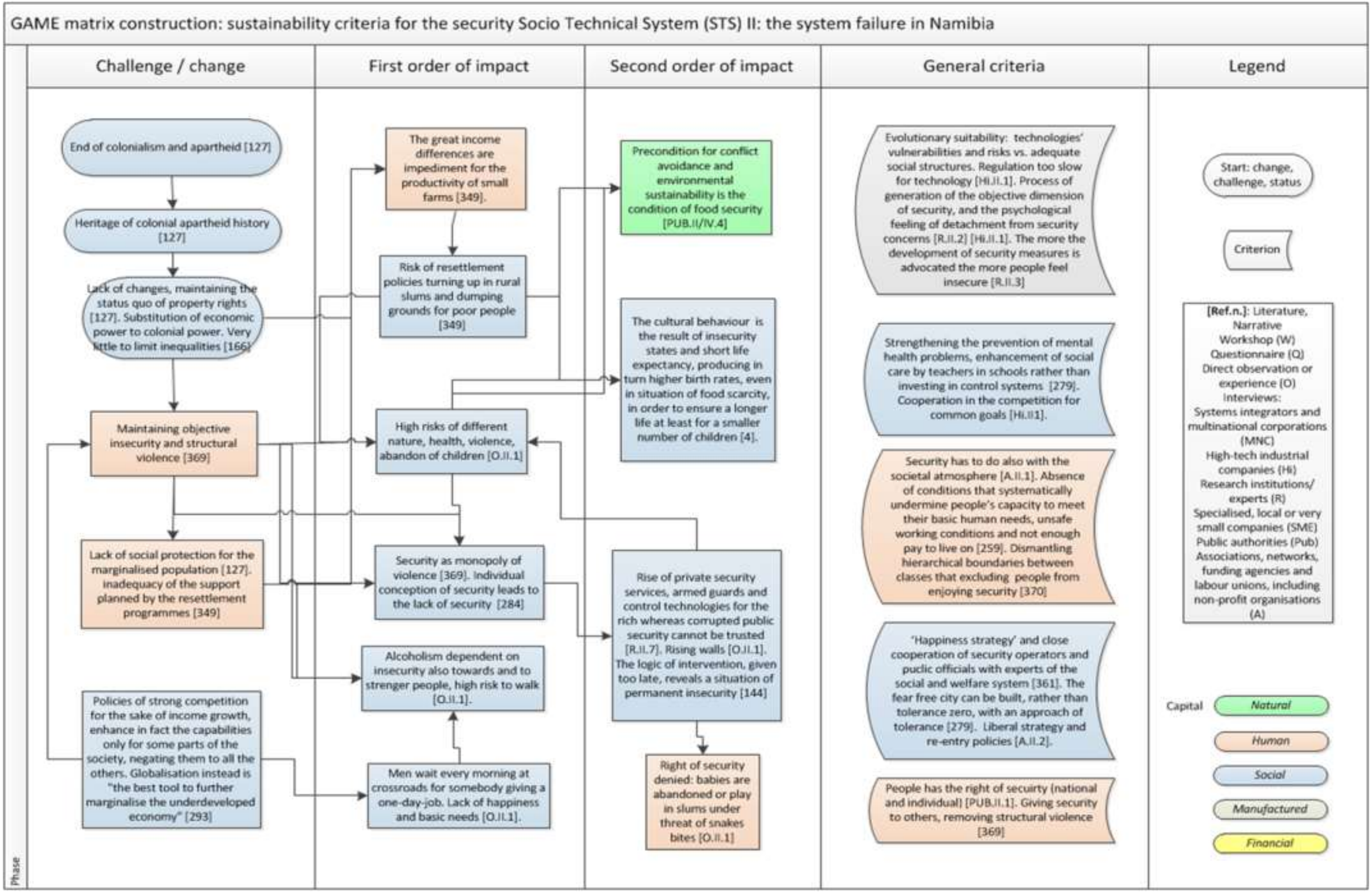


Figure 28. The cause-effect relationship in case study of security Socio-Technical Systems (STS): the Namibian context

Table 29. The grouping of issues and the interaction between the security and food systems

Thematic analysis for Governance Assessment Matrix Exercise (GAME) for the Finnish security system: the interaction with the food system

Dimension	NATURAL CAPITAL		HUMAN CAPITAL	SOCIAL CAPITAL			FINANCIAL CAPITAL
Sub-dimensions	Environment produced change and challenges	Impact from humans	Impact on and from humans	Social sustainability: public relevance	Governance	The reliability of markets	The reliability of the financial system
SYSTEMS' FAILURE				Failure of security systems			
		Security		Policies of strong competition for the sake of income growth, enhance in fact the capabilities only for some parts of the society, negate to all the others [293]. Looking at the discrepancies between the GDP and Gini Index, it is possible to see how economic growth can take place even while producing benefits only for the dominant classes and excluding the		«It is humankind's predilection with continued growth, not the lack of growth (except for the world's most impoverished nations), that poses the greatest threat to democracy, freedom in the Liberal-democratic tradition, capitalism, and international peace» [147] .	
			Unsustainability of overpopulation and poverty	In many developing countries half the population of a country lives in conditions of poverty and the 50% of the total income is enjoyed by only 20%, another 20% having the 20% and the last fifths have respectively 14%, and 9% and 7% (UN, 1987) [278]. In the 90s in Namibia Gini's index of income	Current problems cannot be attributed to the inefficiency of small landholding agricultural production but to the lack of support and entitlement for resettled farmers, not enabled to exert their agency, with the risk of resettlement policies turning up in rural slums and dumping grounds for poor people	While in Finland, even covering a large range of surveillance services, private security agents do not even carry arms [MMC.II.1] and in case of danger do not take risks and call the police [SME.II.2], in Namibia the same multinational security companies surveil private households	While nations' development depend today largely on the growth of private investments, in the poorest countries countercyclical policies are much dependent on Official Development Assistance (ODA), showing the inadequacy of unregulated markets to solve
	Overpopulation unsustainable in itself for the hosting ecosystems, not in harmonic balance with its productive potential and carrying capacity [4]			A person who approaches an cash machine, even inside a shopping mall, is immediately looked after by a security guard, without			
			The insecurity state and short life expectancy lead in fact to very high birth rates, even in situation of food scarcity, because in order to ensure a longer life at least for a smaller number of children it is necessary to generate more of them [4]	The lack of security for certain parts of the population means also the lack of security and freedom for the others [210].	Policies or actions of intervention on insecurity states are not able to achieve the goal of solving security problems and maintain the system in equilibrium, because «the help is given too late» [144]		
			While democracy, development and freedom, intended as capabilities and entitlements of citizens to achieve own security and well-being reduce insecurity, the desire for freedom, as being free from laws, for self- fulfillment rather than self-restraint or self-government decreases security and increases political instability (Ward and Fott, 2007 18-20) [284]. The usefulness of fortresses leaves room to doubt, as they can give help as give harm; «A prince who is more afraid of his own people than of foreigners ought to build fortresses, but one who fears foreigners more than he does his people ought to do without them» [156].				
				Links between well-being, food insecurity and international security			
			Hunger a matter of poverty and distrubution		Inadequacy of free markets and governance		
			Famines due to oppression, injustice, destitution, breakdowns in distribution, and not to shortages in production. With these «misleading variables as food output per unit of population, the Malthusian approach profoundly misspecifies the problems facing the poor in the world», and that «it is often overlooked that what may be called 'Malthusian optimism' has actually killed millions of people». [231]		The neoliberal economic policies and programmes for the commercial agricultural land reform in Namibia, and in other Southern African countries have created conditions for the perpetuation of concentration of land among new black elites, besides the older white ones [349]. The national reconciliation fostered the mutual benefits between economic and political elites preserving the benefits of the postcolonial political and economic changes for a restricted and fortunate group of individuals previously disadvantaged, who through the liberation struggle stepped into State powers and through that into the privileged white minority elite [349].		The rising and the volatility of food prices and the increase of competition for scarce water, land, energy and other important natural resources, represent conditions of severe threats especially for the poor and the hungry [344] [R.IV.3]. The sudden and very significant increase of food prices between 2006 and 2009 has provoked a crisis that has reduced tens, or even hundreds of millions people into poverty [303]
			Hidden hunger, over 800 million people lacks calories, and 2 billion people is affected by various micronutrient deficiencies, and opposite problem of overweight, affecting over 1.4 billion people, including 300 million women and 200 million men clinically obese, also in				
Food security			Famines as failures of entitlement, in other words the inability of parts of population to access food in one of the ways defined by social structures, economic distasters and not just as mere food crisis [354]	Inequalities and lack of redistribution of property rights cause of hunger, insecurity and underdevelopment [127] [166].	Initiatives for the assurance of global and national food stocks abandoned due to corruption and bad administration,so that just one bad harvest could possibly trigger a	A small elite enjoying high standards of living and a large poor majority: great income differences are impediment for the productivity of small farms	
			«Despite the growth in per capita food production in the past four decades, an estimated 852 million people were under-nourished in 2000-02» [168]. «All the food in the world won't help if people are too poor to afford it» [303].		Questioning whether globalisation is «the best tool to further marginalise the underdeveloped economy». «Neoliberal economic orientations, even in the long term, tend to affect or even negate collective structures based on social solidarity» «The liberal discourse, …, boldly rests on the glorification of the principle of social retardation: first comes the successful individual, .. then (if		«left unregulated, financial institutions behave badly» [303].
			Poverty a matter of lack of entitlements		Very little has been made to reduce the enormous inequalities [166]	In some cases the arable land is available but not used because not profitable enough in global markets [R.IV.3]	
			Poverty as lack of freedom, capabilities and entitlement to command for the satisfaction of basic needs [354]. Unemployed people, living in an informal Cultural, social and economic reasons of failure of human security [O.II.3].	Work under 'labour hire' contracts, victims of a labour market forcing them to accept any job under any conditions [127]			
			Impacts on international security				
	The lack of redistribution, poverty and absence of food security, as it was stated above, is a factor generating uncertainty and insecurity states, undermining the equilibrium of security systems, possibly generating conflicts and preventing environmental sustainability [R.II/IV.5] [R.II/IV.6].				«if we don't change how the world produces and distributes its food then the suffering and violence of the past few years will be repeated – but a thousand times worse» [303].		
			Poverty and food insecurity may result in future food, water and energy shortages, cause of more poverty and civic and/or international conflicts [303]. Food security as one of the factors responsible of social imbalances and potential conflict [PUR.II/IV.4] [303].				

Table 30. Example of the data analysis for the Finnish Security System (Sajeva, Sahota and Lemon, 2015)

Example: thematic analysis for Governance Assessment Matrix Exercise (GAME) for the Finnish Security Socio-Technical System (STS)							
Capitals	**Scores**	**Phase**	**NATURAL CAPITAL**	**HUMAN CAPITAL**	**SOCIAL CAPITAL**	**MANUFACTURED CAPITAL**	**FINANCIAL CAPITAL**
ECEI process of social learning and mind mapping		ECEI Sustainability criteria	Produce without affecting the environment [332]	Reduction of threats for well-being, standards of living, human safety [310] [220] [9] [323] [159] human rights and and human development [41] or irreversible harm [310]	Adequacy in relation to security: assuring the ability to maintain own functions in relation to the possible security threats and imminent disturbances [321] [308] [220]. Sustainability of systems as integrated mantaining and endurance of interdependent functions [337]. Systems kept well below their limits, avoiding to work under conditions of stress [347] [322].		Rising awareness on the uncertainty of financial systems: alternative evaluation systems [310]
MORE SUSTAINABLE CHOICES: GOALS TO ACHIEVE	4	Social learning and furture vision	Need to change consumption habits and production models, common principles of inclusive green economy, for the goal of sustainable development [361]. Absence of systematic increase of concentrations of substances produced by society, or extracted from the earth's	Security: «living in the middle of nowhere», space and peace [R.II.2], living without worries, with a minimal protection [MNC.II.1] living safely, in «absence or with limited presence of threats» [R.II.2]. Absence of conditions that systematically undermine people's capacity to meet their basic human needs, unsafe working conditions and not enough pay to live on [259]. Strengthening the prevention of mental health problems, enhancement of social care by teachers in schools rather than investing in control systems [279].	Security as a public good : the goal of businesses to increase their operations does not contribute to the achievement of the goal of security, which is the minimization of threats and the related intervention. The fear free city can be built, rather than tolerance zero policies, with an approach of tolerance [279]. 'Happiness strategy' and close cooperation of security operators and poclic officials with experts of the social and welfare system [361]. «Cooperation in the competition» and a strong	Communication of limits and rules on data management to stakeholders and the general public [Hi.II.1].	Frauds are relatively rare and culturally condemned, so insurance companies provide very good services and are ready to cover a wide range of risks, even more extensive, if compared to other European countries [A.II.2]
SOCIAL LEARNING ABOUT CONSTANT IMPROVEMENT: HOW TO REACH THE GOALS	3			During the past 20 years, the situation has been quite stable and even Russian crime has not been as bad as it was expected, contradicting the subjective risk expectations of a substantial worsening of the security state [A.II.2]. Even if some organized crime groups from the former Soviet Union and Eastern Europe are present, there are not specific dangers for residents or tourists [179]. Street shootings and gang violence are extremely rare [179].	Ethical values on security issues are focused on transparency, human rights, peace and safety than on privacy or personal data protection. Ethical branding relates much more to trust, reliability of security operators and authorities, safety, care of citizens, respect of legislation, control and rejection of the culture of corruption [A.II.1] [MNC.II.1]. Joint goals are pursued according to a long tradition of cooperation, also with security agencies, and in Finland there are not secret services [R.II.1].		
CHALLENGES, VULNERABLE STATES OR CHANGES OF UNSUSTAINABLE FUTURES	2	Critical thinking ('critique phase')		Traditional state centric conception of security as national defence (external): major challenge and key determinant of security policies, for maintaining independency against the threat of the Soviet Union (preparation to war or crises) [A.II.1]. The Russian border has always been the first security concern for Finns [A.II.1] [MNC.II.1] [R.II.1] [R.II.2] [SMS.II.1] [A.II.2]		Growing cities require more and stricter surveillance services and technological systems as new forms of social control [R.II.1] [R.II.2]. In urban systems there is a need of a new form of social control, 'just in case' technologies [A.II.1]. This may be the result of the historical Russian model of central control, made of procedures by which count every people [R.II.2].	
CONSTANT WORSENING, MAKING RISKY CHOICES: SYSTEMS' INADEQUACY AND INABILTIY TO LEARN, CAUSAL FACTORS OF FAILURE	1			The term security used also to rise a feeling of fear of being attacked, there is no reason to separate the concept from that of safety as the unique word of 'turvallisuus' suggests [R.II.4]. The more the development of security measure is advocated the more people feel insecure [R.II.3]	«Social exclusion is the biggest threat to internal security» [364].	People are not even aware how much they are controlled or monitored [MNC.II.1]. The main worry is that these changes would lead to the indifference of people and pursuit of own individualistic security and lack of care for others' security from a perspective of public good [279].	
SYSTEMS' FAILURE	0			Lack of redistribution, poverty and absence of food security, factor generating uncertainty and insecurity states, from the objective and subjective perspectives and eventually undermining the equilibrium of security systems, possibly generating conflicts and preventing environmental sustainability as well [R.II/IV.5] [R.II/IV.6]. Food security as one of the factors responsible of social imbalances and potential conflict [PUB.II/IV.4].	While in Finland, even covering a large range of surveillance services, private security agents do not even carry arms [MNC.II.1] and in case of danger do not take risks and call the police [SMS.II.2], in Namibia the same multinational security companies surveil private households carrying pistols or submachine guns [O.II.3]	The usefulness of fortresses leaves room to doubt, as they can give help as give harm: «A prince who is more afraid of his own people than of foreigners ought to build fortresses, but one who fears foreigners more than he does his people ought to do without them» [156].	While nations' development depend today largely on the growth of private investments, in the poorest countries countercyclical policies are much dependent on Official Development Assistance (ODA), showing the inadequacy of unregulated markets to
Generalisation and integration							
SECURITY process of social learning and mind mapping		SECURITY Sustainability criteria	Produce without affecting the environment [332]. Living integrated int he environment [MNC.II.1] according to sustainable priciples for consumption models [361].	Reduction of threats for well-being, standards of living, human safety [310] [220] [9] [323] [159] human rights and and human development [41] or irreversible harm [310]. Convergence between subjective and objective security [179] [A.II.1].	Adequacy in relation to security: assuring the ability to maintain own functions in relation to the possible security threats and imminent disturbances [321] [308] [220]. Sustainability of systems as integrated mantaining and endurance of interdependent functions [337]. Systems kept well below their limits, avoiding to work under conditions of stress [347] [322]. Security as a public good to be faced by prevention and cooperation [279]. 'Happiness strategy' and close cooperation of security operators and public officials with experts of the social and welfare system [361].		Rising awareness on the uncertainty of financial systems: alternative evaluation systems [310]

Table 31. The Matrix of criteria for the GAME methodology as integration of the case studies on the ECEI and on the Finnish Security System

<table>
<tr><th colspan="8">MATRIX OF CRITERIA FOR GAME METHODOLOGY. ECEI and SECURITY SOCIO-TECHNICAL SYSTEMS (STS)</th></tr>
<tr><th rowspan="2">NATURAL CAPITAL</th><th rowspan="2">HUMAN CAPITAL</th><th colspan="3">SOCIAL CAPITAL</th><th>MANUFACTURED CAPITAL</th><th>FINANCIAL CAPITAL</th><th rowspan="2">Criteria thematic areas</th></tr>
<tr><th>Social sustainability</th><th>Governance</th><th>The reliability of markets</th><th>Sustainability and reliability of infrastructures</th><th>The reliability of the financial system</th></tr>
<tr><td colspan="7">Interdependent systems can not be operated as if they were independent and cluser coordination is required [337]. Entities for cooperation and governance and mandatory standards to deal with public relevance [218]. Cooperation int he competition for questions of public relevance [Hi.II.1] [R.II.4] [R.II.3] [A.II.3] [350].</td><td rowspan="3">Systems limits and adequacy</td></tr>
<tr><td colspan="7">Adequacy in relation to security: assuring the ability to maintain own functions in relation to the possible security threats and imminent disturbances [321] [308] [220] [Hi.II.1]. Systems reliability: continuous long-term functioning throughout time according to accepted quality and quantity standards of delivered service and possible failures [125] [316] [220] [320] [318] [308] [314].</td></tr>
<tr><td colspan="7">Systems kept well below their limits, avoiding to work under conditions of stress, adaptive capacity, adaptation of all systems to changes [347]. Adequacy of systems in relation to larger systems: security, sustainability, economic efficiency, reliability, technical performance. Collective security considered as the overarching concept [102], involving sustainable development [210] and human security [A.II.1] as a human righ (national and individual) [PUB.II.1], basic need in itself and a public collective good [210] [279] even implying reduced economic results [337]. related to safety and development [R.II.2] strictly interrelated with the need of food security, seen as a human right [362] [PUB.II.2].</td></tr>
<tr><td>Reducing overpopulation in harmonic balance with its productive potential and carrying capacity of the hosting ecosystems [4]</td><td colspan="2">Focus on real causal factors: happiness and well being, freedom from threats [EII.1] [R.II.2]. Connection of safety and security policy issues [R.II.2]. Security as 'absence' or minimisation of threats, or 'freedom from fear' or 'freedom from want' [275].</td><td>Anticipating the need for control [279]. Logic of prevention, intervention at the level of self-control, leaving at last social control and official control [389]. Education based on ethics and cultural virtue [284] [389]. Development policy to strengthening international stability, security, peace, justice and sustainable development, rule of law, democracy and human rights. Focus on future needs and «help countries to free themselves from aid dependency», pursuing people entitlements [361].</td><td>Entitlements and enablers for local and smallholder farms to exert their agency [349].</td><td>Spreading the risk: local self-sufficiency to break the complexity and reduce vulnerabilities [R.I.1]</td><td>Security insurance services focused on needs [MNC.II.1].</td><td rowspan="5">Sustainability of systems and their priorities. focus on reduction of minimization of threats</td></tr>
<tr><td>Consumption and production responding to common criteria of inclusive green economy (use of resources for meeting basic needs) [361]. Absence of systematic increase of concentrations of substances produced by society or</td><td rowspan="3">Reduction of threats and entitlement for well-being, standards of living, human safety [310] [220] [9] [323] [159] [PUB.II.1] human rights and human development [41] or irreversible harm [310]. Poverty and inequality reduction [361], distribution policies, entitlements and enablers for citizens to exert their agency, avoidance of non decent living conditions in rural slums [349]. Absence of conditions that systematically undermine people's capacity to meet their basic human needs, unsafe working conditions and not enough pay to live on [259]. Cultural elements of honesty and trust [A.II.1]. "Happy and wellbeing people do not make crimes" [144]. Absence of economic and social disparities that can produce violence. Intervention at the self-control level [389]. Feeling to live in a fair and equal society regardless of identity [86]. Extending to all the possibility to meet basic needs and also the opportunity to achieve higher levels of quality of life, capabilities, and freedom [230] to live within system's boundaries [126] by mean of the social structures [354]. Absence of economic and social disparities that can produce violence (physical or structural), empowerment of women [369]</td><td colspan="3">Trust, reliability of security operators and authorities, safety, care of citizens, respect of legislation, control and rejection of the culture of corruption, tolerance [278]. Absence of culture of fear and aggression/intervention [279]</td><td>Flexibility and adaptive capacity of physical, regulatory and social infrastructures. Precautionary principle. [R.I.1]</td><td>Communicating uncertainty of financial evaluation systems and associating alternative evaluations [310] [332]</td></tr>
<tr><td>Favorable conditions, incentives and policies for the flourishing of renewable energy technologies [311]. Creating opportunity for self-organization towards social-ecological sustainability [304]. Localisation and flexibility for improving sustainability and reliability [R.I.1]</td><td>Security services focused on real needs. Convergence of subjective and objective security [MNC.II.1] [BME.II.1].</td><td colspan="2">A good can be public in force of political considerations and social constructs [133]. Adequacy of regulatory systems to market and technological development [Hi.II.1] [102]. Cooperation and instant communication between contractors and adoption of common protocols [R.I.1]. Cooperation in the competition and participatory and inclusive 'good' governance for matters of public relevance and definition of regulatory standards [210] [Hi.II.1]: requirements approved by an authority for reliable operation of a system [316]</td><td></td><td>Growth acceptable if not reducing employment and not increasing energy consumption or income distribution, nor undermining environmental and human health or the meeting of basic needs, and in general causing irreversible damage onto the other overarching capitals [60]. Growing capital when security is met [310].</td></tr>
<tr><td>Mitigate the environmental impact on humans by prevention action (precautionary principle) [322]. Assurance of crucial functions of productivity, hydrological cycles, social relations and economic prosperity [202][321].</td><td></td><td colspan="2">Well-being main factor for assuring security, to be approached holistically through interaction [PUB.II.1]. Governance of security not delegated to technology [Hi.II.1]. 'Happiness strategy' and close cooperation of security operators and public officials with experts of the social and welfare system [361]. Governance for security as making people happy and not being hated, having no need for fortresses [156]. Private security sector in the shadow of the national security [MNC.II.1]. Professionality of security services [389]</td><td></td><td>Limiting valuable losses [310]</td></tr>
<tr><td colspan="2">Focus on the relation human-nature. Environmental protection and sustainable management of natural resources are as well a precondition for food security. Food security is in turn also a condition for environmental sustainability.The systemic vision allows a deeper understanding of all possible implications and interconnections [361].</td><td colspan="3">Application of principles of good governance: participation (a voice for all in decision-making), transparency, responsiveness, consensus orientation and mediation of interests towards the general interest, equal opportunities of involvement, effectiveness and efficiency of result oriented processes (meeting needs with the best use of resources), accountability of decision-makers to stakeholders and strategic, long perspective vision, understanding complexity and heading to human development [41]. Definition of roles and responsibilities of public institutions and private operators to assure security and adaptive capabilities of systems [220].</td><td></td><td></td></tr>
<tr><td colspan="3">Alternative evaluations for non valuable impacts and not accounted losses [310]</td><td></td><td></td><td></td><td></td><td rowspan="2">Knowledge transfer and social learning</td></tr>
<tr><td></td><td colspan="3">Reducing uncertainty and approaching subjective and objective risk [159]: raise awareness of major emerging risks relevant to society: standardising disclosure, stakeholder dialogue; knowledge sharing and developing best practice solutions [310]. Systematic and immediate communication about systems' interactions and failures [R.I.1]. «Learning to live with change and uncertainty» [304]. Uncertainty to be faced by 'Science and Art' [102] and phronesis: becoming experts [90] continuous social learning on the complex systems' evolution [102] and impacts. Long-term impact analysis for understanding institutional and operational changes required [322]. Promoting learning and continuous improvement of operations and adapt to lessons learned for improved system reliability [342]. Social learning for approaching science, policy and society, combining different types of knowledge for learning [304]. Nurturing diversity for resilience [304].</td><td></td><td></td><td></td></tr>
</table>

The security analysis reveals a first scenario of the historical situation of Finland. This is represented by the absence of internal security concerns (other than those deriving from the abuse of alcohol) and the previous international threat coming from the Eastern border with the former Soviet Union (see Figure 29, page 158).

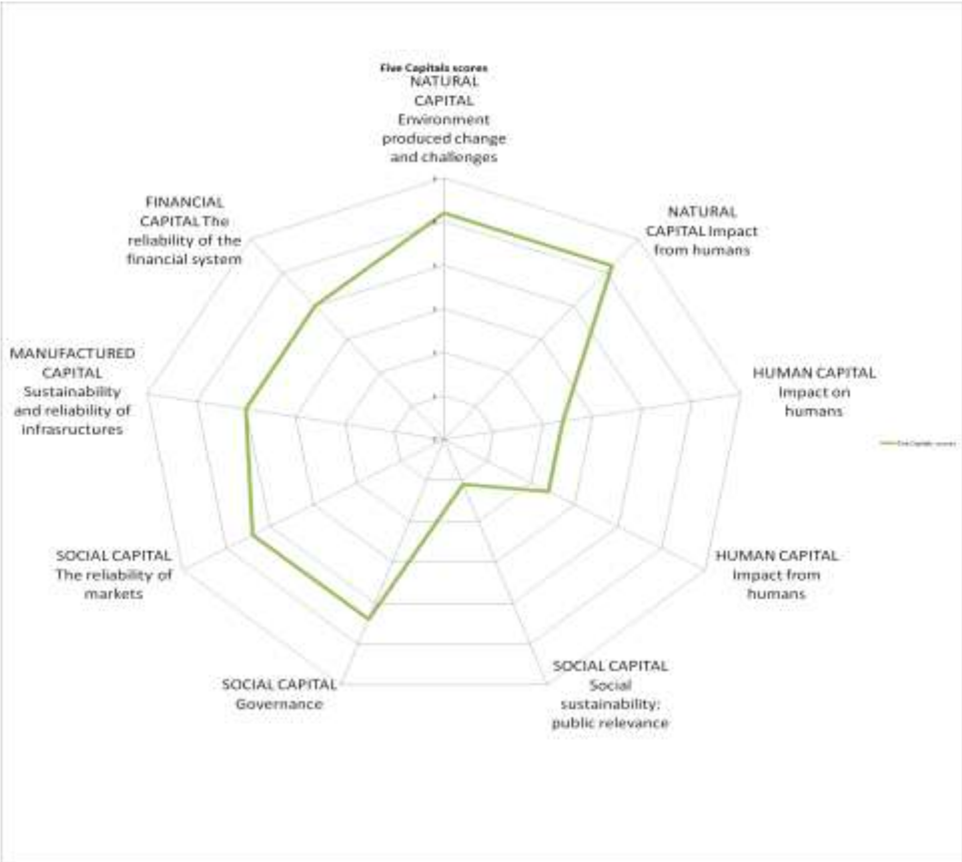


Figure 29. Scenario II.1: the historical perspective

The changing international scenario with the fall of Soviet Union and the opening of Eastern borders caused the decrease of subjective security more than an objective situation of increased threats (see Figure 30, page 159). In summary, the analysis has revealed low human and social capitals for the first scenario (see Figure 29, page 158), due to the risk of war or domination and to the social problems of alcohol abuse. The changed situation after the collapse of Soviet Union and the consequent threat has produced a second scenario (see Figure 30, page 159), where the only internal security problem is related to the social aspect of marginalisation and abuse of alcohol, even if the perception of internal security has decreased. The changing of the situation and the collapse of Soviet Union has determined a greater sustainability level for the Finnish security system in all capitals, with the exception of social capital, as the problem of alcohol remains a significant issue.

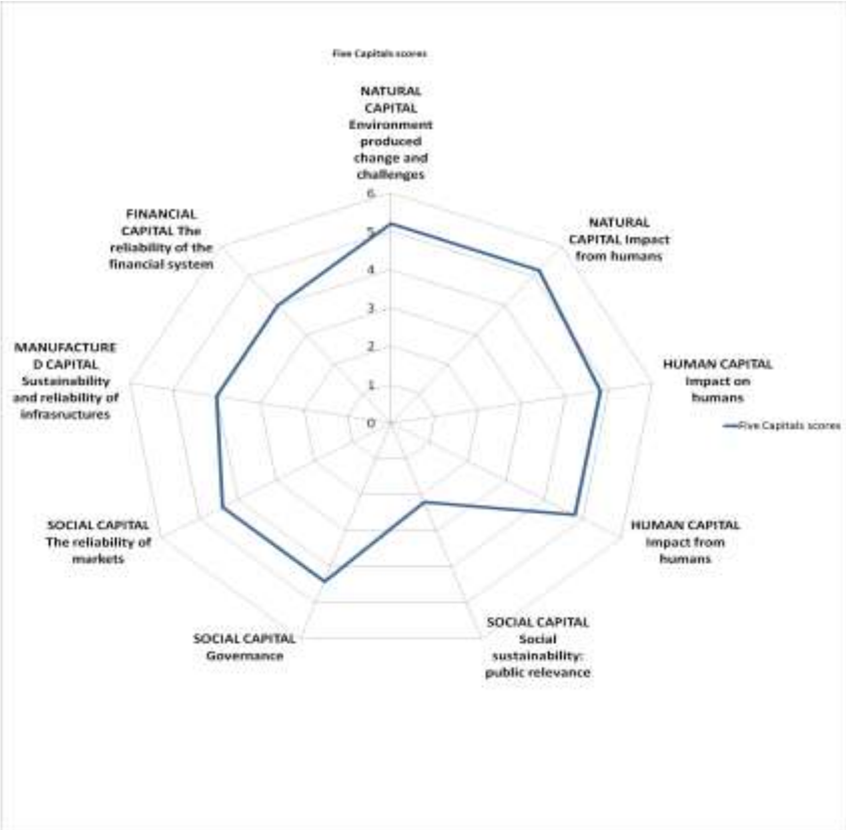


Figure 30. Scenario II.2: the current perspective

However, the reduced subjective security determined the rise of private security services and policies of intervention, even if not really justified, as the conception of security remains related to individual and the social control prior to official control. The massive use of security technologies might generate in the future new risks due to the shift from real sources of insecurity, i.e. the threats, towards a logic of intervention and culture of fear. According to Koskela (University of Helsinki, 2011) **[279]**, the fear free city can be built, rather than tolerance zero policies, with an approach of tolerance: according to research by the Finnish Safety and Chemicals Agency (Tukes) the more the development of security measures is advocated the more people feel insecure **[R.II.3]**. The possibility that a future scenario of risk will be produced is represented by a third scenario (see Figure 31, page 160).

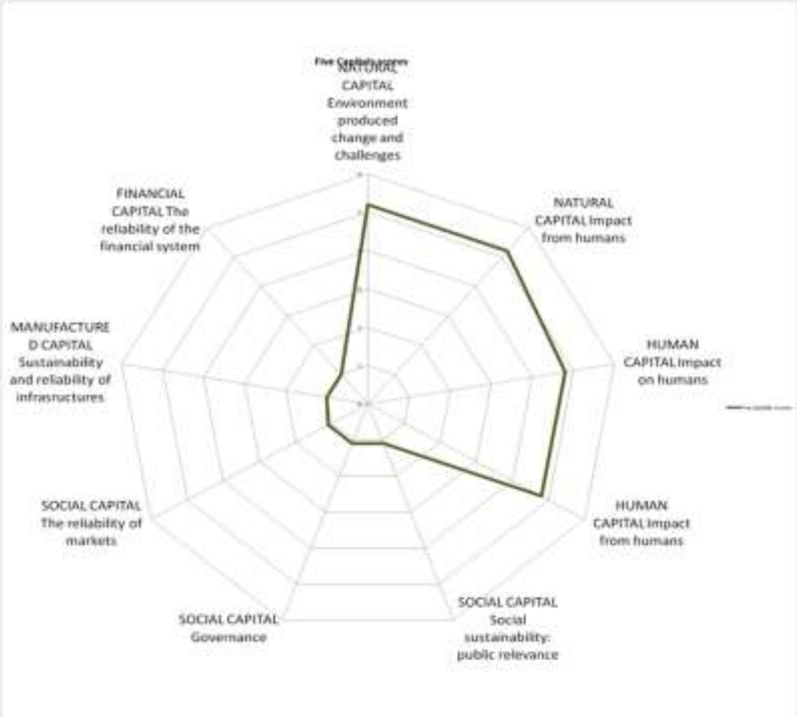


Figure 31. Scenario II.3: the possible risk, result of subjective security feelings

The case study of the security system has been carried out mainly in the context of one country, Finland, which can be taken as highly developed from human, economic, social and technological perspectives. The analysis revealed sources of insecurity that related in the past mainly to the external threat of the Soviet Union, while more recently decreases in security have been attributed to the opening of the borders and to the social problems within families and social groups, especially referring to situations of abuse of alcohol.

However, through experience as a volunteer in a Namibian orphanage, the ‘Dolam’ (see Figure 33, page 164) in the slum of Katutura (see Figure 32, page 163) in the outskirts of the capital Windhoek, the author had occasion to analyse the situation of security in a cultural, and social context which appears very different to the Finnish situation. The more contexts differ from each other, the more they can contribute to the generic understanding of sustainability. The same principle has been followed in the previous case study when treating the electric power infrastructures: the physical infrastructure, even belonging to very diverse European and American contexts, shared the same complexity and objective public relevance for the functioning of their entire societies.

In the case study of security related Socio-Technical Systems (STS), the basic needs of safety and security are the same for every human being, as Campbell (2006) reminds us in sub-section 2.3., once a concept of 'harm' has been defined, for instance in terms of physical or psychological damage, this remains valid for every human being, independent of how used an individual is to it.

A further justification for the Namibian case is that in developing countries the outcomes are often similar to those of the developed world, in terms of qualitative aspects and the differences lie mainly in the much stronger impact produced in a context that is more sensitive to change **[W.IV.1]**. The analysis realised on the security system in the Finnish and Namibian contexts certainly reveals the great distance between them. In Namibia the security problems are the consequences of past colonial history and the huge inequalities present today, the lack of citizens' entitlement and capabilities expansion and the liberal economic policies, advantaging only small portions of the population, as it results for the case study analysis. In this case, Namibian citizens are accustomed to insecurity, so that they might experience a low subjective perception of insecurity in a situation of higher objective risk, which increases uncertainty. In the Finnish context, the feeling of insecurity derived in the past from very different historical facts, such as the threats for the East. Currently, it is instead induced from the loss of isolation and space available, resulting much higher than the more objective and measurable danger.

In the Finnish systems, the factors of insecurity can be linked on the one hand to a limited presence of foreign crime, to the opening of the borders with the EU (the Schengen treaty) and with the Russian border **[R.II.1][R.II.2][SME.II.2]**, and, on the other hand, to the social problems especially the abuse of alcohol **[PUB.II.1][A.II.2]**. Even if this latter factor of insecurity can also be found in the Namibian context, the Finnish system suffers only a cultural and social problem, while in Namibia this is more the result of multiple deprivation—unemployment, lack of social well-being, extreme poverty, lack of food security, etc, as it results from the case study analysis.

While in Finland it is possible to walk safely during the day and night in parks, forests and urban spaces, episodes of violence very rarely happen outside, in Namibia the situation is the extreme opposite and it is not advised to go walking alone (excluding perhaps the very centre of the city of Windhoek). While in Finland houses can usually be left unlocked, in Namibia the objective security is pursued by isolating the elite living in residential areas within household walls, electric cables, security systems and armed guards, measures which are not always effective. However, the security problems do not concern just elite, and even the

Dolam orphanage is protected by a wall and barbed wire, in order to avoid the kidnapping of children (see Figure 33, page 164). Still, for local people this is seen as an acceptable security level.

6.3.1.1 Understanding the meaning of security through the direct experience of insecurity

My direct experience in the volunteer work in an orphanage of the Katutura slum **[O.II.1]** (see Figure 32 (page 163) of the capital, Windhoek, has put in evidence the difference in the life conditions of the people belonging to the different classes as listed above. While in the city centre, as well as in the richer neighbourhoods, the levels of wealth and well-being are close to those of European countries, the outskirts of the cities host the poorest part of the population in large slums, so-called ‘informal settlements’, where problems of health, sexual and physical violence, alcoholism and malnutrition, are part of everyday life, as referred by the manager and the teachers of the Dolam orphanage **[O.II.1]** and by a local Professor of sociology **[R.II.7]**. Moreover, elements of cultural unsustainability, referring to cultural acceptance of practices spreading HIV or giving birth to children even in absence of security, food and resources for them to grow could be acknowledged **[O.II.1]**. Questioning the sustainability of a culture means recognising the existence of behaviours that are the source of objective harm, as previously treated, involving high risk of diseases and other kind of dangers (e.g. when a little girl died because of a snake bite), that are not a matter of individual preference. Children are often abandoned, because the families cannot provide for their basic needs, and further threatened by risk of kidnapping, from which the orphanage is protected by the simple means, such as the barbed wired (see Figure 33, page 164).

The cultural behaviour described is the result of insecurity and short life expectancy, producing in turn higher birth rates, even in a situation of food scarcity, in order to ensure a longer life at least for a smaller number of children (Anand and Sen, 1994) **[4]**. As overpopulation is in itself unsustainable for the hosting ecosystems, because it is not in balance with its productive potential and carrying capacity, a key factor to achieve sustainability is the reduction of poverty and the increase of life expectancy. As Anand and Sen remark, education and entitlement of women, which are the main actors in farming systems in developing countries, may lead them to evaluate other priorities than just creating large families. On the other hand, a precondition for conflict avoidance and environmental sustainability is the condition of food security **[PUB.II/IV.4]**.

Figure 32. The Katutura slums of Windhoek in Namibia

Education, information and knowledge and transparency, contrasting phenomena of corruption and corruptive behaviours, can also increase trust and induce best practices and people involvement in decision-making **[PUB.II/IV.3]**. The fact that a decrease of poverty might imply an increase in expectations and of pressure on ecosystems has also to be taken into consideration. However, we can consider that the exit from a condition of poverty does not necessarily mean following a model of continuous growth but could mean the accomplishment of basic needs (MacLeod, 2014) by the rational use of resources and a balanced growth or de-growth of the different forms of capital a holistic approach to sustainability. All these factors look closely interrelated and show how security, food security, sustainability and development are strictly interdependent, so that oversimplified, unique measurements, policies and solutions are inadequate to give answers to sustainability and development problems **[R.II/IV.5]**. In this view, the condition of sustainability requires extending to meet both basic needs and the opportunity to achieve higher levels of quality of life, capabilities, and freedom (Sen, 1999) **[230]**. In contradiction to this as mentioned above, the neoliberal economic policies and programmes for the commercial agricultural land reform in Namibia, as well as in other several Southern African countries, have created conditions for landownership among new black elites, and the established white ones (Kaapama, 2007) **[349]**.

Figure 33. The Katutura orphanage.

In this way, the old pre-independence ideologies of economic accumulation are translated to new similar models of development, strengthen social differences between the beneficiaries of the economic status quo and those social groups who see the enfranchisement from the past marginalisation denied (Kaapama, 2007). The national reconciliation fostered the mutual benefits of economic and political elites preserving the benefits of the postcolonial political and economic changes for a restricted and fortunate group of previously disadvantaged individuals who, through the liberation struggle, stepped into State powers and through that into the privileged white minority elite (Kaapama, 2007) **[349]**. The presence of social tension already breaks the equilibrium and represents a latent insecurity, and when it explodes *«the help is given too late»* (Lauttamäki and Hietanen, 2006) **[144]**.

The significant differences between the two countries can be seen also when comparing the functions and activities of security services. While, as reported by a Finnish interviewee, private security services operate in Finland in the shadow of the national security, **[MNC.II.1]** (see sub-section 7.2), in contrast with the preference in Namibia for private security in case of emergency, as referred by a local Professor of Sociology **[R.II.7]**. Whereas in Finland police forces have gained the esteem of citizens **[SME.II.2]**, in the Namibian context doubts arise about their effectiveness **[R.II.7]**. In Finland, even covering a large range of surveillance services, private security agents do not even carry arms **[MNC.II.1]** and in case of danger do not take risks but call the police **[SME.II.2]**. In Namibia, the same multinational security companies survey private households and carry pistols or submachine guns **[O.II.1]**. Moreover, a person who approaches a cash machine, even inside a shopping mall, is immediately looked after by a security guard, without any request (personal experience of the author) **[O.II.1]**. Moving from one safe place to another, outside of the central areas, is not recommended without a private car and knives, arms and other tools for self-defence or aggression (sprays for self-defence, brass knuckles, clubs, sticks and so forth) are sold in the same shops as post-cards and maps **[O.II.1]**.

The Finnish security policy treats social welfare as being connected to safety **[R.II.2]**. As the outcome of a Finnish study 'POLTU' on the future of security reports, "*happy and wellbeing people do not make crimes*" (Lauttamäki and Hietanen, 2006) **[144]**. The *'happiness strategy'*, as defined by the authors, has generated a close cooperation of security operators and public officials with experts of the social and welfare system. The POLTU study, starting from the analysis of threats and came to the conclusion that interventions or actions on situations of insecurity are not able to achieve the goal of solving security problems and maintain the system in equilibrium (i.e. maintaining security states), because *«the help is given too late»*, when that security equilibrium is already broken. When a situation requires the intervention of police forces, this reveals the existence of a more or less severe security problem at a late stage, when it is already producing its negative effects. When security is defined as 'absence' or minimisation of threats, or *'freedom from fear'* or *'freedom from want'* (UNDP, 1994) **[275]**, which includes hunger, disease or natural disaster, the provision of security and control services, directed to manage threats and emergencies, reveals a state of insecurity. In the consideration of what mentioned above, security is not an individual good or need but a collective and public good and a basic need, which cannot be satisfied by the simple provision of locks, alarms or security services of intervention (Sajeva, 2012) **[210]**. The sustainability and endurance of security systems can be based on processes involving more and different actors within a social system **[R.II.2]** that would focus on people's behaviour, for the pursuit of human development, intended as satisfaction of basic needs, happiness and capability expansion (Sen, 1989) **[228]**. In a systemic vision, secured and happy citizens ensure the security and well-being of all their neighbours, as security and freedom more hardly can be achieved individually, as they are the result of a more holistic and collective thinking, involving the pursuit of the desire to feel safe and provide security to others (Sajeva, 2012: 221) **[210]**. According to these earlier studies security and freedom of single individuals implies the security and freedom of them, detaching from a logic of protection, to embrace a logic of reduction of threats.

The relationship between security and development (sustainable) is a virtuous cycle (feedback). The achievement of these integrated objectives is recognised by the Ministry of Foreign Affairs of Finland (2012) **[361]** in the following factors, that involve the realisation of capabilities and freedoms for citizens, as well as boundaries:

- a democratic and accountable society that promotes human rights
- an inclusive green economy promoting employment
- a result-based approach risk assessment analyses the accountability of decision-makers towards citizens, manifesting in the respect for the rule of law, and in policies of good governance, transparency and openness of the results;
- that entitle and enable people to influence own futures
- the focus on long-term partnerships with countries in the world, which are least developed and at the same time committed to common principles of good governance of sustainable development, implying also humanitarian assistance, supported by specific funds for development cooperation.
- Some additional factors are proposed and identify the drivers of the phenomenon **[R.II/IV.6]**:
- Sustainability: the security policies are aware of socio-economic and environmental sustainability in the long run and take into account of the final goal of citizens' well-being
- Evaluation of objective and subjective security
- Security as removing threats more than confronting them, prevention rather than intervention approach. Awareness of the public nature of security, intended as citizens' rights

- Recruiting standards for security organisations and continuous social learning
- Legal provisions and beyond: respecting laws and initiating processes of inclusive governance additional standards and ethical codes including basic needs and human rights, trust, race, religion, political and gender equality
- Accountability of public and private security actors towards users, citizens and stakeholders: transparency reliability of operations, information, and communication

As highlighted in the interviews, security is to trust and be trusted, minimisation of threats, being happy (Lauttamäki and Hietanen, 2006) **[144]**. Security is also development and freedom from fear or from want (UNDP reports (1994)). **[275]**.

Therefore, the public nature of security has to be acknowledged, as a basic need in itself and a collective good (Sajeva, 2012) **[210]**, related to safety and development **[R.II.2]** strictly interrelated with the need of food security, seen as a human right (Ministry of Foreign Affairs of Finland, 2010) **[362] [PUB.II.2]**. In the Namibian context the reduction of security to a private service and the ineffectiveness of public police forces determines a situation in which only a part of the society is secured, by a repressive approach.

6.3.2 The concept of security

The empty structure applied to the security Socio-Technical System (STS) has provided evidence of the main aspects of the concept of security. The complexity of security Socio-Technical Systems (STS) and the public nature of the security 'good' imply that it can hardly be guaranteed by isolated intervention actions and market structures, because of two main factors:

1. Intervention and repressive actions mobilise when the insecure state exists, therefore when a system is not sustainable nor reliable. This has to do with both public intervention and provision of private services.
2. The presence of a conflict of interest in the private sector, for which economic results improve when more intervention is needed and worsen in a situation of security, i.e. minimisation of threats.

The ethical objective of security relates to the absence of fear and the absence of objective insecurity, which relate respectively to the best-informed knowledge and learning about possible threats and the actual minimisation of threats. From the analysis made for the construction of the GAME methodology (see Table 29, page 155), the failure of security systems derives from the lack of entitlements and provision of security to others.

6.3.3 Case study discussion: towards a framework for the evaluation of systems' sustainability

In order to introduce the next case study, some considerations can be made about the aspects of sustainability that have come up until now. The first case study (see sub-section 3.2) of the European Critical Electricity Infrastructure (ECEI) STS generated criteria, that are mostly social and infrastructural and related to the manufactured and environmental capital (see Table 26, page 146). The analysis of the of the security Socio-Technical System (STS) case study provided an important contribution for the GAME methodology and framework especially for the inclusion of the social and human aspects of sustainability and associated manufactured capital (security technologies) (see Table 55 in the Appendix I, page 276 and Table 32, page 169).

The analysis of the case of security did not provide any elements that are in conflict with the sustainability criteria previously identified for the ECEI, In many cases they can be confirmed.

However, the security case integrated the previous criteria with new findings, as summarised in Table 32 (page 169), provides additional insights that integrate the previous criteria, as reported in correspondence to the second case study. As Table 32 shows, the security case englobes the criteria found for the case of ECEI and extends them to other perspectives.

In the following sub-section 6.4. a third case study is presented on a very different issue, i.e. the future pathways towards a post carbon society, with the aim to analyse more environmental aspects of sustainability, inherent in the visioning of the future of energy systems. The analysis that has been done has, once again, integrated the sustainability criteria, to end up with the final matrix of sustainability criteria, that incorporates the outcome of the all three case studies. Even if it is never possible that the final criteria represent all the aspects of sustainability, the consideration of Socio-Technical Systems (STS) and smaller contextual systems-of-systems (e.g. the Finnish and Namibian security STSs) that are very diverse from one another provide a wider coverage of contexts and perspectives that contributes to build more objective criteria that can be generalised.

Table 32. A scheme for the analysis of sustainability criteria throughout the integration of more successive case studies: Case studies I and II

<table>
<tr><th colspan="9">Integration of themes from case studies: the sustainability criteria for ECEI and security Socio-Technical Systems (STS)</th></tr>
<tr><th colspan="4">CASE STUDIES</th><th rowspan="2">NATURAL CAPITAL</th><th rowspan="2">HUMAN CAPITAL</th><th rowspan="2">SOCIAL CAPITAL</th><th rowspan="2">MANUFACTURED CAPITAL</th><th rowspan="2">FINANCIAL CAPITAL</th></tr>
<tr><th>IV</th><th>III</th><th>II</th><th>I</th></tr>
<tr><td rowspan="12">x</td><td rowspan="12">x</td><td rowspan="12">Integration ECEI + SECURITY</td><td rowspan="6">ECEI</td><td colspan="5">Priority of systems' security, systems kept below conditions of stress: risk awareness and learning of emergent risks. Systems' thinking: acting/producing without affecting greater systems</td></tr>
<tr><td colspan="5">Avoiding concentration of risk, spreading it to reduce complexity and vulnerability, systems' reliability and efficiency (local self-sufficiency and independency)</td></tr>
<tr><td colspan="5">Adequacy: assuring systems' ability to maintain own functions in relation to security threats and potential or actual disturbances or changes through space and time. Sustainability of systems as integrated mantaining and endurance of interdependent functions</td></tr>
<tr><td colspan="5">Cooperation, governance and mandatory standards on issues of public relevance. Knowledge sharing and developing best practice solutions</td></tr>
<tr><td colspan="3">Alternative evaluations for non-evaluable impacts and not accounted losses, precautionary principle about unknown unknowns, uncertainty assessment.</td><td>Governance and cooperation for systems' security and reliability</td><td>Rising awareness on the uncertainty of financial systems</td></tr>
<tr><td>Mitigation of environmental impact on humans and of human impact on nature: acting without breaking/impacting on other systems.</td><td colspan="2">Priority to well-being, security and safety, human basic needs. Minimisation of threats for well-being, standards of living, human safety, human rights and and human development or irreversible harm. Scurity focused on needs.</td><td>Adequacy of infrastructural systems to changes: use of smart grids to minimise risks</td><td>Adequacy of the financial system to measure the other capitals: growing capital when security is met. Communication and transparency on the reliability of financial system to measure different kind of losses</td></tr>
<tr><td rowspan="6"></td><td rowspan="3">Consumption and production according to cyclical green economy. Focus of human-nature relation. Environmental protection and sustainable management of natural resources, use of resources for meeting basic needs</td><td>Learning and convergence of subjective and objective security. Freedome from threats through well-being human rights of security and safety for all, minimisation of theats for people security. Human collective security: happy and well-being people do not commit crimes</td><td colspan="2">Flexibility and adaptive capacity of physical, regulatory and social infrastructures. Adequacy of regulatory systems to market and technological development.</td><td rowspan="2">Growth acceptable when not reducing employment nor increasing energy consumption, nor undermining hunam and environmental health nor basic needs (irreversibale damage).</td></tr>
<tr><td colspan="3">Entitlements and enablers for local operators and farms</td></tr>
<tr><td colspan="2">Trust, tolerance, reliability and security for all, rejection of corruption, culture of fear and aggression. Prevention instead of intervention. Anticipating the need for control, intervention at the level of self-control, leaving social and official control as residual.</td><td></td><td></td></tr>
<tr><td>Reducing overpopulation in harmonic balance with the carrying capacity of hosting ecosystems.</td><td>Equal society regardless of identity, freedon form thereats and irreversible harm. Absence of conditions that systematically undermine people's capacity to meet their basic needs, unsafe working conditions and not enough pay to live on.</td><td>Application of principles of good governance, consensus based, accountability</td><td></td><td></td></tr>
<tr><td>Favourable conditions incentives and policies for renewable technologies.</td><td>Assurance of bounded capabilities</td><td>Definition of public goods as social constructs. Cooperation in the competition for questions of public relevance</td><td></td><td></td></tr>
<tr><td colspan="5">Assurance of crucial functions of productivity. hydrological cicles, social relations and economic prosperity.</td></tr>
</table>

6.4 The evolution of the energy Socio-Technical System towards a post-carbon society

The case study of the ECEI presented scenarios that are mostly based on an historical perspective, the critical analysis of systems' failure that is one step of the 'Future workshop' (Jungk and Müllert, 1987; Valqui Vidal, 2005) and will be part of the GAME methodology and framework (see section 7.1). This 'critique phase' allows understanding the lessons to be learnt (see Table 17 in sub-section 5.3, page 112), for instance for the formation of the blue scenario of Table 25 and Figure 26 in sub-section 6.2.1 (see page 145 and 148) and also adopted by Schläpfer and Glavitsch (2006) in their report on the failure of the ECEI. This approach is based on the idea of learning from failures. The second case study of the security Socio-Technical Systems (STS) is also based on a critical analysis of past failures, and has added to that a possible vision of the future concerning the risks of security technologies (scenario II.3 of Figure 31 in sub-section 6.3.4.2, page 160). However these cases do not attempt to imagine alternative future pathways.

The Cross-European case study of the pathways towards post-carbon Socio-Technical System, was carried out in connection with the research carried out for the European FP7 project *"Pathways for Carbon Transition (PACT)"* and published in the project Deliverable 4.2. (Sajeva and LaBelle, 2010). It introduced the element of choice of alternative futures through the consultation of stakeholders on the probability and possibility that a future scenario can be generated by our choices, thereby contributing to the construction of the GAME by introducing the possible actions that do not currently exist, or are only partially present, and trying to imagine the pathways towards future development. For example, the hypothesised substitution of oil by macroscopic algae for the production of biofuels or the abandonment of nuclear power and investment in renewables are some examples of creating a future that is in line with a section of the community (see graph 20 in sub-section 6.4.2). From a methodological perspective this case study introduces the idea of future scenario building, that linked with the concept of social learning can lead us to an idea of 'learning from the future', which does not exclude, but complements the idea of 'learning' from past failures.

From the perspective of the dimensions of sustainability, the previous case studies have treated sustainability from infrastructural (manufactured capital) human and social perspectives, leaving limited room for environmental aspects. The case study is interesting for the development of the GAME methodology as it complements the analysis previously done with aspects of sustainability, mostly concerning environmental issues. In particular, this cross-European case study aims at understanding the risk acceptability and the opportunities of future post-carbon transition scenarios of energy infrastructures and technologies. The study also hypothesises possible structures and arrangements for decision-making.

The research was organised along the following activities:

- Identification of some major technologies and infrastructures, as well as risks and opportunities, for inclusion in the Delphi on-line questionnaire by the contribution of a focus group (see sub-section 6.4.1).
- Stakeholder assessment for the characterisation of their values and perceptions on the acceptability of different types of risk (technological, health and environmental, socio-economic, market and regulatory, by the use of frames of meaning, see sub-section 6.4.2)
- Evaluation of the expectations and perceptions of experts and stakeholders, specifically referred to the risks and opportunities inherent in the transition to a post-carbon society (by the use of Delphi methodology, composed of a questionnaire and a cluster analysis for the grouping of the results, see Appendix I)

When looking at the possibilities to realise a carbon-free society, the complexity of the energy industry, in its interactions with the external environment, throws up uncertain futures. Many possible scenarios might arise, and a number of different interests and perspectives may collide, according to the nature of the impacts on the stakeholders, the value chain, the socio-economic sphere, and the environment. Last but not least, as we have learnt from the ECEI case study, in the presence of great changes in energy Socio-Technical Systems (STS) a substantial revision of regulations and legislations following technological changes is needed.

6.4.1 The focus group

A first focus group was carried out to support the formation of a questionnaire for the Delphi methodology; this was submitted to the same respondents to elicit their views about possible future policies for the transition towards a post-carbon society, and the related risks and opportunities. In this first round—the first focus group **[W.III.1]**—experts (see Table 29, page 155) were called to express their visions and perspectives and discuss the impacts of the transition process towards a post-carbon society, with regard to different areas, concerns, type of impact or concern, by written suggestions. A set of key topics, and the related perspectives of risk and opportunity, were suggested (Table 34, page 172 and Table 35, page 173). The discussion and consultation with the experts of the first focus group resulted in the formulation of a classification according to different subset areas (e.g. environment, health, public economy, business perspective, land use, etc.) and of a number of issues that were incorporated into the on-line questionnaire of the Delphi methodology (**[Q.III.1]**, see Appendix I).

Table 33. The focus group participants

Country	Participant
Italy	Professor of Energy Technology
Finland	Futures researcher in the field of energy
Hungary	Professor of Energy Policy and Regulatory Governance
Italy	Social scientist (energy field)
Italy	Researcher in Economics of Energy sources
International	Head of Institute of Energy of an international organisation
Italy	Italian Energy Industry Foundation
Italy	Health Institute of Italian organisation
Italy	Italian national Energy Research Centre
International	European Technology Platform for the Electricity Networks of the Future – Smart Grids Team EMEA Industries SAP Deutschland AG & Co. KG
Italy	Italian National Energy Industries
Italy	Professor of Energy Technology

Table 34. The key energy issues: energy sources and related infrastructures [W.III.1]—

Energy	Transportation	Infrastructures
Decentralised and local: renewables Hydrocarbon-based (coal, oil) Centralised nuclear Natural gas Waste burning	Electricity-based Hydrocarbon-based Other: hydrogen, gas, nuclear, bio-fuels	Road Rail ICT Air Electric Other: water infrastructures and distribution of goods and services Intangible infrastructures: administrative and organisational networks

The questionnaire was sent to more than 3000 European respondents that the University of Turku had selected as a sample for previous projects. The list included energy and environmental experts from European Universities and private companies, as well as policy makers and public functionaries in the area of energy and environmental policy, at both national and international level. It also covered representatives of consumers' associations, environmental organisations, health institutions and NGOs.

Table 35. The perspectives of risk and opportunity

Perspectives	Costs – Risks – Threats	Effectiveness – opportunities
Security	Prevention costs: setting control systems	Greater systems security
	Harm or risk from the ICT infrastructure	Opportunities from information technologies
	Lack of risk awareness perspectives	Risk awareness
	Risk of technological change	Opportunities from technological development
Reliability	Reduction of a service or/and its quality (efficiency, effectiveness)	Efficiency and effectiveness in the provision or restoring of a service
Environment	Greater energy consumption	Reduction in energy consumption
	Reduction of energy efficiency	Increases in energy efficiency
	Costs of damage related to waste treatment or storage	Waste reduction or improvement of waste quality
	Environmental costs or harms related to the land use or urbanisation pattern	Improvement of environmental health through the land use or urbanisation pattern
Health	Investments or resources in prevention	Reduction of risks for human health
	Costs for health / harm to persons and their security	Reduction of health costs
Society	Losses in welfare or well-being	Increases in health and quality of life
Business and management	Costs and harms from gaps in traditional management practices	Improvements from new approaches of integrated management (governance)
	Unawareness of plurality of perspectives	Consideration of participatory approaches
Regulation and market	Problems or costs of the current de-regulation of the regulatory framework	Improvements and opportunities in the market model and/or the regulatory framework
	Globalisation, expansion or localisation of markets (cons)	Globalisation, expansion or localisation of markets (pros)

6.4.2 The Delphi on-line questionnaire and cluster analysis

The previous stakeholders' assessment described the qualitative composition of the respondents involved in the Delphi on-line questionnaire (distributed and analysed by the Webropol software). The Delphi survey was aimed at analysing the risks and opportunities relating to the alternative elicited futures for a post-carbon society (see Table 35, page 173).

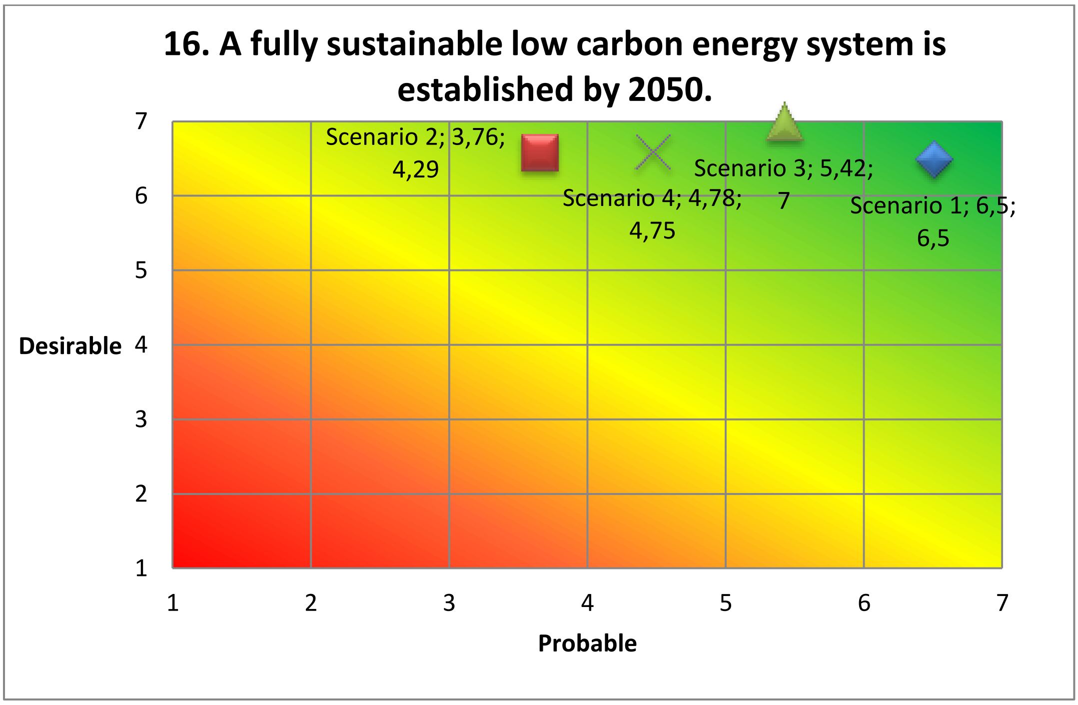
The questionnaire was built upon four main areas of interest, by assessing the probability and desirability of each possible change or effect:

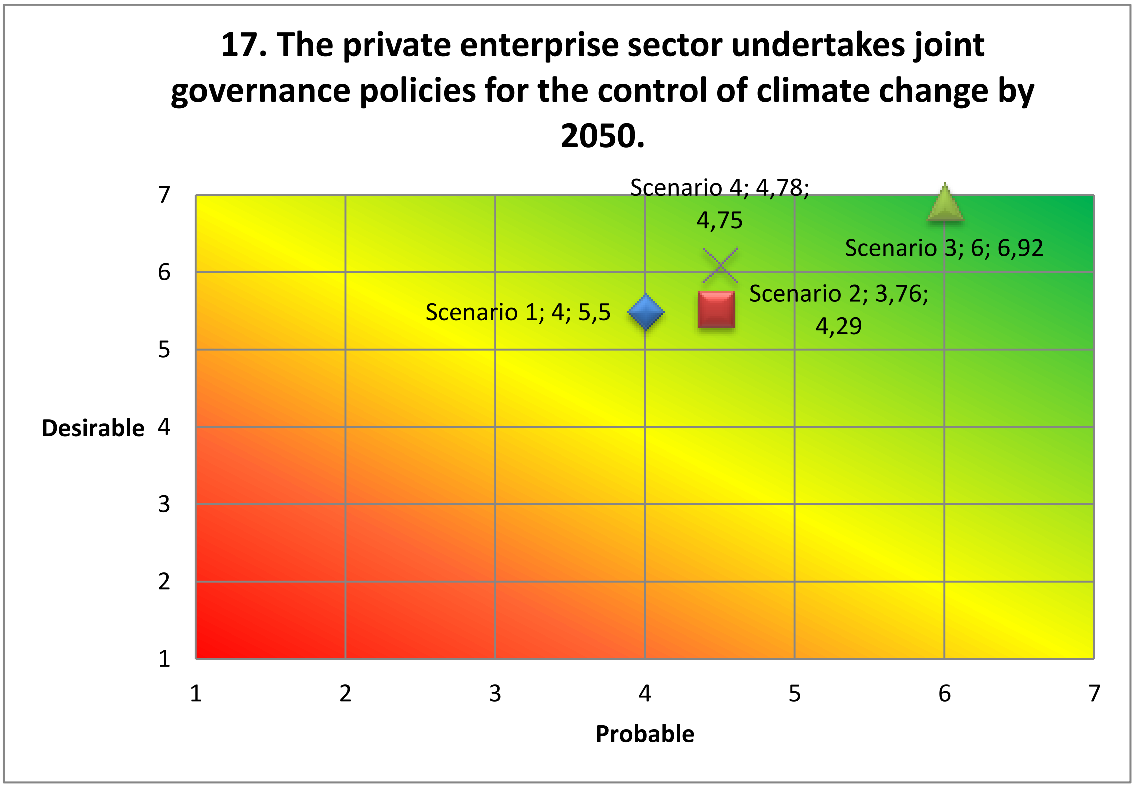
- Technological effects
- Health and environmental effects

- Socio-economic and political effects
- Market and regulatory effects

As was already mentioned in sub-section 6.4, the dimensions of probability and desirability allow for visions and perceived futures. Possible pathways towards a post-carbon society can populate the empty framework of the GAME with aspects of sustainability that are complementary to those already identified in the European Critical Electricity Infrastructure (ECEI) and security case studies.

In order to analyse the qualitative information generated by the survey, the answers were translated into quantitative format through classification and scoring in a range from one to seven for each of the dimensions of probability and desirability. A cluster analysis (using the SPSS software) grouped the answers of the Webropol questionnaire into four clusters, on the basis of their similarity in probability and desirability. Each cluster represents a different transition scenario, which refers to a stakeholder group having similar preferences for the future energy system of 2050. The representation of the clusters is given in Appendix I (see Table 57, page 287, and Figure 48, page 293, while some examples of clustered answers to single questions have been selected to indicate the range of responses are represented in the following graphs 16, 17, 19, 20, 31 and 79. These graphs describe the four groups of clustered answers (the 'scenarios' in the graphs), defined by the average scores of their two dimensions of probability (x axis) and desirability (y axis).




17. The private enterprise sector undertakes joint governance policies for the control of climate change by 2050.
Scenario 4; 4,78; 4,75
Scenario 3; 6; 6,92
Scenario 2; 3,76; 4,29
Scenario 1; 4; 5,5
Desirable
Probable
1
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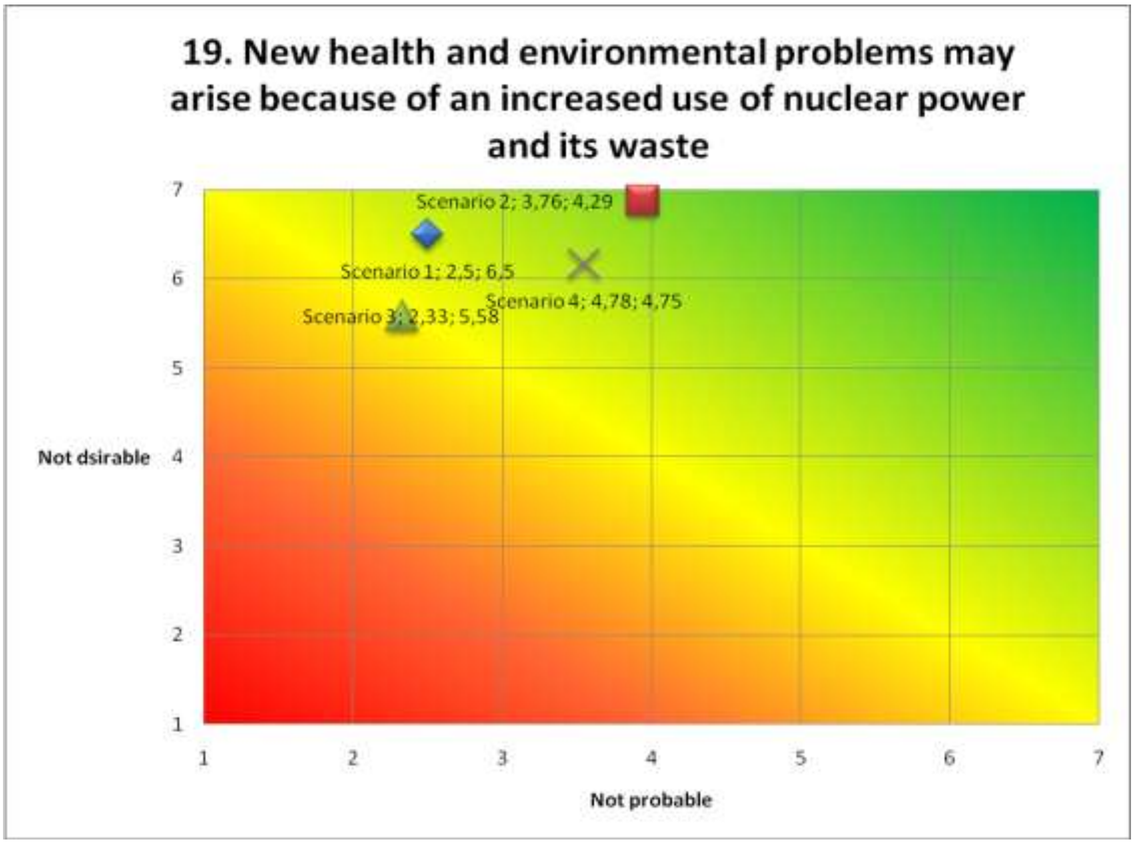
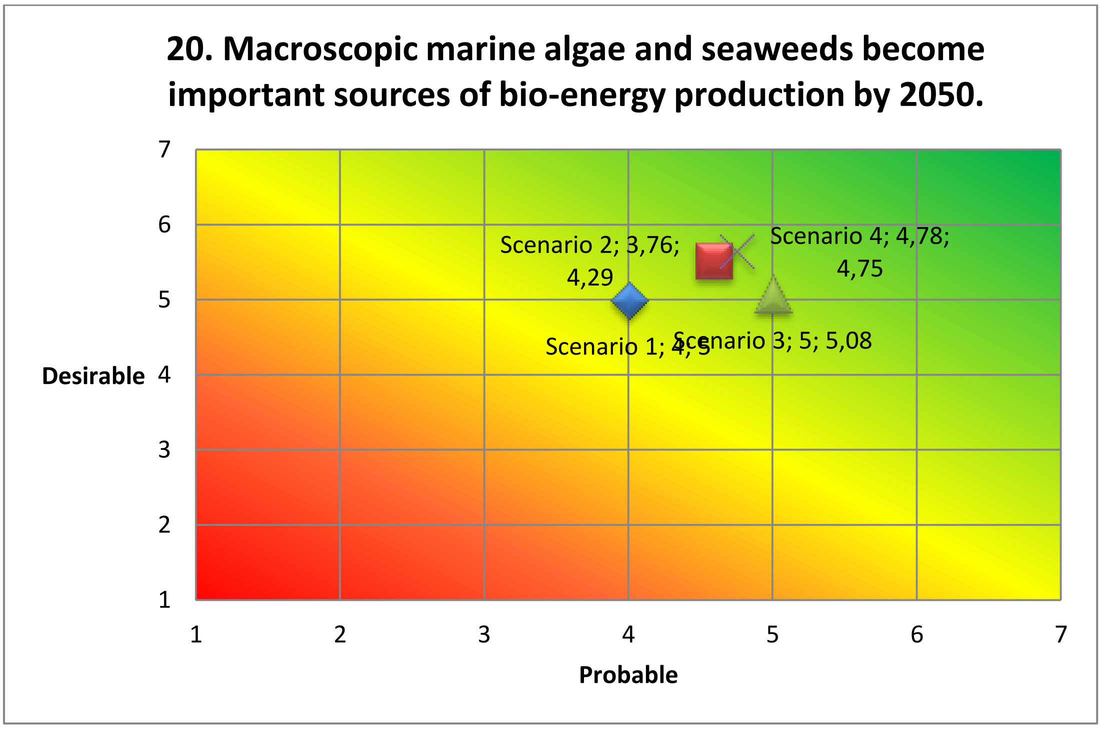
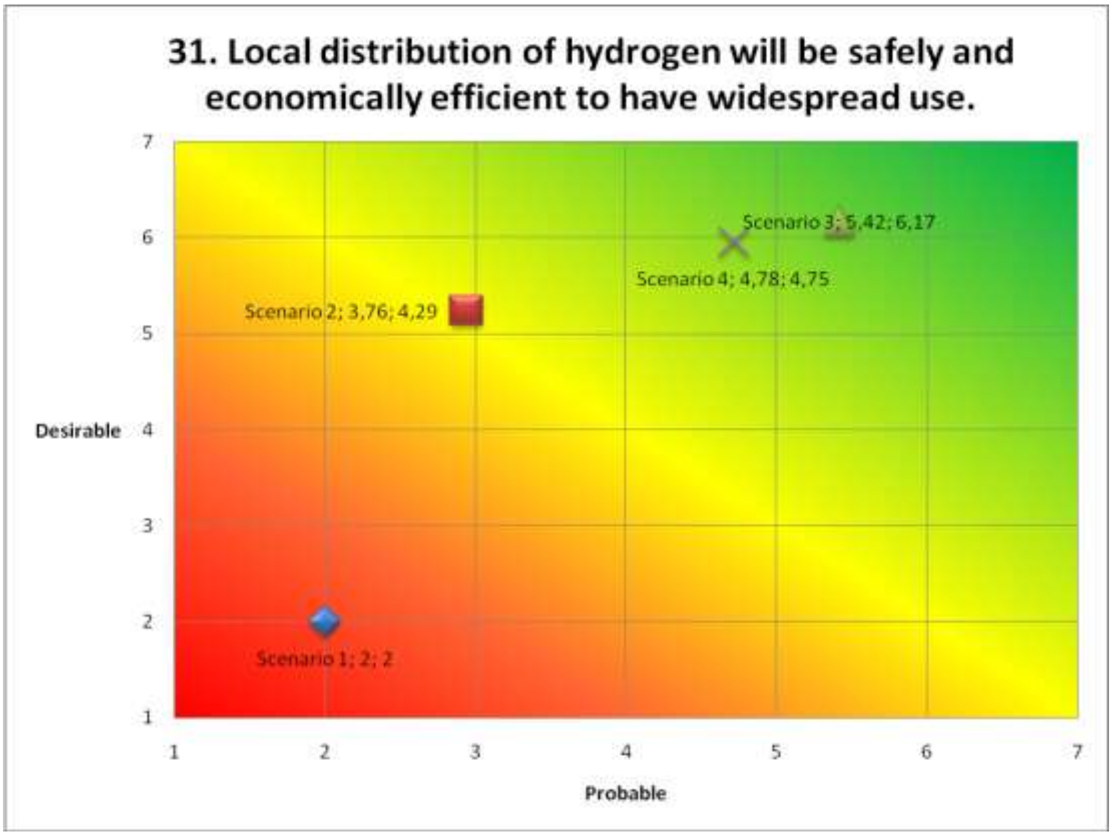
3
4
5
6
7

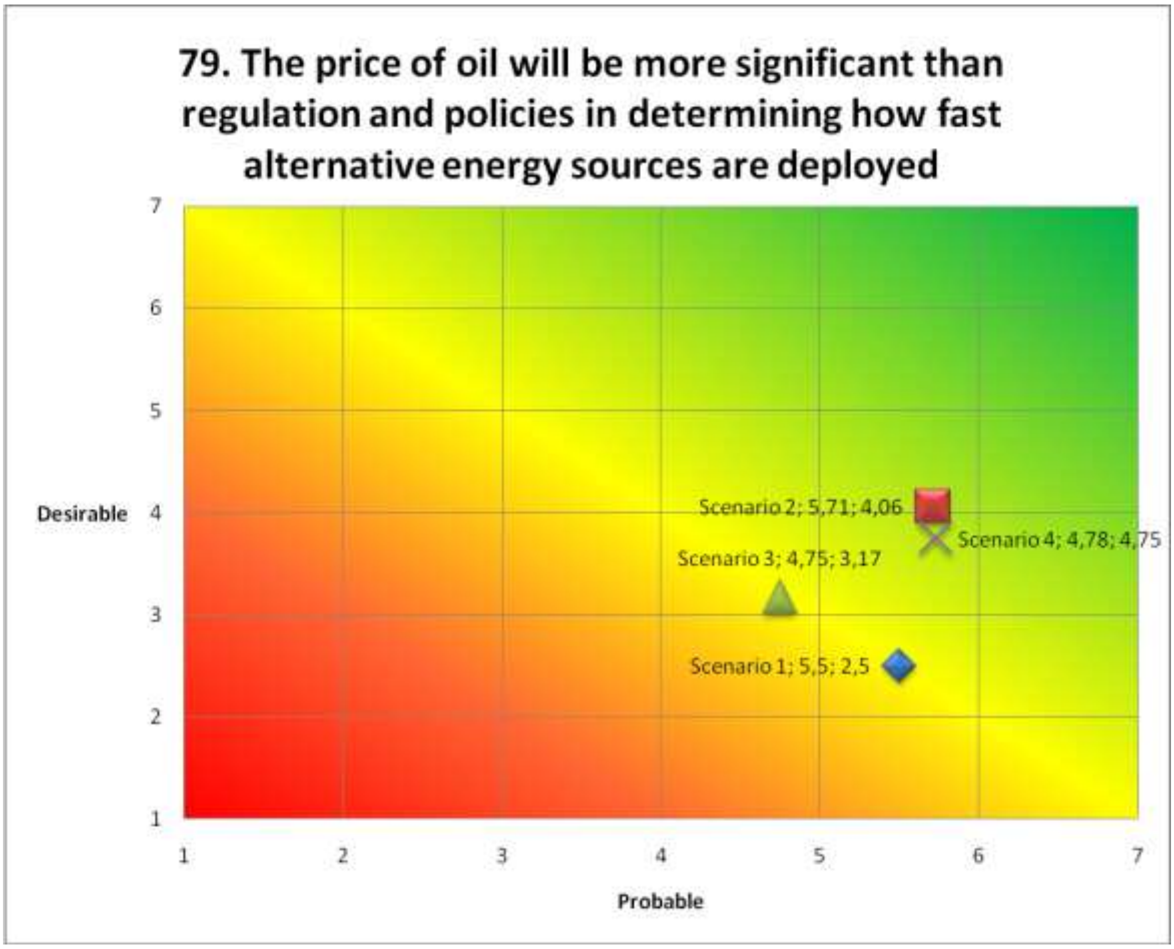

19. New health and environmental problems may arise because of an increased use of nuclear power and its waste
Scenario 2; 3,76; 4,29
Scenario 1; 2,5; 6,5
Scenario 4; 4,78; 4,75
Scenario 3; 2,33; 5,58
Not dsirable
Not probable
1
2
3
4
5
6
7



20. Macroscopic marine algae and seaweeds become important sources of bio-energy production by 2050.
Scenario 2; 3,76; 4,29
Scenario 4; 4,78; 4,75
Scenario 1; 4; 5
Scenario 3; 5; 5,08
Desirable
Probable
1
2
3
4
5
6
7



31. Local distribution of hydrogen will be safely and economically efficient to have widespread use.
Scenario 3; 5,42; 6,17
Scenario 4; 4,78; 4,75
Scenario 2; 3,76; 4,29
Scenario 1; 2; 2
Desirable
Probable
1
2
3
4
5
6
7



The data resulting from the cluster analysis and therefore the preferences and evaluations contained in the previous graphs, have been incorporated into the same empty framework structure used for the previous case studies presented in Figure 18 (page 124). Based on the previously established sustainability criteria for the Five Capitals Models of sustainability a scenario III.1 is generated, as represented in the graph of Figure 34 (page 178). The analysis is the generalisation and integration of the latest outcomes with the previous matrix of sustainability criteria, from this a final matrix is produced for building the methodology (see Table 38 in chapter 7, page 183). Some main low-carbon energy oriented outcomes of the analysis relate to the preference for electric forms of energy, the possibility of increase of energy production from macroscopic algae, the urgency of decreasing CO2 emissions and the general impact onto the environment, through local renewable based energy production. The presence of conflict of interest and opinions about hydrogen use for transportation was acknowledged, due to the uncertainty of the related risks and feasibility. This third case study does not appear to be in contrast with the criteria of the previous cases, and, as represented in Table 36 (page 179) it provides additional ones.

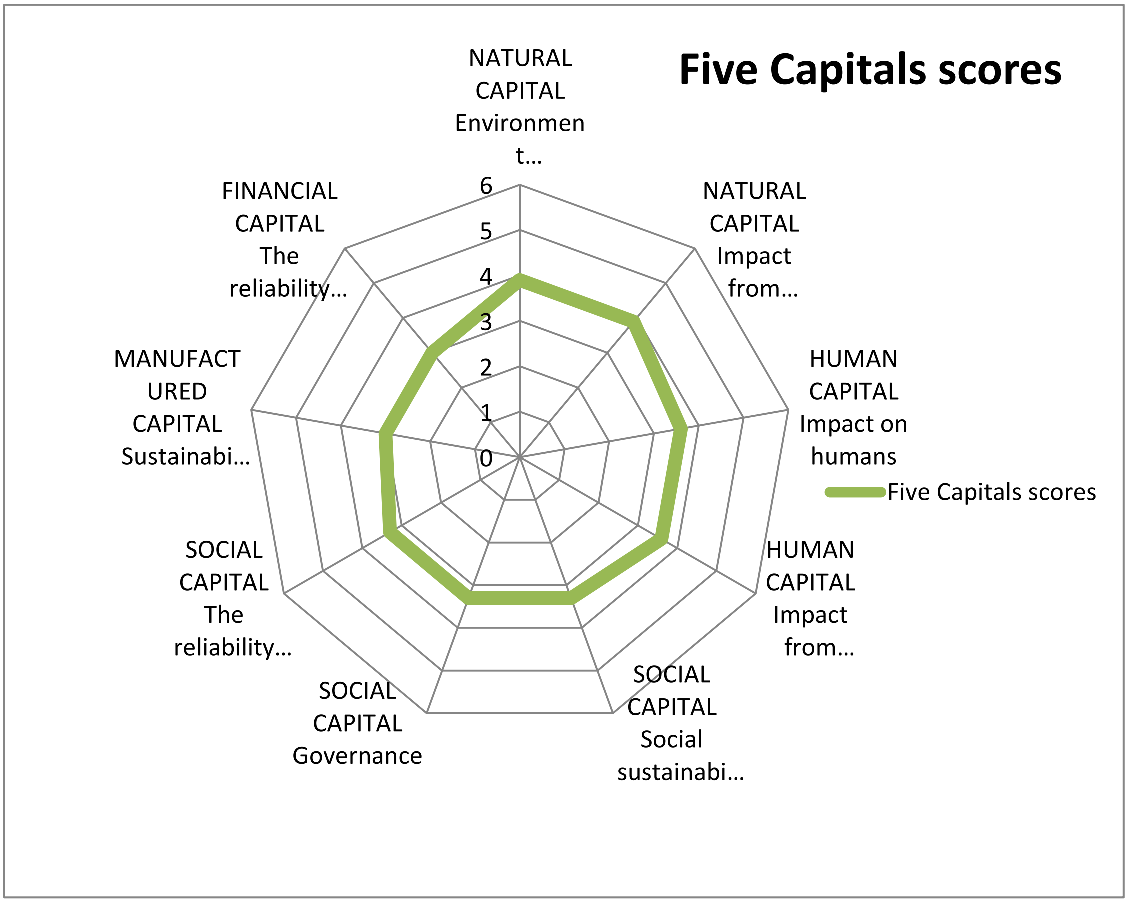


Figure 34. The scenario III.1 for the post-carbon society case study

Table 36. A scheme for the analysis of sustainability criteria throughout the integration of more successive case studies: Case studies I, II and III

CASE STUDIES IV	III	II	I	Integration of themes from case studies: the sustainability criteria for Socio-Technical Systems (STS) — NATURAL CAPITAL	HUMAN CAPITAL	SOCIAL CAPITAL	MANUFACTURED CAPITAL	FINANCIAL CAPITAL
				Priority of systems' security, systems kept below conditions of stress: risk awareness and learning of emergent risks. Systems' thinking: acting/producing without affecting greater systems				
				Avoiding concentration of risk, spreading it to reduce complexity and vulnerability, systems' reliability and efficiency (local self-sufficiency and independency)				
				Adequacy: assuring systems' ability to maintain own functions in relation to security threats and potential or actual disturbances or changes through space and time. Sustainability of systems as integrated mantaining and endurance of interdependent functions				
				Cooperation, governance and mandatory standards on issues of public relevance. Knowledge sharing and developing best practice solutions				
			ECEI	Alternative evaluations for non-evaluable impacts and not accounted losses, precautionary principle about unknown unknowns, uncertainty assessment.			Governance and cooperation for systems' security and reliability	Rising awareness on the uncertainty of financial systems
		Integration ECEI + SECURITY		Mitigation of environmental impact on humans and of human impact on nature: acting without breaking/impacting on other systems.	Priority to well-being, security and safety, human basic needs. Minimisation of threats for well-being, standards of living, human safety, human rights and and human development or irreversible harm. Scurity focused on needs.		Adequacy of infrastructural systems to changes: use of smart grids to minimise risks	Adequacy of the financial system to measure the other capitals: growing capital when security is met. Communication and transparency on the reliability of financial system to measure different kind of losses
	Integration ECEI + SECURITY + POST-CARBON ENERGY			Consumption and production according to cyclical green economy. Focus of human-nature relation. Environmental protection and sustainable management of natural resources, use of resources for meeting basic needs	Learning and convergence of subjective and objective security. Freedome from threats through well-being human rights of security and safety for all, minimisation of theats for people security. Human collective security: happy and well-being people do not commit crimes	Flexibility and adaptive capacity of physical, regulatory and social infrastructures. Adequacy of regulatory systems to market and technological development.		Growth acceptable when not reducing employment nor increasing energy consumption, nor undermining hunam and environmental health nor basic needs (irreversibale damage).
					Entitlements and enablers for local operators and farms			
x					Trust, tolerance, reliability and security for all, rejection of corruption, culture of fear and aggression. Prevention instead of intervention. Anticipating the need for control, intervention at the level of self-control, leaving social and official control as residual.			
				Reducing overpopulation in harmonic balance with the carrying capacity of hosting ecosystems.	Equal society regardless of identity, freedon form thereats and irreversible harm. Absence of conditions that systematically undermine people's capacity to meet their basic needs, unsafe working conditions and not enough pay to live on.	Application of principles of good governance, consensus based, accountability		
				Favourable conditions incentives and policies for renewable technologies.	Assurance of bounded capabilities	Definition of public goods as social constructs. Cooperation in the competition for questions of public relevance		
				Assurance of crucial functions of productivity. hydrological cicles, social relations and economic prosperity.				
				Absence of systematic increase of concentrations of human produced subsances, or extractes fron Earth's crust.	Economic development as social well-being, generals ecurity, trust in the economy and business expectations		Absence of systematic degradation through increase of physical artificial capital.	
				Setting environmental sustainability goals and standards by governance processes: e.g. CO2 to be reduced by 2056 below 400 ppm.	Minimisation of risks for human health	Participatory decision-making and social responsibility to assure security and adaptive capability of systems.	Electricity fro low-carbon sources. Mix of renewable technologies	
				Focus on the relation human-nature: health and environmental factors first order determinants for the energy supply mixture. Assurance of crucial functions of productivity, hydrological cycles, social relations and economic prosperity. Regulatory standards for systems' governance				
				Environmental protection and sustainable management of natural resources as preconditions for food security and environmental sustainability. Systemic vision for undeerstanding the interrelations.				

7 The construction of the GAME framework for choosing between alternative futures

Objective	To present the GAME structure and framework, with a synthesis of core sustainability criteria for effective governance and generation of future scenario
Content	

The incorporation of the data from the three case studies into the empty GAME framework and the successive classification, integration and generalisation has produced core sustainability criteria, as represented in Table 38 (page 183). These criteria are taken as the guiding principles when applying the GAME methodology to other systems.

The final Governance Assessment Methodology Exercise (GAME) builds on the empty structure (see Table 20, page 122) and adds a dynamic perspective of visioning future goals contained in the 'future workshop' (Jungk and Müllert, 1987; Valqui Vidal, 2005), as well as the back-casting approach used for decision-making in the Natural Step (Dreborg, 1996; Vergragt, 2011; The Natural Step, 2013), in order to reflect the concept of 'governance for sustainability' as described in Chapter 4 and to implement the principle of accountability by the indication of a decision-making process (see Table 37, page 180).

Table 37. The conceptual ideas of GAME assessment methodology inspired by existing frameworks (dynamic element of the 'future workshop' and the back-casting approach added)

Governance for Sustainability requirements	Existing methodologies or conceptual frameworks
Allow the reporting of multiple data-types, realising social learning through generalisation of case study findings and re-application of generalised criteria to specific contexts.	Edsteps Global Competence Matrix concept. Encoding system for referencing different data. Analyse, integrate, and synthesize insights: clustering, integration and summary of homogeneous data (categorisation of Futures methodologies).
Allow a holistic evaluation of Socio-technical Systems' sustainability that is extended to different capital dimensions	Qualitative matricial structure of the pedigree matrix and scoring of attributes (Funtowicz and Ravetz, 1990) Five Capitals Model of sustainability.
Allow the visioning of **future implications emerging from current actions for scenario building and** the cross-impact analysis within and between systems.	Futures Wheel conceptual structure for analysing orders of impact
Allow the implementation of governance processes by a participatory social learning about alternative futures and indicates the actions needed to reach them (criteria and actions).	Participatory brainstorming and visualisation through the 'future workshop' (Jungk and Müllert, 1987; Valqui Vidal, 2005). Back-casting approach (Dreborg, 1996; Vergragt, 2011; The Natural Step, 2013)

In this view, the GAME methodology has a function similar to the existing Natural Step, in the determination of the contextual actions by a backcasting approach. However while this latter aims at the determination of possible solutions for private and public organisations, the GAME allows a more structured evaluation of the impacts and an assessment of the different solutions, as well as a holistic approach covering more capitals.

The final GAME methodology and framework incorporates the back-casting approach that supports the practical application of the GAME through interviews and workshops, allowing the participation of more stakeholders. The framework also supports a process of social learning about challenges, failures, sustainability goals and actions to be implemented, agreed among a multi-stakeholder community. This, on the one hand will entitle participating stakeholders for facilitating human agency, and on the other end will provide with sustainability criteria that represent the systems' boundaries, among which human agency can take place.

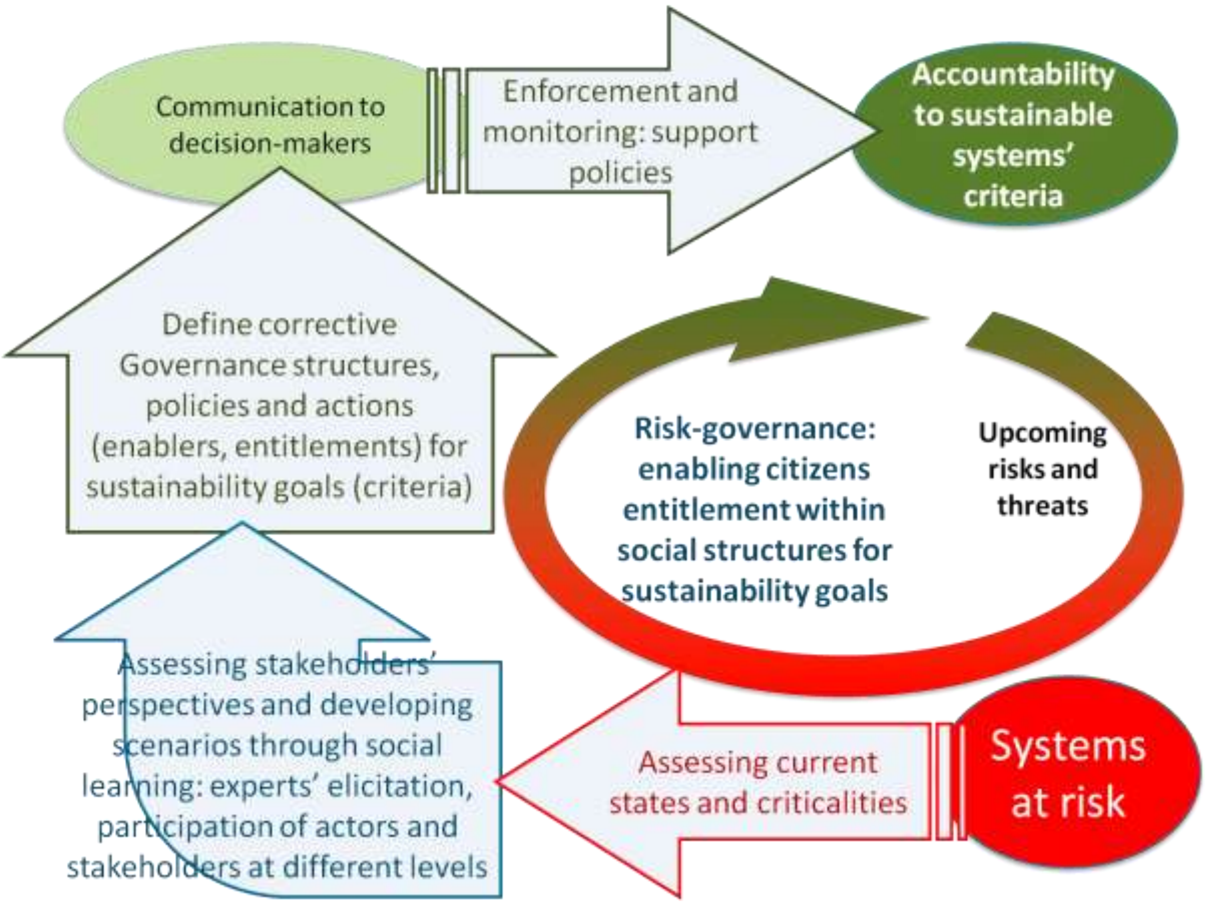


Figure 35. The risk governance process (development of Sajeva, 2012)

This way, the GAME strives towards more concrete participatory procedure and framework that can operationalise the governance process (Figure 35, page 181) and implement the principle of accountability. The tool, representing the implementation of ‘governance for sustainability’, exceeds the role of information provision and aims to a that of contributing to governance for sustainability through participatory deliberation and accountability of decision-making.

The GAME matrix operationalises the risk governance process by eliciting, presenting and integrating known and perceived impacts across the five capitals, building a process of participatory and systemic social learning and understanding about the sustainability of Socio-Technical Systems (STS). The framework, in common with Vidal’s (2005) *«visualised brainstorming»*, integrates documentary, qualitative and quantitative data to identify the key challenges, as well as the causes of possible systems’ failures, to define possible goals and countermeasures on the basis of sustainability criteria and to provide general guiding principles for moving towards the desired goal.

7.1 The structure and procedure of the GAME matrix

The structure for the GAME methodology and toolkit (see Figure 36) is subdivided into 4 phases.

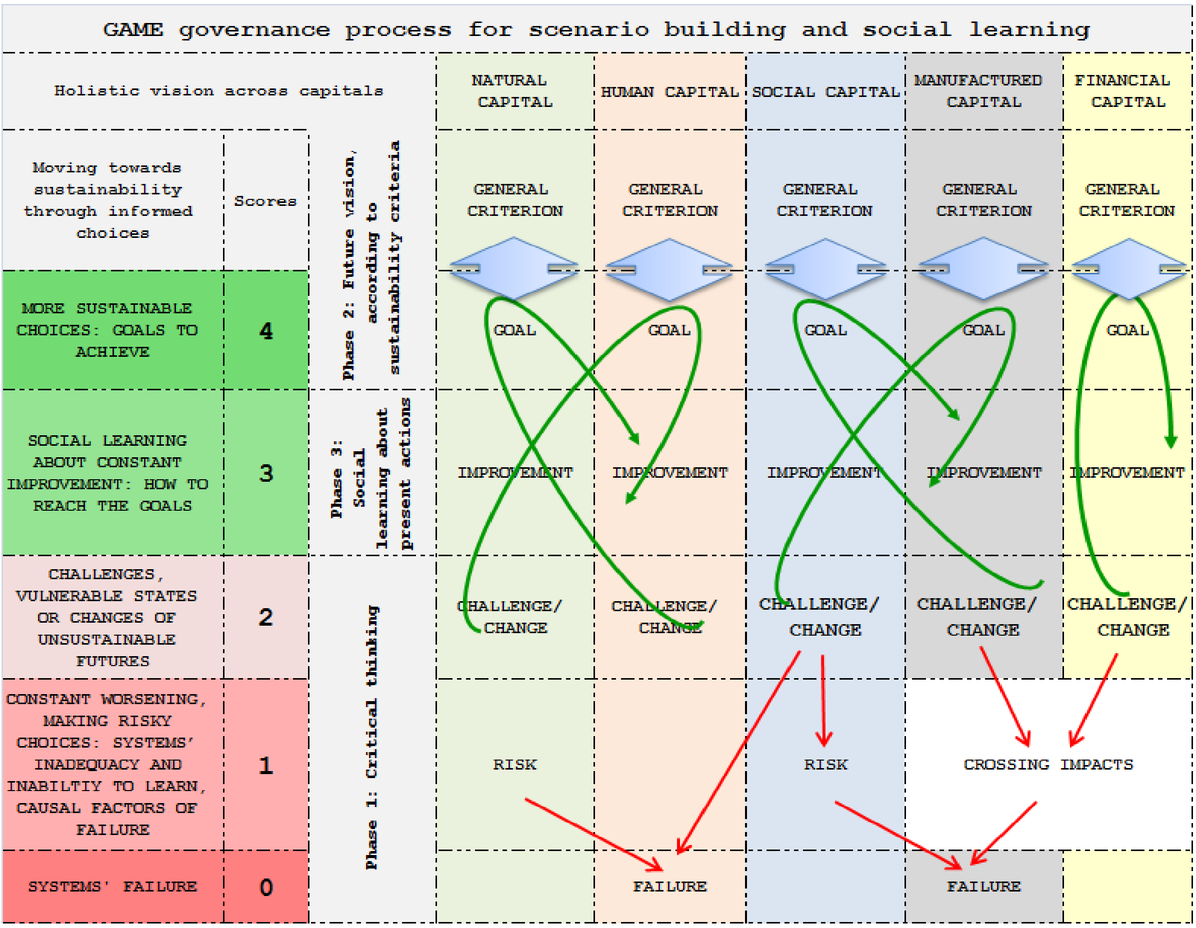


Figure 36. The GAME process for scenario building and social learning on systems’ sustainability

Table 38. GAME matrix of criteria as resulting from the case studies

NATURAL CAPITAL	HUMAN CAPITAL	SOCIAL CAPITAL			MANUFACTURED CAPITAL	FINANCIAL CAPITAL	Criteria thematic areas
		Social sustainability	Governance	The reliability of markets	Sustainability and reliability of infrastructures	The reliability of the financial system	
Interdependent systems can not be operated as if they were independent and closer coordination is required [337]. Entities for cooperation and governance and mandatory standards to deal with public relevance [218]. Cooperation can be competition for questions of public relevance [HL.II.1] [R.II.4] [R.II.3] [A.II.3] [393].						Rising awareness that the market signals do not reflect properly the physical limits [378].	Systems limits and adequacy
Adequacy in relation to security: assuring the ability to maintain own functions in relation to the possible security threats and imminent disturbances [321] [398] [223] [HL.II.1]. Systems reliability: continuous long-term functioning throughout time according to accepted quality and quantity standards of delivered service and possible failures [125] [318] [220] [320] [318] [388] [314].						Communicating uncertainty of financial evaluation systems and associating alternative evaluations [310] [332]	
Systems kept well below their limits, avoiding to work under conditions of stress, adaptive capacity, adaptation of all systems to changes [347]. Adequacy of systems in relation to larger systems: security, sustainability, economic efficiency, reliability, technical performance. Collective security considered as the overarching concept [102], involving sustainable development [215] and human security [A.II.1] as a human right national and individual [PVR.II.1], basic need in itself and a public collective good [220] [275] even implying reduced economic results [337], related to safety and development [R.II.2] strictly interrelated with the need of food security, seen as a human right [362] [PVR.II.2].							
Reducing overpopulation in harmonic balance with its productive potential and carrying capacity of the hosting ecosystems [4]	Focus on real causal factors: happiness and well being, freedom from threats [RII.1] [R.II.2]. Connection of safety and security policy issues [R.II.2], security as 'absence' or minimization of threats, or 'freedom from fear' or 'freedom from want' [275]. Increase in health and quality of life, reduction of risks for human health [M.III.1].	Strengthening of general economic development, in terms of social well-being, general security, trust in the economy and business expectations [Q.III.1]. Strengthened social welfare, during the transition process (social effects, labour policies, jobs) [Q.III.1]	Anticipating the need for control [279]. Logic of prevention, intervention at the level of self-control, leaving at last social control and official control [389]. Education based on ethics and cultural vision [384] [389]. Development policy to strengthening international stability, security, peace, justice and sustainable development, rule of law, democracy and human rights. Focus on future needs and help countries to free themselves from aid dependency, pursuing people entitlements [361].	Entitlements and enablers for local and smallholder farms to exert their agency [349].	Spreading the risk: local self-sufficiency to break the complexity and reduce vulnerabilities [M.I.1]	Security insurance services focused on needs [MMC.II.1].	
Consumption and production responding to common criteria of inclusive green economy (use of resources for meeting basic needs) [361]. Absence of systematic increase of concentrations of substances produced by society or extracted from the earth's crust, absence of systematic physical degradation of nature and natural processes [253].	Reduction of threats and entitlement for well-being, standards of living, human safety [319] [220] [6] [323] [159] [PVR.II.1] human rights and human development [41] or irreversible harm [310]. Poverty and inequality reduction [361], distribution policies, entitlements and enablers for citizens to exert their agency. Avoidance of non decent living conditions in rural slums [349]. Absence of conditions that systematically undermine people's capacity to meet their basic human needs, unsafe working conditions and not enough pay to live on [289]. Cultural elements of honesty and trust [R.II.1]. "Happy and wellbeing people do not make crimes" [44]. Absence of economic and social disparities that can produce violence. Intervention at the self-control level [389]. Feeling to live in a fair and equal society regardless of identity [66]. Extending to all the possibility to meet basic needs and also the opportunity to achieve higher levels of quality of life, capabilities, and freedom [230] to live within system's boundaries [126] by mean of the social structures [354]. Absence of economic and social disparities that can produce violence (physical or structural), empowerment of women [388]	Trust, reliability of security operators and authorities, safety, care of citizens, respect of legislation, control and rejection of the culture of corruption, tolerance [279]. Absence of culture of fear and aggression/intervention [278]. Corruption systems should not be tolerated [Q.III.1]			Flexibility and adaptive capacity of physical, regulatory and social infrastructures. Precautionary principle. [R.I.1] [HL.II.1]	Growth acceptable if not reducing employment and not increasing energy consumption or income distribution, not undermining environmental and human health or the meeting of basic needs, and in general causing irreversible damage into the other overarching capitals [40]. Growing capital when security is met [102]. Economic growth based on green technologies [378].	
Sustainable and low carbon energy system is established by 2050. Environmental risk based appreciative value system [Q.III.1]. Favorable conditions, incentives and policies for the flourishing of renewable energy technologies [311], creating opportunity for self-organization towards social-ecological sustainability [364]. Localization and flexibility for improving sustainability and reliability [R.I.1]. Non negotiable an absolute ceiling for greenhouse gases [GHG] concentration, to keep the earth temperature increase below 2°C [378]. Green technology with reduced use of water, no waste and lower risk to human and environmental health. Investment in reduction of transport, energy consumption and increase of efficiency, especially through decentralized renewable energy sources [M.III.1] [Q.III.1]. Nuke and fossil generation to be abandoned [Q.III.1]		Security services focused on real needs, convergence of subjective and objective security [MMC.II.1] [MMR.II.1].	A good can be public in force of political considerations and social constructs [132]. Adequacy of regulatory systems to market and technological development [HL.II.1] [102], cooperation and instant communication between contractors and adoption of common protocols [R.I.1]. Cooperation in the competition and participatory and inclusive 'good' governance for matters of public relevance and definition of regulatory standards [219] [HL.II.1]; requirements approved by an authority for reliable operation of a system [316]		Smart Grids and a more internet-based infrastructure for energy seems needed for facilitating the reduction of emissions and nuclear waste [Q.III.1]. Replacement of transport technologies and infrastructures by advanced lower-impact ones (intangible or 'less tangible'). "Cross-border regulatory cooperation is essential to build the necessary smart grid to handle new and revised energy generation technology." Increase investments in cross-border transmission lines and realize regional market integration [Q.III.1]. A more powerful,	Limiting valuable losses [310]	Sustainability of systems and their priorities. Focus on reduction or minimization of threats
		Well-being main factor for assuring security, to be approached holistically through interaction [PVR.II.1]. Governance of security not delegated to technology [HL.II.1]. "Happiness strategy" and close cooperation of security operators and public officials with experts of the social and welfare system [361]. Governance for security as making people happy and not being hated, having no need for fortresses [156]. Private security sector in the shadow of the national security [MMC.II.1]. Improvements from new participatory approaches of integrated management (governance) [M.III.1]. Professionality of security entities [388]			Electricity generated by using low carbon energy sources. Concentrated Solar Power (CSP) is at the same time the most effective renewable resource of energy but not necessarily local: 'CSP will be essential to balance supply and demand, unless we are happy to be cold and poor'. The key future solutions as a mix of transmission (wind, CSP) / distribution connected (photovoltaic, biomass) generation systems, bio-fuels (trucks, ships, planes), and electrical/hybrid vehicles [Q.III.1].	Reduction of health costs [M.III.1]	
		Improvements and opportunities in the market model and/or the regulatory framework. Globalisation, expansion or localisation of markets, according to the needs [M.III.1]. "Local communities will determine whether new technologies and policies conform to their local societal norms." Avoidance to depend on only an energy source: spreading the risk [Q.III.1]				Prevention costs: setting control systems [M.III.1]	
Security of supply risks can be reduced by establishing long term strategies for low or zero carbon technologies in generation, transmission and distribution [Q.III.1]. Macroscopic marine algae and seaweeds, or microalgae, to become important sources of bio-energy production, and to replace oil by 2050, as a cheap and carbon neutral form of energy production, but also a good way to carbon caption from atmosphere [Q.III.1].		International governance of climate change and hydrocarbon resources scarcity, on the basis of appropriate international mechanisms and global agreements to mitigate GHG emissions [378]. The private enterprise sector undertakes joint governance policies for the control of climate change by 2050. An energy governance council to be established at the European level, to identify and limit the risks. Participatory decision-making process for establishing common goals and ensuring the implementation of energy goals by mandatory standards. 'The "stick" can be used by regulators in a mandatory quota system for utilities to reduce energy consumption' [Q.III.1].			Replacement of transport technologies and infrastructures by advanced lower impact ones (intangible or 'less tangible'). "Cross border regulatory cooperation is essential to build the necessary smart grid to handle new and revised energy generation technology." [Q.III.1].		
Focus on the relation human-nature. 'Health and environmental factors are becoming first order determinants for the energy supply mixture' [Q.III.1]. Environmental protection and sustainable management of natural resources are as well a precondition for food security. Food security is in turn also a condition for environmental sustainability. The systemic vision allows a deeper understanding of all possible implications and interconnections [361].		A European regulatory agency is required for the evolution towards a common Internal Energy Market with high levels of security of supply. Regional and EU-level cooperation between investors and regulators to assure the correct functioning of the market. [Q.III.1]. Application of principles of good governance: participation (a voice for all in decision-making), transparency, responsiveness, consensus orientation and mediation of interests towards the general interest, equal opportunities of involvement, effectiveness and efficiency of result oriented processes (meeting needs with the best use of resources), accountability of decision-makers to stakeholders and strategic, long perspective vision, understanding complexity and heading to human development [41]. Definition of roles and responsibilities of public institutions and private operators, criteria of social responsibility, to assure security and adaptive capabilities of systems [226] [Q.III.1].			Replacing oil with algae biofuel doesn't require major investments and changes in the current energy chains. Post-carbon energy sources will increase the capacity to mitigate the risk of disruptions in the energy supply [Q.III.1].		
Alternative evaluations for non valuable impacts and not accounted losses [310]							
Urgency of setting sustainability goals. CO2 has to be reduced below 10% by 2050. There are no much chances if the governance process don't set the scenario to 2035 below the 400 ppm of CO2 [Q.III.1]. Mitigate the environmental impact on humans by prevention action (precautionary principle) [222]. Assurance of crucial functions of productivity, hydrological cycles, social relations and economic prosperity [202][321].	Reducing uncertainty and approaching subjective and objective risk [159]: raise awareness of major emerging risks relevant to society; standardising disclosure, stakeholder dialogue; knowledge sharing and developing best practice solutions [310]. Systematic and immediate communication about systems' interactions and failures [R.I.1]. Learning to live with change and uncertainty [308]. Uncertainty to be faced by 'science and art' [102] and phronesis; becoming experts [90] continuous social learning on the complex systems' evolution [102] and impacts. Raise awareness of major emerging risks relevant to society; standardising disclosure, stakeholder dialogue; knowledge sharing and developing best practice solutions [310]. Long-term impact analysis for understanding institutional and operational changes required [321]. Promoting learning and continuous improvement of operations and adapt to lessons learned for improved system reliability [361]. Social learning for approaching science, policy and society, combining different types of knowledge for learning [306]. Nurturing diversity for resilience [394].						Knowledge transfer and social learning

The starting point is represented by the ‘critique phase’, part of the concept of “future workshop” (Jungk and Müllert, 1987; Valqui Vidal, 2005), a methodology designed to facilitate greater participation into processes addressing real-life problems. In this phase some challenges are identified (score 2 in the matrix), identifying current states or changes that can be considered systems’ vulnerabilities, challenging the achievement of sustainability.

A theme falling into the category of constant worsening (score 1) indicates a risky choice related to the challenge or other worsening cause, possibly leading to a failure. It is a state of inadequacy of the system to maintain its equilibrium and endure throughout time, conserving its own functions. It says: ‘BEWARE!’ A situation of ‘SYSTEM FAILURE’ (score 0) indicates a state in which the system is compromised and irreversible losses are produced. This critical thinking can be associated with the conceptual idea that characterises the Futures Wheel (2013), i.e. the brainstorming about impacts of different order that are produced by given policies or actions and the choice between alternative futures. The critical phase is important for understanding which lessons can be learnt, as for instance Schläpfer and Glavitsch do in their report on the failure of the ECEI (2006).

Indeed failure events can be addressed and possibly reversed (Valqui Vidal, 2005), so if a given factor or action is proven (even if partially) to have failed, its avoidance or an alternative action might indicate the right direction to follow. Thus, the additional element that helps in defining possible present choices is given by the preventative definition of the future goal that is considered as desirable, according to the concept of back-casting (Dreborg, 1996; Vergragt, 2011). This was introduced in the first chapter as *«generating a desirable future, and then looking backwards from the future to the present in order to strategise and to plan how it could be achieved»*. We can often build our desired future by ourselves, among the many possible futures. The representation of the backcasting process is described in Figure 37 (The Natural Step, 2013; page 185) and suggests that in order to know *how* to behave at present and design our strategies (i.e. plans or methods to achieve a future goal), it is important to be aware of *what* goal we would like to reach. According to this approach, the challenges and the potential impacts, that we define by critical analysis through the futures workshop (Jungk and Müllert, 1987; Valqui Vidal, 2005) and potential impact (the Futures Wheel) are addressed by the definition of future goals and the choice of actions, belonging perhaps to the possible scenarios, that are needed to achieve them.

Following this reasoning, level 4 in Figure 36 (page 182) represents the desired goals, in terms of the more sustainable or less unsustainable goals to be reached, in relation to the challenges. It indicates a possible state of equilibrium and systems' endurance and reliable functioning. As already mentioned, it can be represented in short by the definition of the 'WHAT'. Once the goals have been set, level 3 indicates the 'HOW', i.e. the possible actions or behaviours to learn (or those that have already been learnt) in order to pursue more sustainable pathways and possibly achieve the identified goals. In the Socio-Technical Systems (STS) case presented above, the 'how' consists of raising of awareness and learning about systems' dynamics. This follows a phronetic research planning approach (Flyvbjerg, 2004) that, through learning processes, represents a key factor for maintaining the sustainability of those Socio-Technical Systems (STS). It is important to mention that the goals and the actions identified respect the GAME sustainability criteria for STSs—the non-negotiable or less negotiable general rules or guiding principles previously identified in Table 41 (page 196) that are built upon a more objective evaluation of evidence. This helps reducing the uncertainty of subjective value-judgments, and individual or societal preferences. Certainly, the outcomes of each contextual application can and should help in adjusting the criteria, thereby contributing to a continued social learning process.

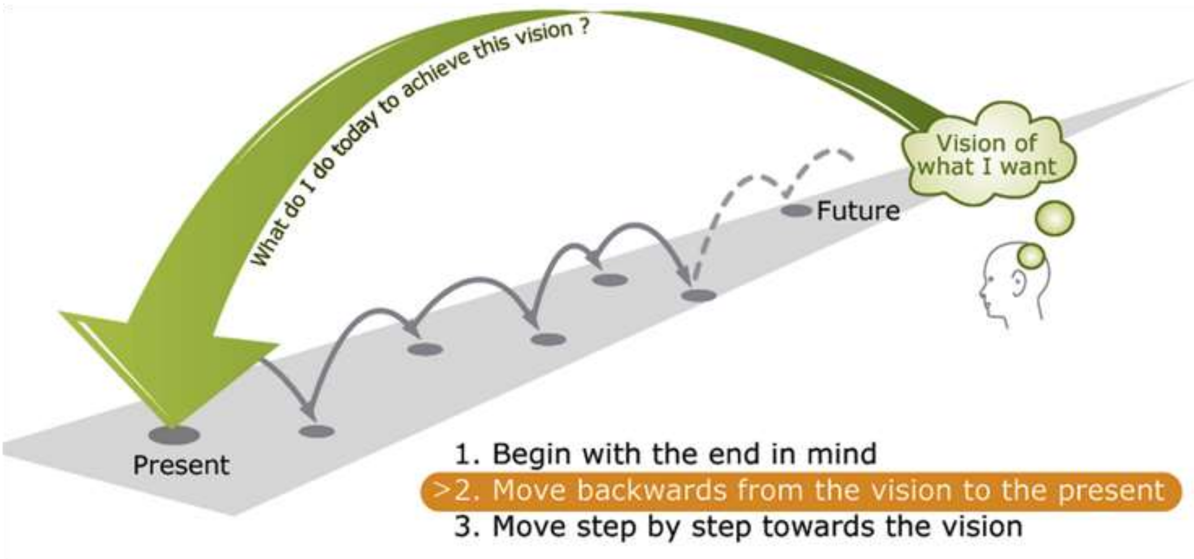


Figure 37. The backcasting approach (source The Natural Step, 2013)

The GAME approach integrates a number of existing frameworks and theories:

- the Five Capitals Model of Sustainability provides the most important dimensions relating to sustainability issues (Forum for the Future, 2013);

- examples of qualitative assessment matrices provide a useful framework for assessing data of different forms (Funtowicz and Ravetz, 1990; EdSteps, 2014);
- the Future Workshop, involves the critique phase for learning from the past and the visionary phase to set future goals and corrective actions (Jungk and Müllert, 1987; Valqui Vidal, 2005);
- the concept of backcasting, on which the Future Workshop is also based (Dreborg, 1996; Vergragt, 2011; The Natural Step, 2013);
- brainstorming, mind mapping (Valqui Vidal, 2005) and phronetic learning about possible impacts and countermeasures (Flyvbjerg, 2012)
- the Futures Wheel (2013) for carrying out the systemic multi-impact analysis.

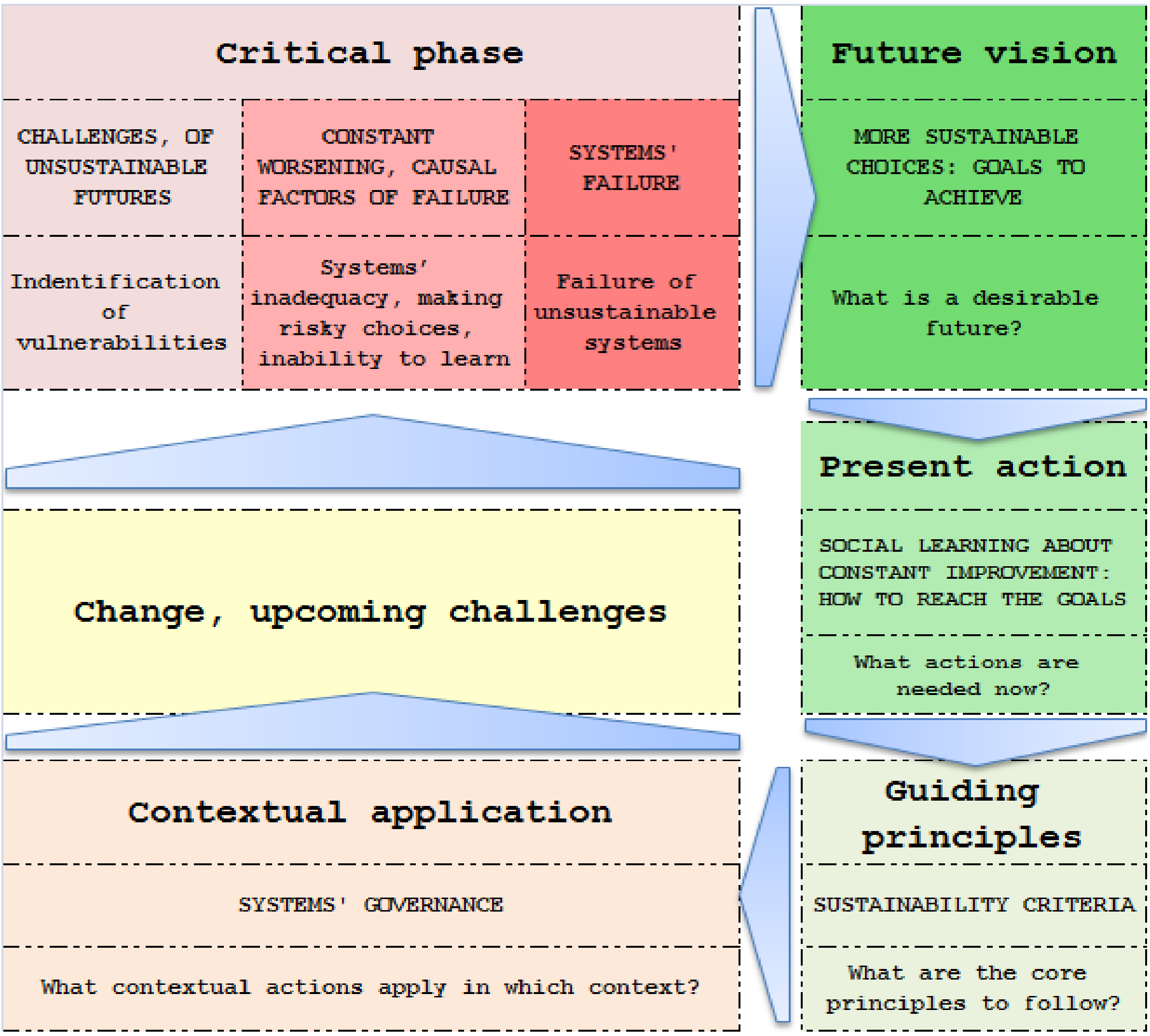


Figure 38. The GAME methodological and learning process

The criteria should also contribute to reducing uncertainty, by allowing the participation of a plurality of stakeholders on an equal basis and avoiding dominant positions, considering all possible perspectives and interests. Starting from a plurality of different subjective visions or preferences, sometimes conflicting, governance builds increasing agreement around more or less general constraints and enablers for the action of the community of stakeholders. For instance, everybody could possibly agree that the first condition of security is absence of threats, a condition that could be established as a key criterion. Consensus as agreement can be considered alongside consensus about difference, for instance in relation to the specific measures to be realised in specific contexts in order to comply with the general criterion. This means excluding all those solutions potentially increasing threats and promote those solutions, which do not increase or, even better, decrease them. In a subsequent phase, more specific issues could be addressed and key findings used to adjust or integrate the already existent sustainability criteria. In this way, the governance action defines the availability of resources and the entitlements needed to enter and proceed within the sustainability space and adapts to the changing conditions of the external environment in order to maintain the sustainability equilibrium. This approach is intended to realise an open, transparent and auto-corrective process that is continuously evolving (see Figure 38, page 186).

In light of the approach presented above, governance means allowing for the sharing of responsibilities among a plurality of participants and also ensuring the accountability of decision-makers towards stakeholders. The theory, and the analysis performed, do not aim at achieving an established truth, but at the realisation of an evolving process of open-ended social learning and continuous development, which is affected by the capture and assimilation of experiences from local contexts. Such an abductive approach is able to form the scientific theory, i.e. the rules or criteria or constraints, within human agency that can develop in different situations and local contexts, providing specific solutions that respond to more general non-negotiable sustainability constraints, related to ethical considerations or urgent issues.

The use of multiple techniques is not required to provide the same response for different contexts, but instead to verify the compatibility of results in terms of scale and the possibility to integrate them, in order to build a holistic understanding of phenomena. This social learning can help integrate information from a variety of sources and provide knowledge and general expertise that can be defined more as the necessary wisdom for understanding whole systems (see Figure 39, page 188). This acquired expertise applies beyond the dimensions of

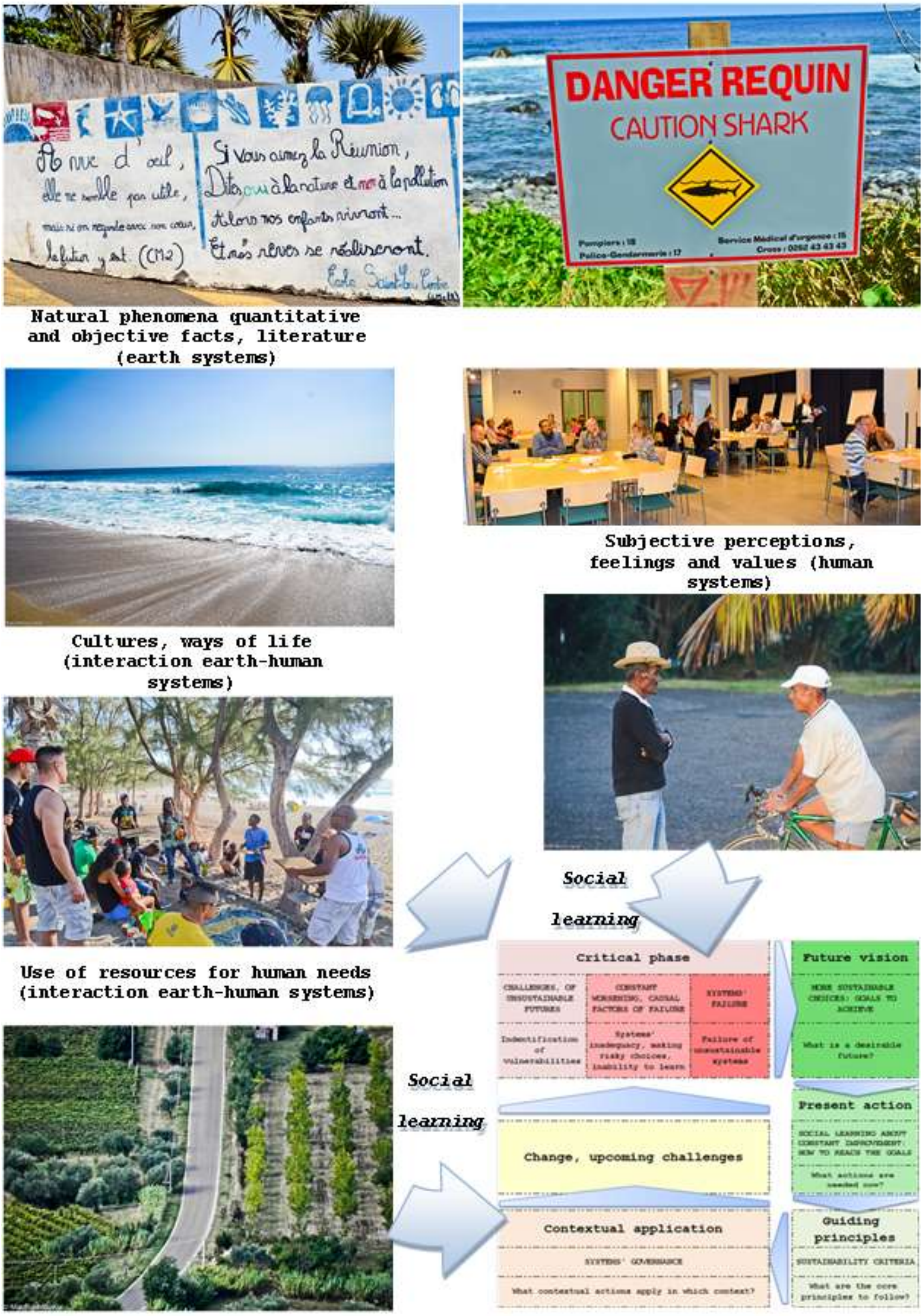


Figure 39. The translation of unstructured data into knowledge and wisdom by phronesis

space and time and is able to understand human actions according to a principle of ethics, that divides them between right or wrong, for what concerns rights, obligations, social benefits, fairness, or other kind of virtues (Velasquez et al., 1997).

Starting from the experience of existing approaches, such as for instance 'Imagine' (Bell and Coudert, 2005), the GAME methodology allows interpreting, integrating and associating unstructured data of different forms (quantitative or qualitative, subjective or objective) from a variety of sources that are measured or expressed in a variety of ways (what the authors call rich pictures), to realise structured scenarios that can actually tell a story of the possible futures and translate data into structured information (the capitals) and then into knowledge; the systemic interaction and the building of consciousness and wisdom about Socio-Technical Systems (STS) sustainability or about the sustainability of a single context (see Figure 39, page 188).

7.2 Time to play the 'GAME'

The three case studies that have been described in chapter 6 have produced criteria which define the 'rules of the GAME', the non-negotiable or less-negotiable general sustainability criteria, that have been classified according to the Five Capitals Model of sustainability in Table 38 (page 183). From a theoretical starting point, a key aspect for the GAME methodology, as previously mentioned (sub-section 1.3) is the priority given to basic needs, those at the bottom of the Maslow pyramid (Sajeva, 2012) and environmental resources. This idea of priority and the concentric structure of the sustainability pillars that are unequal in terms of importance and dimensions (Scott Cato, 2009), detaches from the logic of compromise. This is why the general expertise and wisdom has to be used in order to understand and assess contextual needs within resources. This means entitling and enabling human agency, within the established ethical standards or general rules, non-negotiable boundaries and virtuous behaviours that we need to follow in other to produce sustainably and avoid harm, founded on ideals of honesty, compassion and loyalty (Velasquez et al., 1997). However, the 'rules' of the GAME, based on ethical standards, evolve; perceptions, laws, markets and social norms do not necessarily develop in an ethical way reflecting sustainability goals, so the GAME structure has to be able to adapt. In this way, the GAME is based upon a continuous endeavour for social learning about systems' dynamics, that are the basis for the achievement of sustainability goals.

In sub-section 7.1, the structure of the 'GAME' has been defined as a participatory and multi-disciplinary analysis of information within and between systems; it is intended to identify challenges and possible failures, vision future goals and thereby learn how to avoid failures and move towards the achievement of those goals.

Once the rules and the methodology are defined, the 'GAME' can be played for the first time on a test case study, as described in Chapter 8.

7.2.1 The plan for a test case study

The GAME methodology derived from the development of the first three cases will be tested in a final case (see the graph on the social learning process in Figure 22, page 133) on the security and sustainability of the food system. This will be done in connection with the work of the researcher as a Scientific Liaison Officer at Natural Resources Institute Finland Luke (MTT Agrifood Research Finland until the end of 2014), a research institute under the Ministry of Agriculture and Forestry of Finland. In particular, the testing of the GAME methodology and framework will be undertaken through the analysis of data collected during three participatory workshops in which the author has been actively engaged as researcher, facilitator and chair. These focused on the challenges, the goals and the necessary policy and operative actions in relation to three main areas:

- Food security
- Sustainable food production and consumption
- Sustainable organic farming

These activities have been based on the *ad-hoc* structure characterising the GAME methodology and framework, made of challenges, risks, goals and policies to be put in place for their achievement (see the GAME framework in Chapter 7). Furthermore, the workshops have been complemented by the insights and outcomes of the EURAGRI Conference, held on 28-30 September 2014 at IAMM, Montpellier, France and content analysis of relevant literature and reports.

This last phase of my research has also been presented in a seminar at the Department for Innovation in Biological, Agro-food and Forest systems (DIBAF) of the Tuscia University of Viterbo, Italy and the GAME exercise presented at Universitas Mercatorum (Rome, Italy), Business Systems Laboratory (Sajeva, Sahota and Lemon, 2014, 2015).

8 Testing the GAME methodology on the case of the security and sustainability of the food system

Objective	To test the GAME matrix on a practical example the security and sustainability of food systems for the determination of the sustainability goals in the food sector and of actions needed for their achievement
Content	8.1. The methodology for the case study analysis 8.2. The social learning process through data triangulation and integration 8.3. Substantive and methodological findings of the application of the GAME to the security and sustainability of the food system

According to the concept of requisite variety, *«to deal properly with the diversity of problems the world throws at you, you need to have a repertoire of responses which is (at least) as nuanced as the problems you face»* (Requisite Variety website, 2014). The GAME exercise aims at initiating a process of social learning about possible social structures, which would be more appropriate to the complexity of systems' interrelations and the challenges of present and future uncertainty. Following the concept of requisite variety, the GAME exercise aims at understanding the multifaceted dimensions of sustainability to derive some general sustainability criteria that would inform more sustainable choices. The case studies previously carried out have been used to generate the GAME methodology and framework, on the basis of sustainability criteria, generalised in successive steps from the final matrix generated from the case studies (Table 38, page 183) to a more aggregated version for the purpose of the test case study (Table 41, page 195). A more general and aggregated version of the criteria is represented in Table 42 (page 196) and is presented in Sajeva, Sahota et.al. (2015). The challenge in the definition and generalisation of the GAME matrix lies, in large part, with the considerable amount of data to be grouped and aggregated.

The aim of the following test case study is, on the one hand, to verify whether the GAME framework and methodology can be effectively applied to a different Socio-Technical System (STS), and on the other hand, whether the criteria derived can be confirmed as being of general value and or modified according to the findings of the new study. The nature of the GAME methodology, as treated in the literature and as specified in sub-section 8.2. is to learn and realise a process of interchange of different types of tacit and explicit knowledge, between experts and participants in the process. The governance process is meant to be adaptive and able to learn from the interactions among and between systems, so that these general criteria might be adjusted over time. When the general criteria are identified, they are used to provide a direction to follow when contextual strategies and operations are put in place.

8.1 The methodology for the case study analysis

The sustainability of the food system has been assessed through the GAME matrix by narrative analysis, interviews and workshops, according to the general criteria of reference identified by the previous case studies (see Table 41, page 195).

The methodology adopted for this last case study has taken advantage of narrative material of websites and reports (e.g. the CGIAR, the Consortium of International Agricultural Research Centres (2014: 3) **[344]** and the Susfood ERA-net Strategic Research Agenda on sustainable production and consumption (Dahl Kristensen, Kurppa and Darcy-Vrillon, 2014: 7) **[352]**. Moreover a number of foresight studies have also been analysed: SCAR **[246]**, Foresight studies on scarcities **[328]**, FAHRE **[79]** **[80]**, Agrimonde **[330]**, DuALIne **[65]**, Roadmap to a Resource Efficient Europe **[32]**, HDHL JPI, FACCE JPI, ETP Food for Life, Corpus **[64]**, Defra 2030. In addition, the narratives of the following three workshops have been generated and analysed:

- The priorities in food security (internal workshop at Natural Resources Institute Finland Luke) **[W.IV.1]**
- Sustainable food production and consumption (within an EU FP7 ERA-net project) **[W.IV.2]**
- The specific area of organic and low-input food production (within an EU FP7 project) **[W.IV.3]**

On the basis of the general GAME sustainability criteria previously determined by the earlier case studies I, II and III (Table 41, page 195 and Table 42, page 196), and the GAME methodology and framework (Figure 36, page 182), the workshops aimed to generate participatory interaction for the identification of challenges (Table 43, page 203), possible worsening situations (Table 44, page 204) as well as potential failures (Table 45, page 205), goals (Table 47, page 207) and policy actions (Table 46, page 206) relating to the sustainability of the food system. These were then linked to the GAME criteria (Table 41, page 195) and to the new ones that were generated (see Table 48, page 209). The proceedings of the workshops were confidential and the identity of all participants and experts interviewed remained anonymous (see Table 40, page 194). Besides the workshops, the GAME matrix has been used at the EURAGRI Conference held in Montpellier on the 29th and 30th of September 2014 (EURAGRI, 2014) **[345]**. Here it was used to map a range of information, starting from the challenges and possible states of unsustainability, leading to discussions about the possible improvements, policies and actions that would support the identified sustainability goals. The information delivered and the discussion held at the conference were mapped onto the GAME framework, according to the five capitals and the level of sustainability. Finally, a number of interviews were carried out with experts in different fields associated with the food sector as listed in Table 39 (page 194). The interviews were realised following the same process as described in Chapter 7 for the workshops. This time, as the process was not participatory, the experts were asked individually to talk about a challenge in the food system they have been analysing, the possible worsening and failure situations, and their vision of the goals and actions to address them.

All the data gathered in the previous analyses have been mapped through the GAME framework (Table 43, page 203; Table 44, Page 204; Table 45, page 205; Table 46, page 206; and Table 47, page 207 of sub-section 8.2), to identify the interconnections within and between systems, to determine possible actions according to the criteria and to identify possible additional criteria. The mapping process is clarified in the narrative on the sustainability and security of food systems, as described in sub-section 8.2.

Table 39. Interviews performed on the basis of the GAME methodology for the food system.

Research experts	Public institutions	Associations, non-profit organisations
[R.IV.1] Expert in dairy technology, organic production (sensory evaluation)		**[A.II/IV.1]** Finnish independent non-profit organisation for conflict resolution and sustainable peace
[R.IV.2] Expert in organic and agro-ecological livestock farming approaches, standard development and values in organic farming		
[R.IV.3] Expert in quality and responsibility in the food chain, consumer oriented food chain	**[PUB.II/IV.3]** Ministerial research and development department for research and knowledge transfer on security	
[R.IV.4] Expert in food technology	**[PUB.II/IV.4]** Expert in hygiene, food security and safety in developing countries of a Ministerial research department	
[R.II/IV.5] Expert in regional development		
[R.II/IV.6] Expert in political studies		
[R.IV.7] Expert in economic analysis of food markets: price formation, food choices and nutritional health		
[R.IV.8] Expert in breeding, organic breeding, social farming and rural development		

Table 40. The participants in the workshops on the security and sustainability of food systems

Food security [W.IV.1]	Sustainable food production and consumption [W.IV.2]	Sustainable organic farming [W.IV.3]
Expert in hygiene, food security and safety in developing countries of a Ministerial research department	French Agricultural Research Institute: experts in agricultural and water technologies, chemistry, toxicology, human nutrition	Organic and conventional farmers (food producers)
Expert in quantitative genetics in fish breeding and dairy production systems, environmental impact	Finnish Agricultural Research Institute: experts in governance of sustainability, futures studies, agroecology, biochemistry	Representative of organic food association
Expert on environmental protection, pollution, climate change, greenhouse gases	Expert form Estonian Ministerial research and development department for research and knowledge transfer on security	Policy officer
Experts in lawn research, potato, biotechnology, tissue culture, plant breeding, genomics, food security in development countries	Belgian Agricultural Research Institute expert in food safety, marine biology	Mangers, distributors and retailers
Expert in food technology, organic production	Animal expert, veterinary	Feed nutritionist
Expert in agricultural and food sciences	Food expert from Turkish Ministry of Agriculture	Extension services
Expert in animal health economics and land use	Expert on post-harvest technologies	Farm animal experts and veterinaries
Expert in food security and gender issues	Professor of Agricultural and Resource Economics	Other stakeholders
Expert in molecular biology, molecular genetics, gene technology	Food policy makers and economists from European Ministries and National Agencies	Agronomist and organic certification controller
Expert in organic farming, climate change, biocontrol, biochar	Experts in food science and humanities, chemistry and toxicology, human nutrition	Adviser to production and distribution

Table 41. The criteria for the GAME methodology

MATRIX OF CRITERIA FOR GAME METHODOLOGY

NATURAL CAPITAL	HUMAN CAPITAL	SOCIAL CAPITAL			MANUFACTURED CAPITAL	FINANCIAL CAPITAL	Criteria thematic areas
		Social sustainability	Governance	The reliability of markets	Sustainability and reliability of infrastructures	The reliability of the financial system	
Alternative evaluations for non valuable impacts [310]. Reducing uncertainty and approaching subjective and objective risk [159], raise awareness of major emerging risks relevant to society: standardising disclosure, stakeholder dialogue; knowledge sharing and developing best practice solutions [310]. Systematic and immediate communication about interactions and failures [R.I-1]. «Learning to live with change and uncertainty» [304], to be faced by 'Science and Art' [102] and phronesis: becoming experts [90] on the complex systems' evolution [102] and impacts. Long-term impact analysis for understanding changes required [322]. Learning, adaptation and continuous improvement of operations for system reliability [342] for approaching science, policy and society, combining different types of knowledge [304].							Knowledge transfer and social learning
Governance and cooperation in the competition and mandatory standards for interdependent systems questions of public relevance [Hi.II.1] [R.II.4] [R.II.3] [A.II.3] [350] [218] [337].						Rising awareness of failure of market signals in reflecting physical limits [378]. Alternative evaluation systems [310] [332]	Systems limits and adequacy
Adequacy and reliability of systems in relation to security: assuring the ability to maintain own functions in the long-term in relation to the possible security threats and imminent disturbances according to quality and quantity standards [321] [308] [220] [Hi.II.1] [125] [316] [228] [320] [318] [308] [314].							
Systems well below their limits and within larger systems, avoiding to work under conditions of stress, adaptive capacity, adaptation of all systems to changes [347]. Collective security considered as the overarching concept [102] related to safety and development [R.II.2] strictly interrelated with the need of food security, seen as a human right [362] [PUB.II.2]. Sustainable development [210] and human security [A.II.1] as a human right (national and individual) [PUB.II.1], basic need and a public collective good [210] [279] even implying reduced economic results [337].						Growth acceptable if not reducing employment and not increasing energy consumption or income distribution, nor undermining environmental and human health or the meeting of basic real needs, and in general causing irreversible damage onto the other overarching capitals [60] [MBC.II.1]. Growing capital when security is met [102], based on green technologies [378].	
Common criteria of inclusive green economy (use of resources for meeting basic needs) for consumption and production [361]. Absence of systematic increase of concentrations of substances produced by society or extracted from the earth's crust, absence of systematic physical degradation of nature and natural processes [259]. Self-organization towards social-ecological sustainAbility [304]. Environmental risk based appreciative value system [Q.III.1]. Favorable conditions, incentives and policies for the flourishing of renewable energy technologies [311]. Localisation and flexibility for improving sustainability and reliability [R.I.1]. Non negotiable an absolute ceiling for greenhouse gases (GHG) concentration [378]. Green technology with reduced use of water, no waste and lower risk to human and environmental health. Investment in reduction of transport, energy consumption and increase of efficiency, decentralised renewable energy sources [W.III.1] [Q.III.1]. Nuke and fossil generation to be abandoned [Q.III.1]. Low or zero carbon technologies in generation, transmission and distribution [Q.III.1]. Macroscopic marine algae and seaweeds, or microalgae, to become important sources of bio-energy production, and to replace oil by 2050, as a cheap and carbon neutral form of energy production, but also a good way to carbon caption form atmosphere [Q.III.1].	Happiness and entitlement for well-being, standards of living, human safety [310] [228] [9] [323] [159] [PUB.II.1] human rights and human development [41] or irreversible harm [310] freedom from threats [RII.1] [R.II.2] [275] for human health and quality of life, [W.III.1]. "Happy and wellbeing people do not make crimes" [144]. Absence of economic and social disparities that can produce violence (physical or structural), empowerment of women [389]. Intervention at the self-control level [389]. Cultural elements of honesty and trust [A.II.1]. Feeling to live in a fair and equal society regardless of identity [86]. Connection of safety and security policy issues [R.II.2]. Poverty and inequality reduction [361], distribution policies, avoidance of non decent living conditions in rural slums [349]. Absence of conditions that systematically undermine people's capacity to meet basic human needs, unsafe working conditions and not enough pay to live on [259] higher levels of quality of life, capabilities, and freedom [230] to live within system's boundaries [126] by mean of the social structures [354].	Strengthening of general economic development, in terms of social well-being, general security, trust in the economy and business expectations [Q.III.1]. Strengthened social welfare, during the transition process (social effects, labour policies, jobs) [Q.III.1]	Anticipating the need for control [279]. Logic of prevention, intervention at the level of self-contol, leaving at last social and official control [389]. Education based on ethics and cultural virtue [284] [389]. International stability, security, peace, justice, rule of law, democracy and human rights. Focus on future needs and entitlements [361].	Entitlements and enablers for local and smallholder farms to exert their agency [349].	Smart Grids and "cross-border regulatory cooperation for revised energy generation technology." for energy [Q.III.1]. Replacement of transport technologies and infrastructures by advanced lower-impact ones (intangible or 'less tangible'). Investments in interconnected systems for security, reliability and regional market integration [Q.III.1] [W.III.1].		Sustainability of systems and their priorities, focus on reduction of minimisation of threats
		Trust, reliability of security operators, safety, care of citizens, respect of legislation, control and rejection of the culture of corruption, tolerance [279]. Absence of culture of fear and aggression/intervention [279]. Corruption not be tolerated [Q.III.1]. Well-being main factor for assuring security, to be approached holistically through interaction [PUB.II.1]. Governance of security not delegated to technology [Hi.II.1]. 'Happiness strategy' and close cooperation of security operators and public officials with experts of the social and welfare system [361]. Governance for security as making people happy and not being hated, having no need for fortresses [156].			Low-impact transport technologies and infrastructures (intangible or 'less tangible'). "Cross-border regulatory cooperation and smart grid to handle revised energy generation technology." Replacing oil with biofuel. Capacity to mitigate the risk of disruptions in the energy supply [Q.III.1].	Increasing prevention expenditure: setting control systems [W.III.1]	
		Security services focused on real needs. Convergence of subjective and objective security [MNC.II.1] [SME.II.1]. Public goods as policy design and social constructs [133]. Adequacy of regulatory systems to market and technological development [Hi.II.1] [102]. Cooperation in the competition and participatory and inclusive 'good' governance for matters of public relevance; definition of regulatory standards [210] [Hi.II.1], adoption of common protocols [R.I.1] approved for reliable operation of a system [316]			Spreading the risk: local self-sufficiency to break the complexity and reduce vulnerabilities [R.I.1]. Flexibility and adaptive capacity of physical, regulatory and social infrastructures. Precautionary principle. [R.I.1] [Hi.II.1]		
Urgency of setting sustainability goals, by governance process: CO2 to be reduced below 10% by 2050, below the 400 ppm of CO2 [Q.III.1]. Mitigate the environmental impact on humans by prevention action (precautionary principle) [322]. Assurance of crucial functions of productivity, hydrological cycles, social relations and economic prosperity [292] [321]. Reducing overpopulation in harmonic balance with its productive potential and carrying capacity of the hosting ecosystems [4]		A joint energy governance council to identify and limit the risks. Participatory decision-making process for establishing common goals and ensuring the implementation of energy goals by mandatory standards, for the control of climate change. Mandatory quota system for efficient utilities' [Q.III.1]. Regional and EU-level cooperation between investors and regulators for the correct functioning of the market. [Q.III.1]. Principles of good governance: participation (a voice for all in decision-making), transparency, responsiveness, consensus orientation, equal opportunities of involvement, effectiveness and efficiency of processes (meeting needs with the best use of resources), accountability of decision-makers to stakeholders and strategic, long perspective vision, understanding complexity and heading to human development [41]. Social responsibility, to assure security and adaptive capabilities of systems [230] [Q.III.1].			Electricity generated by using low carbon energy sources. Concentrated Solar Power (CSP) is at the same time the most effective renewable resource of energy but not necessarily local: "CSP will be essential to balance supply and demand, unless we are happy to be cold and poor". Mix of transmission (wind, CSP) / distribution connected (photovoltaic, biomass) generation systems, bio-fuels (trucks, ships, planes), and electrical/hybrid vehicles [Q.III.1].		
Focus on the relation human-nature. 'Health and environmental factors first order determinants for the energy supply mixture' [Q.III.1]. Environmental protection and sustainable management of natural resources are as well a precondition for food security. Food security is in turn also a condition for environmental sustainability. The systemic vision allows a deeper understanding of all possible implications and interconnections [361].		Improvements and opportunities in the market model and/or the regulatory framework. Globalisation, expansion or localisation of markets, according to the needs [W.III.1]. "Local communities will determine whether new technologies and policies conform to their local societal norms." Avoidance to depend on only an energy source: spreading the risk [Q.III.1]					

Table 42. The generalized criteria for the GAME methodology (as published in Sajeva, Sahota and Lemon, 2015)

<table>
<tr><td colspan="8">MATRIX OF CRITERIA FOR GAME METHODOLOGY</td></tr>
<tr><th rowspan="2">NATURAL CAPITAL</th><th rowspan="2">HUMAN CAPITAL</th><th colspan="3">SOCIAL CAPITAL</th><th>MANUFACTURED CAPITAL</th><th>FINANCIAL</th><th rowspan="2">Criteria thematic areas</th></tr>
<tr><th>Social sustainability</th><th>Governance</th><th>The reliability of markets</th><th>Sustainability and reliability of infrastructures</th><th>The reliability</th></tr>
<tr><td colspan="7">Awareness of failure of market signals in reflecting physical limits [378]. Alternative evaluations for non valuable impacts [310] [332], environmental risk based value system [Q.III.1]. Reducing uncertainty, approaching subjective and objective risk [159], raise awareness of emerging risks to society: standardising disclosure, stakeholder dialogue, knowledge sharing and best practice [310]. Systematic communication of interactions and failures [R.I.1]. «Learning to live with change and uncertainty» [304], by 'Science and Art' [102] and phronesis: becoming experts [90] on the complex systems' evolution [102] and impacts. Long-term impact analysis and learning, approaching science, policy and society, combining different types of knowledge [304], for adapting to changes [322] and continuous improvement for system reliability [342].</td><td>Knowledge transfer and social learning</td></tr>
<tr><td colspan="6">Adequacy and reliability of systems in relation to security: assuring the ability to maintain own functions in the long-term in relation to the possible security threats and imminent disturbances according to quality and quantity standards [321] [308] [220] [Hi.II.1] [125] [316] [220] [320] [318] [308] [314]. Systems well below their limits and within larger systems, not working under stress, adaptive capacity, adaptation of all systems to changes [347].</td><td rowspan="3">Economic material growth acceptable if not reducing employment and not increasing energy consumption or income distribution, nor undermining environmental and human health or the meeting of basic real needs (irreversible damage) [60] [MNC.II.1]. Growing capital when security is met [102], based on green technologies [378].</td><td>Adequacy to systems' limits</td></tr>
<tr><td rowspan="3">Common criteria of inclusive green economy (use of resources for meeting basic needs) for consumption and production [361]. Absence of systematic increase of concentrations of substances produced by society or extracted from the earth's crust, absence of systematic physical degradation of nature [259]. Governance of social-ecological sustainability [304]. Incentives for renewable energy technologies [311]. Localisation and flexibility for sustainability and reliability [R.I.1]. Non negotiable limits [378]. Reduced use of water, no waste and lower risk to human and environmental health. Reduction of transport, energy consumption and increase of efficiency, decentralised renewable energy sources [W.III.1] [Q.III.1]. Abandon of nuke and fossil energy [Q.III.1], cheap and carbon neutral bio-energy production and carbon caption form atmosphere, (e.g. macroscopic or microalgae) to replace oil by 2050 [Q.III.1].</td><td rowspan="4">Sustainable development [210] and human collective security [A.II.1] as a human right (national and individual) [PUB.II.1], basic need and a public collective good [210] [279] even implying reduced economic results [337], as the overarching concept [102] related to safety and development [R.II.2] strictly interrelated with the need of food security, seen as a human right [362] [PUB.II.2]. Happiness and entitlement for well-being, human safety and security [310] [220] [9] [323] [159] [PUB.II.1] [R.II.2], human rights and human development [41], freedom from threats [RII.1] of irreversible harm [310] [R.II.2] [275] for human health and quality of life [W.III.1]. "Happy and wellbeing people do not make crimes" [144]. Equal society regardless of identity [86] and free from economic and social disparities that can produce violence (physical or structural), empowerment of women [369]. Cultural honesty and trust [A.II.1]. Poverty and inequality reduction [361], distribution policies, avoidance of non decent living conditions in rural slums [349]. Absence of conditions that systematically undermine people's capacity to meet basic human needs, unsafe working conditions and not enough pay to live on [259] higher levels of quality of life, capabilities, and freedom [230] to live within system's boundaries [126] by mean of the social structures [354].</td><td colspan="2">Anticipating the need for control [279]. Prevention, intervention at the level of self-contol, at last social and official control [389]. Education based on ethics and cultural virtue [284] [389]. International stability, security, peace, justice, rule of law, democracy and human rights. Focus on future needs and entitlements [361].</td><td>Entitlements and enablers for local and smallholder farms to exert their agency [349].</td><td>Smart Grids and "cross-border regulatory cooperation for revised energy generation technology." for energy [Q.III.1]. Replacement of transport technologies and infrastructures by advanced lower-impact ones (intangible or 'less tangible'). Investments in interconnected systems for security, reliability and regional market integration</td><td rowspan="5">Sustainability of systems and their priorities, focus on reduction of minimisation of threats</td></tr>
<tr><td colspan="3">Economic development as social well-being, general security, trust in the economy and business expectations [Q.III.1]. Trust, reliability of security operators, safety, care of citizens, respect of legislation, rejection of corruption, tolerance [Q.III.1] [279]. Absence of culture of fear and aggression/intervention [279]. Well-being for security, holistically through interaction [PUB.II.1]. Governance of security not delegated to technology and control [Hi.II.1]. 'Happiness strategy' and close cooperation of security operators and experts of the social and welfare system [361]. Governance for security as making people happy and not being hated, no need for fortresses [156].</td><td>Low-impact transport technologies and infrastructures (intangible or 'less tangible'). "Cross-border regulatory cooperation and smart grid to handle revised energy generation technology." Replacing oil with biofuel. Capacity to mitigate the risk of disruptions in the energy supply [Q.III.1].</td></tr>
<tr><td colspan="3">Security services focused on real needs. Convergence of subjective and objective security [MNC.II.1] [SME.II.1]. Public goods as policy design and social constructs [133]. Adequacy of regulatory systems to market and technological development [Hi.II.1] [102].</td><td>Spreading the risk: local self-sufficiency to break the complexity and reduce vulnerabilities [R.I.1]. Flexibility and adaptive capacity of physical, regulatory and social infrastructures.</td><td>Increasing prevention expenditure: setting control systems [W.III.1]</td></tr>
<tr><td>Urgency of setting sustainability goals, by governance process: CO2 to be reduced below 10% by 2050, below the 400 ppm of CO2 [Q.III.1]. Mitigate the environmental impact on humans by prevention action (precautionary principle) [322]. Assurance of crucial functions of productivity, hydrological cycles, social relations and economic prosperity [202][321]. Reducing overpopulation in harmonic balance with its productive potential and</td><td colspan="3">Joint participatory governance and cooperation in the competition for questions of public relevance [Hi.II.1] [R.II.4] [R.II.3] [A.II.3] [350] [210] [337] [210] , participatory decision-making for common goals by mandatory standards [Hi.II.1], adoption of common protocols [R.I.1] approved for reliable operation of a system [316] Cooperation between investors and regulators for the correct functioning of the market [Q.III.1]. Principles of good governance: participation (a voice for all in decision-making), transparency, responsiveness, consensus orientation, equal opportunities of involvement, meeting needs with the best use of resources, accountability of decision-makers to stakeholders and long perspective vision, understanding complexity and heading to human development [41]. Social responsibility to assure security and adaptive capabilities of systems [220] [Q.III.1].</td><td>Low carbon energy sources. Concentrated Solar Power (CSP)most effective renewable resource but not necessarily local: 'CSP will be essential to balance supply and demand, unless we are happy to be cold and poor'. Mix of transmission (wind, CSP) / distribution connected (photovoltaic, biomass) generation systems, bio-fuels (trucks, ships, planes), and electrical/hybrid vehicles [Q.III.1].</td><td></td></tr>
<tr><td colspan="2">Focus on the relation human-nature: 'health and environmental factors first order determinants for the energy supply mixture' [Q.III.1]. Environmental protection and sustainable management of natural resources as preconditions for food security, in turn also a condition for environmental sustainability. Systemic vision for a deeper understanding of implications and interconnections [361].</td><td colspan="4">Improvements and opportunities in the market model and/or the regulatory framework. Globalisation, expansion or localisation of markets, according to the needs [W.III.1]. "Local communities will determine whether new technologies and policies conform to their local societal norms." Avoidance to depend on only an energy source: spreading the risk [Q.III.1]</td><td></td></tr>
</table>

8.2 The social learning process through data triangulation and integration

Following the GAME methodology as described in Chapter 7, the test case into the security and sustainability of the food system was carried out by incorporating the data collected from the workshops, conference, interviews and published material (academic and policy documentation) into the GAME framework. Through this approach, the GAME triangulates data of different types and from different sources on the basis of the criteria defined for each of the sustainability capitals or for linking more than one capital (see Table 41, page 195). This triangulation process reinforce the validity of the findings.

In this test case, the GAME methodology and framework has demonstrated its validity first, as a learning process about possible goals and actions to be performed. The criteria have first provided guiding principles of sustainability in the analysis of alternative futures. Secondly, they have given the opportunity to confirm or refute them, on the basis of counterarguments. The data and analysis presented hereafter fitted with the sustainability criteria, and helped in a second phase to integrate and slightly modify the framework.

In the 'critique phase' of the GAME methodology, some challenges have been identified (see Table 43, page 203) and linked to cases representing the worsening, or failure of food systems, as described in Table 44 (page 204) and Table 45 (page 205). In the 'vision phase' (see Table 46), the goals for a more secure and sustainable food system have been identified and then the ways to reach them have been hypothesised (see Table 47, page 207). It is important to specify that the analysis presented in the Tables mentioned above, represents an integration and summary of all the contributions given, this is further indicated by the references attached (see Table 41, page 195, and Table 42, page 196). The brainstorming and mind mapping performed has been integrated into the GAME criteria (see Table 48, page 209) with the aim to generate social learning. This social learning process was evident in the workshops, as well as in the interviews. This has been undertaken through knowledge transfer between different levels—the explicit level descending from the criteria and the literature, and the tacit level belonging to the expertise of local practitioners and actors—moving between policy and implementation decisions and learning from 'the local' (Lemon *et.al*, 2004). On this basis more general guiding principles referring to systems limits can be set, as mentioned in sub-section 2.4.2, reconciliating ecology with economics, and shaping the *"right size"* of human systems in relation to the *«natural infrastructure»* (Sagoff, 2012). This supports learning through 'games' and 'rules' (Flyvbjerg, 2001), 'enablers' and 'constraints' (Giddens, 1984), ‘entitlements’, ‘freedoms’, ‘capabilities’ and ‘boundaries’ (Sen, 1997; Jackson, 2009) and refers to the concepts of ‘limits’ and ‘needs’ (Meadowcroft, 2013) and subjective preferences about objective facts and systems’ boundaries (Campbell, 2006). The Brundtland Commission also (1987), in referring to the satisfaction of current and future needs, poses limits to the former to satisfy also the latter, in this way also defining sustainability based on the satisfaction of human needs in relation to the resources available. This vision implicitly rejects the possibility of enlarging needs to be satisfied in a limited environment, without causing resource depletion and therefore imposes the need to respect systems’ limits.

For instance, we learnt that for the improvement of food security only partially depends upon the actual capacity of production. The basic assumption is that it is not possible (referring to the criterion of keeping systems well below their limits) to assure food security for all with significant increases in population. In order to limit population growth, one strategy focuses on poverty reduction, empowering women and assuring basic needs (EFARD, 2014) **[400] [4]**. In fact, many problems of hunger are due to the volatility of prices, to the condition of poverty and to the related inaccessibility of food, especially for small farmers. A solution was suggested at the EFARD conference in Brussels (EFARD, 2014) **[400]**, where the representative of an industrial actor described the efforts to create cooperatives in Africa (a solution that follows the criterion based on the joint integrated governance of public goods for issues lying outside individual responsibilities and administrative areas, see Table 41, page 195), as criterion for the social capital **[Hi.II.1] [R.II.4] [R.II.3] [A.II.3] [350] [218] [337]**. This also reflected the need that was expressed by other contributions for the establishment of an integrated food sustainability label **[64] [W.IV.2]** and for more healthy and sustainable approaches, such as the adoption of organic farming **[W.IV.2] [W.IV.3]**, collectively gathering the products of all small famers. These contributions support the criterion of local self-sufficiency assurance (see Table 41, page 195) that was introduced in the first case study of electricity infrastructure systems, for manufactured capital **[R.I.1] [Hi.II.1]**) and the provision of the necessary services of sanitation of products. Such intervention could also enhance the role of local farmers and productions and reinforce their position against the power of multinationals. The dominant position of food distribution, the importance of knowledge transfer and the identification of best practices were also highlighted during the workshops. Even having reached high technological levels and being able to increase food production, the presence of social inequalities and poverty, the lack of knowledge sharing and entitlements for accessing food and food resources all combined to mean the aim of food security could hardly be achieved.

The assurance of security (and the factors of trust, happiness and well-being that were evident in the second case study) in its more general sense is also a precondition for realising food security, as the first impact of conflicts is the lack of food. However, we see from the food case study that the lack of food security is also triggering potential conflicts itself **[PUB.II/IV.4]**. Through the consideration of the criteria of natural capital, we have learnt that the sustainability of food systems depends upon closing the cycles of food production and consumption, towards models of organic farming **[W.IV.2] [W.IV.3]**. These are not necessary related to current niche markets and have to put the conflict with traditional production to an end, and realise transparent and fair markets that focus on the relation and balance human-nature. Governance of fair trade schemes and certification of 'organic' food could be a strategy to put in place in order to integrate human and natural systems **[W.IV.2] [W.IV.3]**. The poverty previously considered is a threat to the achievement of environmentally sustainable food systems.

The testing exercise through the food case study has confirmed the validity and relevance of the criteria previously identified for the other three Socio-Technical Systems (STS), in order to evaluate a fourth and different STS. The GAME has allowed for the evaluation of the food system by the analysis of its internal interrelations and the interrelations with other STSs, as presented in Table 45 (page 205), Figure 41 (page 208) and in Chapter 9 in Figure 43 (page 222) and Figure 44 (page 225). The strong linkages between food and energy systems and food and security systems naturally arise. Consequently, in the light of the testing process on the security and sustainability of the food system, the criteria of the GAME matrix have been confirmed, and further integrated with aspects that are specific to the food sector but that are deeply interconnected with the existing criteria and non-negotiable aspects of sustainability.

A criterion of the primacy of the objective of food security and the subordination of sustainable energy production has been established by focusing on human-nature interrelations in the same way as health and environmental factors have been considered first order determinants for the energy supply mixture **[Q.III.1]**. This has been confirmed also by the Development policy guidelines on agriculture and food security of the Ministry of Foreign Affairs of Finland (2010) **[362]**, as small-scale biofuels can be produced whereas it would not reduce or jeopardise food production and the use of agricultural residues for the generation of energy is to be preferred. However, the criterion of avoidance of conflict and competition between the two has also been established, as the preservation of a clean environment is also a precondition for human health and food security **[361]**. That is why food and energy production should be planned and designed as interconnected and mutually supporting, according to a systemic perspective.

The case study of future energy systems has identified the relation between energy and food production and the case study on the security and sustainability of food system the need of food security to pursue environmental sustainability and security. The case study on security systems has also highlighted the interrelations between security and food security. In this case, the competition between food and energy production is highly unsustainable, as it would involve the option of a more competitive production of energy and would jeopardise food security. According to the interview and workshop sources introduced above food security has the priority **[Q.III.1] [362]** and according to an interviewed expert in food, insecurity is a key factor potentially causing conflict **[PUB.II/IV.4]**.

In the analysis performed on the food system, the worst scenario, represented by the failure of the system (see Table 45, page 206) might be represented by the focus on production policies, which do not always represent the main cause of failure. The actions needed (Table 47, page 209) to reach the goals (Table 46, page 207) have to address the challenges by actions that not only improve production processes, but that instead give pre-eminence to the entitlements for accessing food and combine them with adequate markets structures.

On the basis of the analysis for the GAME methodology, a possible evaluation graph representing the dimensions of sustainability of the food sector at present would give a totally unsustainable result (see Table 39, page 205). This is why the evaluation graphs of these two scenarios of failure of food and security systems are not represented. Current policies that claim to address the problem of overpopulation, food security and environmental sustainability of food systems by increasing food production through a focus on economic growth are often ineffective, because they do not focus on the real causal factors of inequality, lack of entitlements, education and security, food accessibility and poverty—i.e. the basic human needs—for larger portions of the global population **[W.IV.3] [345]**. According to the case study analysis, possible solutions could focus more on the establishment of fair trade organic food systems, good governance, transparency of information, local production, knowledge transfer, education and incentives for small farmers. This approach is expected to limit the volatility of prices in developing countries and empower smallholder farmers against the dominance of multinational companies **[W.IV.2] [W.IV.3]**.

The analysis has identified first a scenario (the orange lines in Table 43, page 203; Table 44, page 204; Table 45, page 205; Table 46, page 206; and Table 47, page 207), in which the problem of food security and the sustainability of food systems is treated merely by current approaches, leading to a failure, for the reason that with incremental increases in food production and applying technology, the real causal factors of food insecurity are not adequately addressed. Markets remain free and without control, so that the less advantaged people still cannot access food. Consequently, problems of environmental sustainability also arise. This scenario is not represented, as it is considered to be unsustainable.

An alternative scenario (the green line) is proposed, as a mix of policies that address societal, market, and technological issues in an integrated way, proposing solutions for reducing poverty, empowering women, and through that limiting population growth and proposing environmentally sound solutions for meeting their needs and living with dignity. The organic fair trade certification has been proposed in two different workshops, one on sustainable food production and consumption and one on organic dairy production, where different people were participating (they varied by educational background, affiliation and objectives, see Table 39, page 194). However, a scenario involving possible failures is also taken into consideration, as represented in Figure 57 (page 285). These failures might be caused by extensive industrial organic monocultures, involving higher risk of disease and of producing damage to the soil **[R.IV.8]**. The industrialisation of organic agriculture and adoption of monocultures may cause the destruction of biodiversity, causing in turn, from the social perspective, the separation between work and free time, the lack of appurtenance to the system. This could cause lack of responsibility, knowledge alienation and detachment from holistic and systemic views of ecosystems **[R.IV.2]**. According to the same expert, industrialized organic agriculture could increase the tangible infrastructure and lose flexibility of operational activities (manufactured capital) **[R.IV.2]**.

Other possible risks could be related to the rise of new diseases due to the reduction in pesticide use, or to the decrease of yields due to the lack of nutrients typical of some areas (coming from fertilisers). In this latter case a proposal has been to detach the use of the fertilizers from that of pesticides (currently they are produced by the same producers so that they are mostly combined together) **[400]**. However, the expert in organic food **[R.IV.2]** still does not support this last proposal, and compare fertilisers for fields to medicines for humans.

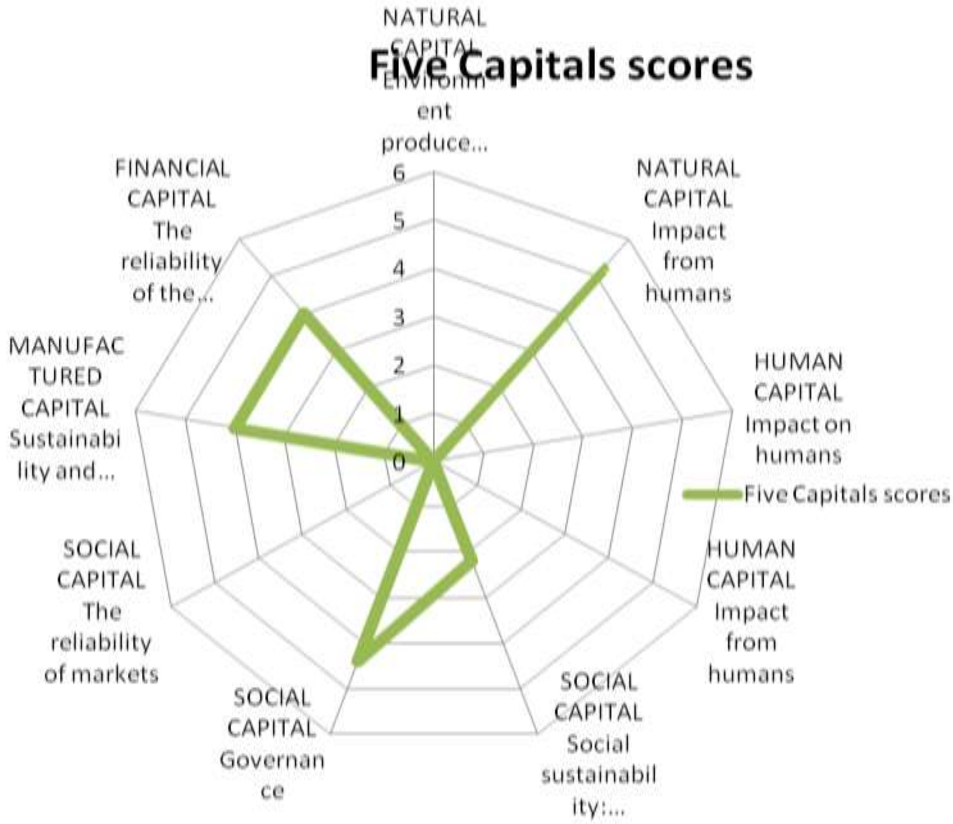


Figure 40. The possible failure of organic farming

In the view of the expert, artificial fertilisers just provide the needed chemicals but they remain detached from the whole life that exists in the agricultural land. In this view, chemical fertilisers increase yields, but remain detached from the ecological system. Instead, the expert continues **[R.IV.2]** natural fertilisers, obtained from composting of organic material, could be used, in order to integrate agricultural practices with ecological cycles. Another possible failure could be related to the lack of trust and unfair practices in certification **[W.IV.3]** **[R.IV.4]**, which would require both control systems and education within the society. The sustainability criterion of trust is an essential element that plays together with the environmental sustainability criteria of systems' harmonisation.

Table 43. GAME for the security and sustainability of the food system: critique phase, challenges

	NATURAL CAPITAL	HUMAN CAPITAL		SOCIAL CAPITAL			MANUFACTURED CAPITAL	FINANCIAL CAPITAL	Criteria thematic areas
		Impact on humans	Impact from humans	Social sustainability: public relevance	Governance	The reliability of markets	Sustainability and reliability of infrastructures	The reliability of the financial system	
	Sustainable food system: «A food system that supports food security, makes optimal use of natural and human resources, respects biodiversity and ecosystems for present and future generations and which is culturally acceptable and accessible, environmentally sound, economically fair and viable and which provides the consumer with nutritionally adequate, safe, healthy and affordable food» [352]								
	The tightening of water, energy and food resources [W.IV.2]	Food security unanimously recognised [W.IV.1] [W.IV.2] [W.IV.3] [PUB.II/IV.3] [PUB.II/IV.4] [R.II/IV.5] [R.IV.1][R.IV.2] [R.IV.3] [R.IV.8] [R.IV.2] [R.IV.7] [R.II/IV.6]. 870 hungry people on the planet, according to FAO sources [303], due mainly to the uneven food distribution (about 1.5 billion of adult people overweight or obese), as also above revealed by CGIAR data [344] (2014), and to the about one third of food waste [303]. Food security main aspect of international development policies, because of the growing amount of people affected by hunger. «The right to food is part of the right to live in dignity» [362].	«..increased demand for quantity and quality of food from a global population that will grow from 7 billion today to 9 billion by 2050» [352]. More than half of the world population lives urban areas, and expected to rise to 67% by 2050 [344]. Growing population, estimated as reaching 9 billion people by 2050, the changing diets and increased pressure on the finite natural resources [344]. Meet the demand for more nutritious, safer and cheaper food for all [352].	The greatest challenge for food security, for meeting the basic needs of the world's poorest is related to the sharing of the resources and to the reduction of food waste, which is at its highest in the low techoology processes of production of the developing world [N.IV.2] [R.IV.4]. Many poor people live in remote areas and cannot access the food which is available in the markets of develnped countries [303]	The urgency of action is required because, while in most years we produce enough food to cover the demand, or a little less, as it occurred in six of the last eleven years, the system is not adequately dimensioned in relation to social and human systems, and vulnerable to possible changes. Inadequate reserve capacities and inadequacy of the systems to satisfy the demand [303]		There is a risk that current advances of techoology are developed for industrial adoption and do not respond to the needs of the society, so that there is a need to understand how the supply chain influence agricultural production [R.IV.3][W.IV.2]. Risk of opposition by large producers and traders and preference for more profitable alternatives, other than the most sustainable ones. Too much power of the distribution [W.IV.2].	Transferring food from areas of surplus to areas of deficit, for instance by aid initiatives is not a better solution, as this contributes to reduce agricultural prices in developing countries, negatively impacting on farmers' incomes, i.e. the poorest in the world [303]. «Food insecurity in Africa is directly correlated with poverty» [356].	System adequacy
	Climate change and reduction of the agricultural production by 2% every decade, in contrast with an expected increase of demand of food by 14% every decade until 2050 [344]		«Increase global agricultural productivity using fewer inputs and with reduced environmental impacts, is it possible? [344].					The financial system is not adequate to evaluate the complexity of the systems [R.IV.2]	
CHALLENGES, VULNERABLE STATES OR CHANGES OF UNSUSTAINABLE FUTURES 2		Human development, employment, prosperity and well-being of the society [76] [W.IV.2]. Almost half the population living in developing countries, about 2.5 billion people, is located in rural areas and their subsistence depends on their own agricultural productions [362]							System adaptive capability (growing population and environmental constraints)
	The food system has to adapt to such changes, and increase the production to meet the the demand of a larger middle-income group for more protein-rich food, increased pressure on natural resources such as water and energy, climate change. So the challenge is to meet the demand for more nutritious, safer and cheaper food for all [352]. When the world population is growing and diets tend to be always richer, rising the demand for food up to 50% more food by 2050, as forseen by experts, more and more resources will be required. Meeting such demand might result quite difficult and expensive, especially because of the rising energy prices and climate change [303].								
	Dairy and crop production areas are kept as separated, making more difficult to build synergies, for instance for the recycling of nutrients. Low profitability and the bad reputation of feed efficiency of ruminants, requiring intensive feeding strategies by grains and concentrates for achieving higher productions of organic milk. Lack of homegrown protein feeds, such as beans or other protein sources replacing the too massive use of soy and concentrates, for producing more health benefits. The best forage management systems are not applied by all farmers and there is a serious disconnection between research results and actual practices. [W.IV.3]				Threat/risk of organic farming, of possible inability of organic farming to produce food enough, with possible increase of inequalities in food distribution and the rise of prices in given areas more than in others, so that scheme would eventually risk to fail in achieving more sustainable, secure and healthy food systems [W.IV.2]. In order to prevent such risk, policies for maintaining prices stable should be adopted, e.g. throught the early production and storage of stocks as buffers in times of crisis [303]				
	In organic agriculture much more land is required to produce the same quantities, if compare to conventional productions. However, research in such direction has not been developed enough, because the big companies are apparently not interested in investing in organic breeding [R.IV.8].	In organic farming, due to the absence of pesticides, risk of rise of new diseases coming from the reuse of food waste, for instance due to presence of heavy metals, so appropriate action should identify the best practices in order to avoid such risk [W.IV.2].		Impossibility in organic productions to use chemical fertilisers and just copper and sulphur, which means much lower yields [R.IV.4]	The certifying body is payed for accrediting the certification in certain local contexts there is a risk of lack of rigour, from the perspective of the technical requirements and from the perspective of the consequent message that is delivered to consumers. Presence of corruption [R.IV.4]	In some countries there is a lack of trust by consumers that do not believe that organic food would be in some way different from the conventional one [R.IV.4].		High cost for the organic certification, which often cannot be paid back by the production realized [R.IV.8]	Challenges of organic production

Table 44. GAME for the security and sustainability of the food system: critique phase, constant worsening

<table>
<tr><th rowspan="2"></th><th rowspan="2"></th><th rowspan="2">NATURAL CAPITAL</th><th>HUMAN CAPITAL</th><th colspan="3">SOCIAL CAPITAL</th><th rowspan="2">Criteria thematic areas</th></tr>
<tr><th>Impact on humans</th><th>Social sustainability: public relevance</th><th>Governance</th><th>The reliability of markets</th></tr>
<tr><td rowspan="5">CONSTANT WORSENING, MAKING RISKY CHOICES: SYSTEMS' INADEQUACY AND INABILTIY TO LEARN, CAUSAL FACTORS OF FAILURE</td><td rowspan="5">1</td><td>Grain productions have already suffered of yield reductions of 40 million metric tons per year from 1981 to 2002, which can be attributed to climate change, and it is estimated that yields of major crops will drop of 8% in Africa and South Asia by 2050. Novel climates, and new pest and weed could possibly develop on up to 40% of the world's land surface [344].</td><td></td><td colspan="2">Food insecurity is not so much the result of food scarcity, but instead the result of the lack of empowerment of citizens from an economic and political perspective for demanding food in a global market system, which includes exteme rich and extreme poors [303]. «Starvation ... is a function of entitlements and not of food availability as such. Indeed some of the worst famines have taken place with no significant decline of food availability per head» [354]. The focus on technology isn't enough, as it is necessary to act also on the ground of a better distribution [303].</td><td></td><td rowspan="2">Decrease of food security: climate change and failure of market structures</td></tr>
<tr><td colspan="3">The adaptation of the inner market system to the demand of a growing population might well encounter the limits of larger social, human and environmental systems [344]. The rural residents represent more than two-thirds of people living in extreme poverty, even if the high rate of urbanisation brought poverty and malnutrition in urban areas as well. The poorer the country, region and family, the smaller is the share of food women and girls can enjoy inside families, while having at the same time the responsibility of food production and preparation [362]</td><td colspan="2">Focus of food policies on big companies as a limitation that does not take the needs of small countries and communities into account and lack of flexibility and information at different levels, (consumers, research, processors, farmers). Lack of participation of smaller countries and weaker sociel groups [PUB.II/IV.3].</td></tr>
<tr><td colspan="2">The rapid urbanisation is also changing people diets, involving social, economic, political, and environmental impacts. The changes in the habits in urban spaces include a more frequent eating in restaurants and a reduced diet awareness. This typically causes a reduced intake of starchy crops and an increased consumption of livestock and other kind of industrially processed products [344].</td><td>The world's biggest cities growth leads to the increase of poverty in specific areas of the planet [W.IV.2]</td><td colspan="2">Very little has been made to reduce the enormous inequalities [166].</td><td rowspan="2">Decrease of food security: cultural structures and consumer behaviour</td></tr>
<tr><td>The development of China and other emerging countries poses great problems, as the demand of animal proteins continues to grow, posing serious concerns in terms of environmental sustainability. Meat and dairy consumption are in fact rapidly rising, revealing that human diets proceed in the direction of being very resource demanding and not very socially and environmentally efficient [R.IV.4].</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Extensive industrial organic monocoltures, involving higher risk of disesase and of producing damage to the soil [R.IV.8]</td><td></td><td></td><td></td><td></td><td>Risk of worsening for organic productions</td></tr>
</table>

Table 45. GAME for the security and sustainability of the food system: critique phase and system's failure

	NATURAL CAPITAL	HUMAN CAPITAL		SOCIAL CAPITAL			MANUFACTURED CAPITAL	FINANCIAL CAPITAL	
	Impact from humans	Impact on humans	Impact from humans	Social sustainability: public relevance	Governance	The reliability of markets	Sustainability and reliability of infrastructures	The reliability of the financial system	Criteria thematic areas
SYSTEMS' FAILURE 0	Already broken planetary limits, such as climate change, rate of biodiversity loss and changes to the global nitrogen cycle [N.IV.2]. Various types of chemicals have been found in the fat of penguins [345].	Hidden hunger, over 800 million people lacks calories, and 2 billion people is affected by various micronutrient deficiencies, and opposite problem of overweight, affecting over 1.4 billion people, including 300 million women and 200 million men clinically obese, also in developing countries, where rates of obesity and overweight have tripled between 1980 and 2008 and affecting more than 30 million children [344]	Following the 'population bomb', between 1960 and 2000, when world food production more than doubled, and per capita food production also increased. «Despite the growth in per capita food production in the past four decades, an estimated 852 million people were under-nourished in 2000-02» [168].	Famines as failures of entitlement, in other words the inability of parts of population to access food in one of the ways defined by social structures, economic distasters and not just as mere food crisis [354]. The neoliberal economic policies and programmes for the commercial agricultural land reform in Namibia, as well as in other several Southern African countries, have created conditions for the perpetuation of concentration of land among new black elites, besides the older white ones [349].		In some cases the arable land is available but not used because not profitable enough in global markets [R.IV.3]		The rising and the volatility of food prices and the increase of competition for scarce water, land, energy and other important natural resources, represent conditions of severe threats especially for the poor and the hungry [344] [R.IV.3]. The sudden and very significant increase of food prices between 2008 and 2009 has provoked a crisis that has reduced tens, or even hundreds of millions people into poverty [303]	Beyond systems' limits
	Situations of overpopulation are unsustainable for the hosting ecosystems, because not in harmonic balance with its productive potential and carrying capacity, a key factor to achieve sustainability is the reduction of poverty and the increase of life expectancy [4]								
		Famines occur because of oppression, injustice, destitution, breakdowns in distribution, and not because of the shortages in production. With these «misleading variables as food output per unit of population, the Malthusian approach profoundly misspecifies the problems facing the poor in the world», and that «It is often overlooked that what may be called 'Malthusian optimism' has actually killed millions of people». [231]				«Left unregulated, financial institutions behave badly. In the same way, we need a robust legal framework to restrain agriculture from destroying the environment» and that «if we don't change how the world produces and distributes its food then the suffering and violence of the past few years will be repeated - but a thousand times worse» [303].			Inadequacy of social structures
		Poverty as lack of freedom, capabilities and entitlement to command for the satisfaction of basic needs [354]. «All the food in the world won't help if people are too poor to afford it» [303].		In Namibia, seventeen years after independence and many good plans for its economic development, huge socioeconomic inequalities can be found, heritage of its colonial apartheid history [127]. Maintaining of the existing socioeconomic structures and of the status quo in terms of	Initiatives for the assurance of global and national food stocks were affected by phenomena of corruption and bad administration so that they were eventually abandoned, raising				
		Poverty and food insecurity provokes riots (e.g. in 2011 in the Middle East), physical damage and governments breakdowns, possibly just weak signals of possible future food, water, and energy shortages, cause of more poverty and civic and/or international conflicts [303]. Food security as one of the factors responsible of social imbalances and potential conflict [PUB.II/IV.4].							
				In Namibia, the huge differences in income can be seen in a labour market, which divides the population into four classes [127], great differences that are impediment for the productivity of small farms, due to the inadequacy of the support planned by the resettlement programmes [349]. : 1. A small elite enjoys standards of living similar to those of the 'first world', if we consider the low costs of living. Those are managers in the civil service (US$ 35,000-57,000 per year), and some managers in parastatal companies earning even three times more. 2. A group of formal-sector workers having permanent jobs and average/low incomes;					
	The industrialisation of organic agriculture and adoption of monocultures causes the distruction of biodiversity [R.IV.2].		industrialisation of organic agriculture: separation between work and free time, lack of appartenence to the system and lack of responsibility and knowledge and in the end system's failure [R.IV.2].	The industrialisation of organic agriculture and adoption of monocultures causes alienation and detachment from ecosystems, loss of knowledge and lack of holistic and systemic views [R.IV.2]			Industrialised organic productions have increase the tangible infrastructure and lose flexibility of operational activities [R.IV.2]		Failure of industrialised organic productions

Table 46. GAME for the security and sustainability of the food system: what are the goals to achieve?

	NATURAL CAPITAL		HUMAN CAPITAL		SOCIAL CAPITAL			MANUFACTURED CAPITAL	FINANCIAL CAPITAL	Criteria thematic areas
	Environment produced change and challenges	Impact from humans	Impact on humans	Impact from humans	Social sustainability: public relevance	Governance	The reliability of markets	Sustainability and reliability of infrastructures	The reliability of the financial system	
MORE SUSTAINABLE CHOICES: GOALS TO ACHIEVE 4	[illegible]	[illegible]							[illegible]	General goals and governance
	[illegible]				[illegible]	[illegible]	[illegible]		[illegible]	
			[illegible]		[illegible]					
	[illegible]									Social learning and knowledge transfer, adaptive capacity
					[illegible]					
	[illegible]									
		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]		Basic needs and human rights
		[illegible]								
			[illegible]							
			[illegible]							

Table 47. GAME for the security and sustainability of the food system: social learning on how to reach the goals

	NATURAL CAPITAL	HUMAN CAPITAL		SOCIAL CAPITAL			MANUFACTURED CAPITAL	FINANCIAL CAPITAL	Criteria thematic areas
	Impact from humans	Impact on humans	Impact from humans	Social sustainability: public relevance	Governance	The reliability of markets	Sustainability and reliability of infrastructures	The reliability of the financial system	
SOCIAL LEARNING ABOUT CONSTANT IMPROVEMENT: HOW TO REACH THE GOALS 3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

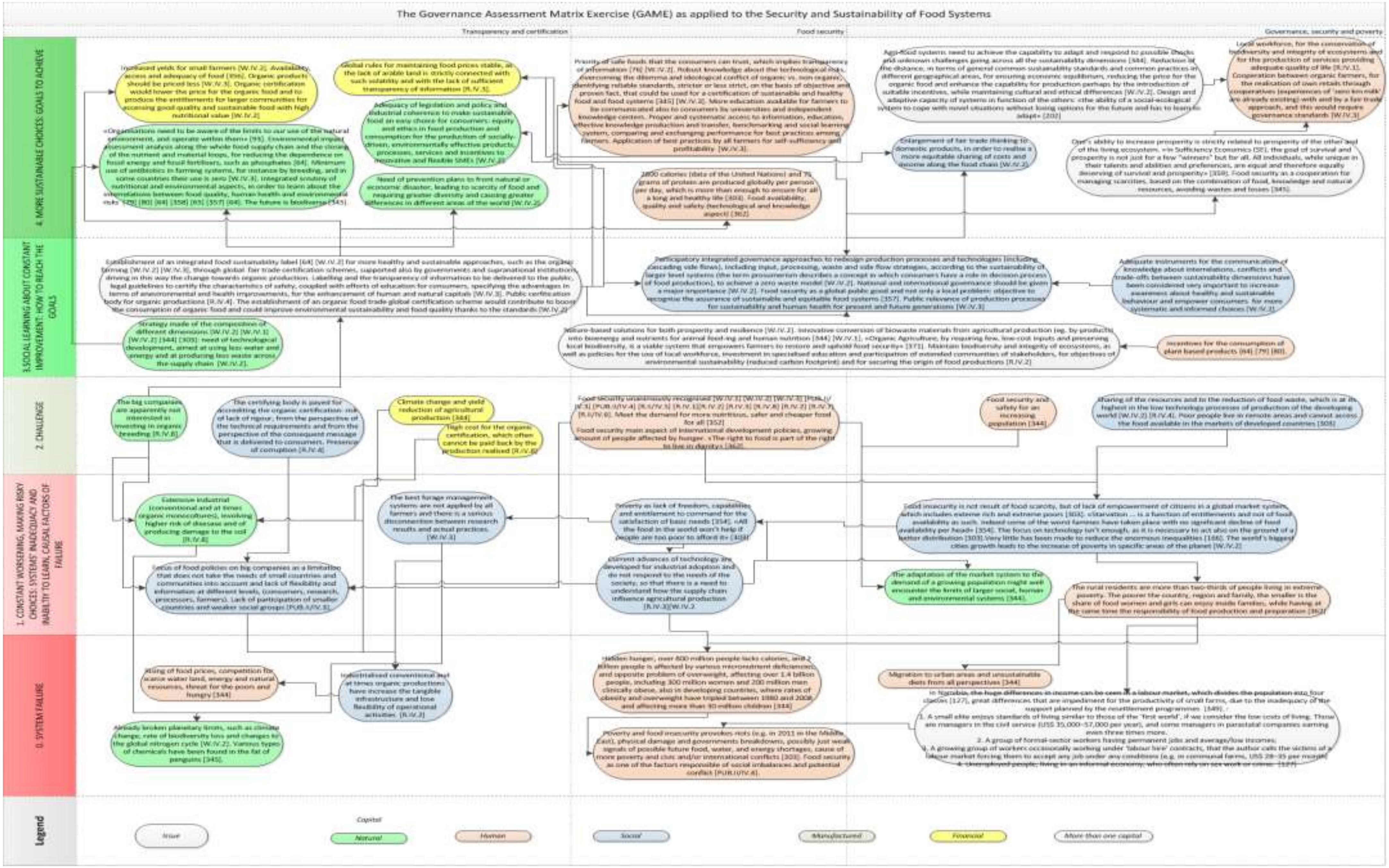


Figure 41. An example of the social learning process for the test case study of the security and sustainability of the food system by the GAME methodology

Table 48. The modified GAME criteria by the application of the methodology to the food system

MATRIX OF CRITERIA FOR GAME METHODOLOGY (modified for food systems)

NATURAL CAPITAL	HUMAN CAPITAL	SOCIAL CAPITAL			MANUFACTURED CAPITAL	FINANCIAL CAPITAL	Criteria thematic areas
		Social sustainability	Governance	The reliability of markets	Sustainability and reliability of infrastructures	The reliability of the financial system	
Alternative evaluations for non valuable impacts and not accounted losses [310]. Reducing uncertainty and approaching subjective and objective risk [159], raise awareness of major emerging risks relevant to society: standardising disclosure, stakeholder dialogue; knowledge sharing and developing best practice solutions [310]. Systematic and immediate communication about systems' interactions and failures [R.I.1]. «Learning to live with change and uncertainty» [304]. Uncertainty to be faced by 'Science and Art' [102] and phronesis: becoming experts [98] continuous social learning on the complex systems' evolution [102] and impacts. Long-term impact analysis for understanding institutional and operational changes required [322]. Promoting learning and continuous improvement of operations and adapt to lessons learned for improved system reliability [342]. Social learning for approaching science, policy and society, combining different types of knowledge for learning [304]. Nurturing diversity for resilience [304]. «Knowledge is probably the only resource that grows with use» [345]. Best practices for healthy and sustainable behaviour: tools on nutritional information, processing, origin, use and impact of food products. Education to increase awareness about the systemic interrelations between the sustainability dimensions [W.IV.2] [W.IV.3]							Knowledge transfer and social learning
Governance and cooperation in the competition and mandatory standards for interdependent systems questions of public relevance [Hi.II.1] [R.II.4] [R.II.2] [A.II.3] [350] [218] [337]. Establishment of an integrated food sustainability label [64] [W.IV.2] for more healthy and sustainable approaches, such as the organic farming [W.IV.2] [W.IV.3].						Rising awareness that the market signals do not reflect properly the physical limits [378]. Alternative uncertainty of financial evaluation systems [310] [332]. Global rules for the stability of food prices [W.III.3]	Systems limits and adequacy
Adequacy and reliability of systems in relation to security: assuring the ability to maintain own functions in the long-term in relation to the possible security threats and imminent disturbances according to quality and quantity standards [321] [308] [220] [Hi.II.1] [125] [316] [220] [320] [318] [308] [314].							
Systems well below their limits and within larger systems, avoiding to work under conditions of stress; adaptive capacity, adaptation of all systems to changes [347], collective security considered as the overarching concept [102] related to safety and development [R.II.2] strictly interrelated with the need of food security, seen as a human right [362] [PUB.II.2]. Sustainable Development [210] and human security [A.II.1] as a human righ (national and individual) [PUB.II.1], basic need in itself and a public collective good [210] [275] even implying reduced economic results [337].						Growth acceptable if not reducing employment and not increasing energy consumption or income distribution, nor undermining environmental and human health or the meeting of basic real needs, and in general causing irreversible damage onto the other overarching capitals [80] [MMC.II.1], growing capital when security is met [102], based on green technologies [378].	
Consumption and production responding to common criteria of inclusive green economy (use of resources for meeting basic needs) [361]. Absence of systematic increase of concentrations of substances produced by society or extracted from the earth's crust, absence of systematic physical degradation of nature and natural processes [289]. Creating opportunity for self-organization towards social-ecological sustainability and low carbon energy system [304]. Environmental risk based appreciative value system [Q-III.1]. Favorable conditions, incentives and policies for the flourishing of renewable energy technologies [311]. Localization and flexibility for improving sustainability and reliability [R.I.1]. Non negotiable an absolute ceiling for greenhouse gases (GHG) concentration [378]. Green technology with reduced use of water, no waste and lower risk to human and environmental health. Investment in reduction of transport, energy consumption and increase of efficiency, decentralised renewable energy sources [W.III.1] [Q.III.1]. Nuke and fossil generation to be abandoned [Q.III.1]. Low or zero carbon technologies in generation, transmission and distribution [Q.III.1]. Macroscopic marine algae and seaweeds, or microalgae, to become important sources of bio-energy production, and to replace oil by 2050, as a cheap and carbon neutral form of energy production, but also a good way to carbon caption form atmosphere [Q.III.1]. Designing of low consumption, waste and side flow strategies and the definition of coherent policies which would make sustainable food an easy choice for consumers [W.IV.2]	Happiness and entitlement for well-being, standards of living, human safety [310] [220] [9] [323] [159] [PUB.II.1] human rights and human development [41] or irreversible harm [310] freedom from threats [RII.1] [R.II.2] [278] for human health and quality of life, [M.III.1]. "Happy and wellbeing people do not make crimes" [144]. Absence of economic and social disparities that can produce violence (physical or structural), empowerment of women [369]. Intervention at the self-control level [289]. Cultural elements of honesty and trust [A.II.1]. Feeling to live in a fair and equal society regardless of identity [88]. Connection of safety and security policy issues [R.II.2]. Poverty and inequality reduction [361], distribution policies, avoidance of non decent living conditions in rural slums [349]. Absence of conditions that systematically undermine people's capacity to meet basic human needs, unsafe working conditions and not enough pay to live on [289] higher levels of quality of life, capabilities, and freedom [230] to live within system's boundaries [128] by mean of the social structures [354].	Strengthening of general economic development, in terms of social well-being, general security, trust in the economy and business expectations [Q.III.1]. Strengthened social welfare, during the transition process (social effects, labour policies, jobs) [Q.III.1]	Anticipating the need for control [278], logic of prevention, intervention at the level of self-contol, leaving at last social control and official control [389]. Education based on ethics and cultural virtue [284] [389]. International stability, security, peace, justice and sustainable development, rule of law, democracy and human rights. Focus on future needs and «help countries to free themselves from aid dependency», pursuing people entitlements [361].	Entitlements and enablers for local and smallholder farms to exert their agency [349]. Regional self-efficiency (not currently supported), including more opportunities for more, smaller and more differenciated farms [W.IV.3]	Spreading the risk: local self-sufficiency to break the complexity and reduce vulnerabilities [R.I.1]. Flexibility and adaptive capacity of physical, regulatory and social infrastructures. Precautionary principle. [R.I.1] [Hi.II.1]		Sustainability of systems and their priorities, focus on reduction or minimization of threats
		Trust, reliability of security operators and authorities, safety, care of citizens, respect of legislation, control and rejection of the culture of corruption, tolerance [279]. Absence of culture of fear and aggression/intervention [279]. Corruption systems should not be tolerated [Q.III.1]. Well-being main factor for assuring security, to be approached holistically through interaction [PUB.II.1]. Governance of security not delegated to technology [Hi.II.1]. "Happiness strategy" and close cooperation of security operators and public officials with experts of the social and welfare system [361]. Governance for security as making people happy and not being hated, having no need for fortresses [156]. Private security sector in the shadow of the national security [MMC.II.1]. Improvements from new participatory approaches of integrated management (governance) [W.III.1]. Professionality of security services [389]			Replacement of transport technologies and infrastructures by advanced lower-impact ones (intangible or "less tangible"). "Cross-border regulatory cooperation is essential to build the necessary smart grid to handle new and revised energy generation technology." [Q.III.1]. Replacing oil with biofuel. Zero-carbon energy sources to increase the capacity to mitigate the risk of disruptions in the energy supply [Q.III.1].	Increasing prevention expenditure: setting control systems [W.III.1]	
Integrated scrutiny of nutritional and environmental aspects, in order to learn about the interrelations between food quality, human health and environmental risks [79] [80] [64] [308] [65] [337] [66]. The future is biodiverse [345].		Security services focused on real needs, convergence of subjective and objective security [MMC.II.1] [HMR.II.1]. A good can be public in force of political considerations and social constructs [133]. Adequacy of regulatory systems to market and technological development [Hi.II.1] [102]. Cooperation and instant communication between contractors and adoption of common protocols [R.I.1]. Cooperation in the competition and participatory and inclusive 'good' governance for matters of public relevance and definition of regulatory standards [210] [Hi.II.1]; requirements approved by an authority for reliable operation of a system [316]			Smart Grids-based infrastructure and "cross-border regulatory cooperation to handle new and revised energy generation technology." for energy [Q.III.1]. Replacement of transport technologies and infrastructures by advanced lower-impact ones (intangible or "less tangible"). Increase investments in interconnected systems for [illegible]		
Urgency of setting sustainability goals, CO2 has to be reduced below 15% by 2050. There are no much chances if the governance process don't set the scenario to 2050 below the 450 ppm of CO2 [Q.III.1]. Mitigate the environmental impact on humans by prevention action (precautionary principle) [322]. Assurance of crucial functions of productivity, hydrological cycles, social relations and economic prosperity [202] [321]. Reducing overpopulation in harmonic balance with its productive potential and carrying capacity of the hosting ecosystems [4]	«Goal of survival and prosperity not just for a few "winners" but for all. All individuals, while unique in their talents and abilities and preferences, are equal and therefore equally deserving of survival and prosperity» [359]. Food security [W.IV.1] [W.IV.2] [W.IV.3] [PUB.II/IV.3] [PUB.II/IV.4] [R.II/IV.5] [R.IV.1] [R.IV.2] [R.IV.3] [R.IV.8] [R.IV.2] [R.IV.7] [R.II/IV.6].	«Organisations need to be aware of the limits to our use of the natural environment, and operate within these» [93]. International governance of climate change and hydrocarbon resources scarcity, on the basis of appropriate international mechanisms and global agreements to mitigate GHG emissions [378]. The private enterprise sector to undertake joint governance policies for the control of climate change. An energy governance council to be established at the European level, to identify and limit the risks. Participatory decision-making process for establishing common goals and ensuring the implementation of energy goals by mandatory standards. Mandatory quota system for utilities to reduce energy consumption' [Q.III.1]. European regulatory agency for the evolution towards a common Internal Energy Market with high levels of security of supply. Regional and EU-level cooperation between investors and regulators to assure the correct functioning of the market. [Q.III.1]. Principles of good governance: participation (a voice for all in decision-making), transparency, responsiveness, consensus orientation and mediation of interests towards the general interest, equal opportunities of involvement, effectiveness and efficiency of result oriented processes (meeting needs with the best use of resources), accountability of decision-makers to stakeholders and strategic, long perspective vision, understanding complexity and heading to human development [41]. Definition of roles and responsibilities of public institutions and private operators, criteria of social responsibility, to assure security and adaptive capabilities of systems [223] [Q.III.1].			Electricity generated by using low carbon energy sources; Concentrated Solar Power (CSP) is at the same time the most effective renewable resource of energy but not necessarily local: 'CSP will be essential to balance supply and demand, unless we are happy to be cold and poor'. The key future solutions as a mix of transmission (wind, CSP) / distribution connected (photovoltaic, biomass) generation systems, bio-fuels (trucks, ships, planes), and electrical/hybrid vehicles [Q.III.3].		
Focus on the relation human-nature. 'Health and environmental factors first order determinants for the energy supply mixture' [Q.III.1]. Environmental protection and sustainable management of natural resources are as well a precondition for food security. Food security is in turn also a condition for environmental sustainability. The systemic vision allows a deeper understanding of all possible implications and interconnections [361]. Production of small-scale biofuels for the local needs whereas it would not reduce or jeopardise food production, use of agricultural residues for generation of energy [362].		Improvements and opportunities in the market model and/or the regulatory framework. Globalisation, expansion or localisation of markets, according to the needs [W.III.1]. "Local communities will determine whether new technologies and policies conform to their local societal norms." Avoidance to depend on only an energy source: spreading the risk [Q.III.1]					

8.3 Substantive and methodological findings of the application of the GAME to the security and sustainability of the food system

The final GAME evaluation of the security and sustainability of the food system described in the previous sub-section has been represented by Table 43 (page 203), Table 44 (page 204), Table 45 (page 205), Table 46 (page 206), Table 47 (page 207) and the final modified matrix of criteria in Table 48 (page 209). An example of the process of brainstorming carried out during the workshops and the interviews is represented in Figure 41 (page 208). This has involved the evaluation of the impacts, the understanding of the causes of failure, the identification of the goals and of the policies to achieve them.

In this specific case study (see the tables and the analysis provided above), the substantive findings have highlighted a need to set nature based processes for safe and environmentally sustainable foods. This implies the focus on local production, local workforces and policies that enhance the transparency of the food systems, in order to allow consumers to make sustainable choices. In order to support this objective, during two different workshops **[W.IV.2] [W.IV.3]** the establishment of fair trade and organic certification schemes was promoted and supported, even if the organic agriculture should not continue on the role of niche sector. Instead, conventional and organic agriculture should converge towards agricultural models that realise the harmonisation of human and natural systems. This clearly responds to the GAME sustainability criterion of the avoidance of constant uptake and release of substances that might alter the natural cycles. In order to facilitate this process, technology transfer and definition of best practices should be enhanced and improved, as well as practically implemented. In the area of food security, the need to act on poverty and on the access to food by the poorest, as well as the enhancement of entitlements for small farmers, especially female, were unanimously acknowledged **[W.IV.1]**. This includes the support for stable and fair food prices and decrease of prices for environmentally sustainable and safer foods production, as well as cooperation and governance (including the introduction of mandatory standards).

The interrelations of these findings with the other case studies and the implications for the GAME methodology and framework need to be considered. The case of food systems confirms many of the criteria previously introduced, such as the respect for the boundaries of overarching systems, and the consequent need for appropriate technological progress to

Table 49. A scheme for the analysis of sustainability criteria through the integration of successive case studies: Case studies I, II, III and IV

Integration of themes from case studies: the sustainability criteria for Socio-Technical Systems (STS)					
CASE STUDIES IV / III / II / I	NATURAL CAPITAL	HUMAN CAPITAL	SOCIAL CAPITAL	MANUFACTURED CAPITAL	FINANCIAL CAPITAL
I: ECEI	Priority of systems' security, systems kept below conditions of stress: risk awareness and learning of emergent risks. Systems' thinking: acting/producing without affecting greater systems				
	Avoiding concentration of risk, spreading it to reduce complexity and vulnerability, systems' reliability and efficiency (local self-sufficiency and independency)				
	Adequacy: assuring systems' ability to maintain own functions in relation to security threats and potential or actual disturbances or changes through space and time. Sustainability of systems as integrated mantaining and endurance of interdependent functions				
	Cooperation, governance and mandatory standards on issues of public relevance. Knowledge sharing and developing best practice solutions				
	Alternative evaluations for non-evaluable impacts and not accounted losses, precautionary principle about unknown unknowns, uncertainty assessment.			Governance and cooperation for systems' security and reliability	Rising awareness on the uncertainty of financial systems
	Mitigation of environmental impact on humans and of human impact on nature: acting without breaking/impacting on other systems.	Priority to well-being, security and safety, human basic needs. Minimisation of threats for well-being, standards of living, human safety, human rights and and human development or irreversible harm. Scurity focused on needs.		Adequacy of infrastructural systems to changes: use of smart grids to minimise risks	Adequacy of the financial system to measure the other capitals: growing capital when security is met. Communication and transparency on the reliability of financial system to measure different kind of losses
II: Integration ECEI + SECURITY	Consumption and production according to cyclical green economy. Focus of human-nature relation. Environmental protection and sustainable management of natural resources, use of resources for meeting basic needs	Learning and convergence of subjective and objective security. Freedome from threats through well-being human rights of security and safety for all, minimisation of theats for people security. Human collective security: happy and well-being people do not commit crimes	Flexiblility and adaptive capacity of physical, regulatory and social infrastructures. Adequacy of regulatory systems to market and technological development.		Growth acceptable when not reducing employment nor increasing energy consumption, nor undermining hunam and environmental health nor basic needs (irreversibale damage).
		Entitlements and enablers for local operators and farms			
		Trust, tolerance, reliability and security for all, rejection of corruption, culture of fear and aggression. Prevention instead of intervention. Anticipating the need for control, intervention at the level of self-control, leaving social and official control as residual.			
	Reducing overpopulation in harmonic balance with the carrying capacity of hosting ecosystems.	Equal society regardless of identity, freedoo form thereats and irreversible harm. Absence of conditions that systematically undermine people's capacity to meet their basic needs, unsafe working conditions and not enough pay to live on.	Application of principles of good governance, consensus based, accountability		
	Favourable conditions incentives and policies for renewable technologies.	Assurance of bounded capabilities	Definition of public goods as social constructs. Cooperation in the competition for questions of public relevance		
	Assurance of crucial functions of productivity. hydrological cicles, social relations and economic prosperity.				
III: Integration ECEI + SECURITY + POST-CARBON ENERGY	Absence of systematic increase of concentrations of human produced subances, or extractes fron Earth's crust.	Economic development as social well-being, generals ecurity, trust in the economy and business expectations		Absence of systematic degradation through increase of physical artificial capital.	
	Setting environmental sustainability goals and standards by governance processes: e.g. CO_2 to be reduced by 2050 below 400 ppm.	Minimisation of risks for human health	Participatory decision-making and social responsibility to assure security and adaptive capability of systems.	Electricity fro low-carbon sources. Mix of renewable technologies	
	Focus on the relation human-nature: health and environmental factors first order determinants for the energy supply mixture. Assurance of crucial functions of productivity, hydrological cycles, social relations and economic prosperity. Regulatory standards for systems' governance				
	Environmental protection and sustainable management of natural resources as preconditions for food security and environmental sustainability. Systemic vision for undeerstanding the interrelations.				
IV: Test on FOOD SYSTEM	Designing of low consumption, waste and side flows strategies. Definition of policies for sustainable food consumption an easy choice.	Globalisation and/or localisation of markets according to the needs	Production of small scale biofuels for local needs that woudl not jeopardise food production. Use of agricultural residues for energy generation.		
	Food security necessary for assuring environmental sustainability	Food security as human right: goal of survival and prosperity not just for winners but for all.	Organisation operating in the limits of the environmental system		
	Biodiversity: intefgrated scrutiny of nutritional and environmental aspects, social learning about the interrelations between food quality, human health and environmental risk.		Establishment of fair trade organic production schemes, for transparency of the whole value chain		

address the constraints (see Table 49, page 211). As previously mentioned, additional case studies will integrate less and less insights, as many aspects are already covered by existing criteria, unless additional cases would demonstrate that those criteria are not general rules that can be applied for every case. In this latter situation, they would need to be revised or reframed for covering specific situations. In the study that has been carried out some of these criteria are of particular importance, as they represent strong links between systems that might seem so different from one another.

The themes of food security and entitlements for small farmers had already arisen in the discussion on security and especially in connection with the Namibian experience. The concept that is promoted in the Finnish security system, according to which security is a public collective good and in order to achieve security it is necessary to provide it for others. The idea that happy and well-being people are less likely to commit crimes applies to the food system as well. As Fraser (2014) **[303]** reports, North African revolutions were primarily caused by the instability of food prices and the lack of food security. The continuation of huge income differences, as reported for the Namibian case, potentially threatens the whole community. The food system is also interconnected with the energy system, as in order to maintain stable prices and farmers' security it is important to avoid too challenging competitive advantages for alternative land uses, such as for instance for energy production. A solution has been identified in the integration and cooperation among these sectors, the use of agricultural residues for purposes of energy production and the reduction of forage for the production of meat because it is also considered as an unhealthy and environmentally unsustainable choice.

From the perspective of substance, the GAME methodology has demonstrated how sustainability can be summarised according to some general criteria—adequacy to systems' boundaries and respect of non-negotiable constraints of well-being and the concept of 'folkhemmet'. This is presented in the security case study of safe and secure home **[MNC.II.1]**, that also intersects with Sachs concept of the need to avoid structural violence (2003) **[369]**. This means assurance of basic needs and entitlements, as harmonised with the greater environmental system, as highlighted in Figure 45 of the next chapter (page 226). The food system is particularly important, as food security and safety are the most basic needs for human beings and its production has great implication for environmental systems. The competition with other systems is a sensitive issue and the failure of food systems might be a potential source for failures of other systems.

From a methodological viewpoint, the GAME testing, by triangulating data within and between systems, has demonstrated the holistic and multi-dimensional nature of the sustainability issue and thereby the need for holistic governance approaches that can represent these multifaceted and complex aspects and more effectively regulate human societies. The GAME approach has also demonstrated the need to approach sustainability through a systemic and cross-cutting analysis. Isolated efforts to evaluate sustainability for too restricted (bounded) areas might provide solutions that are only partial, and have to be abandoned, sooner or later, when they affect other systems.

9 Conclusions, outcomes and challenges

Aim	To conclude the research analysis, describe the research outcomes in relation to the aim and objectives set in Chapter 1
Content	9.1. Summary of thesis: problems, aim, objectives 9.2. Key findings of the thesis 9.3. Contribution to knowledge 9.4. Impact and usability in the real world 9.5. Future challenges and work (research and practice)

The present research has investigated governance and sustainability from a systemic perspective. In this chapter, a summary of the study focus and the problems it addresses, the planned aims and the contribution to knowledge are summarised and future developments discussed.

9.1 Summary of thesis: problems, aim, objectives, research questions and findings

The summary of the thesis is exemplified in Figure 42 (page 215), with reference to the initial research and thesis structure Figure 2 (page 10). In relation to the research problem as outlined in the introduction— i.e. how societies organise and govern themselves for achieving sustainable development— the literature analysis looks at the current situations in which *«we are changing Earth more rapidly than we are understanding it»* (Vitousek et al., 1997), and to the urgent need to keep systems under control, before irreversible changes are produced. Existing literature (Evans, 2012) considers sustainability more a social than an environmental phenomenon that has to do with how societies and the systems they are built on impact on both the environment and social well-being itself (sub-section 1.1). This raises concerns about the adaptive capacity of societies. The literature analysis explores, in Chapter 2, the field of systems' theory, referring more specifically to Socio-Technical Systems (STS) that are formed by the interactions between humans and technological infrastructures. The analysis initiated a discussion about the adequacy of social structures for pursuing STSs' reliability and sustainability. This reveals some critical factors that are inherent in STSs, and some elements of inadequacy of current social structures—i.e. market and legislation—for addressing them, possibly determining the rise of sustainability problems. The analysis has identified three main criticalities of Socio-Technical Systems (sub-section 1.6).

Research summary: objectives, research questions and findings

	Chapter objectives	Content/findings
1	Introduction of the research problem, the motivations for investigation, the aim and the objectives thesis structure	Research problem: how societies organise and govern themselves for achieving sustainable development. Changes happens more rapidly than understanding.
	Literature review	
2	Governance of complex systems: critical factors of inadequacy of current social structures and arrangements for the pursuit of sustainable development	Control of upper level systems instead of adapting to them. Detachment from environmental systems. Anthropocentric vision of development based on utilitarianism and continuous growth. Failure of simplified models valid in all places and times: critical factors of complexity, uncertainty and public relevance.
	Research question a: Is current governance adequate to harmonise the different components of social, economic and ecological systems?	
3	Governance and sustainable development: analysis of existing governance initiatives and evaluations, and reasons of inadequacy of current approaches	Governance arrangements, valid but isolated sustainability evaluations, based on recommendations and not internalised in the society. Lack of empowerment and mandatory standards. Delegation to traditional social structures.
	Research question b: How to design the concept of governance for the purpose of systems' sustainability?	
4	Governance for sustainable development: theoretical insights to bridge the gaps of current approaches	Governance as a process of cooperation and a holistic and systemic social learning about complexity, for the definition of sustainability criteria. Choices about future scenarios and actions for achieving them, in relation to basic needs and systems' constraints ('bounded capabilities', 'systems' adequacy' and 'harmonisation')
	Research question c: How to apply the concept of governance identified through an innovative methodological framework?	
	Methodologies	
5	A methodology of evaluation reflecting the conceptual idea of 'governance for sustainability' of Chapter 4: - an abductive approach from multi-method data collection and literature - thematic analyses and integration of multiple data sets in rising themes.	Qualitative assessment matrix based on existing evaluation concepts: Global Competence Matrices, Pedigree Matrix, Futures Wheel, Five Capitals Model of sustainability
6	Case studies of 3 different Socio Technical Systems (STS)	Building a methodological structure and framework, and the sustainability criteria by thematic and impact analysis, aggregation and generalisaiton by successive integrations
7	**Final aim**: generation of a toolkit, built on the conceptual idea of governance of Chapter 4 and on the methodology of Chapter 5, to enable capabilities within boudaries and to facilitate social learning for contextual situations, according to the overarching sustainability criteria	The operationalisation of the GAME toolkit by: - 'Future workshop' and back-casting approach - diverse data-types from different sources - social learning about systemic interactions and - generation of scenarios and best practices - possible revision of core sustainability criteria for effective governance for sustainability
8	Final test case study and validation of the methodology	Testing the GAME matrix on a practical example the security and sustainability of food systems, validating it through triangulation of multiple data-type, -source and collection methods
9	Discussion on the usefulness of the research and of its contribution to knowledge. Key findings, future challenges and work	Substance and methodological aims: systemic and holistic sustainability evaluation for enabling an entitling human agency, increasing capabilities, setting standards (rules of the 'game' of systems' limits). Impact: learning and support to decision-making for sustainability, through a toolkit supporting deliberation and implementing accountability. Indicators and geospatial analysis for future research.

Figure 42. Summary of objectives, research questions and findings.

First, the increasing complexity of systems has been acknowledged, determining the unpredictable propagation of impacts within and between systems across long chains of cause-effect relationships, characterised by non-linear behaviour. This characteristic involves the inability for current arrangements, i.e. the market and the legislation to maintain systems under control, because of the tendency towards liberalisation of markets and rapid technological development. The increasing rapidity of technological change and lack of control of market structures on the one hand can hardly be regulated for and on the other creates more and more interconnections between systems belonging to different administrative structures at various levels of organization.

Secondly, the increasing uncertainty that derives from the complexity mentioned above increases the subjective dimension of risk and generates more and more diversified perspectives, transforming sustainability problems into political problems and enlarging the distance between subjective and objective risk. This high uncertainty manifests itself in the reduction of sustainability problems to a plurality of politically driven solutions which are at least partially detached from the perceived and measurable realities, and compromise our ability to agree about future actions and thereby to introduce effective governance.

Thirdly, the relevance of socio-ecological systems for human life identifies them as public goods, even when, on the basis of primarily economic considerations, they could be liberalised and regulated by market structures. In spite of the increasing scientific uncertainty and of the plurality of perspectives about the possible solutions, the more objective risk that results from the process of social learning about irreversible changes and damage, and the consequent urgency to move towards sustainability pathways, should be acknowledged. This can be done by social structures designed to maintain systems below their limits of resilience, in order to conserve their capacity to endure throughout time. The existing uncertainty about the relative objectivity of subjectivity of risks suggests the adoption of a precautionary principle.

The thesis claims that current social structures are inadequate for addressing these criticalities. A major problem of market and legislative structures has been acknowledged; this is their tendency to oversimplify systems, according to human centred evaluation models and criteria. In other words, the analysis has highlighted a lack of systemic approaches and awareness about the interrelations of the parts within and between systems, as well as the existence of more objective and non-negotiable systems' constraints. First, humans have become detached from the natural world and have conceived systems, which are not harmonised between one another and with the greater natural system. Secondly, unidimensional evaluation models undermine the reliable evaluation of goods (and natural resources) because they only focus on the satisfaction of human needs, which is, once again, anthropocentric, i.e. based on the utility that we humans can have from them. The evaluation of resources, based on the value of their exchange, does not take into account their intrinsic value as important elements contributing to the reliability and sustainability of systems. Social structures (markets, legislation and international governance) subordinate in this way larger overarching systems to human created systems, systematically neglecting non-negotiable constraints and overcoming the limits of upper or interconnected systems. Legislative systems, limited to single administrative areas or individual responsibilities are not integrated and are therefore unable to deal with matters exceeding their range and power of action, leaving room to uncontrolled and non-regulated human agency.

In relation to the critical factors exposed, and the possible adoption of governance approaches for their solution, a research question a) emerges about whether current governance approaches are adequate for harmonising systems' environmental, social and economic components.

In order to address a second research question, the areas of governance and sustainable development were investigated in Chapter 3, by means of analysis of existing governance initiatives and evaluation methodologies and frameworks. The acknowledgement of the some gaps of current governance approaches that determine partial inadequacy for the pursuit of sustainable development leads to research question b) about how to design the concept of governance for the purpose of systems' sustainability. In the light of this question, in Chapter 4, a concept of governance for sustainable development, according to a holistic and systemic approach, was identified. This innovative theoretical framework of 'governance for sustainability' was built by literature analysis on governance, sustainable development, social learning and systems' thinking. The identified governance concept, according to the principles identified in sub-section 4.5, incorporates the following key approaches, as represented in Table 50 (page 218).

The conceptual vision of governance for sustainability supports a third research question c): how to apply the concept of identified governance through an innovative methodological framework?

This last question, refers to the final aim of the thesis of building an innovative methodology of sustainability evaluation in support to the concept of 'governance for sustainability' identified in Chapter 4. This objective was pursued by planning a research methodology that incorporates the key insights of the identified concept of governance, reflecting systems' complexity and addressing the gaps identified in Chapter 2, thereby building adequacy to systems' complexity and paving the way for building the final methodology (see Table 50, page 218).

Table 50. From the governance for sustainability conceptual idea to its implementation by a conceptual framework

Driving principles of the conceptual idea of governance for sustainability	Approaches used for the implementation of the idea into a conceptual governance for sustainability framework
1. Systems' adequacy: keep within the limits	Focus of adaptive capacity and systems' adequacy, systemic thinking about the sustainability pillars (Forum For the Future, 2013; Scott Cato, 2009)
2. Learning about (1) and building adaptive capacity	Holistic and multidimensional conception of sustainability of the Five Capitals Model (Forum For the Future, 2013) and future perspective
3. Creating entitlements for meeting basic needs and human rights	Focus on basic needs and resources' availability (Brundtland)
4. Governing systems by setting standards for systems' reliability and sustainability and entitlements for meeting needs: human-nature relationships balance and harmonisation	Accountability, participation and transparency (EC and OECD principles of governance)

This approach was supported by the concept of Requisite Variety (2014), holding that a «*repertoire of responses which is (at least) as nuanced as the problems you face*» is needed in order to deal with complex and multifaceted issues. Evaluation models should adequately reflect and represent the diversity of the issues being treated (Türke, 2008), this is in line with the concept that «*every good regulator of a system must be a model of that system* because, the actors of a model (Conant and Ashby, 1970). Therefore, the methodology has been built to be systemic and holistic, on the basis of the experiences of existing methodologies, and in order to be able to assess multiple data-types and collection methods. The methodology has involved the realisation of an empty framework for data analysis (described in Chapter 5) and an abductive approach joining inductive literature and documentary analysis to deductive case study analysis. This is presented in Chapter 6 with case study analysis of different Socio-Technical Systems (STS), representative of the critical factors found in the literature analysis of Chapter 2. The cases are the European Critical Electricity Infrastructure (ECEI), the

Finnish socio-technical security system and the process of transition towards a post-carbon society. The initial framework has supported mind mapping, gathering varied information relating to one or more systems (possibly including big data), and structuring it across the capitals of the Five Capitals Model. The combination of the theoretical and the empirical evidence described in Chapter 6 has identified the specific and common critical elements of (un)sustainable STSs and derive core governance for sustainability criteria by generalisation and successive integration across the first three case studies. These criteria have been incorporated into a generic participatory framework and toolkit, i.e. the Governance Assessment Matrix Exercise (GAME), a qualitative assessment matrix, and the identification of core sustainability criteria for the different dimensions of sustainability.

9.2 Key findings of the thesis

The main key finding of the thesis is related to the aim, the development of a conceptual framework and methodology, i.e. the GAME, that:

- Realises a participatory brainstorming about systems' critical aspects and failures and the goals and operational strategic actions to be implemented on the basis of phronetic thinking and generates insight about systems' dynamics and requirements for their sustainability.
- Bases its own application on the contextual, bottom-up and pro-active participation of extended communities of actors and stakeholders.
- Identifies core sustainability criteria to be used as guiding principles for each successive application of the GAME, and thereby constitutes a tool for self-learning at each successive step.
- Takes into account the systems' complexity and the interrelations of the parts, incorporating big data of different forms, avoiding the reliance to oversimplified evaluation methods yet realising a mind mapping towards the definition of common goals.
- Acknowledges decision making about alternative future scenarios and supports informed and accounted choices for matters of public interest and high uncertainty.
- Contributes to reducing uncertainty and complexity by the integration of subjective and objective evaluation and the identification of real causal factors and most sustainable

goals. In this way a more rigorous conception of governance and decision-making, based on the acknowledgement of more objective and evidence-based evaluations, is supported.

- Supports a more structured, and goals oriented, process of governance on the basis of well-defined sustainability criteria, to which decision making would be accountable. This way the GAME represents a methodology for the implementation of governance for sustainability and deliberative action.

9.3 Contribution to knowledge

The contribution to knowledge of the research carried out is described below from the perspective of the substance (theoretical findings in the field of governance and sustainability), as well as from the perspective of their practical implementation and methodological approach.

9.3.1 Substantive knowledge

A key theoretical contribution of the present research is to develop a more rigorous understanding of the concept of sustainability and governance. The systemic approach allows considering sustainability as a condition determined by the relations between systems. In particular, the degree of sustainability of Socio-Technical Systems (STS), involving the natural, human, social, manufactured and financial capitals, is determined by the relative ability of a system to maintain its own equilibrium and the equilibrium of the larger systems in which it is embedded. The sustainability of STSs is indeed their degree of harmonisation and integration, across all dimensions (the five capitals) and space and time. We can therefore state that governance of sustainability has the responsibility of assuring the adequacy of STSs for maintaining their own equilibrium and ensure their endurance throughout time, as well as for maintaining the equilibrium and endurance of larger systems.

In this vision, the research first demonstrates the inadequacy of current social structures for the achievement of sustainability because of their inability to maintaining systems' equilibrium. Secondly, the research demonstrates, consequently, that alternative governance arrangements are needed:

- to generate a systemic understanding of systems and deeper knowledge about the interactions between the constituent parts
- to increase the participation by all concerned stakeholders and set roles and responsibilities, going beyond single regulatory areas

- to indicate possible directions towards sustainable futures, to which both decision-makers and private actors would be accountable

As mentioned in Table 50 (page 218), this research bases the idea of governance of sustainability on:

1. Systems' adequacy: keep within the limits
2. Learning about (1) and building adaptive capacity
3. Creating entitlements for meeting basic needs and human rights
4. Governing systems by setting standards for systems' reliability and sustainability and entitlements for meeting needs: human-nature relationships balance and harmonisation

The research has proposed the Governance Assessment Matrix Exercise (i.e. the 'GAME'), as a multi-method abductive methodology of evaluation that realises a participatory process of social learning across the different dimensions of sustainability (according to the structure proposed by the Five Capitals Model of Sustainability), using a multiplicity of data-types and applicable to different Socio-Technical Systems (STS) belonging to different geographical, cultural and socio-economic contexts.

The GAME process systemically assesses and triangulates data of different forms, highlighting the interactions of the parts within and between capitals and systems.

The practical implementation of the GAME is structured as indicated in the final testing case study. This involves a first 'critique phase', in which the existing challenges and potential failures are assessed, and some desirable sustainability goals for the specific context, reflecting the GAME criteria, are identified. Once determined the 'what we want to achieve', a brainstorming and mind mapping about 'how' to act at present to achieve future goals identifies possible policies, strategic actions or necessary standards to be implemented. This process has realised indeed the social learning process, to be integrated by information derived from existing scientific achievements or from other contexts, thinking about the possibility of transferring knowledge, policies and practices. For instance, the food system case was especially successful as it commenced with the analysis of general matters of food security and overpopulation, to end up with proposals of concrete specific action, concerning food production technologies and arrangements for governance and cooperation for the promotion of sustainable and healthy foods. Or it suggested how to create entitlements for the less advantaged people and for the less empowered market actors. This way, the GAME has finally, with some modifications, confirmed the validity of the sustainability criteria previously defined.

From a practical perspective, the research has led to the development of a tool that is able to indicate, for specific contexts potential futures and direction of travel. The research has provided some general sustainability criteria (see Figure 43, page 222 and Figure 44, page 225), for each of the capitals of the Forum for the Future, that can be kept in mind when making choices affecting our future. These identify needs and conditions that are critical for systems' functioning and non-negotiable, yet they can be explored and reframed according to supported arguments. Their importance, in principle, start from the greatest capital, the environmental (see Figure 43, page 222, based on Forum for the Future, 2014 and Scott Cato, 2009), as all the others are dependent on those. At a successive level the human needs are the most important because essential for human life and well-being the Maslow pyramid and the Brundtland definition of sustainability refers to.

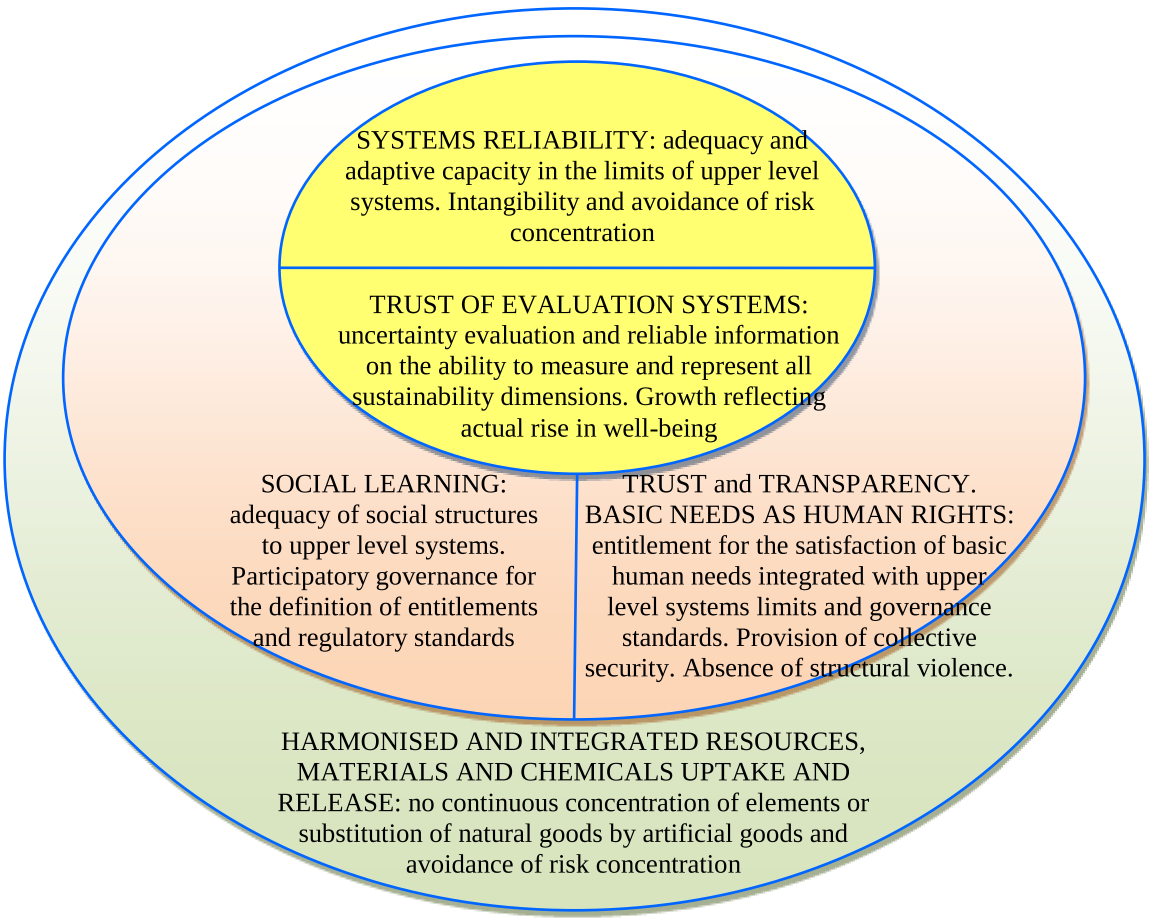


Figure 43. A summary of the general sustainability criteria for the dimensions of the Five Capitals Model

Those are followed by the sustainable functioning and organisation of societies that (market and governance policies and structures, is constrained within the limits of the upper systems. This means that social structures have the main objective of realising the conditions that achieve the sustainability of the environmental and human capitals. In order to do this, they make use of manufactured capital and infrastructures that are valuated by the financial capital. Whenever this last capital would be considered the most important, even if unable to evaluate the major needs, environmental, human and social, the risk of systems' failure would be very high.

Even considering such hierarchy, at a certain extent the different needs can be balanced according to specific local contexts, when, for instance the ecological system can be temporarily affected with recoverable impacts, in order to provide with basic needs a local population. However, is such a situation would last longer and cause permanent damage, this would mean that present needs will be achieved at the expenses of future needs or present needs in other contexts (for instance when the environmental damage is cause of disease in a neighbour area), which identifies a situation of failure of the system. In this case, alternative solutions have to be learnt, under the guidance of the sustainability criteria. This is the principle guiding the governance process of learning and implementation of possible solutions, as represented in Figure 45 (page 226).

The sustainability criteria can of course be discussed and modified in relation to new achievements, however the principle of accountability would mean that the criteria chosen within a governance process would hold until possible counterarguments have been properly demonstrated on solid basis. More particular, from a practical perspective, the GAME approach has shown the following abilities:

- To approach events or interact with stakeholders in an accessible way, giving the opportunity to deepen the understanding of the complexity at hand by systemic and holistic thinking.
- To initiate a process of participatory brainstorming and social learning about the possible 'alternative futures' and their risks and opportunities, which can be used for the transfer of knowledge between different stakeholders.
- To define a structure for social learning in which the actions are clearly linked to challenges and goals to be achieved, and contextual needs to be satisfied, so that whenever

potential problems are identified adaptive responses can be suggested and implemented (see Figure 45, page 226).

- To define actions according to sustainability principles, criteria that are important for maintaining the given systems' equilibrium, giving the possibility to adjust them according to concepts of self- learning and evolutionary system design.
- To describe complex systems by big data and rich pictures, in the terminology of Bell and Coudert (2005). This is composed of diverse data from different sources and supports 'stories' or narratives about scenarios.
- To provide decision-makers with useful insights, on what basis decisions can be made about governance standards, laws or regulatory acts and to which they need to be accountable in order to achieve minimisation of risks and the predefined sustainability goals. This will allow for the contribution of larger communities of stakeholders into decisional processes.
- To link science, policy and society, providing the opportunity to define political goals on the basis of real needs and scientific evidence.

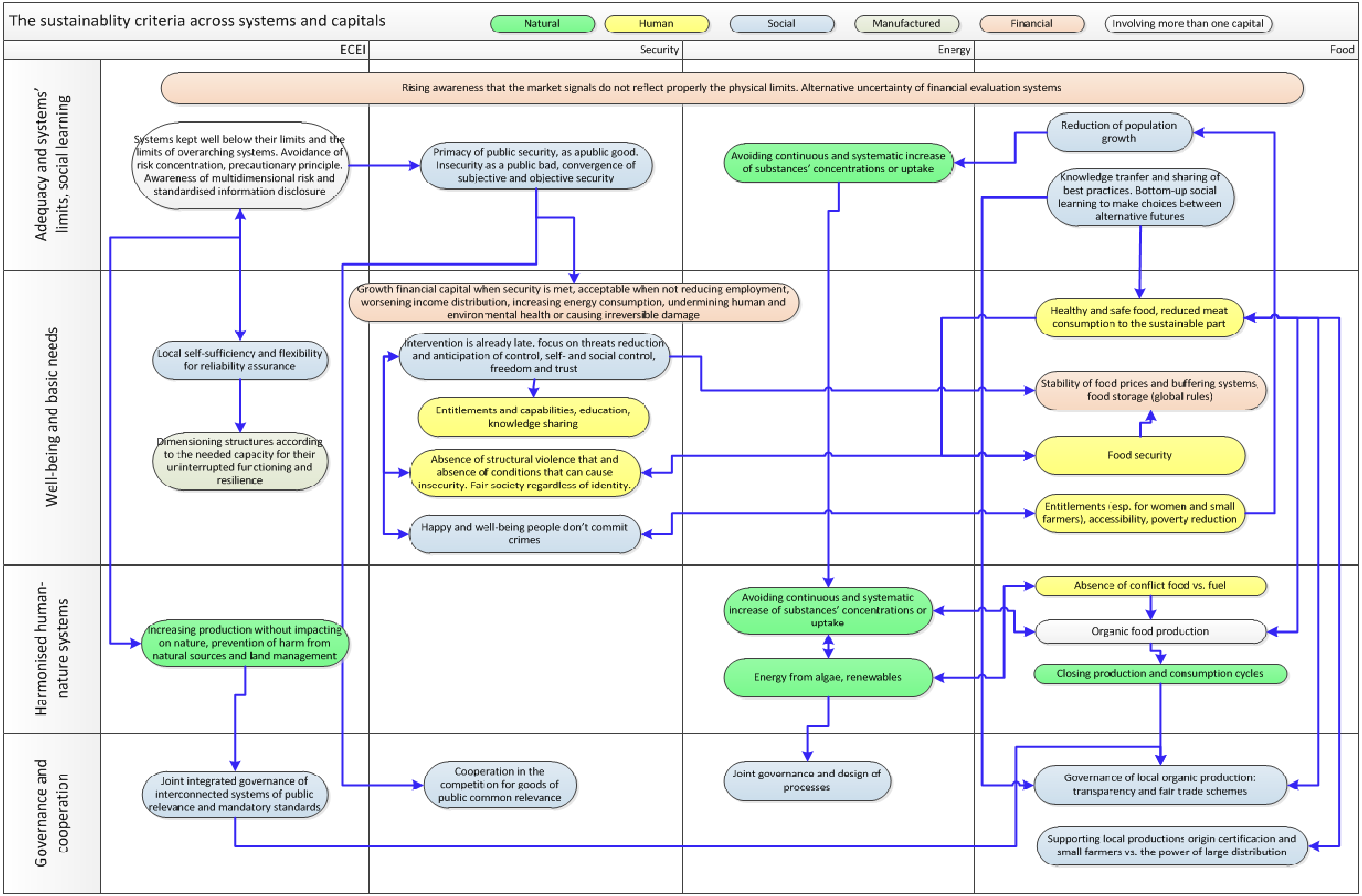


Figure 44. The systems' sustainability criteria and their interrelations

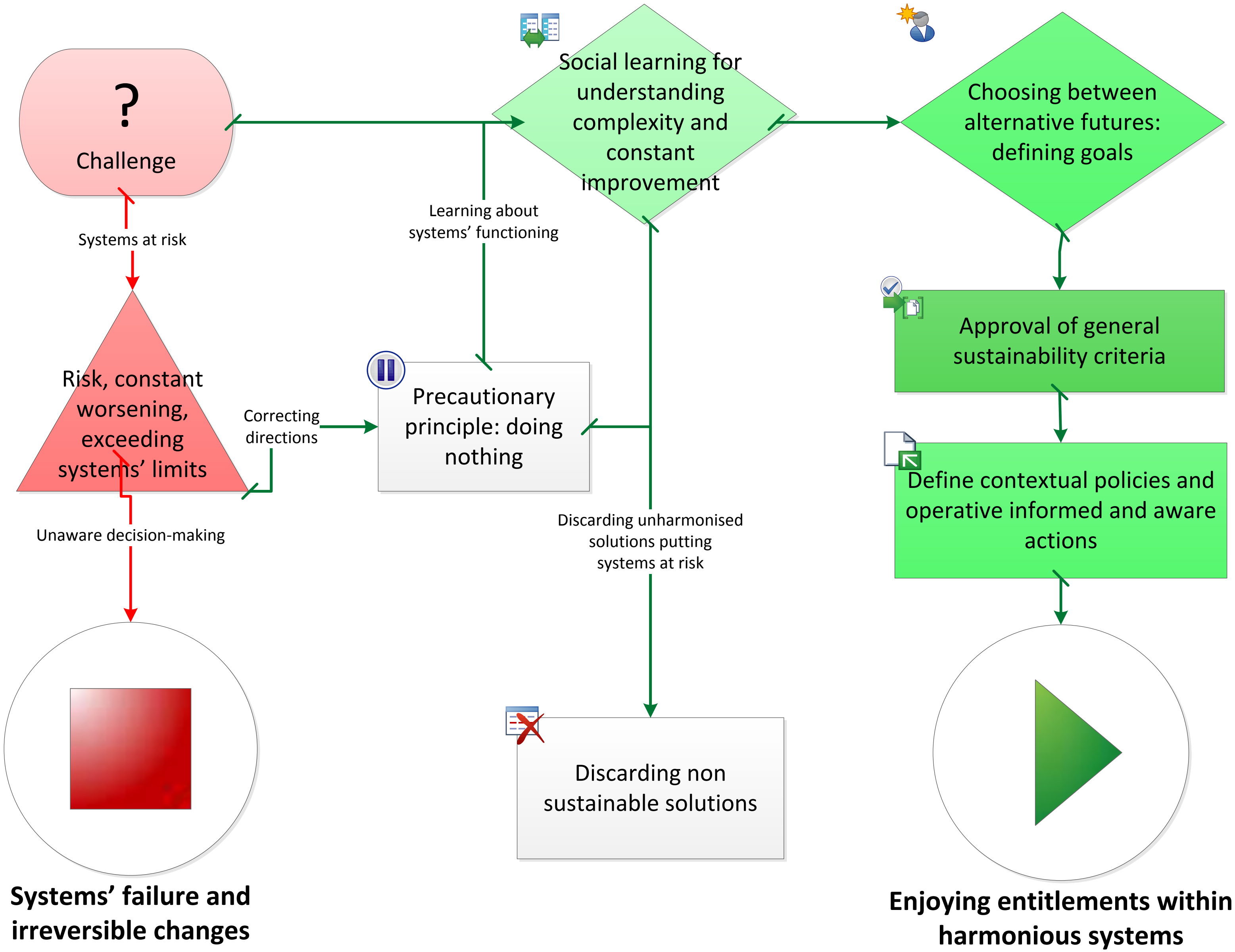


Figure 45. The structure of social learning of the GAME matrix

9.3.2 Methodology

The research methodology has been developed around three successive case studies of Socio-Technical Systems (STS). Analysis of these has been used to populate, and modify, an empty governance framework by integrating diverse data obtained from different sources and collection methods.

The initial empty structure for the GAME has been realised by a qualitative assessment matrix constituted by the dimensions of the Five Capital Model of sustainability of the Forum of the Future (2013) and the successive orders of impact (from failure to improvement) of the Futures Wheel (2013). The GAME methodology has been developed by the use of three case studies, based on multi-disciplinary historical analyses and futures approaches. The aim of the analysis has been the identification of sustainability criteria, through a systemic approach, exploring the complexity of cause-effect relationships within and between systems. It has provided, starting from a systemic perspective, a number of general common sustainability criteria for the first case, which have been used for assessing the second case, modified by this analysis and then integrated with additional outcomes, into a third case prior to the final evaluation and modification of the GAME for assessing the sustainability and security of food systems. The specific objectives of the approach were to:

- Test the validity of the approach to initiate a process of social learning, in order to understand the complexity above mentioned.
- Confirm and/or modify the general sustainability criteria, responding to the conceptual idea of systems' adequacy.
- Identify practices and goals that are specific to the scientific field and applicable to the particular contexts, from a cultural, geographic, ecological, climatic, human, social or economic perspective.

In summary, the GAME methodology, can be described as in Figure 46 (page 228): Challenge → Risk → System Failure → Social learning for improvement → Definition of sustainable goals → Generalisation of criteria

Moreover, the GAME has provided a framework for discussion and dialogue within the study interviews, for the realisation of the workshops and for the analysis of narratives and reports.

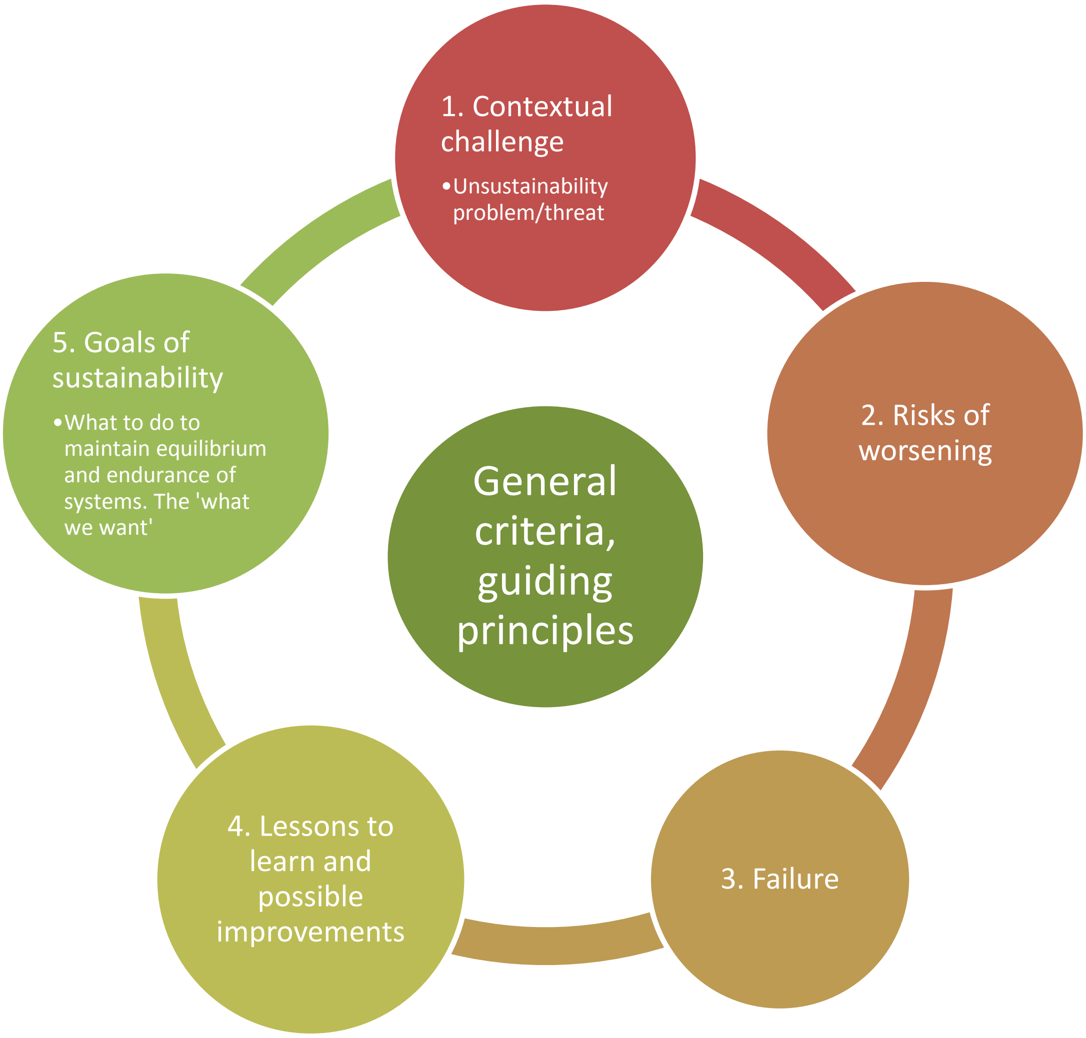


Figure 46. The methodological approach of the GAME methodology

The analysis of the successive case studies have largely confirmed the general sustainability criteria previously identified or produced very similar concepts, sometimes adding to them further aspects, typical of the particular field of science and vision of the participants, related to their cultural and scientific background. Therefore, in the 'playing of the GAME' the loop as represented in Figure 46 is to be reiterated and applied in different contexts, in order to give the possibility to adjust the criteria, through phronetic thinking.

The GAME approach has identified, through the acknowledgement of the general criteria, especially in the final food study, technical solutions and participatory governance arrangements and concrete structures, standards and incentives for achieving the sustainability goals.

The research proposes a methodology for the participatory, holistic and systemic evaluation of sustainability, going across the sustainability capitals. This is follows the work of Scott Cato (2009) in his conceptual understanding of sustainability, and the development made by the

Five Capitals Model of sustainability (Forum for the Future, 2013) and applying to it a dynamic element of interaction, based on The Futures Wheel (2013). The final methodology developed for the GAME exercise also draws on the futures workshop (Jungk and Müllert, 1987; Valqui Vidal, 2005) and the concept of backcasting (Dreborg, 1996; Vergragt, 2011; The Natural Step, 2013). The methodological achievement is indeed a model of evaluation that detaches from the logic of unidimensional and oversimplified approaches and promotes a systemic thinking, taking into account of all implications of human actions and societal choices.

From the methodological perspective, the GAME offers the opportunity to analyse great amounts of data of different types and from different sources and through this to support a process of social learning and interaction between different actors belonging to different backgrounds, cultures and geographical areas. Indeed, the GAME methodology has identified goals and ways to reach them, providing the possibility to make informed choices among alternative futures. In this way, the GAME provides an alternative vision on how to make decisions, that is not just based on political or economic interests or personal preferences, but that is based on a phronetic approach and process, reducing uncertainty by reducing the divergence between subjective and objective risk and reducing complexity by the careful understanding of the real causal factors and the most appropriate solutions. In this way, we can say that larger participation is pursued, but at the same time it does not result in a plurality of disconnected and unstructured views, that only increase the uncertainty. The participation is important to increase the visions and the knowledge, so as to understand the best solution and build a more objective understanding.

9.3.3 Evaluation of the tool and publication of outcomes

This research has been realised in a long time span and many insights of it have been published in peer-reviewed publications and conference papers, as it appears clear from the references. The first intention was to realise an article-based thesis. However, due to the extent and volume of the research done, a choice for a monograph has been made. The strong link to the publications done still remains. The GAME methodology and framework constitutes the implementation of the very first governance concept and process (Sajeva and Masera, 2006; Masera, Sajeva et al. 2006) for which the case study of the ECEI was realised (Sajeva, Stefanini and Masera, 2006), of the conceptual analysis of security systems (Sajeva, 2012). These peer-reviewed publications are complemented by deliverables for EC FP7 research projects, treating the security and the post-carbon society case studies.

The research can be evaluated as successful, first as the construction of the GAME methodology and framework that incorporates the analysis of the three case studies has been also presented at Business Systems Laboratory - 2nd International Symposium *"Systems Thinking for a Sustainable Economy. Advancements in Economic and Managerial Theory and Practice"*, Universitas Mercatorum, Rome, Italy (Sajeva, M. P. Singh Sahota and M. Lemon, January 23-24, 2014. *Giving Sustainability a Chance: a Participatory Framework for Choosing between Alternative Futures*), and then revised and published in the peer reviewed Journal of Organisational Transformation and Social Change (JOTSC) (Sajeva, Singh Sahota and Lemon, 2015).

Secondly, good results have been obtained in occasion of the application of the GAME methodology in the test case. Besides the successful implementation of the future workshop, the participants in the workshop provided themselves useful narratives afterwards, indicating challenges, risks failures and goals, as well as actions to reach them. At the end of the workshop a general consensus could be observed. During the interviews performed for this case study, a direct question was posed to the interviewees about the validity of the method, which revealed its general appreciation.

On the application of the GAME to the issue of food security and the generation and evaluation of alternative scenarios, a second conference paper (Sajeva, M., P. Singh Sahota and M. Lemon, 2016. *A Vision and a Framework of Governance for Sustainability: Assuring Food Security within Natural Systems*) was accepted and presented at the 158th Seminar *"Euro-Mediterranean Cooperation in Sustainable Agriculture and Food Security: Policies, Sustainability, Marketing and Trade"*, organised by the European Association of Agricultural Economists (EAAE), at the Mediterranean Agronomic Institute of Chania (CIHEAM-MAICH) in Greece, on the 8th and 9th of September 2016.

A good evaluation of the approach and the tool has also been expressed by positive comments received during the above mentioned conferences and during a seminar at University of Tuscia (Italy), especially about the highly innovative and interesting approach and the strong vision proposed. Joint publications with other scientists have been as well hypothesised

9.4 Impact and usability in the real-world

The GAME framework and toolkit support governance arrangements that better reflect and represent the complexity of systems' sustainability, reducing the related uncertainty and implementing the principle of accountability towards a larger community of stakeholders in matters of public interest. This is done by the conception of a process of social learning, for the purpose of understanding the impacts and defining the general constraints (i.e., the sustainability criteria), as well as and the ways of enabling contextual human agency. The GAME identifies a phronetic process directed to enabling development, capabilities and freedom within the boundaries identified by the resilience of systems. In other words, the GAME represents an idea, framework and phronetic tool for self-learning about the wisdom of self-regulated freedom.

The present thesis, therefore, is not aimed at providing the only possible solution for sustainable development. It is instead aimed at developing a theoretical thinking focused on the idea of adequacy of Socio-Technical Systems (STS) to reach sustainable development. This means designing social structures as appropriate to the specific purpose of sustainable development and prosperity and as able to adapt to changes. This also means rejection of unique or oversimplified systems of economic growth and de-growth of the steady-states of economy, in order to instead embrace an approach of modulation of the various dimensions of sustainability; an approach that would reflect the complexity of systems that are interconnected at various levels. This way, the thesis represents a contribution to knowledge, as it provides a holistic and systemic approach of governance for sustainable development and contributes to the integration of human, social, economic and ecological systems.

The usability in the real world has been tested during the interviews, the workshops and at the conference carried out for the test case study, connected with on-going research projects and activities at international level for the formation of Strategic Research Agendas (SRA). The GAME has also been accepted as a tool for the determination phase in on-going activities according to a multi-actor approach that include the active participation of stakeholder platforms.

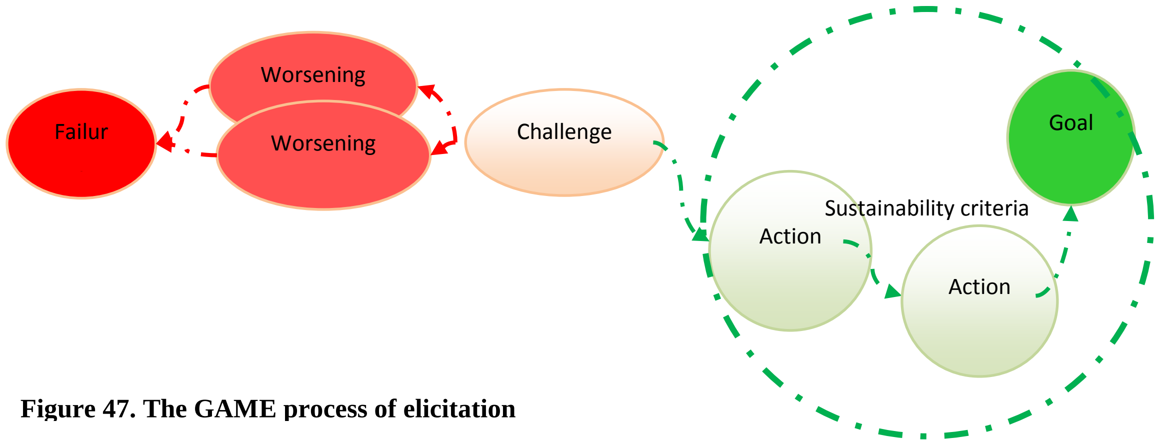


Figure 47. The GAME process of elicitation

As reported in the description of the procedure used for implementing the GAME methodology, the “future workshop” (Jungk and Müllert, 1987; Valqui Vidal, 2005), has been chosen for its characteristic of being designed to facilitate wider participation into processes addressing real-life problems. A clear process has been planned, accordingly as described in

Figure 47 (page 231). This has been done by the definition of a clear process carried out during workshops and interviews and an activity of facilitation that has proposed participants a structure and procedure of the GAME matrix, by questions on the challenges, worsening situations (‘beware’), failures, then goals (‘what to achieve’) and actions needed to reach them (‘how’), as described in sub-section 7.1. Of course this has required, like in every workshop, an effort of facilitation and explanation of the procedure in an easy understandable way by different participants. In the interviews and workshops the GAME matrix has been populated by a question as hereafter:

«With reference to your activity (research or production or other), what kind of challenge have you encountered as a matter of the sustainability of the system in which you operate? Please try to locate the challenge in the capital dimension appropriate and refer to some key sustainability criteria for that capital». Similar questions were made for the worsening situations, failures, goals to achieve and actions to be implemented.

A technique usually implemented in workshops has been to divide the participants in groups, in order to have form them different perspectives that in a final phase are shared, realising social learning and knowledge transfer. The procedure allowed to come up with stronger views that participants shared. In the workshops, a further ‘narrative homework’ was asked from each group, telling a possible story of sustainable practices, summarising the possible scenarios. The narrative produced where used as material for populating the GAME matrix. The outcome of the GAME exercise has been a confirmation or modification of the sustainability criteria and the definition of possible actions and policies that can achieve the goals. One of the main outcomes of one of the workshops has been the goal of realising global fair trade scheme for organic food production. In order to achieve this goal, some possible policies have been identified in the empowerment of local producers, the rise of farmers educational level and entitlements, knowledge exchange, best practices and transparency of the food system and of food products, cooperative solutions for food distribution, and policy intervention to incentivise and boost local and sustainable productions versus the dominance of long and globally spread distribution chains.

At the Conference, the GAME matrix allowed the researcher to:

- Populate it according to the interventions and presentations, strictly following what communicated by the presenters by speech or written slides, in terms of what constituted a challenge, what a failure and what a goal.
- Ask from the participants during breaks clarifications and specifications about the issues treated.

The EURAGRI conference gave the researcher the opportunity to pose questions about governance, where a number of needs were recognised for the problem of food security, such as scholarisation and empowerment of women. The researcher asked: *«if we well know the ways to achieve food security, how about setting a global governance scheme for empowerment of local productions, education, transparency and healthy food, and institutional agreements for mandatory standards»?* The question, based on the results of the previous workshop, did not receive any answers, even if disagreement was not expressed. The concerned presenter, during the lunch after the session apologised for not having answered but the question was too difficult. In the discussion at the table it resulted a certain difficulty to express opinions that, even if condivisible, would sound contrary to the status-quo of liberalised markets because would produce regulatory standards.

The GAME methodology is currently used for the planning of a research for a Horizon 2020 Workpackage, where also De Montfort University is partner and will work with the researcher if the grant is assigned. The methodology has got the appreciation by all scientific partners involved in the consortium.

As recalled in sub-section 6.2.2, the GAME acknowledges the limited ability of univocal indicators or unidimensional measurements to describe complex matters, and provides the possibility to explore the background data that behind the sustainability criteria (and the indicators proposed for future research) and provide the explanation on the reasons for the sustainability evaluation performed. The GAME methodology and framework will allow building general principles on the basis of specific contexts and, on the other way around, to open successive boxes, from more general to more specific issues. These latter will explain in more detail the contextual situations, the possible failures, problems and risky choices that need changes and innovations at local level. This way, the evaluation realises an integrated and holistic methodology of social learning and co-creation. The GAME methodology and framework, empirical achievement of this thesis, allows implementing the conceptual framework of governance for sustainability as theorised in Chapter 4, by allowing the implementation of the principle of accountability through a holistic and transparent evaluation of systems' sustainability, from contextual data towards general criteria and from general criteria to the planning of actions. This allows to learn about human agency as adequate to the systems in which it applies and to put the basis for the construction of Jackson's 'bounded capabilities'.

9.5 Future challenges and work (research and practice).

This research has presented visions that have been judged by some as idealistic, a term that can be interpreted perhaps in the sense of non-realistic or non-applicable in today's societies.

The first reaction to this comment of the author of a scientific work is to relate the term 'idealistic' to the state-of-the-art of science. The arguments presented in the thesis have found strong support by a wide range of accredited scientific literature, and have been confirmed by concrete and documented failures of current systems in addressing sustainability issues. Moreover, the research is not discarding market and legislative systems, nor reducing their value. Even with these structures being valid for managing many human systems, the results demonstrate that, in order to proceed towards sustainability, they should be integrated in more holistic and systemic arrangements. Too often current social structures have shown their inability to manage complexity, enhanced risks and produced actual failures, many of them involving very severe or irreversible consequences of which single actors cannot take the responsibility. So, from a scientific perspective, the need of alternative governance arrangements for purposes of systems' sustainability should not be classified as a fantasy.

From a practical perspective, the current challenges of the GAME, according to the experience of the present research are mentioned and possible solutions that could be object of future research are mentioned in Table 51 (page 234).

Table 51. The GAME challenges and possible future research development

Challenges	Future research
Metagovernance evaluation about the institutional arrangements and able to implement governance for sustainability and internalised it in social structures within the society	Identification of appropriate governance partnerships, participatory entities that are responsible and accountable for sustainable development.
The space/integration problem: qualitative data, consisting of narratives, is not easy to aggregate, integrate and summarise and represent in the limited space of the GAME matrix.	Geospatial representation, following the example of the Dashboard of Sustainability Indicators for user-friendly information about contextual situations and planned actions to be taken. A dedicated software could identify similar text and allow the integration and summary, while keeping track of the sources.
Holistic systemic representation of the evaluation of systems' sustainability	Translation of multi-type qualitative and quantitative data into an indicator with the specification of the component elements for the different capitals.

Currently, an international research project is being planned on the implementation of the GAME methodology and framework through a sustainability indicator and a geospatial representation tool. This aims at providing a holistic, yet user-friendly tool that would deliver information about the sustainability of food systems for different productions and in different local areas. The tool will allow representing the all process of sustainability evaluation in a transparent way, from original data to general sustainability criteria, by opening successive sub-sets, containing more specific data.

9.5.1 The challenge of the organisation of governance structures

In relation to the question posed at the EURAGRI conference in the previous sub-section and recalling also the question posed to the European Bioeconomy Observatory Panel about the priorities to be given to the three pillars of sustainability (see sub-section 3.2), a first challenge has been acknowledged about the practical application of 'governance for sustainability' at institutional level. On this matter, a reference to the Metagovernance, or governance of governance, also mentioned in Chapter 4, can be made with reference to the design and managing of sound combination of hierarchical, market and network governance for the pursuit of sustainable development that has been analysed by the Brazilian government by *'The Green Grant Program – Bolsa Verde'* (Christo et. al., 2013). Even owing 54% of the world's tropical forests and the related biodiversity, large portions of population of the rural areas live in poor conditions, so that the program promotes the improvement of well-being aiming at taking the concerned people above the poverty line, by conservation policies and use of ecosystem services. The Metagovernance approach, the authors report, acknowledges «*the need for effective governance through vertical and horizontal coordination between institutions, and promotion of good governance practices for sustainable development*».

As reported by Christo et. al. (2013) and reported also in sub-section 4.1., recommendations for policy-makers are made and future research needs are identified. Deeper empirical investigation is also indicated to inform and guide policy-making processes and develop a handbook for community development and cooperative self-empowerment, as well as training modules for sustainable land-use. In governance for sustainability process and practices have to be implemented in order to assure governance modes that are integrated in social structures and are able to actually implement the recommendations formulated. The GAME methodology and framework incorporates governance processes with the aim of implementing the principle of accountability through the non-negotiable sustainability criteria, that reflect the idea of the Metagovernance handbook, but that would establish them as mandatory guidelines. The concrete application of governance at institutional level can take place, for instance, through institutional agreements about possible governance entities and structures.

Table 52. Elements of Metagovernance identified in the Bolsa Verde Program (source Christo et. al, 2013)

Elements of Metagovernance	Analysis of Bolsa Verde
Integration of different modes of governance	Hierarchy (government) and network (NGOs)
Provision of and access to information	New media (vs. old media) NGOs and trainings
Utilisation of endogenous knowledge	Not identified
Empowerment of weaker players	Partial = financial support without any enabling element
Deliberation on appropriate choices in governance and policy making	Low level, comparing to other programs (Bolsa Familia, Brasil sem Miseria etc.)
Interactive learning process	In course
Enabling good local practices (scaling up)	State borders

The institutional solutions can be diverse, example of these could be the North American Electric Reliability Corporation (NERC), a not-for-profit international regulatory authority whose mission is to assure the reliability of the bulk power system in North America (NERC, 2011) and the proposal made (Masera, Sajeva et. al, 2006) for the realisation of the European Council for the Security of Electric Power (ECSEP). However, the investigation on the most convenient and efficient governance arrangements, in terms of Institutions involved or possible governance entities and their organisation goes beyond the scope of this research and could constitute a good prosecution for future studies.

In this way, the GAME, on the one hand has planned in order to provide an evaluation of the situation at present. But its impact goes beyond measurements and recommendations, towards the implementation of the concept governance, through the definition of goals and of the implementation actions that are preferable.

Decision-makers and possible partnerships among them, or entities established for joint governance, are supposed to be accountable to the community, and justify the decision according to the sustainability criteria and the actions proposed. The GAME has indeed the aim to impact as a tool for implementing the concept of governance and the principle of accountability, from a conceptual perspective. Therefore, the GAME is useful to policy-makers, stakeholders, industries that would be willing to make decisions by a holistic approach of systems' integration for the sake of more sustainable solutions.

9.5.2 Tools for aggregation and representation

A second challenge is represented by the not easy task of aggregation and integration of big data in the small cells of a matrix that become unreadable. In the current analysis, the cause-effect relationships have been just described in the narratives and in the examples of Futures Wheels in sub-section 6.2 and 6.3.1 (see Figure 24, page 141, Figure 27, page 153 and Figure

28, page 154). In order to describe in a systematic way all the cause-effect relationships that happen or might happen in the future for systems characterised by high complexity, and in which big data converge, an automatic GAME tool, by use of geospatial representation, on the example of the Dashboard of Sustainability Indicators, could be developed. This would allow an easy-to-read representation of data related to contextual situation and a record tracking the path that leads to the sustainability criteria, to the goals, and to the planned actions to be taken. A dedicated application could be used to support the identification of similar text and help the process of aggregation, integration and summary, while keeping track of the original data and the related sources. This way, the GAME matrix could be designed as interactive software that would be able to provide direct potential to explore cause effect relationships. Such a GAME tool could:

- Allow for the inserting of data of different forms and from different sources, according to the ethical evaluation of their sustainability and the capitals they belong.
- Allow for establishing the relationships between such data, which cannot be immediately grasped in a unique visual representation.
- Allow aggregating and summarising the data in a more integrative format.
- Allow generating a matrix of criteria from the previous aggregations, *ad hoc* for different case studies and their possible integration.
- Provide a repository of case examples and data.
- Help in understanding the spatial distribution of different solutions, according to different contexts and cultures and the applicability of the general criteria.

Such a tool could be dynamically available at virtual level and could allow wide transparently and open communication to policy-makers and the public, and work, as previously mentioned, for implementing the principle of accountability. This could help the exchanging of best practices in different place and the social learning at a wider level.

9.5.3 An systemic and holistic indicator of sustainability

A third challenge it would be interesting to be able to translate the multi-type qualitative and quantitative big data into a quantitative but holistic indicator of sustainability, indicating at the same time the composition of its dimensions, perhaps not in the form of a unique composite indicator but as a multi-dimensional indicator representable as a set of vectors, which would be complemented by the qualitative information as well, in order to keep the informative value. Examples of this attempt are given in Table 53 (page 239) and Table 54 (page 240), referring to the spider diagrams of Figure 26 (page 148). The indicator is as calculated by the weighted average of the scores that correspond to the sustainability level, multiplied by the minimum value of the score themselves. The rationale for this is the principle of integration rather than the mere sum of dimension scores. Whenever only one dimension of sustainability is low, it influences or will influence in the future the others as well, so that presence of one score equal to zero makes the total index zero as well.

9.5.4 Final considerations

The challenges here presented are planned to be the object of future investigations. The continuous application and revision of the GAME methodology is also a future aim that naturally characterises a participatory process of self-learning. In fact, the GAME is only one of the available tools, and can be adapted and modified according to the needs. The main outcome of this research is the conceptual idea of a concrete implementation of governance that would induce to learn the rules for human action and to assure the entitlements for performing these actions, a virtuous organisation of societies in the pursuit of a more sustainable world.

Table 53. A proposal on the calculation of an index (Scenario I.1)

A GAME indicator for European Critical Electricity Infrastructure (ECEI)											
Variables	NATURAL CAPITAL Environment produced change and challenges	NATURAL CAPITAL Impact from humans	HUMAN CAPITAL Impact on humans	HUMAN CAPITAL Impact from humans	SOCIAL CAPITAL Social sustainability: public relevance	SOCIAL CAPITAL Governance	SOCIAL CAPITAL The reliability of markets	MANUFACTURED CAPITAL Sustainability and reliability of infrastructures	MANUFACTURED CAPITAL Technical aspects of the electricity infrastructure	FINANCIAL CAPITAL The reliability of the financial system	Σ
Scenario I.1: the failure of the ECEI											
Xi	1	1	0	0	0	0	0	0	0	0	
wi	1,3	1,3	1,2	1,2	1,1	1,1	1,1	1	1	1	11,3
	1,3	1,3	0	0	0	0	0	0	0	0	2,6

$$\min x_i \times \frac{\sum_{i=1}^{10} w_i \times x_i}{\sum_{i=1}^{10} w_i} \quad 0$$

Sustainability indicator (normalised)

0

Table 54 . A proposal on the calculation of an index (Scenario I.2)

A GAME indicator for European Critical Electricity Infrastructure (ECEI)											
Variables	NATURAL CAPITAL Environment produced change and challenges	NATURAL CAPITAL Impact from humans	HUMAN CAPITAL Impact on humans	HUMAN CAPITAL Impact from humans	SOCIAL CAPITAL Social sustainability: public relevance	SOCIAL CAPITAL Governance	SOCIAL CAPITAL The reliability of markets	MANUFACTURED CAPITAL Sustainability and reliability of infrasructures	MANUFACTURED CAPITAL Technical aspects of the electricity infrastructure	FINANCIAL CAPITAL The reliability of the financial system	Σ
	Scenario I.2: a vision for a reliabile ECEI										
Xi	3	3	3	3	4	3	3	3	3	4	
wi	1,3	1,3	1,2	1,2	1,1	1,1	1,1	1	1	1	11
	3,9	3,9	3,6	3,6	4,4	3,3	3,3	3	3	4	36
Score motivation	Actions on how to mitigate the environmental impact on							Sustainability indicator (normalised)			
					9,5575				0,5973		

$$\min x_i \times \frac{\sum_{i=1}^{10} w_i \times x_i}{\sum_{i=1}^{10} w_i}$$

REFERENCES *(numbers in brackets indicate data used for analysis)*

Abel, A. (2000). *Electric Utility Restructuring Briefing Book: Reliability*. Congressional Research Service. 13 October 2000. **[317]**

Abloy.fi; consulted in 2010 **[368]**

Adams, W.M. (2006). The Future of Sustainability: Re-thinking Environment and Development in the Twenty-first Century. Report of the IUCN Renowned Thinkers Meeting, 29–31 January 2006. **[1]**

Agrimonde – *Scenarios and Challenges for Feeding the World in 2050.* December 2009 – Summary Report; INRA-CIRAD **[330]**

American Economic Association, http://www.aeaweb.org/students/WhatIsEconomics.php, consulted on 12.12.2013 **[2]**

American Electric Reliability Corporation (2013) website: http://www.nerc.com/AboutNERC/Pages/default.aspx - information retrieved on 22.10.2013. **3**

Amin, M. (2007). P*owering the 21st Century: We can — and must — modernize the grid*. http://www.todaysengineer.org/2005/Mar/grid.asp **[343]**

Anand, S. and A. Sen (2000). *Human Development and Economic Sustainability*. World Development Vol. 28, No. 12, pp. 2029-2049, Elsevier Science Ltd **[5]**

Anand, S. and Sen, A.K. (1994). *Sustainable human development: concepts and priorities*. Office of Development Studies Discussion Paper, No. 1, UNDP, New York http://hdr.undp.org/sites/default/files/anand_sudhir_-_sustainable_human_development-_concepts_and_priorities.pdf ; consulted on 04.10.2014 **[4]**

Annan, K. A., United Nations Secretary-General, July 2002 - http://web.undp.org/globalpublicgoods/globalization/endorsements.html, consulted on 19.09.2014 **6**

Archer, T. (2004). *Kansainvälinen terrorismi ja Suomi (International Terrorism and Finland).* UPI-raportti 7:2004. Helsinki. **[7]**

Archick, K. (2016). The European Union: Current Challenges and Future Prospects. Congressional Research Services, US https://www.fas.org/sgp/crs/row/R44249.pdf

Association of Local Government Engineers New Zealand, (1998). *Infrastructure Asset Management Manual.* - Edition 1.1 **8**

Bachelorandmaster (2015). *Plato's The Allegory of the Cave: Meaning and Interpretation.* http://www.bachelorandmaster.com/creationofknowledge/allegory-of-the-cave.html **399**

Bacher R. and U. Näf, with contributions from M. Renggli and W. Bühlmann; external expert: Prof. Dr. Hans Glavitsch, Nussbaumen (2003). *Report on the blackout in Italy on 28 September 2003*; Swiss Federal Office of Energy (SFOE), November 2003 **[9]**

Baker, S. (2006). *Sustainable Development.* London, UK and New York, USA: Routledge **11**

Bakker, K. (2004). An uncooperative commodity: privatizing water in England and Wales, Oxford: Oxford University Press. **12**

Barnes, P., M. and T. C. Hoerber (2013). *Sustainable Development and Governance in Europe, The evolution of the discourse on sustainability*. Routlegde, New York **13**

Barzel, Y. (1997). *Economic Analysis of Property Rights.* 2nd ed. Cambridge: Cambridge University Press.

Beck, U. (1992). *Risk Society: Towards a New Modernity*, trans. Mark Ritter (London: sage). **14**

Bell, S. (2014). http://www.sysweb.open.ac.uk/People/simon.bell; consulted on 18.11.2014 **[374]**

Bell, S. and E. Coudert (2005). *A practitioner's guide to 'Imagine', the systemic and prospective sustainability analysis*. Blue Plan Papers (3). Valbonne, France: UNEP **377**

Bell, Simon; Berg, Tessa and Morse, Stephen (2015). *Rich pictures – beyond the tipping point.* In:ISDR2015.

Berkes, F., and C. Folke, editors (1998). *Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience.* Cambridge University Press, Cambridge, UK.

Bertalanffy, L. von. (1968). *General system theory: Foundation, development, application.* New York: George Braziller **15**

Bierman, F. (2013). *Curtaindown and nothing settled: global sustainability governance after the 'Rio+20' Earth Summit*. In *Environment and Planning: Government and Policy*, 2013, volume 13, pages 1099-1114 **16**

Bone, J. D. (2005). The Social Map & The Problem of Order: A Re-evaluation of 'Homo Sociologicus', Theory & Science **17**

Braynov, S. and T. Sandholm (2002). *Contracting With Uncertain Level Of Trust*. Computational Intelligence 18(4): pp. 501–514. **18**

Bromley, D.W. (1990). *Essays on the Commons.* Madison: University of Wisconsin Press.

Brown, J. H.; W. R. Burnside, A. D. Davidson, J. R. Delong, W. C. Dunn, M. J. Hamilton, N. Mercado-Silva, J. C. Nekola, J. G. Okie, W. H. Woodruff and W. Zuo (2011). *Energetic Limits to Economic Growth*. BioScience, University of California Press. **19**

Bull, R. (2013). *Achieving sustainability through deliberation – reflections from Hampshire's municipal waste-management strategy*; in Barnes, P., M. and T. C. Hoerber (2013). *Sustainable Development and Governance in Europe, The evolution of the discourse on sustainability*. Routlegde, New York; p.14 **20**

Buzan, B., O. Wæver and J. de Wilde, (1998). *Security: A New Framework for Analysis*. Lynne Rinner Publisher, Colorado. **[21]**

California Electricity Price Spikes: An Update on the Facts

Pope, S. L. *California Electricity Price Spikes: An Update on the Facts* http://www.hks.harvard.edu/hepg/Papers/Pope_CA.price.spike.update_12-9-02.pdf; consulted on 24.9.2014 **[51]**

Callicott, J.B. (1989). In Defense of the Land Ethic: Essays in Environmental Philosophy. Albany, NY: State University of New York Press **22**

Campbell, S. (2006). *Risk and the Subjectivity of preference*. Journal of Risk Research, Vol. 9, No. 3, 225-242. **[23]**

Capra, F. (2007). *Social learning towards a sustainable world. Principles, perspectives and praxis.* A. E.J. Wals, Wageningen Academic Publishers. **24**

Carter, N. (2007). *The politics of the Environment*. Cambridge University Press, Cambridge **25**

Castree, N. (2007). *Neoliberal ecologies*, in Nik Heynen, James McCarthy, Scott Prudham and Paul Robbins (eds.) *Neoliberal environments*, London: Routledge, p. 281. **26**

Central Maine Power Company. *The Great Northeast Blackout of 1965.* http://www.rense.com/general40/95.htm; consulted on 24.9.2014 **[341]**

CGIAR (Consortium of International Agricultural Research Centers) (2014). *CGIAR Strategy and Results Framework.* **[344]**

Château, B. and B. Bougnoux (2011). *3 scenarios to assess post-carbon transitions*. PACT: Pathways for Carbon Transition Deliverable D6. EC/DG Research Project 225 503. http://www.pact-carbon-transition.org/delivrables/D-6.pdf **[378]**

Chowdhry, B. H. (2001). *Power Quality*, IEEE Potentials April/May 2001. Vol. 20, No. 2:5-11 **[27]**

Christo, G. S. Christopoulos and M. Kull, (2013) *Governing Environmental Conservation through Green Grant support in Brazil: A metagovernance analysis*; paper presented at the XXVth ESRS Congress, 29 July – 1 August, Florence Italy **28**

Christopoulos, S., B. Horvath, M. Kull (2012) – Advancing the governance of cross-sectoral policies for sustainable development: A metagovernance perspective. Public Admin. Dev. 32, 305-323 **29**

CITEPA (2015). http://www.citepa.org/en/activities/emission-inventories/namea

Clark, C.W. (1990). *Mathematical bioeconomics: the optimal management of renewable resources.* 2nd edn. Wiley, New York **30**

Coley, F. J. S. (2008). *Exploring Whole System Design.* PhD Thesis, Cranfield University. **31**

Coolican, H. (1999). *Research Methods and Statistics in Psychology.* London, Hodder and Stoughton.

Complex Systems Society, http://www.complexssociety.eu/aboutComplexSystems.html, retrieved on 7.4.2014 **42**

Conant, R.C. and Ashby, W.R. (1970). *Every Good Regulator of a System Must be a Model of that System.* International Journal of System Science, ½, 89

Cook, D. N. 28 Jun 2001; Testimony before the United States Senate Committee on Governmental Affairs. **[43]**

Cordaro, R. (2001). Electric Reliability in Deregulated Markets: A Look at the ERO. Iowa State University WISE 2001 Intern Institute of Electrical and Electronics Engineers (IEEE) **[308]**

CORPUS (2011) – *Enhancing the Connectivity between Research and Policy-making in Sustainable Consumption*. FP 7 | Project No. 244103. Gerald Berger, Umberto Pisano (WU Wien), Jozsef Szlezak, Eva Csobod (REC) – on behalf of the CORPUS Consortium. The CORPUS Research Agenda for Sustainable Food Consumption in Europe. June 2011. http://www.scp-knowledge.eu/ **44**

CORPUS (2013). *Enabling Sustainable Consumption. Making Better Use of Research Evidence in Policy-Making*. http://www.scp-knowledge.eu/sites/default/files/knowledge/attachments/CORPUS%20Policy%20Brief.pdf consulted on 19.09.204 **[64]**

Costanza, R. (1989). *What is ecological economics?* Ecological Economics 1:1-7. **46**

Costanza, R. et al. (1998). *The value of the world's ecosystem services and natural capital*. Ecological Economics 25 (1): 3–15. doi:10.1016/S0921-8009(98)00020-2. **45**

Costanza, R. et al., (1997). *The value of the world's ecosystem services and natural capital, Nature.* 387(6630): pp. 255 **47**

Costanza, R., H.E. Daly, and J.A. Bartholomew (1991). *Goals, agenda, and policy recommendations for ecological economics.* In*: Ecological Economics: The Science and Management of Sustainability*, ed. R. Costanza, pp. 1–20. New York, **48**

NY, USA: Columbia University.

Costanza, R., R.D'Arge, R.de Groot, Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R.V., Paruelo, H., Raskin, R.G., Sutton, P., and van den Belt, M. (1987). *The value of the world's ecosystem services and natural capital*. Nature 387, 253-260 **49**

CPUC (California Public Utilities Commission). http://www.cpuc.ca.gov/puc/; consulted on 23.9.2014 **[333]**

Creswell, J. W. (2007). *Qualitative inquiry & research design: Choosing among five approaches.* Thousand Oaks: Sage Publications.

CRO Forum (2011). *Power Blackout Risks. Risk Management Options*. Emerging Risk Initiative – Position Paper, November 2011. https://www.allianz.com/v_1339677769000/media/responsibility/documents/position_paper_power_blackout_risks.pdf consulted on 14.09.2014 **[310]**

Cropper, M. L. and W. E. Oates. (1992). *Environmental Economics: A Survey*. Journal of Economic Literature. 30: 675-740 **50**

Dahl Kristensen J., S. Kurppa and B. Darcy-Vrillon (2014). *Strategic Research Agenda on Sustainable Food Production and Consumption*. https://www.susfood-era.net/lw_resource/datapool/_items/item_192/sra-final_website_update.pdf **[352]**

Dahrendorf, R. (1996). *Prosperity, Civility and Liberty: Can We Square the Circle*' The British Academy **52**

Daily, G.C. (1997). *Nature's Services: Societal Dependence on Natural Ecosystems.* Washington, DC: Island Press **53**

Dake K. (1992). *Myths of nature: culture and the social construction of risk.* Journal of Social Issues 1992;48(4) :21–37. **54**

Daly, H. and J.Cobb (1989). *For the Common Good.* Beacon Press, Boston. **55**

de Haan, M. and P. Kee (2015). *Accounting for Sustainable Development: the NAMEA-based approach.* Statistics Netherlands. Division of Macro-economic Statistics and Dissemination Development and support department. http://www.cbs.nl/nr/rdonlyres/789fc43c-28ac-4a07-a4e1-158745589a50/0/accountingforsustainabledevelopmentthenameabasedapproach.pdf ; consulted on 03.12.2015

Defra (2010). *Food 2030*. Department for Environment, Food and Rural Affairs, UK **[357]**

Demsetz, H. (1967). *Toward a Theory of Property Rights.* American Economic Review 57 (2): 347–59.

Denzin, N. (1970). *The Research Act in Sociology: A Theoretical Introduction to Sociological Methods.* London, Butterworths.

Department for Environment, Food and Rural Affairs (DEFRA) (2010). *Food 2030*. http://archive.defra.gov.uk/foodfarm/food/pdf/food2030strategy.pdf **56**

Descartes, 1638: *Discours de la Methode*, Part VI.

Diamond, J. (1996). *The Roots of Radicalism.* The New York Review of Books. Vol. 4-6.

Douglas Harper online etymology dictionary, http://www.etymonline.com/index.php?term=economy retrieved in 19.3.2014 **57**

Douglas M. (1994). *Risk and blame: essays in cultural theory*. Routledge, London. **58**

Douglas, M., (1985). *Risk Acceptability According to the Social Sciences, Social Research Perspectives.* Occasional Reports on Current Topics, Russell Sage Foundation **59**

Douthwaite (1999). *The Need to End Economic Growth*; in M.S. Cato and M. Kennett. *Green Economics: Beyond Supply and Demnad to Meeting Human Needs*. Aberystwyth: Green Audit **[60]**

Dreborg, K. E. (1996). *Essence of backcasting*. Futures, Elsevier Science, UK **375**

Drexhage, J. and D. Murphy (2010). *Sustainable Development: From Brundtland to Rio 2012.* Background Paper prepared for consideration by the High Level Panel on Global Sustainability at its first meeting, 19 September 2010. United Nations Headquarters, New York. International Institute for Sustainable Development (IISD) **61**

Dryxek, J.S. (2005). *The politics of the Earth*. Oxford University Press. Oxford, UK, and New York, USA. **62**

Dryzeck, J. S. (2005) (2nd edition). *The Politics of the Earth: Environmental Discourses*. Oxford, UK and New York, USA: Oxford University Press **63**

DuALIne (2011). *An INRA-CIRAD prospective study on Food System and Sustainability*; Catherine Esnouf, Nicolas Bricas and Marie Russel 2011. **[65]**

Dubois, A.and L.E. Gadde (2002). *Systematic combining: an abductive approach to case research.* Journal of Business Research 55 (2002) 553-560 **66**

Dubois, D. (2002). *The attack of 11 September.EU-USA cooperation against terrorism in the field of justice and home affairs*. European Foreign Affairs Review. Vol 7, pp. 317-335. **[67]**

Easterby, M., Malina, Danusia (1999). *Cross-cultural collaborative research: Toward reflexivity.* Academy of Management Journal; Feb 1999; 42, 1; ABI/INFORM Global **68**

EC, European Commission - http://europa.eu/legislation_summaries/energy/internal_energy_market/l27066_en. **307** htm consulted on 13.09.2014

EC, European Commission (2006), Proposal for a Directive of the Council on the identification and designation of European Critical Infrastructure and the assessment of the need to improve their protection **35**

EC, European Commission (2011). Communication from the Commission to the European Parliament, the council, the European economic and Social Committee and the Committee of the Regions. *Roadmap to a Resource Efficient Europe Brussels*, 20.9.2011. COM (2011) 571 final **[32]**

EC, European Commission, Brussels, 25.7.2001 -COM(2001) 428 final; EUROPEAN GOVERNANCE - A WHITE PAPER http://eur-lex.europa.eu/LexUriServ/site/en/com/2001/com2001_0428en01.pdf **41**

EC, European Commission, COMMUNICATION FROM THE COMMISSION - COM(2012) 750 final. Annual Growth Survey 2013(a). Brussels, 28.11.2012 http://ec.europa.eu/europe2020/pdf/ags2013_en.pdf - retrieved on 13.10.2013 **33**

EC, European Commission, DG Enterprise and Industry (2010) Security research and development; http://ec.europa.eu/enterprise/policies/security; retrieved on 22.04.2010 **36**

EC, European Commission, DIRECTIVE 2003/54/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 26 June 2003 concerning common rules for the internal market in electricity and repealing Directive 96/92/EC **37**

EC, European Commission, Directorate General for Research and Innovation (2012). *Innovating for Sustainable Growth. A Bioeconomy for Europe*. **75**

EC, European Commission, Green Paper, A European Strategy for Sustainable, Competitive and Secure Energy, COM(2006) 105 final, Brussels, 8.3.2006 **38**

EC, European Commission, REGULATION (EC) No 1228/2003 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 26 June 2003 on conditions for access to the network for cross-border exchanges in electricity **39**

EC, European Commission. The Europe 2020 Strategy http://ec.europa.eu/europe2020/europe-2020-in-a-nutshell/index_en.htm retrieved on 13.10.2013(b) **34**

EC, European Commission; Brussels, 25.7.2001 -COM(2001) 428 final; *EUROPEAN GOVERNANCE - A WHITE PAPER* **40**

ECFESD (2000). Sustainable Governance European Consultative Forum on the Environment and Sustainable Development (European Commission, Brussels) **69**

EdSteps (2014). *Global Competence Matrices.* http://www.edsteps.org/ccsso/DownloadPopUp.aspx?url=SampleWorks/GC_Subject_Matrices.pdf, consulted on 22.10.2014 **353**

EdSteps (2015). *Global Competence Matrices.* https://www.neafoundation.org/content/assets/2012/11/Global%20Competence%20Content-Area%20Matrices.pdf; consulted on 01.12.2015

Edsteps website, consulted on 4.3.2014 http://www.edsteps.org/ccsso/SampleWorks/matrix.pdf **70**

EFARD's role in responding to the Global Food and Nutrition Challenge (2014) Annual Technical and Business Meeting, 12-13 November, 2014 **[400]**

Ehrlich, P. R. (1970). *Looking Backward From 2000 A.D.* The Progressive. 34: 23-25. **[71]**

Eickhoff, P. and S. G. Geffers (2006). *Power of Imagination Studio - A Further Development of the Future Workshop Concept*, in Holman, P. T. Devane and S. Cady (ed.): The Change Handbook -The Definitive Resource on Today's Best Methods for Engaging Whole Systems -2nd edition, San Francisco ISBN 1576753794 **381**

ELCON (Electricity Consumers Resource Council), 2004. *The Economic Impacts of the August 2003 Blackout*. **[328]**

Emergent By Design (2015). *3 Steps For Plotting Your Personal Future In An Uncertain World*. http://emergentbydesign.com/tag/futures/, consulted on 07.12.2015

Energent Futures (2009). http://www.emergentfutures.com/wpdl/Emergent%20Futures%20Consequence%20Wheel%20Tool%20Download.pdf, consulted on 03.08.2016

Emery, F. E., and E. L. Trist (1960). *Socio Technical Systems*. In Management Sciences Models and Techniques , vol. 2. London. **72**

Empter, S. and J. Janning (2009). *Sustainable Governance Indicators 2009 - An Introduction*. In Stiftung, Bertelsmann. Policy Performance and Executive Capacity in the OECD. Gütersloh: Verlag Bertelsmann Stiftung. **73**

Energy Policy Act (2005). *SUMMARY OF RELIABILITY LEGISLATION* (Source: Section 1211 of H.R. 6, the "Energy Policy Act of 2005," signed by the President on August 8, 2005.) https://www.rfirst.org/Documents/Summary%20of%20Reliability%20Legislation%20-%2020050808.pdf consulted on 15.9.2014 **[316]**

Environmental protection Agency website http://www.epa.gov/brownfields/policy/initiatives_co.htm, retrieved on 18.10.2013 **74**

ETP, European Technology Platform *'Food forLife'* (2012). http://etp.fooddrinkeurope.eu/asp/groups/index.asp?doc_id=644, consulted on 19.09.20148 **[76]**

Eurelectric (2004). Power Outages in 2003. http://www.globalregulatorynetwork.org/Resources/PowerOutagesin2003.pdf, consulted on 23.09.2014 **[337]**

EURGRI Conference 28,29 & 30 Septembre 2014 - IAMM, 3 Montpellier, France https://colloque6.inra.fr/euragri_conference_2014_fre **[345]**

European Commission, Standing Committee on Agricultural Research (SCAR). (2011). The 3rd SCAR Foresight Exercise. *Sustainable food onsumption and production in a resource-constrained world* **[327]**

European Union, European Innovation partnerships website http://ec.europa.eu/research/innovation-union/index_en.cfm?pg=eip consulted on 18.9.2014 **[329]**

Evans, J. P. (2012). *Environmental Governance*. New York: Routledge. **[77]**

Faber, M. (2008). *How to be an ecological economist*. Ecological Economics 66(1):1 **[78]**

FAHRE, (2010). *Food and health research needs in Europe: synthesis of thematic expert reports*, November 2010. http://www2.spi.pt/fahre/reports/research_needs_synthesis.pdf, consulted on 18.9.2014 **[80]**

FAHRE, *Food and Health Research needs in Europe* (2009). *Final Strategy Proposals Report*. April 2012. http://www2.spi.pt/fahre/index.asp **[79]**

FAO, Food and Agriculture Organisation (2014). *Innovation in family farming.* State of Agriculture Report. **[360]**

Farber, S. C., et al. (2002). *Economic and Ecological Concepts for Valuing Ecosystem Services*. Ecological Economics. 41: 375-392. 382 **81**

Farrell, K., R. Kemp, F. Hinterberger, C. Rammel and R. Ziegler (2005). *From *for* to governance for sustainable development in Europe*. International Journal of Sustainable Development 8 127-150 **82**

Farrington, T., C. Crews and J. Blenkle (2012). *Implications Wheels Structured Brainstorming about the Future.* VISION 2038 - Industrial Research Institute IRI, http://www.iriweb.org/Public_Site/RTM/Volume_56_Year_2013/May-June_2013/Implications_Wheels.aspx; consulted on 07.12.2015

FERC (2003). Summary findings. http://www.ferc.gov/industries/electric/indus-act/wec/enron/summary-findings.pdf; consulted on 23.09.2014 **[338]**

FERC (2014) (b). *The Western Energy Crisis, the Enron Bankruptcy, and FERC's Response*. http://www.ferc.gov/industries/electric/indus-act/wec/chron/chronology.pdf; consulted on 24.9.2014 **[339]**

FERC (Federal Energy regulatory Commission) - http://www.ferc.gov/enforcement/market-manipulation.asp, consulted on 12.09.2014 (a) **[305]**

Finucane, M. L., P. Slovic, C. K. Mertz, J. Flynn, and T. A. Satterfield (2000). *Gender, race, perceived risk: The "white male" effect*. Health, Risk, & Society, 2, 159-172. **87**

Flinders, M. (2002). *Governance in White hall.* Public Administration 80(1) 51-76 **88**

Flyvbjerg, B. (2001). *Making social science matter. Why social enquiry fails and how it can succeed it again.* Cambridge University Press, New York **89**

Flyvbjerg, B. (2004). *Phronetic Planning Research: Theoretical and Methodological Reflections.* Planning Theory & Practice, Vol 5, No.3, 283-306. **90**

Flyvbjerg, B. (2012). *Real social science. Applied phronesis.* Flyvbjerg, Ladman and Schram. Cambridge University Press, New York **91**

Folke C., J. Colding, and F. Berkes (2002). *Building resilience for adaptive capacity in social-ecological systems*. In: Berkes F., J. Colding, and C. Folke (eds). Navigating Social-Ecological Systems: Building Resilience for Complexity and Change. Cambridge University Press, Cambridge, UK. **304**

Fontaine, G. (2007); *Verde y negro: ecologismo y conflictos por petróleo en el Ecuador*, (Green and Black: environmentalism and oil conflicts in Ecuador) in G. Fontaine, G. van Vliet, R. Pasquis (Coord.), *"Políticas ambientales y gobernabilidad en América Latina"* (Environmental policies and governance in Latin America); Quito: FLACSO-IDDRI-CIRAD, pp. 223-254 **92**

Forum for the Future (2013)- website; http://www.forumforthefuture.org/project/five-capitals/overview, consulted on 25.07.2013 **93**

Forum on a new World Governance "World Governance Index 2009 Report". Retrieved on 4 September 2013. http://www.world-governance.org/spip.php?article469 **94**

Foster, Clark, and York (2010a). *The Ecological Rift*, Monthly Review Press, New York, 397-99. **404**

Foster, Clark, and York (2010b). *Capitalism and the Curse of Energy Efficiency*. Monthly Review 62, no. 6 (November 2010): 1-12. **406**

Foster, J. B. (2011). *Capitalism and Degrowth: An Impossibility Theorem*

http://monthlyreview.org/2011/01/01/capitalism-and-degrowth-an-impossibility-theorem/#en15 **402**

Fraser, E. (2014). *The Need For More Equitable Food Distribution*. Feeding Nine Billion website, https://feedingninebillion.com/video/need-more-equitable-food-distribution, consulted on 21.10.2014 **[303]**

Freeman, A. M. (2003). *The Measurement of Environmmental and Resource Values: Theory and Method*. (2nd Edition) Washington, DC: Resources for the Future **95**

Freeman, R. E., G. Rusconi and M. Dorigatti (2007). *Teoria degli stakeholder*. Francoangeli, Fondazione Acli Milanesi; p. 14, 15, 39 **96**

Funtowicz, S. and J. Ravetz (1990). *Uncertainty and quality in science for policy*; Kluwer Academic Publishers, Dodrecht, The Netherlands **97**

Funtowicz, S. and J. Ravetz (2003). *Post-Normal Science*. International Society for Ecological Economics, Internet Encyclopaedia of Ecological Economics, Research Methods Consultancy, London, England **98**

Funtowicz, S. and J. Ravetz (2014). *Post-Normal Science - Environmental Policy under Conditions of Complexity*. Nusap.net website, consulted on 11.02.2013 **99**

G4S, Web: http://www.g4s.fi/fi-fi/, consulted in 2010/2014 **[100]**

Geels, F. W. (2011). *The multi-level perspective on sustainability transitions: Responses to seven criticism.* Elsevier **101**

Gay, L. R. (1996). *Educational Research: Competencies for Analysis and Application*, Fifth Edition, Prentice-Hall.

Gheorghe, A. V., M. Masera, L. de Vries, M. Weijnen, W. Kröger (2007). *Critical infrastructures: the need for international risk governance.* International Journal of Critical Infrastructures **[102]**

Gibson, R.B. (2001). *Specification of sustainability-based environmental assessment decision criteria and implication for determining 'significance' in environmental assessment*. Canadian Environmental Assessment Agency Research and Development Programme, Ottawa **103**

Giddens, A. (1976). *New Rules of Sociological Method: a Positive Critique of interpretative Sociologies*. London: Hutchinson. **105**

Giddens, A. (1984). *The constitution of society: Outline of the theory of structuration.* Cambridge: Polity Press. ISBN 0-520-05728-7. **104**

Gini, C. (1912). *Variabilità e mutabilità* (Variability and Mutability , C. Cuppini, Bologna, 156 pages. Reprinted in Memorie di metodologica statistica (Ed. Pizetti E, Salvemini, T). Rome: Libreria Eredi Virgilio Veschi (1955). **106**

Glaser, B. G. and A. L. Strauss (1967). *The Discovery of Grounded Theory: Strategies for Qualitative Research*. Chicago, Aldine Publishing Company **107**

Glasser, H (2007). *Minding the gap: the role of social learning in linking our state desire for a more sustainable world to our everyday actions and policies.* In: *Social learning towards a sustainable world. Principles, perspectives and praxis.* Arjen E.J. Wals, Wageningen Academic Publishers. **108**

Glesser, H. (2007). *Learning Our Way to a Sustainable and Desirable World: Ideas Inspired by Aarne Naess and Deep Ecology.* , in Arjen E.J. Wals and Peter Blaze Corcoran, eds., *Higher Education and the Challenge of Sustainability: Problematics, Promise, and Practice.* Dodrecht: Kluwer, pp 131-148 **109**

Global Footprint Network (2008), *The Ecological Footprint* Atlas 2008: Version 1.0, Global Footprint Network, Oakland, CA. **110**

Goldstein, H. (1981). Social learning and change: A Cognitive Approach to Human Services. Columbia, SC: Univeristy of South Carolina Press. **111**

Gómez-Baggethun E. and M. Ruiz-Pérez (2011). *Economic valuation and the commodification of ecosystem services*. Progress in Physical Geography **112**

Gomez-Baggethun, E., R.de Groot, P.L.Lomas, and C. Montes, (2010). *The history of ecosystem services in economic theory and practice: From early notions to markets and Payment Schemes.* Ecological Economics 69, 1209-1218 **113**

Government of Finland (2008). Safety first, Internal Security programme, Government Plenary Session, May, 2008 **83**

Graedel, T. E. and R. J. Klee (2002). *Getting serious about sustainability. Environmental Science & Technology* 36(4): 523-529. **393**

Graves, P. E., (2002). Valuing Public Goods. University of Colorado, Department of Economics. http://spot.colorado.edu/~gravesp/GravesRevtext.htm **114**

Green, S. and M. Lemon (1996). *Perceptual Landscapes in Agrarian systems: Degradation processes in North-western Epirus and the Argolid Valley*, Greece, Ecumene, 3(2). pp181-199. **391**

Griffin, L. (2013). *Governance for sustainability in the European Union: a post-political projec*t; in Barnes, P., M. and T. C. Hoerber (2013). *Sustainable Development and Governance in Europe, The evolution of the discourse on sustainability*. Routlegde, New York; p.8 **115**

Grin, J. and H. Van Der Graaf (1996). *Implementation as communicative action*. Policy Sciences, Kluwer Academic Publishers **116**

Grin, J. and H. Van Der Graaf (1996). *Technology Assessment, Policy Sciences*. Kluwer Academic Publishers **117**

Gross, R. And R. Mcilveen (1998). *Psychology a New Introduction.* UK, Hodder and Stoughton.

Haberl, H., Fischer-Kowalski, M., Krausmann, F., Weisz, H. and Winiwarter, V. (2004). *Progress towards sustainability? What the conceptual framework of material and energy flow accounting (MEFA) can offer, Land Use Policy* 21(3) 199-213.

Haftendorn, H. (1991). *The security puzzle: Theory-building and discipline building in international security*. International Studies Quarterly. Vol. 35, No. 1, **[118]** pp. 3-17

Hahn, R. W. (2009). *An Evaluation of Government Efforts to Improve Regulatory Decision Making*. International Review of Environmental and Resource Economics. 3: 245-298. 245 **119**

Harris J. (2006). *Environmental and Natural Resource Economics: A Contemporary Approach*. Houghton Mifflin Company. **120**

Huesemann M. and J. Huesemann (2011). *Techno-Fix. Why Technology Won't Save Us or the Environment.* New Society

HDHL (2011). A Healthy Diet for a Healthy Life Joint Programming Initiative. October 2011. http://www.healthydietforhealthylife.eu/, consulted on 23.10.2014 **[358]**

Holling, C. S., editor (1978). *Adaptive environmental assessment and management.* John Wiley & Sons, London, UK.

Holling, C. S. (2000). Theories for Sustainable Futures. Conservation Ecology http://www.ecologyandsociety.org/vol4/iss2/art7/ **121**

Hines, A., and Bishop, P. (2007). *Thinking About the Future: Guidelines for Strategic Foresight.* Washington, DC: Social Technologies.

http://www.nytimes.com/2003/01/02/international/europe/02FINL.html, consulted on 16.12.2014 **[389]**

http://www.semissourian.com/story/121022.html **[324]**

Huberman, A. Miles M. (2002). *The Qualitative Researcher's Companion.* UK, Sage Publications.

Hulme, M. (2009). *Why We Disagree About Climate Change: Understanding Controversy, Inaction and Opportunity*. Cambridge: Cambridge University Press. **122**

Häder, M. and Häder, S. (1995). *Delphi und Kognitionspsychologie: Ein Zugang zur theoretischen Fundierung der Delphi-Methode*, in: ZUMA-Nachrichten, vol. 37, 19. November 1995, p. 12.

IAAST (2009). Agriculture at a Crossroad. Synthesis report of International Assessment of Agricultural Knowledge, Science and Technology for Development. http://apps.unep.org/publications/pmtdocuments/-Agriculture%20at%20a%20crossroads%20-%20Synthesis%20report-2009Agriculture_at_Crossroads_Synthesis_Report.pdf, consulted on 23.10.2014 **[10]**

IEEE (Institute of Electrical and Electronics Engineers) (2006). Systems, Controls, Embedded Systems, Energy, and Machines. The Electrical Engineering Handbook, Third Edition. Taylor& Francis Group **[318]**

IEEE/CIGRÉ Joint Task Force on Stability Terms and Definitions (2004). Definition and Classification of Power System Stability. IEEE Transactions on **[315]**

Power Systems, Vol. 19, No. 2, May 2004.

IISD, International Institute for Sustainable Development, http://www.iisd.org/sd/; retrieved on 12.12.2013 **123**

Infrastructure for the 21st Century, Washington, DC (1987): National Academy Press **124**

International Federatuion of Agriculture Movements (IFOAM) (2014). Ifoam.org, consulted on 7.11.2014 **[371]**

IRGC, International Risk Governance Council, White paper (2006). *Managing and Reducing Social Vulnerabilities from Coupled Critical Infrastructures.* Geneva **[125]**

Jackson, T. (2009). *Prosperity without growth? The transition to a sustainable economy.* Sustainable Development Commission **[126]**

Jauch, H. (2007). *Between politics and the shop floor. Which way for Namibia's labour movement?*; in Transition in Namibia – Which changes for who? Henning Melber **[127]**

Jessop B. (2002) *Liberalism, Neo-Liberalism and Urban Governance: A State Theoretical Perspective*, Antipode, 34 (3), p. 454. **128**

Johns Hopkins University (2016). *Case Study & Narrative Analysis, Qualitative Data Analysis, Class Session 4* http://ocw.jhsph.edu/courses/qualitativedataanalysis/pdfs/session4.pdf, consulted on 18.01.2016

Johnson, K. A., G. Dana, N. R. Jordan, K. J. Draeger, A. Kapuscinski, L. K. Schmitt Olabisi and P. B. Reich (2012). *Using participatory scenarios to stimulate social learning for collaborative sustainable development. Ecology and Society* 17(2): 9. http://dx.doi.org/10.5751/ES-04780-170209

Johnson, W. C. (2003). *Understanding Failures in International Safety-Critical Infrastructures: A Comparison of European and North American Power Failures*. Department of Computing Science, University of Glasgow, Scotland, U.K. http://www.dcs.gla.ac.uk/~johnson/papersBlackout_Comparison/Johnson_Power_Infrastructure.pdf, consulted in 2014 **[309]**

Joint Programming Initiative (2012). *A healthy diet for a healthy life*. HDHL JPI: Strategic Research Agenda 2012 -2020 and beyond. June 2012. https://www.healthydietforhealthylife.eu/index.php?index=5 Joint Programming Initiative FACCE JPI. Agriculture, food security and climate change. Scientific Research Agenda. Scope, common vision and priority actions. 2010. http://www.faccejpi.com **129**

Joint Programming Initiative FACCE-JPI (2011). *Mapping and Foresight on Mitigation of agricultural greenhouse gas-induced climate change* - Options for strategic collaboration - FACCE CSA Mapping Meeting 1, June 20-21, 2011; The Hague, The Netherlands **130**

Jordan, A. (2008). *The governance of sustainable development: taking stock and looking forward.* Environment and Planning C: Government and Policy, volume 26, pages 17 - 33. **131**

Jungk, R. And N. Müllert (1987). *Future workshops: How to create desirable futures London: Institute for Social Inventions.* Institute of Social Inventions, London **379**

Kaapama, P. (2007). *Commercial land reforms in postcolonial Namibia. What happened to liberation struggle rhetoric?* in Transition in Namibia – Which changes for who? Henning Melber **[349]**

Kastenberg, B. (2005). *Assessing and managing the security of complex systems: shifting the RAMS paradigm*, System Analysis for a More Secure World: Application of System Analysis and RAMS to Security of Complex Systems, ESReDA Seminar at European Commission DG Joint Research Centre, 25–26th October, University of California, Berkeley, USA **132**

Kaul, I. and R. U. Mendoza (2002). *Advancing the Concept of Public Goods; in Providing Global Public Goods – Managing Globalisation*. UNDP. Inge Kaul, Pedro Conceincao, Katell Le Goulven, Ronald U. Mendoza Editors, Oxford University Press. http://web.undp.org/globalpublicgoods/globalization/thebook.html **[133]**

Kemp, R., S. Parto and R.B. Gibson (2005) - *Governance for sustainable development: moving from theory to practice*, Int. J. Sustainable Development, Vol. 8, Nos. ½, pp.12-30 **[134]**

Knight, F. (1921). *Risk, Uncertainty and Profit.* Boston: Houghton Mifflin Company **135**

Kohler-Koch, B. and B. Rittberger (2006). *The 'governance turn' in EU studies.* Journal of Common Market Studies 44 (annual review) 27-49 **136**

Koimaan, J. (1993). *Modern Governance. New Government-Society Interactions*. Sage, London. **137**

Konttila, A. And J. Kaivo-oja (2011). *Trade-off analyses of prison population and classified criminality rates in some European countries, Finland, Turkey, the U.S.A., South Africa and Russia: Integration or disintegration process in the global criminal policies?* In Ekunwe, I.O. and R.S. Jones. Global Perspectives on Re-entry. Tampere University Press. Tampere. In Press. **138**

Kooiman, J. (2003). *Governing as Governance*. Sage publications. p170. **139**

Koshel P. and K. McAllister (2010). *Expanding Biofuel Production: Sustainability and the Transition to Advanced Biofuels: Summary of a Workshop*. National Research Council. The National Academies | 500 Fifth St. N.W. | Washington, D.C. 20001 Copyright © 2015 National Academy of Science http://www.nap.edu/openbook.php?record_id=12806&page=117 **398**

Krippendorff, K. (2004). *Content Analysis an Introduction to Its Methodology*. Ca, USA, Sage Publications.

Krutilla, J. V. (1967). *Conservation reconsidered.* The American Economic Review 57, 777-786 **140**

Krysiak, F. C. (2005). *Entropy, limits to growth, and the prospects for weak sustainability.* Elsevier **141**

Laszlo, A. and S. Krippner (1998). *Systems Theories: Their Origins, Foundations, and Development*; in J.S. Jordan (Ed.), Systems Theories and A Priori Aspects of Perception. Amsterdam: Elsevier Science, 1998. Ch. 3, pp. 47-74. http://archive.syntonyquest.org/elcTree/resourcesPDFs/SystemsTheory.pdf **142**

Laszlo, E. (1991). *The age of bifurcation: Understanding the changing world.* Philadelphia: Gordon & Breach. **[143]**

László P., P, Hardi and P. Bartelmus (2005). *Sustainable Development Indicators. Proposals for a Way Forward.* Prepared for the United Nations Division for Sustainable Development (UN-DSD). International Institute for Sustainable Development (IISD)

Lauttamäki, V. and O. Hietanen (2006). *Uhkien ennakointia ja hyvinvoinnin kehittämistä (Threat Foresight and Welfare Development)*, Raportti vuosien 2003–2006 aikana toteutetun Tulevaisuus ja turvallisuus: Poliisin toimintaympäristö muutoksessa (POLTU) -hankkeen kulusta ja tuloksista, Länsi-Suomen lääninhallitus. Tulevaisuuden tutkimuskeskus. Turku **[144]**

Lawn, P. (2007a). *What value is Gross Domestic Product as a macroeconomic indicator of national income, well-being, and environmental stress?* International Journal of Ecological Economics and Statistics, 8, pp. 22-43. **145**

Lawn, P. (2007b). *Frontier Issues in Ecological Economics*, Edward Elgar, Cheltenham. **146**

Lawn, P. (2011). *Is steady-state capitalism viable?: A review of the issues and an answer in the affirmative,* Ecological Economics Reviews, Annuals of the New York Academy of Science, 1219, pp. 1-25. **[147]**

Lawn, P. and M. Clarke (eds) (2008). *Sustainable Welfare in the Asia-Pacific*, Edward Elgar, Cheltenham. **148**

Leenes, R. J. Schallaböck and M. Hansen (2008). *The PRIME White Paper. The third and final version. Privacy and Identity Management in Europe*. 15 May 2008. **[367]**

Lehtonen, M. (2007). *Environmental policy integration through OECD peer reviews.* Environmental Politics 16 15-35 **149**

Lemon, M. (1999). *Social Enquiry and Natural Phenomena* in Lemon, M. ed. Exploring environmental change using an Integrative Method, Gordon and Breach, Reading (ISBN 90-5699-193-0).

Lemon, M. and Green, S. (1996). *Perceptual Landscapes in Agrarian systems: Degradation processes in North-western Epirus and the Argolid Valley*, Greece, Ecumene, 3(2). pp181-199. **372**

Lemon, M., P. Jeffrey and R. Seaton (1998). *Deconstructing the orange: The evolution of an agricultural milieu in Southern Greece*, Int. J. Sustainable Development, Vol 1 (1) pp 9-23. **373**

Lemon, M., P. Jeffrey, B.S. McIntosh and T. Oxley (2004). Understanding the perceptions of change: a pathways contribution to community consultation and environmental decision-making. Journal of Environmental Assessment Policy and Management. Vol 6, No 2, pp. 1-23. Imperial College Press **390**

Lemos M.C., C. J. Kirchhoff and V. Ramprasad (2012). *Narrowing the climate information usability gap.* Nature Climate Change 2, 789–794 (2012) doi:10.1038/nclimate1614

Levin, S. A. (1999). *Towards a Science of Ecological Management.* Conservation Ecology. 3(2): 6 **150**

Linsley, P. M. and P. J. Shrives, (2009). *Mary Douglas, risk and accounting failures.* Critical perspectives on Accounting 20 (2009) 492-508. **151**

Lintula, M. (2009) University of Helsinki, http://www.helsinki.fi/ajankohtaista/uutisarkisto/8-2009/13-09-48-14 consulted on 10.01.2011 **152**

Loewenstein, G. F., E. U. Weber, C. K. Hsee, E. Welch (2001). *Risk as feelings.* Psychological Bulletin, 127, 267-286. **153**

Lofland, J. and Lofland L. H. (1995). *Analyzing Social Settings: A Guide to Qualitative Observation and Analysis.* California, USA, Wadsworth.

Lowrance, W. W. (1976). *Of Acceptable Risk: Science and the Determination of Safety.* (Los Altos, CA: William Kaufmann). **154**

Lupton D. (1999) *Risk.* London: Routledge. **155**

Machiavelli, N. (1532); *The Prince.* Copyright ©2010–2015 All rights reserved Jonathan Bennet; http://www.earlymoderntexts.com/pdfbits/machpr2.pdf **[156]**

Manning, C. (2009). *The Psychology of Sustainable Behavior - Tips for empowering people to take environmentally positive action*. Minnesota Pollution Control Agency **157**

Marshall, J. D. and M. W. Toffel (2005). *Framing the elusive concept of sustainability: a sustainability hierarchy.* Environmental Science & Technology 39(3):673-682. **396**

Martelius, J. (2010), Kansallisen turvallusuustutkimuksen päivä, 10.6.2010 Paasitorni, *Kansallisen turvallisuustutkimuksen strategia* http://www.minedu.fi/export/sites/default/OPM/Tapahtumakalenteri/2010/06/Kansallinen_Turvallisuustutkimuksen_pxivx_2010/Juha_Martelius.pdf **158**

Martelius, J. (2010). *National Security Research Strategy.* Ministry of Internal Affairs of Finland. http://www.minedu.fi/export/sites/default/OPM/Tapahtumakalenteri/2010/06/Kansallinen_Turvallisuustutkimuksen_pxivx_2010/Juha_Martelius.pdf ; consulted on 18.10.2014 **[351]**

Masera, M., A. Stefanini and G. Domodossola (2006). *Security Conceptual Frameworks,* in Critical Infrastructures at Risk - Securing the European Electric Power System, Springer Verlag **[321]**

Masera, M., Y. Wijnia, L. de Vries, C. Kuenzi., M. Sajeva, M. Wejnen (2006). *Governing risks in the European electricity system*. in "Critical Infrastructures at Risk - Securing the European Electric Power System, Springer Verlag **[159]**

Maxwell, J. A. (2005). *Qualitative research design: An interactive approach* (2nd Ed.). Thousand Oaks, CA: SAGE Publications.

McCauley, D.J. (2006). *Selling Out on Nature.* Nature. 443: 27-28 **160**

McClusky E.J. and S. Mitra (2004). *"Fault Tolerance" in Computer Science* Handbook 2ed. ed. A.B. Tucker. CRC Press **[314]**

McLeod, S. (2014). *Maslow's Hierarchy of Needs.* SimplyPsichology http://www.simplypsychology.org/maslow.html, consulted on 05.02.2015 **392**

McNamara, W. (2002). *The California Energy Crisis: Lessons for a Deregulating Industry*. PenWell Corporation, Tulsa, Oklahoma, U.S. **[332]**

McQueen, R. A. Knussen, C. (2002). *Research Methods for Social Science: A Practical Introduction.* Harlow, UK, Prentice Hall.

Meadowcroft, J. (2000). *Sustainable development: a new(ish) idea for a new century?* Political Studies 48 370-387 **161**

Meadowcroft, J. (2007). *National sustainable development strategies: features, challenges and reflexivity.* European Environment 17 152-163 **162**

Meadowcroft, J. (2013). *Reaching the limits? Developed country engagement with sustainable development in a challenging conjuncture*. In *Environment and Planning: Government and Policy*, 2013, volume 13, pages 988-1002 **[164]**

Meadowcroft, J., K. N. Farrell and J. Spangenberg (2005). *Developing a framework for sustainability governance in the EU*. International Journal of **163**

Sustainable Development 8 3-11

Meadows, Donella *et al.* 1972. *The Limits to Growth*. A Report for the Club of Rome's Project on the Predicament of Mankind. Universe Books. For discussion see Turner, G.M. *«A Comparison of The Limits to Growth with Thirty Years of Reality.»* Global Environmental Change. 18: 397-311 **165**

Melber, H. (2007). *Poverty, politics, power and privilege. Namibia's black economic elite formation?*; in Transition in Namibia – Which changes for who? Henning Melber **[166]**

Meuleman L. (2008) – *Public management and the metagovernance of hierarchies, networks and markets: the feasibility of designing and managing governance style combinations*. In contribution to Management Science XIV. Springer: Verlag Heiderlberg; 401 **167**

Millennium Ecosystem Assessment (2005). *Ecosystems and Human Well-being: Synthesis*. Washington, DC: Island Press. 13. **[168]**

Millennium Project. Global Futures Studies & Research (2009). *Middle East Peace Scenarios.* http://www.millennium-project.org/millennium/ME-Peace-Scenarios.html

Ministry of Agriculture and Forestry of Finland (2014). Maa- ja metsätalousministeriön hallinnonalan tulevaisuuskatsaus 2014. *Hyvinvointia ja kasvua ruuasta ja uusiutuvista luonnonvaroista.* (Well-being and growth by renewable natural resources) http://www.mmm.fi/fi/index/julkaisut/julkaisuarkisto/141003_tulevaisuuskatsaus2014.html, consulted on 30.10.2014 **[172]**

Ministry of Foreign Affairs of Finland (2010). *Development policy guidelines on agriculture and food security*. http://www.formin.finland.fi/public/default.aspx?contentid=203183&contentlan=2&culture=en-US, consulted on 30.10.2014 **[362]**

Ministry of Foreign Affairs of Finland (2010). *Finland's foreign and security policy* - http://formin.finland.fi/Public/default.aspx?nodeid=32280&contentlan=2&culture=en-US **84**

Ministry of Foreign Affairs of Finland (2012). *Finland's Development Policy Programme Government.* Decision-in-Principle 16 February 2012. http://www.formin.finland.fi/public/default.aspx?contentid=251855&nodeid=15457&contentlan=2&culture=en-US , consulted on 30.10.2014 **[361]**

Ministry of Foreign Affairs of Finland (2013). *Development Policy Guidelines for forest sector* http://www.formin.fi/public/default.aspx?contentid=288213&contentlan=2&culture=en-US **[363]**

Ministry of Interior of Finland, (2012). *A Safer Tomorrow*. Internal Security Programme, 2012 http://www.intermin.fi/download/37402_402012_STOeng.pdf?c56c672f1c05d188 consulted on 1.11.2014 **[86]**

Ministry of Interior of Finland, (2014). *A safer community*. Internal security programme. http://www.poliisi.fi/intermin/images.nsf/files/BF6173C421C8B72EC2256F1D00293F11/$file/sis_turv_esite_en.pdf, **[85]**

Ministry of Internal Affairs of Finland (2008). *Safety first.* Internal Security programme, Government Plenary Session, May, 2008 **[364]**

Ministry of Internal Affairs of Finland (2009). *National Security Research Strategy*. Publications of Advisory Board for Sectoral Research 18:2009 http://www.intermin.fi/download/14209_national_security_research_strategy_.pdf?31652d691c05d188; consulted on 18.10.2014 **[350]**

Ministry of Internal Affairs of Finland (2011). Website intermin.fi **[257]**

Mintzberg, H., B. Ahlstrand and J. Lampel (1998). *Strategy Safari. A Guided Tour Throughout the Wilds of Strategic Management*. The Free Press. New York.

Mitchell, R. and R.T. Carson (1993). *Using Surveys to Value Public Goods: The Contingent Valuation Method.* Washington, DC: Resources for the Future **169**

Montesquieu (1748). *De l'Esprit des Loix* **170**

Morgan, P. (2005). *The idea and practice of systems thinking and their relevance for capacity development*. European Centre for Development Policy Management. **171**

Mostert, E., C. Pahl-Wostl, Y. Rees, B. Searle, D. Tábara, and J. Tippet (2007). *Social learning in European river basin management: barriers and fostering mechanisms from 10 river basins.* Ecology and Society 12(1):19. [online] URL: http://www.ecologyandsociety.org/vol12/iss1/art19/.

Mwaniki A. (2014). *Achieving Food Security in Africa: Challenges and Issues.* Cornell University, U.S. Plant, Soil and Nutrition Laboratory UN website http://www.un.org/africa/osaa/reports/Achieving%20Food%20Security%20in%20Africa-Challenges%20and%20Issues.pdf, consulted on 22.10.2014 **[356]**

Najam, A., M. Papa and N.Taiyab (2006) *Global Environmental Governance. A Reform Agenda*; IISD. **173**

Nash, L. (2006). *Inescapable ecologies*, Los Angeles: University of California Press **174**

National Research Council (Commettee on Risk Categorisation), (1996). *Understanding Risk: Informing Decisions in a Democratic Society.* National **175**

Academy Press.

National Security Research Strategy (18:2009). Publications of Advisory Board for Sectoral Research **176**

Nattrass, B. and M. Altomare (1999). The Natural Step for Business: Wealth, Ecology and the Evolutionary Corporation. Gabriola Island, British Columbia: New Society Publishers. **397**

Neher, P. A. (1990). *Natural resource economics: conservation and exploitation.* Cambridge University Press, New York **177**

NERC Reliability Issues White Paper (2008). *Accommodating High Levels of Variable Generation to ensure the reliability of the bulk power system*. http://www.nerc.com/docs/pc/ivgtf/IVGTF_Outline_Report_040708.pdf consulted on 12.10.2014 **[348]**

NERC, North American Electric Reliability Corporation (1988). *Electricity Transfer and Reliability*. Princeton. **[320]**

NERC, North American Electric Reliability Corporation (2012). *Reliability Assessment Guidebook.* http://www.nerc.com/pa/RAPA/rg/ReliabilityGuidelines/Reliability_Assess_Guidebook_3_1Final.pdf, consulted on 16.9.2014 **319**

NERC, North American Electric Reliability Corporation (NERC) - http://www.nerc.com/; consulted in 2011 **[180]**

Neuendorf. (2002). *The Content Analysis Guidebook.* USA, Sage Publications.

Nidumolu, R., C.K. Prahalad and M.R. Rangaswami (2009). *Why Sustainability Is Now the Key Driver of Innovation*. Harvard Business Review http://hbr.org/2009/09/why-sustainability-is-now-the-key-driver-of-innovation/ **178**

Niemelä P, *et al.*. (1997) . *Suomalainen turvattomuus. Inhimillisen turvattomuuden yleisyys, perusulottuvuudet ja tyypittely* - haastattelututkimus 1990-luvun Suomessa. Sosiaali- ja terveysturvan keskusliitto. Helsinki. **[179]**

Norton, B. G. (2012). *Valuing Ecosystems.* Nature Education Knowledge 3(10):2 http://www.nature.com/scitable/knowledge/library/valuing-ecosystems-71373110 **181**

Norton, B.G. (2005). *Sustainability: A Philosophy of Adaptive Ecosystem Management.* Chicago, IL: University of Chicago Press. **182**

Occupational Safety and Health Administration, 2010 http://www.tyosuojelu.fi/fi/workingfinland/ **[183]**

OECD (2001). *Sustainable Development: Critical Issues.* Organisation for Economic Cooperation and Development (OECD, Paris) **184**

OECD (2003). *Report on Emerging Risks in the 21th Century – An Agenda for Action.* OECD publications, Paris. **185**

OECD and IEA (Organisation for Economic Cooperation and Development and International Energy Agency), (2005). *Learning from the Blackouts Transmission System Security in Competitive Electricity Markets*. IEA Publication, Paris, France **312**

Ofgem (2004). *Report on support investigations into recent blackouts in London and West Midlands*. London. www.ofgem.gov.uk. **[326]**

O'Neill, J., A. Holland, and A. Light (2008). *Environmental Values.* London: Routledge. **186**

Organisation for Economic Co-operation and Development (OECD) – (2004) Principles of Corporate Governance - Retrieved on 4 September 2013 http://www.oecd.org/daf/ca/corporategovernanceprinciples/31557724.pdf **187**

Ostrom, E. (1990). *Governing the Commons: The Evolution of Institutions for Collective Action.* Cambridge: Cambridge University Press.

Overseas Development Institute (ODI) (2001), Briefing Paper, *Economic Theory, Freedom and Human Rights: The Work of Amartya Sen* http://www.odi.org.uk/sites/odi.org.uk/files/odi-assets/publications-opinion-files/2321.pdf **188**

Page, E. (2011). *Cashing in on climate change: political theory and global emissions trading*. Critical Review of International Social and Political Philosophy, 14(2), pp. 259-279. **189**

Paxton, Will and Mike Dixon (2004). *The State of the Nation: An Audit of Injustice in the UK.* Institute for Public Policy Research (London, England) **190**

Pearce, D.W. (1983). *The Dictionary of Modern Economics.* MacMillian London

Pearce, D. (1993). *Blueprint 3: Measuring Sustainable Development.* London, Earthscan **191**

Payne G. and J. Payne (2004). *Key Concepts in Social Research*. SAGE Publications

Peck, J. and Tickell, A. (2002) *Neoliberalizing Space*, Antipode, 34(3): p. 382. **192**

Penttilä, R.E.J. (2008). *The Idea of Finnish Foreign Policy*. (In Finnish). Taloustieto. Helsinki. **[193]**

Pepper, D. (1999). *Ecological Modernisation or the "Ideal Model" of Sustainable Development? Questions prompted at Europe's periphery*. Environmental Politics, 8(4) 1-34 **194**

Perrow, C. (1984). *Normal accidents: Living with high risk technologies.* International Journal of Critical Infrastructures, Vol. 1, no. 1, pp. 64-76 **195**

Phanuel Kaapama (2007). *Commercial land reforms in postcolonial Namibia. What happened to liberation struggle rhetoric?*; in Transition in Namibia – Which changes for who? Henning Melber **196**

Pierre, J. and Peters, B. (2005). *Governing Complex Societies.* Palgrave Basingstoke, Hants. **197**

Porrit, J. (2006). *Capitalism as if the World Mattered*. London: Earthscan, p. 46 **198**

Prigogine, I. et al. (1977). *Long term trends in the evolution of complexity, Goals in a global community: The original background papers for Goals for Mankind*, Ervin Laszlo et al. (eds). Vol. 1: Studies on the conceptual foundations. New York: Dutton. **199**

Quinn Patton, M. (2011). *Developmental Evaluation: Applying Complexity Concepts to Enhance Innovation and Use.* New York: Guilford Press. **200**

Reed, M. S., A. C. Evely, G. Cundill, I. Fazey, J. Glass, A. Laing, J. Newig, B. Parrish, C. Prell, C. Raymond, and L. C. Stringer (2010). *What is social learning?* Ecology and Society 15(4): r1. http://www.ecologyandsociety.org/vol15/iss4/resp1/.

Rees, W., and M. Wackernagel (1994). *Our Ecological Footprint: Reducing Human Impact on the Earth.* Gabriola Island, British Columbia: New Society Publishers **395**

Requisite Variety website, consulted on 4.3.2014; http://requisitevariety.co.uk/what-is-requisite-variety/ **201**

Resilience Alliance website, consulted on 11.09.2014 http://www.resalliance.org/index.php/key_concepts **[202]**

http://www.resalliance.org/index.php/adaptive_capacity

Ricigliano, R.and D. Chigas (2011). *Systems thinking in conflict assessment concepts and application.* USAID **203**

Robinson, J. (1982). *Energy backcasting: a proposed method of policy analysis.* Energy Policy 10 4, pp. 337–344. **204**

Robson, C. (2002). *Real World Research.* UK, Blackwell Publishing.

Rolston, III, H. (1988). *Environmental Ethics: Duties to the Natural World*. Philadelphia, PA: Temple University Press **205**

Rophol, G. (1982). *Some Methodological Aspects of Modelling Socio Technical Systems.* in Progress in Cybernetics and Systems Research , vol. 10, ed. R. Trappl et al . Washington, DC: Hemisphere. Pp. 525-536. **206**

Ropohl, G. (1999), Philosophy of socio-technical systems, Society for Philosophy and Technology, ed. Davis Baird **207**

Ropohl, G. (1979*). Eine Systemtheorie der Technik: Zur Grundlegung der Allgemeinen Technologie* . Munich/Vienna: Hanser. 2nd ed., 1998. **208**

Röling, N. G. (2002). *Beyond the aggregation of individual preferences.* Pages 25-48 in C. Leeuwis and R. Pyburn, editors. Wheelbarrows full of frogs: social learning in rural resource management. Koninklijke Van Gorcum, Assen, Drenthe,

The Netherlands.

Sachs, S. E. (2003). *The Changing Definition of Security*. International Relations. Merton College, Oxford http://www.stevesachs.com/papers/paper_security.html; consulted on 6.11.2014 **[369]**

Sagoff, M. (2012). *The Rise and Fall of Ecological Economics* - A Cautionary Tale. Breakthrough Journal website visited on 27.8.2013 http://thebreakthrough.org/index.php/journal/past-issues/issue-2/the-rise-and-fall-of-ecological-economics/#body50 **209**

Sajeva M. (2010a). *Security and development. A holistic approach.* Paper presented at the Futures Conference 2010 – Security in Futures – Security in Change - University of Turku – Finland Futures Research Centre – 3 - 4 June, 2010 **385**

Sajeva M. and M. Masera (2005). *Risk Governance Strategies for the Electric Power Infrastructure* - Proceedings of the 29th ESReDA Seminar - Assessing and managing the security of complex systems: shifting the RAMS paradigm, System Analysis for a More Secure World: Application of System Analysis and RAMS to Security of Complex Systems, European Commission DG Joint Research Centre, 25–26th October 2005 **306**

Sajeva, M. (2004). *The illusion of e-governance. Does technology make the real difference for the good governance?* Pre-proceedings - The NESIS Summative Conference - Athens, Greece, 11 - 14 October 2004 **383**

Sajeva, M. (2005a). *The Technological Risk and Uncertainty in Governance and Economic Development*. European Commission – DG Joint Research Centre Ispra (VA) Italy - EUR 21548 EN **[214]**

Sajeva, M. (2005b). *A Methodology for Quality Assurance of Knowledge Economy Statistical Indicators - The Communication of Risks and Uncertainties for a Continuous Improvement.* European Commission – DG Joint Research Centre Ispra (VA) Italy. EUR 21547 EN **215**

Sajeva, M. (2006a). *Evolutionary Risk Governance Strategies for Security Assurance of European Critical Networked Infrastructures*. Invited key-note presentation at 9th AICEI Conference on Risk and Infrastructures: an Issue of Governance? Delft University of Technology (15 - 16 June 2006). **382**

Sajeva, M. (2006b). *Risk Governance Strategies for Critical Infrastructures.* Paper presented at The 3rd International Conference "European Electricity Market" EEM06 The European Electricity Market Challenge of the Unification, Warsaw (Poland) (24 - 26 May 2006). **384**

Sajeva, M. (2007a). *Risk governance for critical complex infrastructural system.* Network Industries Quarterly **216**

Sajeva, M. (2007b). *Risk Governance Perspectives for cross-border Critical Networked Infrastructures - Modelling integrated risk management solutions for complex systems.* Paper presented at the European Academy of Business in Society's (EABIS) sixth annual colloquium **217**

Sajeva, M. (2010b). *Instances of participatory governance for critical and social-sensitive decision-making*. Paper presented at 'Qualità della vita. Riflessioni, studi e ricerche in Italia', 9.10.2010 **386**

Sajeva, M. (2010c). *Security, quality of life and development. A holistic approach.* Paper presented at 'Qualità della vita. Riflessioni, studi e ricerche in Italia', 9.10.2010 **387**

Sajeva, M. (2012). *Security, quality of life and development. A holistic approach*. in "Quality of Life in Italy - Research and Reflections", Social Indicators Research, an International and Interdisciplinary Journal for Quality-of-Life Measurement, Springer Science+Business Media - Springer Dordrecht Heidelberg New York London **[210]**

Sajeva, M. and J. Kaivo-oja (2010a); *Framing Privacy and Data Protection Finnish report on Symbolic representation of Security Agencies*, Deliverable D 4.2. - Seventh Framework Programme - Collaborative Project FP7-SCIENCE-IN-SOCIETY-2008-1; Privacy Awareness Through Security Branding (PATS) Project number 230473 **211**

Sajeva, M. and J. Kaivo-oja (2010b); *Workshop Report - Privacy Awareness of Security Organisations in Finland*- Deliverable D 3.3. - Seventh Framework Programme - Collaborative Project FP7-SCIENCE-IN-SOCIETY-2008-1; Privacy Awareness Through Security Branding (PATS) Project number 230473 **212**

Sajeva, M. and M. LaBelle (2010). *Risks and governance in the transition process towards post-carbon societies*. Deliverable 4.2 - Seventh Framework Programme - Collaborative Project "Pathways for carbon transitions (PACT)"- Project number 225503 - Workpackage 4 - Transition towards post-carbon society **213**

Sajeva, M. and M. Masera (2006). *A strategic approach to risk governance of critical infrastructures.* International Journal of Critical Infrastructures (IJCIS) **[218]**

Sajeva, M. and M. Masera (2006*). Risk Governance of Critical Infrastructures: Characterising Stakeholders and Defining a Decision–Making Process.* Accepted for publication in the International Journal of Critical Infrastructures (IJCIS) **219**

Sajeva, M., A. Stefanini and M. Masera (2006). *Risk Governance of the Electric Power System in North America: New Strategies for Facing Technological and Economic Changes*. (Technical EUR Report Nº 22288 EN) Ispra, Italy, European Commission JRC. **[220]**

Sajeva, M., M. Mähönen, S. L. Taivalmaa, H. Korhonen, R. Tubb (2014). *Linkages between Agricultural Research (AR) and Agricultural Research for Development (ARD).* Case Study Finland **388**

Sajeva, M., P. Singh Sahota and M. Lemon (2015). *Giving Sustainability a Chance: a Participatory Framework for Choosing between Alternative Futures.* Journal of Organisational Transformation and Social Change (JOTSC), 12 (1), pp. 57–89 **[346]**

Sajeva, M., P. Singh Sahota and M. Lemon (January 23-24, 2014). *Giving Sustainability a Chance: a Participatory Framework for Choosing between Alternative Futures.* Paper presented at Business Systems Laboratory - 2nd International Symposium "Systems Thinking for a Sustainable Economy. Advancements in Economic and Managerial Theory and Practice". Universitas Mercatorum, Roma, Italy **221**

Samuelson, P. A. *Economics* (New York: McGraw-Hill, 1948) **222**

Sardar, Z. (2007). *Prosperity: a transmodern analysis.* Thinkpiece to the SDC seminar: Visions of Prosperity, November 2007. London: Sustainable Development Commission. www.sd-commission.org.uk/pages/redifiningprosperity.html **223**

Sauthoff, N. R. (2001) *Letter to Office of Policy, United States Department of Energy*. 2 Jan. 2001; http://www.ieeeusa.org/policy/POLICY/2001/01jan02.html; consulted on 24.9.2014 **[342]**

SCAR (Standing Committee on Agricultural Research);

http://ec.europa.eu/research/agriculture/scar/groups_en.htm, consulted on 19.09.2014 **[331]**

Schläpfer, M. and H.Glavitsch (2006). *Learning from the Past – Electric Power Blackouts and Near Misses in Europe*, in Critical Infrastructures at Risk - Securing the European Electric Power System, Springer Verlag **[322]**

Schor, J. (2010). *Plenitude.* New York: Penguin; **403**

Schumacher, E. F, (1973). *Small is Beautiful: A Study of Economics as if People Mattered*. London: Abacus **224**

Scott Cato, M. (2009). *Green Economics*. London: Earthscan, pp. 36–37. ISBN 978-1-84407-571-3. **[225]**

Scotti, B. (2015). *Perché non possiamo non crescere?* L'intellettuale dissidente. http://www.lintellettualedissidente.it/economia/perche-non-possiamo-non-crescere/, consulted on 27.12.2015

Second International Conference on Economic Degrowth for Ecological Sustainability and Social Equity (2010). *Degrowth Declaration Barcelona 2010.* March 28-29, 2010, Barcelona, http://degrowth.eu. **401**

Securitas. Web: http://www.securitas.com/fi/fi/, consulted on 2010/2014 **[226]**

Sen, A. (1981). *Poverty and Famines.* Oxford University Press **[354]**

Sen, A. (1984). *Resources, Values and Development.* Cambridge, MA: Harvard University Press. 524; see also, Dreze, Jean and Amartya Sen. 1989. *Hunger and Public Action.* Oxford: Clarendon Press. 26-28. For a recent elaboration of Sen's findings, see: Keneally, Thomas. 2011. *Three Famines: Starvation and Politics Public Affairs* **[231]**

Sen, A. (1987). *Food and Freedom.* Sir John Crawford Memorial Lecture Washington, D.C. October 29, 1987 http://www.worldbank.org/html/cgiar/publications/crawford/craw3.pdf, consulted on 22.10.2014 **[355]**

Sen, A. (1989). *Development as capability expansion*. Journal of development planning **[228]**

Sen, A. (1997), *Development Thinking at the Beginning of the 21st Century*, Harvard University and London School of Economics and Political Sciences **229**

Sen, A. (1999). *Development as Freedom*. New York: Alfred A. Knopf. **[230]**

Sen, A.K. (2000). *The ends and means of sustainability*. Keynote address at the International Conference on Transition to sustainability, Tokyo, May **227**

Silvast, A. and J. Kaplinsky (2007). Project Understand, White Paper on Security of European Electricity Distribution, 20.6.2007 - http://www.understand.se/docs/White_Paper_EN.doc, consulted on 16.9.2014 **[323]**

Simon, H. (1979). *From substantive to procedural rationality.* In *Philosophy and Economic Theory*. Oxford, UK: Oxford University Press. **232**

Singleton, F. (1981), *The myth of finlandisation. International Affairs*. Vol. 57, No. 2, Spring, pp. 270-285. **[233]**

Slim, A. (2013). *The impact of de-growth (la décroissance) on the discourse of sustainability*; in Barnes, Pamela, M. And Thomas C. Hoerber (2013). *Sustainable Development and Governance in Europe, The evolution of the discourse on sustainability*. Routlegde, New York; pp.48-60 **234**

Slovic, P. (1987). *Perception of risk.* Science, 236, 280-285. **235**

Slovic, P. (1999). *Trust, emotion, sex, politics, and science: Surveying the risk-assessment battlefield. Risk Analysis*, 19(4), 689-701. Originally published in M. H. Bazerman, D. M. Messick, A. E. Tenbrunsel, & K. A. Wade-Benzoni (Eds.), *Environment, ethics, and behavior* (pp. 277-313). San Francisco: New Lexington, 1997. Revised version in The University of Chicago Legal Forum, 1997, pp. 59-99. **236**

Slovic, P. and E. U. Weber (2002). *Perceptions of Risk posed by extreme events.* Risk management Strategies in an uncertain world, New York. **237**

Slovic, P. and E.U. Weber, (2002). *Perception of Risk Posed by Extreme Events*. Presented at “Risk Management strategies in an Uncertain World,” Palisades, New York, April 12-13, 2002 **238**

Smithsonian Institute (2014). The Public Utility Regulatory Policies Act PURPA. Government Involvement to Remedy Energy Crisis http://americanhistory.si.edu/powering/past/h4main.htm consulted on 14.9.2014 **[311]**

Smithsonian Institute, *Powering a generation of change,* http://americanhistory.si.edu/powering/ retrieved on 13.05.2014 **[239]**

Snowden, D. And M. Boone (2007). *A Leader’s Framework for Decision Making*. Harvard Business Review. November 2007: 69-76. **240**

Soderbaum P. (2004). *Politics and Ideology in Ecological Economics*. Internet Encyclopaedia of Ecological Economics. **241**

Solow, R. M. (1974). *The Economics of Resources or the Resources of Economics*. American Economic Review. 64(2):1-14. 11. **242**

Solow, R. M. (1991): *Sustainability: An Economist's Perspective,* The Eighteenth J. Seward Johnson Lecture. Woods Hole, MA: Woods Hole Oceanographic Institution, June 14. **243**

Sørensen, E. (2005). *Metagovernance: the changing role of politicians in processes of democratic governance*. American Review of Public Administration 36(1): 98-114 **254**

Spash, C. L. (2013) *The Shallow or the Deep Ecological Economics Movement?* SRE-Discussion 2013/01 2013, Institute for the Environment and Regional Development **244**

Speth, J. G. (2005) *Governance for sustainable human development,* United Nations Development Programme **245**

Standing Committee on Agricultural Research (SCAR) (2012). *Agricultural Knowledge and Innovation Systems in Transition – a reflection paper*. Collaborative Working Group on Agricultural Knowledge and Innovation Systems (CWG AKIS), March 2012 **[246]**

Stavins, R. N. (2008.) *Environmental Economics*. The New Palgrave Dictionary of Economics, Second Edition. Eds. Steven N. Durlauf and Lawrence E. Blum **247**

Stefanini, A. and M. Masera (2006). *Electric System vulnerabilities: a state of the art of defense technologies.* European Commission DG JRC **313**

Sterling, S. (2007). *Riding the storm: towards a connective cultural consciousness.* In In: *Social learning towards a sustainable world. Principles, perspectives and praxis.* Arjen E.J. Wals, Wageningen Academic Publishers **248**

Stern, D. I. (2014). *Economic Growth and Energy.* Rensselaer Polytechnic Institute, Troy, New York, United States , web source, retrieved on 18.3.2014 **249** http://www.sterndavidi.com/Publications/Growth.pdf

Stevens, C. Sustainability Assessment Methodologies, OECD Sustainable Development Advisor; http://www.oecd.org/greengrowth/39925248.pdf, consulted on 02.12.2015

Stevenson, J. (2003). *How Europe and America defend themselves?.* Foreign Affairs. Vol. 82, No. 3, pp. 75-90. **[250]**

Steyaert, P., and J. Jiggins (2007). *Governance of complex environmental situations through social learning: a synthesis of SLIM's lessons for research, policy and practice.* Environmental Science and Policy 10:575-586.

Stiglitz, J. (2014). Intervention at the Italian Parliament on 24 September 2014

Sufficiency Economics. http://www.sufficiencyeconomics.ca/, consulted on 28.10.204 **[359]**

Sundquist, S. (2010) *Turvallisuus-ohjelma, Kansainvälistä liiketoimintaa turvallisuusratkaisuista*, Tietoisku Kansallisessa turvallisuustutkimuksen päivässä 10.6.2010 http://www.minedu.fi/export/sites/default/OPM/Tapahtumakalenteri/2010/06/Kansallinen_Turvallisuustutkimuksen_pxivx_2010/Suvi_Sundquist.pdf **251**

Sundquist, S. (2010). *Security Programme*. Tekes **[365]**

Surrey University website, consulted on 13.01.2015; http://libweb.surrey.ac.uk/library/skills/Introduction%20to%20Research%20and%20Managing%20Information%20Leicester/page_54.htm

Susfood ERA-Net website, consulted on 21.08.2014. https://www.susfood-era.net/ **[252]**

Swyngedouw, E. (2005). *Dispossessing H20: The contested terrain of water privatisation*, Capitalism, Nature, Socialism, 16(1): pp. 1-18 **253**

Tacconi, L. (2011). *Developing environmental governance research: The example of forest cover change studies*. Environmental Conservation, 38(2): 234-246.UNDP website, consulted on 16.08.2013; **255**

Taylor, P. (1986). *Respect for Nature.* New York: Oxford University Press **256**

The Futures Wheel – Source http://www.mindtools.com/pages/article/futures-wheel.htm; consulted on 9.11.2013 **258**

The Natural Step website http://www.naturalstep.org/ retrieved on 09.11.2013 **[259]**

The Wall Street Journal (2002). *New Documents Show Enron Traders Manipulated California Energy Costs.* http://online.wsj.com/articles/SB1020718637382274400; consulted on 24.9.2014 **[340]**

Thomas, S. (2004). *The British Model in Britain: Failing slowly*. Paper presented at International Workshop on: "*Thirty Years of World Energy Policy – cum –* **[334]**

Editorial Board Meeting of Energy Policy" Hong Kong Energy Studies Centre & Department of Geography, Hong Kong Baptist University; 23rd – 25th March 2004

Thompson, M. , Ellis, R. and Wildavsky, A. (1990) *Cultural Theory*. Boulder, CO: Westview Press **260**

Thompson, R. (2010). *Politics and Policy, U.S. Energy Secretary Steven Chu on the Obama adminstration's game plan*. The Wall Street Journal, March 3, sec. R. **261**

Tickner J. A. (1994). *Re-visioning Security*. International Relations Theory Today (Ken Booth and Steve Smith, eds., 1994) **[370]**

Tobin, J. (1970). *On Limiting the Domain of Inequality*. Journal of Law and Economics 13 (2): 263–77. **262**

Togati, T. D. (2004) - *On the stability of the New Economy*, University of Turin, Italy, 2004 – Pre-proceedings - The NESIS Summative Conference - Athens, Greece, 11 – 14 **263**

Togati, T. D. (2005). *Is there a positive relation between welfare and competitiveness? A theoretical justification*; University of Turin **264**

Transparency International website (2010) - [http://www.transparency.org/policy_research/surveys_indices/cpi/2010/results consulted on 31.01.2011](http://www.transparency.org/policy_research/surveys_indices/cpi/2010/results) **265**

Transparency International: *Corruption perception Index results – 2102 -* http://cpi.transparency.org/cpi2012/results/; consulted on 29.01.2013 **[266]**

Treib, O., H.Bahr and G. Falkner (2007). *Modes of governance.* Journal of European Public Policy 14 1-20 **267**

Turner, P.K., C. Perrings and C. Folke (1997). *Ecological economics: paradigm or perspective*. In: van den Bergh JCJM, van der Straaten J (eds) *Economy and ecosystems in change: analytical and historical approaches*. Edward Elgar, Cheltenham **268**

Tversky, A. and D. Kahneman (1974*). Judgment under Uncertainty: Heuristics and Biases.* Science, New Series, Vol. 185, No. 4157. (Sep. 27, 1974), pp. 1124-1131 **269**

Türke, R.E. (2008). *Governance: Systemic Foundation and Framework.* Springer Science & Business Media

U.S. Department of Energy and Natural Resources Canada (2006). *U.S.-Canada Power System Outage Task Force. Report on the August 14, 2003 Blackout*. Recommendation 12 The Relationship between Competitive Power Markets and Grid Reliability http://emp.lbl.gov/sites/all/files/Recommendation-12-aug-14th-blkout.pdf ; consulted on 23.9.2014 **[336]**

U.S. Department of Energy, http://www.southeastchptap.org/cleanenergy/chp/history.aspx, consulted on 22.9.2014 **[332]**

U.S. Fire Administration (FEMA) (2013), - http://www.usfa.fema.gov/fireservice/emr-isac/infograms/index.shtm (consulted on 14.02.2013) **270**

U.S.-Canada Power System Outage Task Force (2004). Final Report on the August 14, 2003 Blackout in the United States and Canada: Causes and Recommendations **[325]**

UCTE (2004). FINAL REPORT of the Investigation Committee on the 28 September 2003 Blackout in Italy - file:///E:/Ts/Food%20System/Publications/20040427_UCTE_IC_Final_report.pdf **[347]**

United Nations, International Monetary Fund, Commission of the European Communities–Eurostat, Organisation for Economic Co-operation and Development, World Bank (1993), *System of National Accounts* 1993, New York

UN (1987). *Our Common Future*. Report of the World Commission on Environment and Development: United Nations General Assembly, March 20, 1987. http://www.un-documents.net/our-common-future.pdf consulted on 20.08.2013 **[278]**

UNDP (1990). Human Development Report **271**

UNDP (1993). *Human Development Report 1993*. United Nations Development Programme. New York: Oxford University Press. **276**

UNDP (1994). *Human Development Report*. United Nations Development Programme **[275]**

UNDP website, consulted on 16.08.2013 **272**

United Nations (1992). *Agenda 21* (United Nations, New York) **273**

United Nations (2002). *Report of the World Summit on Sustainable Development* A/CONF.199/20 and A/CONF.199/20/corr.1 (United Nations, New York) **274**

United Nations General Assembly (2005). *2005 World Summit Outcome*, Resolution A/60/1, adopted by the General Assembly on 15 September 2005 **277**

University of Helsinki website, interview to Hille Koskela, http://www.helsinki.fi/ajankohtaista/uutisarkisto/8-2009/13-09-48-14 consulted in 10.01.2011 **[279]**

US Department of Homeland Security (2013) - http://www.dhs.gov/cipr-month-2012, consulted on 14.02.2013 **280**

Valqui Vidal R. V. (2005). *The Future Work Shop: democratic problem solving*. IMM, Informatik og Matematisk Modelling, DTU **380**

Van den Bergh, J. C. J. M. (2001). *Ecological Economics: Themes, Approaches, and Differences with Environmental Economics.* Regional Environmental Change, 2(1), pp. 13-23 **283**

Velasquez, M., C. Andre, T. Shanks, S.J. and M. J. Meyer (1997). *What is Ethics? Issues in Ethics* IIE V1 N1 - https://www.scu.edu/ethics/practicing/decision/whatisethics.html **288**

Vergragt, J. Q. (2011); *Backcasting for sustainability: Introduction to the special issue*. Elsevier. **376**

Vitali, M. (2013). *Ma perchè ci dicono che il PIL deve crescere?* http://monicavitali10.blogspot.fi/2013/12/ma-perche-ci-dicono-che-il-pil-deve.html consulted on 22.12.2015

Vitousek, P. M., H. A. Mooney, J. Lubchenco, J. M. Melillo (1997). *Human Domination of Earth's Ecosystems;* Science, Vol. 277 no. 5325 pp. 494-499 **[294]**

Wackernagel, M., et al. (2002). *Tracking the ecological overshoot of the human economy.* Proceedings of the National Academy of Sciences of the United States of America 99(14):9266-9271. **394**

Wals, A. E.J. and T. van der Leij (2007). *Social learning towards a sustainable world. Principles, perspectives and praxis.* Wageningen, The Netherlands: Wageningen Academic Publishers. **281**

Ward, A. And D. Fott (2007). *Montesquieu on Federalism and the Problem of Liberty in the International System: Ancient virtue and Modern Executive*, Paper presented at the annual meeting of the American Political Science Association, Hyatt Regency Chicago and the Sheraton Chicago Hotel and Towers, Chicago, IL, Aug 30, 2007 **[284]**

Weber, R. (1995). *Basic Content Analysis.* Ca, USA, Sage Publications.

Weber, E. U. and C. K. Hsee (1998). *Cross-cultural differences in risk perception but cross-cultural similarities in attitudes towards ris*k. Management Science, 44, 1205-1217. **286**

Weber, E. U. and C. K. Hsee (1999). *Models and mosaics: Investigating cross-cultural differences in risk perception and risk preference*. Psychonomic Bulletin & Review, 6, 611-617. **285**

WECD (1987). *Our Common Future.* Oxford, UK and New York, USA: Oxford University Press **[287]**

Webler, T., H. Kastenholz, and O. Renn (1995). *Public participation in impact assessment: a social learning perspective.* Environmental Impact Assessment Review 1:443–463. http://dx.doi.org/10.1016/0195-9255(95)00043-E

Wenger, E. (1998). *Communities of practice: learning, meaning, and identity.* Cambridge University Press, Cambridge, UK.

Whitehead, J. T. (2003). *Analysis of The Blackout Of August 14, 2003*. A report prepared for TVA and U.S. DOE. December. **[335]**

Wilkinson I. (2001). *Social theories of risk perception: at once indispensable and insufficient*. Current Sociology 2001;49(1):1–22. **289**

Williams, B. & Hummelbrunner, R. 2011. *Systems Concepts in Action.* Stanford, CA: Stanford University Press. **290**

Wilson, J. (2005). *Sinister Synergies: How Competition for Unregulated Profit Causes Blackouts*. by Ontario Electricity Coalition; http://www.pulp.tc/html/competition___reliability.html; http://www.pulp.tc/WilsonReliability.pdf **[291]**

Winne, B. (1996). *May the sheep safely graze? A reflexive view of the expert-lay knowledge divide*. In: Lash S. Szerszinsky B., Wunne B. editors. *Risk, environment and modernity - towards a new ecology*. London: Sage; 1996 p. 44-83. **292**

Winterfeldt, V. (2007), *Liberated Economy?* in Transition in Namibia – Which changes for who? Henning Melber **[293]**

Woerdman, E. and O. Couwenberg (2009) *Carbon Capture and Storage in the European Emissions Trading Scheme*, Working Paper Series in Law and Economics; Faculty of Law, Groningen, The Netherlands **295**

Wolcher, L. E.(2014). *Senseless Kindness: The Politics of Cost Benefit Analysis.* http://depts.washington.edu/econlaw/pdf/Wolcher.pdf, retrieved on 3.4.2014 **296**

Woodrum, E. (1984). *Mainstreaming Content Analysis in the Social Sciences: Methodological Advantages, Obstacles and Solutions.* Social Science Research. Vol. 13.

World Bank (1992): World *Development Report 1992: Development and the Environment.* New York: Oxford University Press. **297**

World Bank (2002). *Governance and Development.* World Bank,Washington, DC **298**

World Commission on Environment and Development (WCED) (1987). *Our Common Future*. New York: Oxford University Press. [The Brundtland Report.] **299**

World Health Organization Millennium Ecosystem Assessment (2005). *Ecosystems and Human Well-Being*. Geneva, Switzerland **300**

World Wildlife Fund (2006). *Living Planet Report*. http://panda.org **405**

Xepapadeas A. (2008). *Ecological economics*. The New Palgrave Dictionary of Economics 2nd Edition. Palgrave MacMillan **301**

Yin, R. K. (1994). *Case Study Research: Design and Methods.* California, USA, Sage.

Yin, R.K. (2003). Case Study Research – Design and Methods (3rd ed). London: Sage Publications.

Zak, P. J. and S. Knack (2001). *Trust and growth*. Economic Journal, 111: pp. 295-321

Appendix I. Exemplification of the methodological analysis of the ECEI and security case studies

Table 55. The scenarios of the ECEI

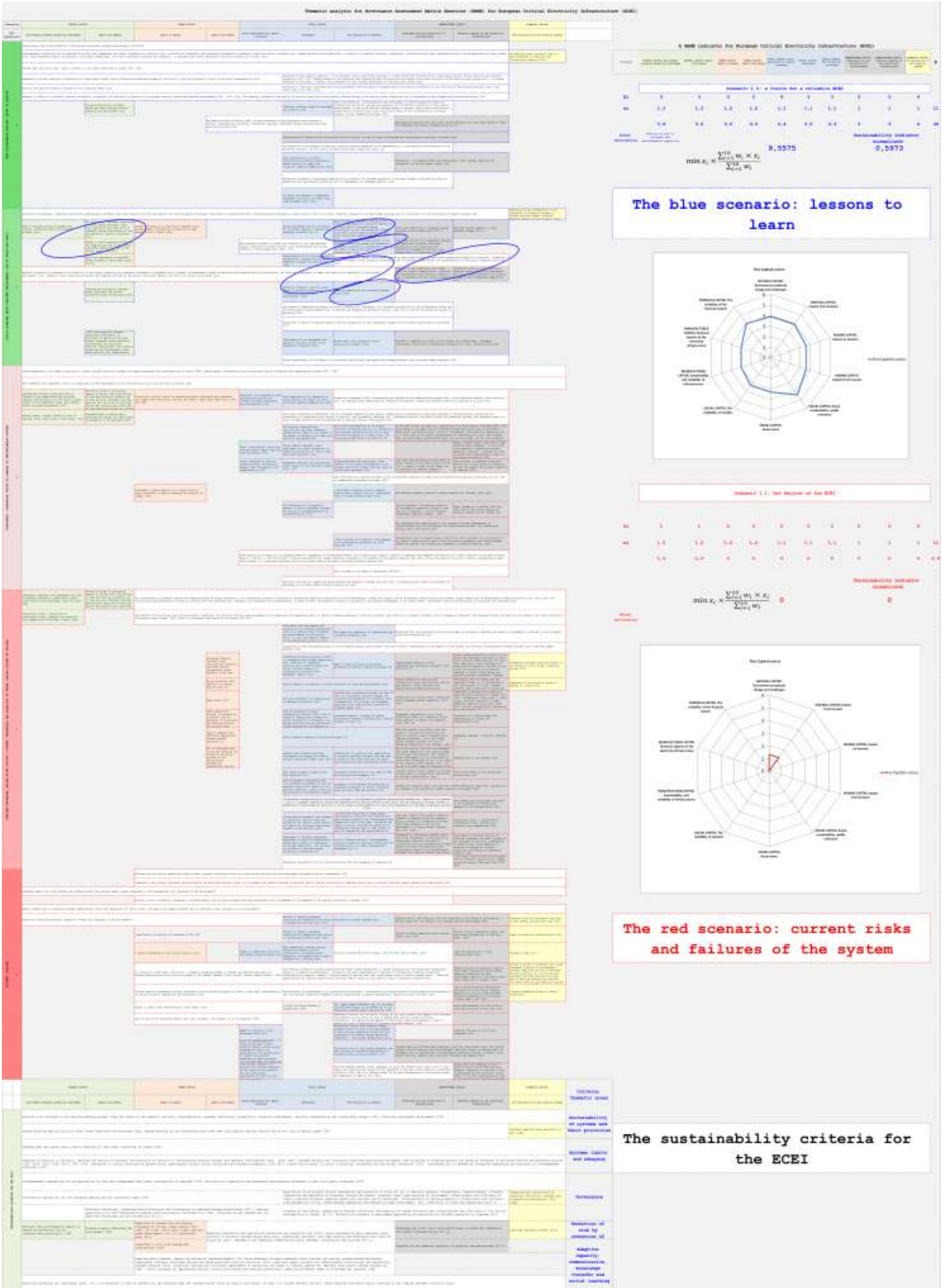
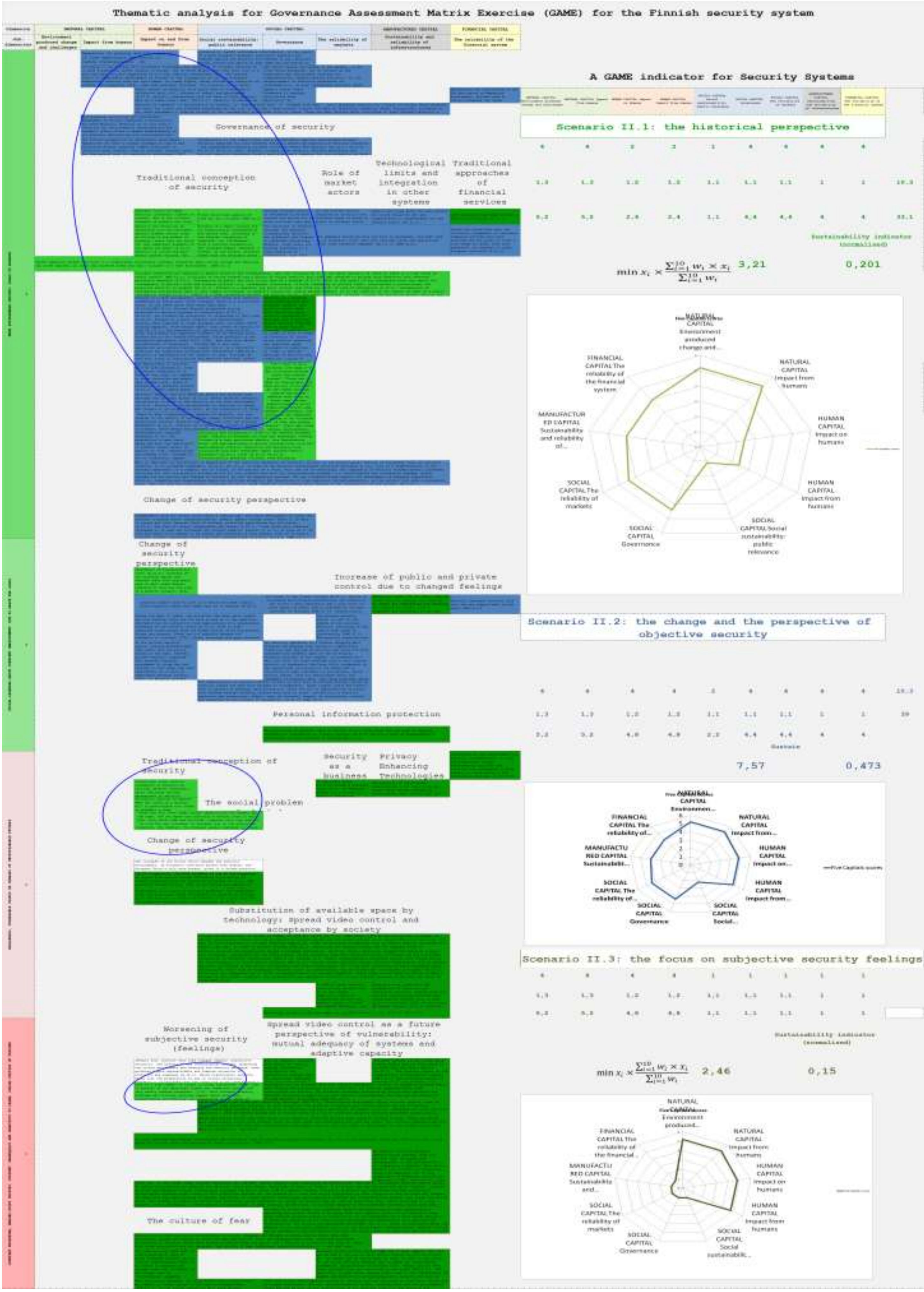


Table 56. The general analysis of the security STS



Appendix II: The questionnaire for the case study of the post-carbon society by area and the grouping of the answers into clusters or similar answers.

Area 1: Technological effects

Item

1. Energy production will decrease considerably by 2050 due to the increase in technological efficiency. [not at all probable]
2. Energy production will decrease considerably by 2050 due to the increase in technological efficiency. [not at all desirable]
3. How probable is it that post-carbon energy production by 2050 is achieved mainly through decentralised, distributed and renewable sources (biomass, biodiesel, wind power, sea, photovoltaic)?
4. Will those be effective for satisfying the demand?
5. Post-carbon energy is achieved through large centralised energy production by 2050 [not at all probable]
6. Post-carbon energy is achieved through large centralised energy production by 2050 [not at all desirable]
7. The current percentage of nuclear power in the EU-27 energy mix is about 15%, what percentage do you believe it will be desirable in respect to the negative impacts, by 2050? What about the other mentioned sources? [Centralised nuclear power]
8. The current percentage of nuclear power in the EU-27 energy mix is about 15%, what percentage do you believe it will be desirable in respect to the negative impacts, by 2050? What about the other mentioned sources? [Decentralised renewable production (municipal or regional self-sufficiency)]
9. The current percentage of nuclear power in the EU-27 energy mix is about 15%, what percentage do you believe it will be desirable in respect to the negative impacts, by 2050? What about the other mentioned sources? [Centralised power from fossil fuels.]
10. New technologies used with fossil fuels will be able to greatly reduce carbon emissions. [not at all probable]
11. New technologies used with fossil fuels will be able to greatly reduce carbon emissions. [not at all desirable]
12. Carbon capture and storage is seen as a future technology that will store the CO2 emissions from coal fired power plants, how important is it that this technology is successfully deployed, in terms of cost-effectiveness? [not at all probable (very expensive)]
13. Carbon capture and storage is seen as a future technology that will store the CO2 emissions from coal fired power plants, how important is it that this technology is successfully deployed, in terms of cost-effectiveness? [not at all desirable, in terms of effectiveness]
14. The current increase of transport infrastructures is not sustainable in the long-term. Current transport technologies and infrastructures will be replaced by more technological advanced and with a lower impact (intangible or 'less tangible'). [not at all probable]
15. The current increase of transport infrastructures is not sustainable in the long-term. Current transport technologies and infrastructures will be replaced by more technological advanced and with a lower impact (intangible or 'less tangible'). [not at all desirable]
16. The development of new transmission networks is essential and at the same time affordable in terms of costs and will help the development of non carbon based energy sources (i.e. CO2, hydrogen). [not at all probable]
17. The development of new transmission networks is essential and at the same time affordable in terms of costs and will help the development of non carbon based energy sources (i.e. CO2, hydrogen). [not at all desirable]
18. Considering that currently fossil fuels account for 80% of energy production, how will the situation develop from 2010 to 2050? (1= will be increased above 80%; 7 will be reduced below 20%) [probably increase above 80%]
19. Considering that currently fossil fuels account for 80% of energy production, how will the situation develop from 2010 to 2050? (1= will be increased above 80%; 7 will be reduced below 20%) [hopefully stay below 80% (especialli in developed countries)]
20. The transition towards post-carbon energy sources will increase or decrease the risk of disruptions in the energy supply. [probably decrease]

21. The transition towards post-carbon energy sources will increase or decrease the risk of disruptions in the energy supply. [hopefully decrease]
22. Local and renewable generation of energy (biomass, windpower, hydropower, photovoltaic etc.) will be enough to guarantee self-sufficient households and cities (excluding industries). [not at all probable]
23. Local and renewable generation of energy (biomass, windpower, hydropower, photovoltaic etc.) will be enough to guarantee self-sufficient households and cities (excluding industries). [not at all desirable]
24. At the moment, emerging technologies would indicate that new energy sources will include sources such as biogas for heating, hydrogen, biodiesel [not at all probable]
25. At the moment, emerging technologies would indicate that new energy sources will include sources such as biogas for heating, hydrogen, biodiesel [not at all desirable]
26. Energy infrastructure will be significantly restructured or changed completely to meet low carbon energy systems. [not at all probable]
27. Energy infrastructure will be significantly restructured or changed completely to meet low carbon energy systems. [not at all desirable]
28. The implementation of energy efficiency programs and materials is essential for reducing energy usage. Is it realistic that the construction industry will progressively increase its use of energy efficient methods? [not at all probable]
29. The implementation of energy efficiency programs and materials is essential for reducing energy usage. Is it realistic that the construction industry will progressively increase its use of energy efficient methods? [not at all desirable]

Area 2: Health and environmental effects

Item

30. It is realistic that a fully sustainable and low carbon energy system is established by 2050. [probable]
31. It is realistic that a fully sustainable and low carbon energy system is established by 2050. [desirable]
32. The private enterprise sector undertake joint governance policies for the control of climate change by 2050 [not at all probable]
33. The private enterprise sector undertake joint governance policies for the control of climate change by 2050 [not at all desirable]
34. Global agreements for the use and protection of natural resources will be central to a post carbon world. [not at all probable]
35. Global agreements for the use and protection of natural resources will be central to a post carbon world. [not at all desirable]
36. New health and environmental problems may arise because of an increased use of nuclear power and its waste disposal [not at all probable]
37. New health and environmental problems may arise because of an increased use of nuclear power and its waste disposal [not at all desirable]
38. Macroscopic marine algae and seaweeds become important sources of bio-energy production by 2050 [not at all probable]
39. Macroscopic marine algae and seaweeds become important sources of bio-energy production by 2050 [not at all desirable]
40. Renewable energy technologies pose a risk to human and environment health [not at all probable]
41. Renewable energy technologies pose a risk to human and environment health [not at all desirable]
42. Electricity is a viable energy source for transport in the transition towards a post-carbon world by 2050 [not at all probable]
43. Electricity is a viable energy source for transport in the transition towards a post-carbon world by 2050 [not at all desirable]
44. Massive lithium production for battery powered cars and the related technology will be development. [not at all probable]
45. Massive lithium production for battery powered cars and the related technology will be development. [not at all desirable]
46. New nuclear technologies rely on a considerable reduction or elimination of hazardous waste [not at all probable]
47. New nuclear technologies rely on a considerable reduction or elimination of hazardous waste [not at all desirable]
48. What currently is the probable level of risk for hydrogen transportation? What is the desirability of making it decreasing by applied research and technology? [probably high]
49. What currently is the probable level of risk for hydrogen transportation? What is the desirability of making it decreasing by applied research and technology? [not at all desirable]
50. Will new energy technologies be harmful for health and the environment? [not at all probable]
51. Will new energy technologies be harmful for health and the environment? [not at all desirable]

Area 3: Socio-economic and political effects

Item

52. The continued economic development of national economies in Asia and Africa will be a large impediment to a transition towards a post-carbon world. [not at all probable]
53. The continued economic development of national economies in Asia and Africa will be a large impediment to a transition towards a post-carbon world. [not at all desirable]
54. Renewable energy sources require vast land areas with negative externalities for other land uses [not at all probable]
55. Renewable energy sources require vast land areas with negative externalities for other land uses [not at all desirable]
56. The problems for the transport of hydrogen as a fuel will be solved by 2050. [not at all probable]
57. The problems for the transport of hydrogen as a fuel will be solved by 2050. [not at all desirable]
58. Local distribution of hydrogen will be safely and economically efficient to have widespread use. [not at all probable]
59. Local distribution of hydrogen will be safely and economically efficient to have widespread use. [not at all desirable]
60. Hydrogen will be produced at night by nuclear power. [not at all probable]
61. Hydrogen will be produced at night by nuclear power. [not at all desirable]
62. The costs for hydrogen transportation will become progressively lower. [not at all probable]
63. The costs for hydrogen transportation will become progressively lower. [not at all desirable]
64. The risks related to hydrogen transportation will progressively drop. [not at all probable]
65. The risks related to hydrogen transportation will progressively drop. [not at all desirable]
66. Increased remote work will reduce moblity. [not at all probable]
67. Increased remote work will reduce moblity. [not at all desirable]
68. Lower transportation costs will increase mobility. [not at all probable]
69. Lower transportation costs will increase mobility. [not at all desirable]
70. Will the transition process imply greater investments for businesses and the whole economy? [not at all probable]
71. Will the transition process imply greater investments for businesses and the whole economy? [not at all desirable]
72. Do the European Union common policies, legislation and regulation progressively weaken on strengthen the effort towards a post-carbon future? [probably weaken]
73. Do the European Union common policies, legislation and regulation progressively weaken on strengthen the effort towards a post-carbon future? [hopefully weaken]
74. Public transport will not develop until greater restrictions on private cars are implemented [not at all probable]
75. Public transport will not develop until greater restrictions on private cars are implemented [not at all desirable]
76. Private ownership is preferred to achieve the most possible secure, reliable, efficient energy system. [not at all probable]
77. Private ownership is preferred to achieve the most possible secure, reliable, efficient energy system. [not at all desirable]
78. Public ownership is preferred to achieve the most possible secure, reliable, efficient energy system. [not at all probable]
79. Public ownership is preferred to achieve the most possible secure, reliable, efficient energy system. [not at all desirable]
80. The European Union will still exist in 2050. [not at all probable]
81. The European Union will still exist in 2050. [not at all desirable]
82. The European Union will increase its Member States [not at all probable]
83. The European Union will increase its Member States [not at all desirable]
84. Developing countries won't be affected by the transition process towards a post-carbon society, that will take place in Europe. [not at all probable]
85. Developing countries won't be affected by the transition process towards a post-carbon society, that

will take place in Europe. [not at all desirable]

86. Will social welfare, during the transition process, progressively weaken on strengthen (social effects, labour policies, jobs)? [probably weaken]
87. Will social welfare, during the transition process, progressively weaken on strengthen (social effects, labour policies, jobs)? [hopefully weaken]
88. Criteria of social responsibility, and the roles and resposibility of different actors, will be better defined in the transition process. [not at all probable]
89. Criteria of social responsibility, and the roles and resposibility of different actors, will be better defined in the transition process. [not at all desirable]
90. Energy intensive industries will shift out of the EU and towards developing countries as a result of tightening emission targets. [not at all probable]
91. Energy intensive industries will shift out of the EU and towards developing countries as a result of tightening emission targets. [not at all desirable]
92. New energy infrastructure should be guided by changed regulations [not at all probable]
93. New energy infrastructure should be guided by changed regulations [not at all desirable]
94. Will the risks for each stakeholder, in relation to different areas, be better defined in the transition process? [not at all probable]
95. Will the risks for each stakeholder, in relation to different areas, be better defined in the transition process? [not at all desirable]
96. My quality of life will improve by transitioning away from a carbon based energy system [not at all probable]
97. My quality of life will improve by transitioning away from a carbon based energy system [not at all desirable]
98. The development of developing countries will increase mobility. [not at all probable]
99. The development of developing countries will increase mobility. [not at all desirable]
100. Will general economic development, in terms of social well-being, general security, trust in the economy and business expectations progressively weaken on strengthen during the transition process? [probably weaken]
101. Will general economic development, in terms of social well-being, general security, trust in the economy and business expectations progressively weaken on strengthen during the transition process? [hopefully weaken]
102. Return on investments, public and private, in research for new energy technologies and education for workers, reconversion of old plants, will cover the current losses in terms of jobs and investments belonging to old technologies. [not at all probable]
103. Return on investments, public and private, in research for new energy technologies and education for workers, reconversion of old plants, will cover the current losses in terms of jobs and investments belonging to old technologies. [not at all desirable]
104. What is the responsibility of business in the transition towards a post-carbon world? [probably (almost) absent]
105. What is the responsibility of business in the transition towards a post-carbon world? [hopefully (almost) absent]
106. What is the responsibility of citizens in the transition towards a post-carbon world? [probably (almost) absent]
107. What is the responsibility of citizens in the transition towards a post-carbon world? [hopefully (almost) absent]
108. What is the responsibility of politics in the transition towards a post-carbon world? [probably (almost) absent]
109. What is the responsibility of politics in the transition towards a post-carbon world? [hopefully (almost) absent]
110. What is the responsibility of pulblic institutions in the transition towards a post-carbon world? [probably (almost) absent]
111. What is the responsibility of pulblic institutions in the transition towards a post-carbon world? [hopefully (almost) absent]
112. Return on investments will equal the costs. A better quality of life, well-being, health, security, high knowledge, technological and educational level, pleasant and clean urban models, dynamic and socially safe work environment will still be produced. [not at all probable]
113. Return on investments will equal the costs. A better quality of life, well-being, health, security, high knowledge, technological and educational level, pleasant and clean urban models, dynamic and socially safe work environment will still be produced. [not at all desirable]

Area 4: Market and regulatory effects

Item

114. A energy governance council will be established at the European level. This would provide a joint integrated and participatory decision-making process for establishing common goals and ensuring implementation of energy goals [not at all probable]
115. A energy governance council will be established at the European level. This would provide a joint integrated and participatory decision-making process for establishing common goals and ensuring implementation of energy goals [not at all desirable]
116. A governance council for the transition process will be actually set up, for the achievement of a post-carbon society, in order to limit the related expected risks and to deal with those that are unexpected. [not at all probable]
117. A governance council for the transition process will be actually set up, for the achievement of a post-carbon society, in order to limit the related expected risks and to deal with those that are unexpected. [not at all desirable]
118. A governance council for the transition will provide decision makers with a clear framework for the identification of main risks in different areas, and with possible countermeasures. [not at all probable]
119. A governance council for the transition will provide decision makers with a clear framework for the identification of main risks in different areas, and with possible countermeasures. [not at all desirable]
120. The energy governance strategy will bring stakeholders together for setting mandatory security and reliability standards and agreeing on voluntary measures [not at all probable]
121. The energy governance strategy will bring stakeholders together for setting mandatory security and reliability standards and agreeing on voluntary measures [not at all desirable]
122. The energy governance strategy will be able to fill the gaps in reliability, risk and security matters, in respect to more traditional and isolated risk management systems. [not at all probable]
123. The energy governance strategy will be able to fill the gaps in reliability, risk and security matters, in respect to more traditional and isolated risk management systems. [not at all desirable]
124. The energy governance strategy will be able to adapt the definition of mandatory standards and voluntary measures to the dynamics of market and technological development. [not at all probable]
125. The energy governance strategy will be able to adapt the definition of mandatory standards and voluntary measures to the dynamics of market and technological development. [not at all desirable]
126. The energy governance strategy will be able to create an alternative system of joint integrated management able to preserve the free market while at the same time guarantee efficient and secure interoperability and preserve critical infrastructural system [not at all probable]
127. The energy governance strategy will be able to create an alternative system of joint integrated management able to preserve the free market while at the same time guarantee efficient and secure interoperability and preserve critical infrastructural system [not at all desirable]
128. During the transition towards a post-carbon world will energy consumption increase or decrease? [probably decrease]
129. During the transition towards a post-carbon world will energy consumption increase or decrease? [hopefully decrease]
130. The progressive reduction of the use of natural resources (tipically hydrocarbon sources) will increase post-carbon energy production costs by 2050. [not at all probable]
131. The progressive reduction of the use of natural resources (tipically hydrocarbon sources) will increase post-carbon energy production costs by 2050. [not at all desirable]
132. Clear regulatory and policy strategies are essential to ensure private investment into energy infrastructure. [not at all probable]
133. Clear regulatory and policy strategies are essential to ensure private investment into energy infrastructure. [not at all desirable]
134. What is the responsibility of regulatory agencies in the transition towards a post-carbon world? [probably (almost) absent]
135. What is the responsibility of regulatory agencies in the transition towards a post-carbon world? [hopefully (almost) absent]
136. The promotion of renewable energy sources by governments may produce market distortion [not at all

probable]

137. The promotion of renewable energy sources by governments may produce market distortion [not at all desirable]
138. How will the gas market increase by 2050 in the European context (4 = EEA area)? [probably national in 2020]
139. How will the gas market increase by 2050 in the European context (4 = EEA area)? [probably national in 2050]
140. How will the gas market increase by 2050 in the European context (4 = EEA area)? [hopefully national in 2020]
141. How will the gas market increase by 2050 in the European context (4 = EEA area)? [hopefully national in 2050]
142. How will the electricity market increase by 2050 in the European context (4 = EEA area)? [probably national in 2020]
143. How will the electricity market increase by 2050 in the European context (4 = EEA area)? [probably national in 2050]
144. How will the electricity market increase by 2050 in the European context (4 = EEA area)? [hopefully national in 2020]
145. How will the electricity market increase by 2050 in the European context (4 = EEA area)? [hopefully national in 2050]
146. Will the transition process bring new business models and greater efficiency / economies of scale? Or will it decrease economic efficiency? [probably decrease]
147. Will the transition process bring new business models and greater efficiency / economies of scale? Or will it decrease economic efficiency? [hopefully decrease]
148. How the transition process will affect energy prices in terms of their increase or decrease? [probably decrease]
149. How the transition process will affect energy prices in terms of their increase or decrease? [hopefully decrease]
150. How do you see the development of smart grids and smart metering of consumption and costs? The dynamic pricing according to demand peaks? [not at all probable]
151. How do you see the development of smart grids and smart metering of consumption and costs? The dynamic pricing according to demand peaks? [not at all desirable]
152. Electricity companies will start owning stations for distribution of such electric energy for transportation. [not at all probable]
153. Electricity companies will start owning stations for distribution of such electric energy for transportation. [not at all desirable]
154. Will pricing be effective for achieving sustainability? Carbon tax? Is it a desirable policy? [not at all probable]
155. Will pricing be effective for achieving sustainability? Carbon tax? Is it a desirable policy? [not at all desirable]
156. The price of oil will be more significant than regulation and policies in determining how fast alternative energy sources are deployed [not at all probable]
157. The price of oil will be more significant than regulation and policies in determining how fast alternative energy sources are deployed [not at all desirable]
158. Is it desirable and probable not to price or tax goods when they are too much valuable and critical for the society? [not at all probable]
159. Is it desirable and probable not to price or tax goods when they are too much valuable and critical for the society? [not at all desirable]
160. A progressive shift towards transport of commoditiý goods to rail will take place [not at all probable]
161. A progressive shift towards transport of commoditiý goods to rail will take place [not at all desirable]
162. More intense international relations, trade and globalisation will increase mobility. [not at all probable]
163. More intense international relations, trade and globalisation will increase mobility. [not at all desirable]
164. Do you believe energy regulators will have the capacity to alter the regulatory framework for an effective and stable transition towards carbon neutral energy system? [not at all probable]
165. Do you believe energy regulators will have the capacity to alter the regulatory framework for an effective and stable transition towards carbon neutral energy system? [not at all desirable]
166. In regards to current energy projects and strategies do national institutions have/will have policies and regulations that are or will be effective in promoting cooperation between countries? [not at all probable]
167. In regards to current energy projects and strategies do national institutions have/will have policies and

regulations that are or will be effective in promoting cooperation between countries? [not at all desirable]

168. How effective do you view European Union institutions for implementing policies, legislation, regulations and directives in helping the effort of transitioning towards a post-carbon future? [not expensive at all]
169. How effective do you view European Union institutions for implementing policies, legislation, regulations and directives in helping the effort of transitioning towards a post-carbon future? [not at all effective]
170. As energy efficient technologies provide significant opportunities to reduce energy use, do you believe there should be more regulations and/or subsidies to encourage the implementation of this technology? [probably significantly less regulation]
171. As energy efficient technologies provide significant opportunities to reduce energy use, do you believe there should be more regulations and/or subsidies to encourage the implementation of this technology? [hopefully significantly less regulation]
172. In comparison with current regulations and legislation, how much change needs to occur in the future to make low carbon energy sources more competitive against high carbon energy sources? [probably no change]
173. In comparison with current regulations and legislation, how much change needs to occur in the future to make low carbon energy sources more competitive against high carbon energy sources? [hopefully no change]
174. Encouraging private investment into low carbon energy production can best be done by what method? [Tax incentives]
175. Encouraging private investment into low carbon energy production can best be done by what method? [Regulatory framework]
176. Encouraging private investment into low carbon energy production can best be done by what method? [Legislative framework]
177. Encouraging private investment into low carbon energy production can best be done by what method? [Subsidies to producers]
178. Encouraging private investment into low carbon energy production can best be done by what method? [Consumer subsidies]
179. Encouraging private investment into low carbon energy production can best be done by what method? [Market based mechanisms]
180. Encouraging private investment into low carbon energy production can best be done by what method? [Carbon tax]
181. Encouraging private investment into low carbon energy production can best be done by what method? [EU level directives]
182. The chart below is a risk assessment survey; the purpose is to identify the significance and the likelihood of different risks relevant to the energy industry in the transition to a post-carbon economy and society. Please place in order and rank the exten [Regulatory continuity: the risk that regulation will unexpectedly change making energy companies' previous investments uneconomical.]
183. The chart below is a risk assessment survey; the purpose is to identify the significance and the likelihood of different risks relevant to the energy industry in the transition to a post-carbon economy and society. Please place in order and rank the exten [Political continuity: the risk that national governments and EU level institutions will unexpectedly alter current policies related to greenhouse gas mitigation]
184. The chart below is a risk assessment survey; the purpose is to identify the significance and the likelihood of different risks relevant to the energy industry in the transition to a post-carbon economy and society. Please place in order and rank the exten [Security of Supply: the risk of supply disruption to non-EU based energy resources (i.e. gas, solar) which will have a significant impact on the availability and price of internal EU energy supplies.]
185. The chart below is a risk assessment survey; the purpose is to identify the significance and the likelihood of different risks relevant to the energy industry in the transition to a post-carbon economy and society. Please place in order and rank the exten [Economic environment: the risk that expected market conditions will not favor investment in low carbon energy sources and infrastructure: high carbon energy sources remain low cost.]
186. The chart below is a risk assessment survey; the purpose is to identify the significance and the likelihood of different risks relevant to the energy industry in the transition to a post-carbon economy and society. Please place in order and rank the exten [Future technology: the risk that technologically advanced forms of energy are not significantly deployed, forcing continued reliance on today's technology.]

187. The chart below is a risk assessment survey; the purpose is to identify the significance and the likelihood of different risks relevant to the energy industry in the transition to a post-carbon economy and society. Please place in order and rank the exten [Transmission and distribution grid: the risk that the electricity transmission and distribution grids will not be upgraded to accommodate the potential growth in new low carbon power sources.]

188. The chart below is a risk assessment survey; the purpose is to identify the significance and the likelihood of different risks relevant to the energy industry in the transition to a post-carbon economy and society. Please place in order and rank the exten [Societal adaptation: the risk that society resists or does not participate in carbon neutral lifestyles]

Table 57. The future transition scenarios towards post-carbon society

n	Scenario dimension	SC. 1		SC. 2		SC. 3		SC. 4	
n	*Technology*	Prob.	Des.	Prob.	Des.	Prob.	Des.	Prob.	Des.
1	Decrease of energy production for increased technological efficiency	3	3	3,18	5,47	3,42	6,25	3,63	6,2
2	Decentralised, distributed and renewable sources and their effectiveness	5,5	5	3,76	4,29	5,42	5,83	4,78	4,75
3	Large centralised energy production	6	4,5	5,06	4,18	3,33	2,08	4,08	3,25
5	High reduction of carbon emissions by new technologies on carbon sources	2	6	4,59	5,35	3,75	4,17	3,88	4,9
6	Development of carbon capture and storage for storing the CO2 emissions from coal fired power plants	1,5	1,5	2,82	4,53	3,08	3,5	2,95	3,98
7	Replacement of current transport technologies and infrastructures by advanced and lower impact (intangible or 'less tangible').	6	6,5	4,71	6,47	5,92	6,83	4,63	6,33
8	The development of new transmission networks is essential and affordable in terms of costs (i.e. CO2, hydrogen).	3	3	4,88	5,94	5,83	6,42	4,65	5,75
9	Currently fossil fuels account for 80% of energy production, how will the situation develop from 2010 to 2050? (1= will be increased above 80%; 7 will be reduced below 20%)	6,5	6,5	4,71	4,88	5,58	6	4,6	4,93
10	The transition towards post-carbon energy sources will increase or decrease the capacity of mitigation of risk of disruptions in the energy supply.	3,5	5	3,88	5,88	5,25	6,42	4	5,65
11	Local and renewable generation of energy will be enough to guarantee self-sufficient households and cities (excluding industries).	6,5	6	3,41	5,71	5,58	6,58	4,4	6,25
12	At the moment, emerging technologies would indicate that new energy sources will include sources such as biogas for heating, hydrogen, biodiesel	3	2,5	5,41	5,35	6,08	5,92	5,6	5,8
13	Energy infrastructure will be significantly restructured or changed completely to meet low carbon energy systems.	4,5	3,5	5,47	5,88	6,25	6,58	5,28	6,05
14	The implementation of energy efficiency programs and materials is essential for reducing energy usage. Construction industry will progressively increase energy efficiency	3,5	7	5,47	6,53	6,75	6,75	5,6	6,7

n.	Scenario dimension ***Environment and Health***	**SC. 1** Prob.	**SC. 1** Des.	**SC. 2** Prob.	**SC. 2** Des.	**SC. 3** Prob.	**SC. 3** Des.	**SC. 4** Prob.	**SC. 4** Des.
16	A fully sustainable and low carbon energy system is established by 2050.	6,5	6,5	3,65	6,59	5,42	7	4,47	6,6
17	The private enterprise sector undertake joint governance policies for the control of climate change by 2050	4	5,5	4,47	5,53	6	6,92	4,5	6,1
18	Global agreements for the use and protection of natural resources will be central to a post carbon world.	5	6,5	4,53	6,41	6,42	6,92	4,97	6,5
19	New health and environmental problems may arise because of an increased use of nuclear power and its waste disposal (not probable/desirable)	2,5	6,5	3,94	6,88	2,33	5,58	3,55	6,17
20	Macroscopic marine algae and seaweeds become important sources of bio-energy production by 2050	4	5	4,59	5,53	5	5,08	4,75	5,65
21	Renewable energy technologies pose a risk to human and environment health (not probable/desirable)	6,5	6,5	4,24	6,65	6,08	7	4,95	6,35
22	Electricity is a viable energy source for transport in the transition towards a post-carbon world by 2050	6,5	6,5	5,71	5,41	6,17	5,92	5,2	5,38
23	Massive lithium production for battery powered cars and the related technology will be development.	5	4,5	5,06	3,82	5,33	4,83	5,13	4,25
24	New nuclear technologies rely on a considerable reduction or elimination of hazardous waste	3,5	6,5	4,65	6,18	3,92	5,5	4,18	5,53
25	Current probable level of risk for hydrogen transportation (High/low)? Desirability of making it decreasing by applied research and technology?	2	4,5	2,82	5	3,5	6,33	4,03	5,7
26	Will new energy technologies be harmful for health and the environment?	6	6,5	3,76	5,65	5	6	4,92	5,72

	Scenario dimension	SC. 1		SC. 2		SC. 3		SC. 4	
n.	***Socio-economic and political aspects***	Prob.	Des.	Prob.	Des.	Prob.	Des.	Prob.	Des.
28	The continued economic development of national economies in Asia and Africa will be a large impediment to a transition towards a post-carbon world (not probable/not desirable).	5	5	2,18	4,82	3,92	5,33	2,65	5,27
29	Renewable energy sources will not require vast land areas with negative externalities for other land uses	5,5	5,5	3	5,71	4,92	6,75	3,5	5,75
30	The problems for the transport of hydrogen as a fuel will be solved by 2050.	2,5	2	3,88	5,88	5,67	6,58	5,13	6,15
31	Local distribution of hydrogen will be safely and economically efficient to have widespread use.	2	2	2,94	5,24	5,42	6,17	4,72	5,95
32	Hydrogen will be produced at night by nuclear power.	1,5	1,5	4,71	3,94	3,67	3,08	4,33	3,7
33	The costs for hydrogen transportation will become progressively lower.	2	2,5	4,41	5,71	5,83	6,42	5,23	6,03
34	The risks related to hydrogen transportation will progressively drop.	2	2	4,29	5,88	5,5	6,58	5,25	6,15
35	Increased remote work will reduce moblity.	6,5	6,5	4,94	5,47	5,58	6,17	5,05	5,1
36	Lower trasportation costs will increase mobility.	4	3	3,29	3,94	4,75	5	3,93	3,95
37	Will the transition process imply greater investments for businesses and the whole economy?	4,5	3,5	5,65	4,24	6,25	4,83	5,7	5,28
38	Do the European Union common policies, legislation and regulation progressively weaken on strengthen the effort towards a post-carbon future?	5,5	6,5	4,88	6	5,33	6,83	5,33	6,15
39	Public transport will develop independently from the implementation of greater restrictions on private cars	2	5	3,06	4,41	2,92	2,92	3,91	3,97
40	Private ownership is preferred to achieve the most possible secure, reliable, efficient energy system.	4	0	4,29	4,82	4	3,33	4,58	3,8
41	Public ownership is preferred to achieve the most possible secure, reliable, efficient energy system.	5	5	3,82	3,35	6	6,33	4,47	4,8
42	The European Union will still exist in 2050.	4	6	5,18	5,53	6,33	6,67	5,8	6,4
43	The European Union will increase its Member States	4,5	5	5,47	4,47	6,33	5,67	5,83	5

	Scenario dimension	SC. 1		SC. 2		SC. 3		SC. 4	
	Environment and Health	Prob.	Des.	Prob.	Des.	Prob.	Des.	Prob.	Des.
44	Developing countries will be affected by the transition process towards a post-carbon society, that will take place in Europe.	4	5	5	3,94	5	4,67	4	4,12
45	Will social welfare, during the transition process, progressively weaken on strengthen (social effects, labour policies, jobs)?	3,5	5,5	3,47	5,41	5,75	6,83	4,95	5,98
46	Criteria of social responsibility, and the roles and resposibility of different actors, will be better defined in the transition process.	4,5	5,5	4,53	5,88	6,08	7	4,9	6
47	Energy intensive industries will shift out of the EU and towards developing countries as a result of tightening emission targets.	5	6	1,88	6,06	2,83	6,33	2,6	5,62
48	New energy infrastructure guided by changed regulations	4,5	5,5	5,65	5,65	6	6,5	5,63	5,7
49	Will the risks for each stakeholder, in relation to different areas, be better defined in the transition process?	4,5	4,5	3,76	5,59	5,25	6,17	4,63	5,8
50	My quality of life will improve by transitioning away from a carbon based energy system	4	6,5	3,24	5,82	6,17	7	4,9	6,08
51	The development of developing countries will increase mobility.	4	4	5,88	3,47	5,83	5,25	5,58	4,1
52	Weakening or strenghtening of general economic development (social well-being, general security, trust and business expectations)?	3,5	5	3,94	6	6,17	6,67	4,55	5,73
53	Return on investments, public and private, in research for new energy technologies and education for workers, reconversion of old plants, will cover the current losses in terms of jobs and investments belonging to old technologies.	6	6,5	4,29	6	6,08	6,92	4,93	6,05
54	What is the responsibility of business in the transition towards a post-carbon world? (probably/hopefully full or absent)	5,5	6,5	5,18	5,65	5,58	6,67	4,83	5,58
55	What is the responsibility of citizens in the transition towards a post-carbon world? (probably/hopefully full or absent)	3	4,5	4,88	5,53	6,17	6,75	5,15	6,08
56	What is the responsibility of politics in the transition towards a post-carbon world? (probably/hopefully full or absent)	4	6,5	6,12	6,18	6,42	6,75	5,53	6,3
57	What is the responsibility of public institutions in the transition towards a post-carbon world? (probably/hopefully full or absent)	4,5	6	5,82	6,06	6,5	6,83	5,43	6,2
58	Return on investments will equal the costs. A better quality of life, well-being, health, security, high knowledge, technological and educational level, pleasant and clean urban models, dynamic and socially safe work environment will still be produced.	3,5	6	4,18	6,53	6,33	7	5,05	6,55

	Scenario dimension	SC. 1		SC. 2		SC. 3		SC. 4	
	Environment and Health	Prob.	Des.	Prob.	Des.	Prob.	Des.	Prob.	Des.
44	Developing countries will be affected by the transition process towards a post-carbon society, that will take place in Europe.	4	5	5	3,94	5	4,67	4	4,12
45	Will social welfare, during the transition process, progressively weaken on strengthen (social effects, labour policies, jobs)?	3,5	5,5	3,47	5,41	5,75	6,83	4,95	5,98
46	Criteria of social responsibility, and the roles and resposibility of different actors, will be better defined in the transition process.	4,5	5,5	4,53	5,88	6,08	7	4,9	6
47	Energy intensive industries will shift out of the EU and towards developing countries as a result of tightening emission targets.	5	6	1,88	6,06	2,83	6,33	2,6	5,62
48	New energy infrastructure guided by changed regulations	4,5	5,5	5,65	5,65	6	6,5	5,63	5,7
49	Will the risks for each stakeholder, in relation to different areas, be better defined in the transition process?	4,5	4,5	3,76	5,59	5,25	6,17	4,63	5,8
50	My quality of life will improve by transitioning away from a carbon based energy system	4	6,5	3,24	5,82	6,17	7	4,9	6,08
51	The development of developing countries will increase mobility.	4	4	5,88	3,47	5,83	5,25	5,58	4,1
52	Weakening or strenghtening of general economic development (social well-being, general security, trust and business expectations)?	3,5	5	3,94	6	6,17	6,67	4,55	5,73
53	Return on investments, public and private, in research for new energy technologies and education for workers, reconversion of old plants, will cover the current losses in terms of jobs and investments belonging to old technologies.	6	6,5	4,29	6	6,08	6,92	4,93	6,05
54	What is the responsibility of business in the transition towards a post-carbon world? (probably/hopefully full or absent)	5,5	6,5	5,18	5,65	5,58	6,67	4,83	5,58
55	What is the responsibility of citizens in the transition towards a post-carbon world? (probably/hopefully full or absent)	3	4,5	4,88	5,53	6,17	6,75	5,15	6,08
56	What is the responsibility of politics in the transition towards a post-carbon world? (probably/hopefully full or absent)	4	6,5	6,12	6,18	6,42	6,75	5,53	6,3
57	What is the responsibility of public institutions in the transition towards a post-carbon world? (probably/hopefully full or absent)	4,5	6	5,82	6,06	6,5	6,83	5,43	6,2
58	Return on investments will equal the costs. A better quality of life, well-being, health, security, high knowledge, technological and educational level, pleasant and clean urban models, dynamic and socially safe work environment will still be produced.	3,5	6	4,18	6,53	6,33	7	5,05	6,55

n.	Scenario dimension ***Market and regulatory effects***	SC. 1 Prob.	SC. 1 Des.	SC. 2 Prob.	SC. 2 Des.	SC. 3 Prob.	SC. 3 Des.	SC. 4 Prob.	SC. 4 Des.
60	Energy governance council for joint integrated and participatory decision-making process established at European level for common goals.	4,5	5,5	4,06	4,29	5,92	6,67	4,9	5,9
61	A governance council for the transition process will be actually set up, for the achievement of a post-carbon society, in order to limit the related expected risks and to deal with those that are unexpected.	4,5	5	3,82	4,18	6	6,67	5,08	6,2
62	A governance council for the transition will provide decision makers with a clear framework for the identification of main risks in different areas, and with possible countermeasures.	4	5	3,53	4,06	5,83	6,83	4,8	6,03
63	The energy governance strategy will bring stakeholders together for setting mandatory security and reliability standards and agreeing on voluntary measures	4	5	3,76	4,71	5,58	6,83	4,83	6,2
64	The energy governance strategy will be able to fill the gaps in reliability, risk and security matters, in respect to more traditional and isolated risk management systems.	4	5	3,29	4,59	5,67	6,58	4,15	6
65	The energy governance strategy will be able to adapt the definition of mandatory standards and voluntary measures to the dynamics of market and technological development.	4	5	3,47	4,76	5,75	6,5	4,38	6,1
66	The energy governance strategy will be able to create an alternative system of joint integrated management able to preserve the free market while at the same time guarantee efficient and secure interoperability and preserve critical infrastructural systems	4,5	4,5	3	4,59	5,5	6,17	4,38	5,93
67	During the transition towards a post-carbon world will energy consumption increase or decrease?	5	3,5	3,47	5,53	3,25	6	3,22	5,85
68	The progressive reduction of the use of natural resources (tipically hydrocarbon sources) will increase post-carbon energy production costs by 2050.	4,5	5,5	2,41	4,47	3,83	4,75	2,92	4,65
69	Clear regulatory and policy strategies essential to ensure private investment into energy infrastructure.	5	5,5	5,47	6,12	6,08	6,5	5,65	6,18
70	What is the responsibility of regulatory agencies in the transition towards a post-carbon world? Probably/hopefully absent/full)	3,5	3,5	5,47	5,82	6,17	6,33	5,28	5,8
71	The promotion of renewable energy sources by governments may produce market distortion	2	6,5	3,16	6,88	4,58	5	3,03	4,52
72	How will the gas market increase by 2020 in the European context (4 = EEA area)? Probably/hopefully national/continental	3	2,5	4,94	5,59	4,42	4,5	4,55	4,35
	How will the gas market increase by 2050 in the European context (4 = EEA area)? Probably/hopefully national/continental	2,5	2,5	5,71	5,65	5	4,67	4,63	4,47
73	How will the electricity market increase by 2020 in the European context (4 = EEA area)? Probably/hopefully national/continental	5,5	5,5	4,94	5,65	5,33	6,5	4,72	4,72
	How will the electricity market increase by 2050 in the European context (4 = EEA area)? Probably/hopefully national/continental	6	6	5,88	6	6,33	6,58	5,18	4,75
74	Will the transition process bring new business models and greater efficiency / economies of scale? Or will it decrease economic efficiency?	6,5	6,5	4,41	5,82	6,25	6,92	5,08	5,85
75	How the transition process will affect energy prices in terms of their increase or decrease?	4	5	2	4,18	3,92	5,92	3,62	4,82
76	How do you see the development of smart grids and smart metering of consumption and costs? The dynamic pricing according to demand peaks?	5,5	5	5,47	5,94	6,25	6,25	5,45	5,65
77	Electricity companies will start owning stations for distribution of such electric energy for transportation.	3,5	3,5	5,06	4,35	5,92	5,42	5,13	4,7
78	Will pricing be effective for achieving sustainability? Carbon tax? Is it a desirable policy?	5,5	5,5	5,06	4,76	6	6,08	5,1	4,9
79	The price of oil will be more significant than regulation and policies in determining how fast alternative energy sources are deployed	5,5	2,5	5,71	4,06	4,75	3,17	5,73	3,75
80	Is it desirable and probable not to price or tax goods when they are too much valuable and critical for the society?	3	3	3,94	4,24	4,42	4,83	4,1	3,98
81	A progressive shift towards transport of commodity goods to rail will take place	3,5	6,5	4,65	6,18	5,33	6,58	4,63	6,05
82	More intense international relations, trade and globalisation will increase mobility.	4	2	5,53	3,82	5,25	4,58	5,4	4,15
83	Ability of energy regulators to alter the regulatory framework for an effective and stable transition towards carbon neutral energy system	3,5	4,5	3,71	6,29	5,33	6,75	4,22	5,75
84	In regards to current energy projects and strategies do national institutions have/will have policies and regulations that are or will be effective in promoting cooperation between countries?	4,5	4,5	4,53	6,12	5,25	6,5	4,9	6,15
85	How effective do you view European Union institutions for implementing policies, legislation, regulations and directives in helping the effort of transitioning towards a post-carbon future?	5,5	4	5,18	3,24	4,08	5,75	4,7	4,75
86	As energy efficient technologies provide significant opportunities to reduce energy use, do you believe there should be more regulations and/or subsidies to encourage the implementation of this technology?	5	3	5,35	4,88	5,25	5,58	5,13	5,35
87	In comparison with current regulations and legislation, how much change needs to occur in the future to make low carbon energy sources more competitive against high carbon energy sources?	4,5	5,5	6	5,53	5,92	6,17	5,65	5,88

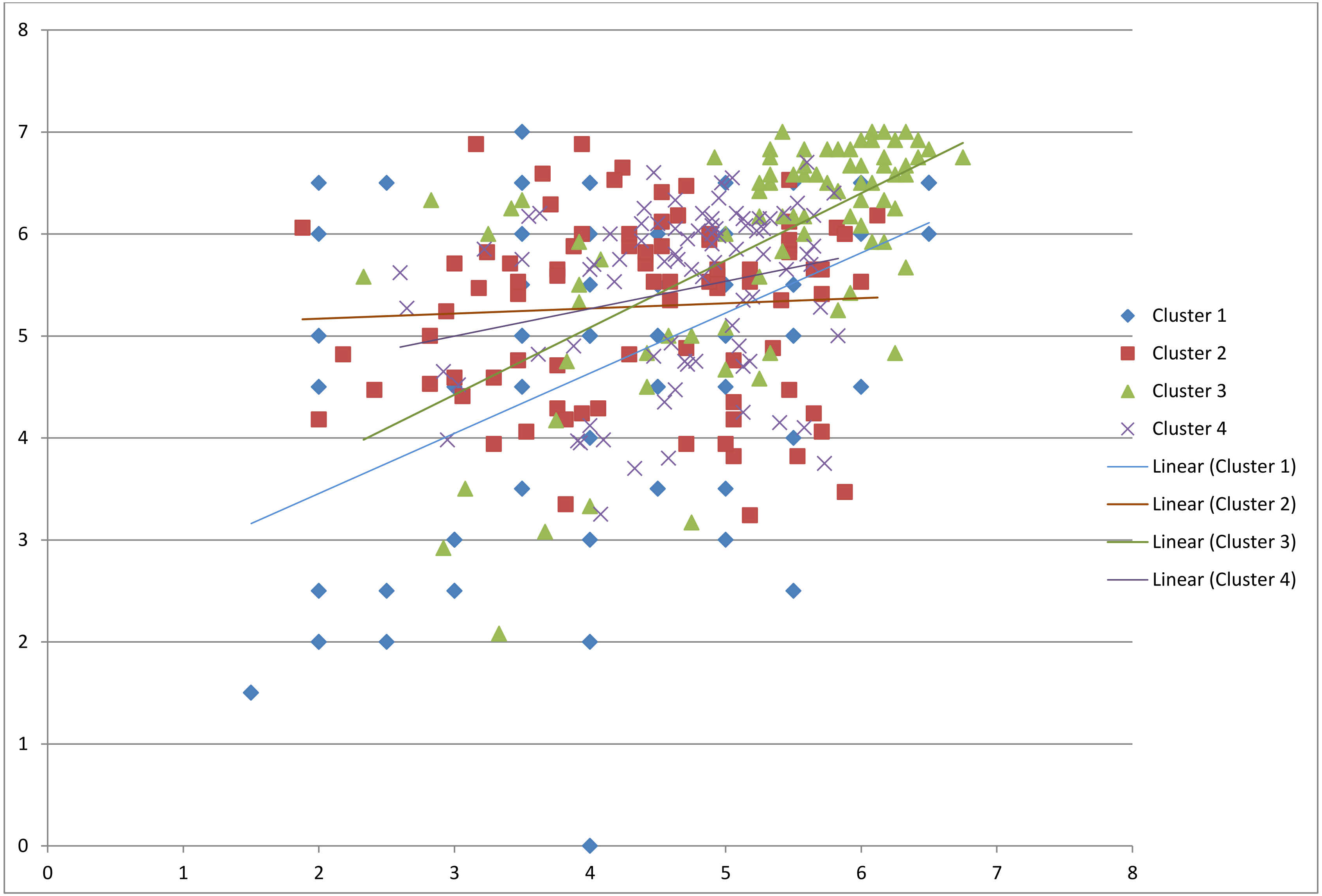


Figure 48. The four clusters of respondents that identify pathways towards a post-carbon society