Chapter 2
Sustainable Innovation: Definitions, Priorities and Emerging Issues

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Abstract The challenges of global societies exert huge pressure on the science community and policymakers to provide solutions that will assure sustainable development. This pressure is evident and results in rapid changes in the concept of innovation systems. These challenges extend beyond national state borders and call for, not only international, but also global action. In addition, it requires a wide range of different stakeholders looking for a multi-policy approach. This chapter presents changes and trends in our understanding of the innovation process and the increasingly important role of different stakeholders involved in the process. Furthermore, it draws on the approach of the EU funded CASI project on 'Public Participation in Developing a Common Framework for the Assessment and Management of Sustainable Innovation' in order to address these questions.

2.1 Introduction

Today we are faced with rapid changes in the development of innovation system concepts. Three major shifts influencing these developments can be observed. The first is a shift towards closer cooperation and networking between the main actors of the innovation system, and their interactions in general. The second shift relates to the increasingly multidisciplinary nature of sustainable innovation, while the third major shift in the perception of the innovation system is manifests through wider societal participation.

Without a doubt, the innovation process involves a growing number of stakeholders. Beyond academia, industry and the government actively contributing to the creation of a general framework for innovation, the role of end-user's knowledge and insights is becoming increasingly important. The knowledge society, which encourages and

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accelerates the production of knowledge, is especially pronounced in the concept of the quadruple and pentacle helix. Overall, interest in innovation and sustainability has increased substantially in recent years. As both, companies and entire nations, receive increasing pressure to consider sustainable development as a way to address social and environmental changes, many have ratcheted up their innovation efforts in order to remain competitive and drive profitable growth (Waite 2014).

This emerging interest in sustainable innovation (SI) also points to a shift from narrow eco-innovation concepts towards broader concepts embracing multiple socio-economic dimensions. In this chapter, this shift will be presented with a review of the existing definitions of SI and the development of such. According to Nidumolu et al. (2013), sustainability is the mother lode of organizational and technological innovation that yields both bottom-line and top-line returns. There are several ways in which companies can benefit from acting in socially responsible and environmentally aware ways. Achieving competitive advantage, building strong corporate brand, and winning the war for talent, are amongst the many examples (Porter and Kramer 2006; Bhattacharya et al. 2008; Hillestad et al. 2010).

The purpose of this chapter is to explore the topic and concepts related to sustainable innovation and to present the readers with relevant SI priorities at both, European and global levels.

This will be presented through a review of contemporary literature on the definitions of innovation with a specific focus on SI, alongside other supporting and complementary concepts. The main goal is to present clear evidence of the growing importance of sustainable innovation in the innovation process, and to demonstrate the ways in which sustainability is a key driver of innovation and its particular relevance in addressing the Grand Societal Challenges, focusing primarily on the fifth Grand Challenge that of “Climate action, environment, resource efficiency and raw materials”.

2.2 Development of Innovation Concepts: From Traditional Actors Towards Public Participation

In order to better understand the evolution of innovation concepts, we present a short overview of the development of the main theoretical concepts of the relationship between science and society. According to the traditional view of these relations, three key actors play the main roles in fast economic development: academia, industry and the government. Research institutions and universities act as the main generators of knowledge and ideas, the industry actors as the main user of this knowledge, and the government, which is in the position to create a normative-regulatory framework for society, plays a vital role in creating the conditions for the successful cooperation of all three actors. From the perspective of time, we could describe the development of relations between all three key actors through three main periods (Viale and Etzkowicz 2002).

The first period covers the time up until the Industrial Revolution of the nineteenth century and defines the role of knowledge as the "controlled observation of our surroundings and economic production is a decisive act of transforming the observed reality with the special purpose of providing comfort, human desires and needs" (Kuznets 1965). Knowledge is the domain of individuals, thus the transferability of knowledge between actors can be challenging.

The period of industrial revolutions is described as a transition period from individual inventors to networks of entrepreneurial scientists. Freeman et al. (1982) describe this period from the beginning of capitalism to the theory of long waves, dividing this period into five parts/waves. These waves denote key changes in technology, social organization and related institutional changes. Most of the technology before 1850 (steam technology, looms and steel production) was engineered by their practitioners. Only a few achievements emerged from empirical models based on natural laws. Inventions largely founded largely based on the principle of experimental trial and error. The second Industrial Revolution was made possible with the breakthrough of natural laws.

The beginning of the Third Industrial Revolution was marked by great scientific discoveries such as nuclear energy, the discovery and development of semiconductors and antibiotics (Viale and Etzkowicz 2002). Here, industry's collaboration with science became very strong. The focus of cooperation comes from within the universities, with the support of industry actors. The reason for this is not a greater intensity of research, but the changing role and function of universities. There is a so-called "institutionalization of innovation" (Mowery and Rosenberg 1998). The strong role of the state in this process is reflected in the promotion, structuring and financing of these discoveries. The so-called entrepreneurial universities, in addition to science, also develop technologies and stimulate innovation. This industry, university or state-supported research and development work is characterized by a close link between science and technology.

The latest phase of the Third Industrial Revolution involves the enhanced integration of various emerging technologies (Roco and Bainbridge 2002). This integration not only means enhanced cooperation between science, the industry and the government, but also the enhanced global role of universities and the emergence of universities with a wide range of disciplines and scientists, which provides a window of opportunities to combine the knowledge from different disciplines, innovations and entrepreneurial models (National Science Foundation 2002).

However, the end of twentieth century brings radical changes in the production of knowledge, including new actors involved in the innovation process and knowledge production. Different theories describe these processes from different points of view.

2.2.1 Mode 2: Changing Mindsets on the Role of Science in the Innovation Process

The concept of Mode 2 was elaborated and presented by experts in the field of policy research (Gibbons et al. 1994). Mode 2 theory deals with the emergence of knowledge, in contrast to the traditional concept of knowledge related to scientific disciplines, in a far wider transdisciplinary social and economic process. The theory was prompted and developed in view of the major changes in science and higher education in the second half of the twentieth century. It redefined the role and place of universities in society. Within the framework of the theory, the authors describe different movements that emerged and developed during this period in the production of knowledge. The theory distinguishes between two distinct types of scientific production: Mode 1, characterized by the gap between research institutions and society, the self-definition and self-sufficiency of scientific disciplines and specialties, interactions between researchers and the economy almost does not exist. The second method, known as Mode 2, points to the disappearance of boundaries between scientific disciplines and self-control over the direction and content of the research (Gibbons et al. 1994; Shinn 2002; Nowotny et al. 2006).

The essence of the Mode 2 concept is the notion of a socially distributed creation of knowledge, which, unlike the traditional way of creating knowledge, was created primarily in academic institutions—in universities, institutes and laboratories, and was coined by Mode 1 as appearing in new places and in a new way. This new Mode 2, differs from the traditional model by virtue of the following characteristics (Gibbons et al. 1994):

- *Contextualization*. Knowledge is generated in the context of its use (which is also possible in Mode 1, but the formation and use of knowledge are strictly separated) (Gibbons et al. 1994).
- *Transdisciplinarity*. The term refers to the fact that the solution to problems in Mode 2 includes a wider range of theoretical and methodological approaches. The concept of transdisciplinarity goes beyond the concept of interdisciplinarity in that interactions between individual disciplines are far more dynamic. When a theoretical consensus is reached, it cannot be reduced to individual disciplines (Gibbons et al. 1994; Hessels and Van Lente 2008). The concept of transdisciplinarity enables different approaches to problem-solving, which encourages collaboration outside or beyond the boundaries of existing disciplines (Mali 2009).
- *Heterogeneity*. Knowledge generated in Mode 2 is created in different organizations. Knowledge is created not only in traditional academic institutions (universities, institutes and laboratories) but also in research centres, public agencies, high-tech "spin off" companies, consulting houses that are interconnected, and new knowledge is a product of mutual interactions (Gibbons et al. 1994).
- *Reflexivity*. Due to the inclusion of different approaches and disciplines, the knowledge gained in Mode 2 has the ability to integrate multiple views and

arise in the form of a dialogue. Researchers are increasingly aware of the social responsibility of their work and from the outset take into account the impact of the results of their research on society (Gibbons et al. 1994).
- *New forms of evaluation of research results* are the fifth characteristic of Mode 2 of knowledge generation. The traditional "peer review" system of knowledge verification limited to individual disciplines now came to include other criteria that take into account economic, political, social and cultural criteria. Evaluation is no longer restricted to specific judgments within individual scientific disciplines (Gibbons et al. 1994; Hessels and Van Lente 2008).

Concluding with the Mode 2 concept, we find that Mode 2 brings and entirely new view on the innovation process by introducing, as well as interdisciplinary, new forms of evaluation, which are far broader than classic evaluation schemes, framed with a single specific scientific discipline.

2.2.2 Finalization of Science

The concept of the "Finalization of science" describes and explains the dynamics of science and its social function. The concept originated in the 1970s, when a German group known as "Starnberger's" developed a research programme based on scientific dynamics consisting of the case studies of various scientific disciplines (Rip 1989).

The main conclusions of the research asserted that disciplines follow a general development in which we can distinguish an explanatory, paradigmatic and post-paradigm phase. In this context, the most important is the final stage in which "finalization" can occur. According to this concept, theoretical development, which is determined by external factors, can be understood. Further, more and more disciplines come to reach the final stage, which points us to the fact that the relationship between science and society is changing. In this relationship, the company is becoming an increasingly active partner and is taking on a role as a leading player (Hessels and Van Lente 2008).

Compared with Mode 2, four important differences are worth mentioning:

- The concept of "finalization" has strong empirical foundations based on several case studies (Böhme et al. 1983).
- The concept of "finalization" clearly distinguishes between scientific disciplines and treats them separately.
- Unlike the production of new knowledge in Mode 2, the finalization of science largely relates to internal causes and not to external ones.
- When it comes to "normative finalization", the concept of finishing science is highly prescriptive. It does not mention the growing social dimension and orientation of science, but makes recommendations to policymakers (Weingart 1997; Hessels and Van Lente 2008).

2.2.3 Post-normal Science: Introducing Public Participation

Post-normal science is referred to as the concept that arises from the problem of managing complex scientific problems, when confronted with a situation that traditional science avoids: uncertainty. Post-normal science accepts the legitimacy of a plurality of views and treats them as an integral part of science. This ensures a wider framework of cooperation in decision-making (Funtowicz and Ravetz 2003).

The concept derives from the solution of complex and acute (typically environmental) problems, as well as lessons about the limitations of a rational decision-making process. Such problems require a redefinition of the role of a scientific approach in solving them. In environmental discussions, "the facts are blurred, the bets are high, and the decisions necessary" (ibid.). Quick decisions are required, while there are many unknowns and expectations. We are confronted with various values that are involved in solving the problem. The usual methodological approach, which Funtowicz and Ravetz (2003) called normal science, deals with the problem of reducing a complex field to simpler building blocks that allow for controlled experiments. Such an approach is suitable for confirming abstract theories, but is not suitable for today's problem-oriented research (ibid.).

The essence of the concept lies in the fact that a required scientific practice, which can be confronted with uncertainty, a plurality of values and stakeholders with different interests, is required. As a supplement, therefore, it can support policymakers, taking into account their time constraints. For this purpose, the term "post-normal science" was conceived. Its most prominent characteristic is public participation, and is called the "extended peer community" (Funtowicz and Ravetz 1993). Despite the involvement of the public, however, advocates of this concept are often limited to the involvement of stakeholders and stakeholders only in the decision-making process or in assessing the quality of scientific production (Hessels and Van Lente 2008).

2.2.4 Triple Helix Model: Taking Roles Between the Players in the Innovation Process

The main factors influencing rapid economic development and the relations between the main actors of this development are also described by the Triple Helix model (Etzkowitz and Leydesdorf 2000), presented as the triple helix model of innovation. This model encompasses the interdependence of the three main players: academia, industry and the government at different points of capitalization of knowledge (Etzkowicz 2002). The idea of a Triple-helix model follows from the evolution of innovation systems and the conflict involved in choosing the path to be taken in terms of the relations between academia and industry. The model itself distinguishes a specific historical situation.

The Triple Helix model describes relations in three dimensions. The first dimension of the model describes the internal transformations in each of the helixes, such as business links, or the awareness of universities about their mission of economic development. In the second dimension, it describes the interaction between helixes, such as the role of the state. The third dimension is the state of overlapping of trilateral networks and organizations among all three helixes created with the aim of producing new ideas and forms of high technological development. The concept of a Triple Helix model defines its beginning as the moment when academia, industry and the government enter into a mutual relationship in which they strive to improve each other's work.

The concepts described here developed with accelerated globalization and the many global challenges of modern society, such as climate change and ageing populations.

2.2.5 Further Development of Innovation Concepts: The Public Becomes an Active Player in the Innovation Process

Further developments of the Triple Helix model led to the emergence of the quadruple or pentacle helix models of innovation. If the Triple Helix model describes the relationship between academia, industry and the government as the main players in the innovation process, the model of the Quadruple helix includes the helix of civil society (Carayannis et al. 2012). While the triple helix emphasizes the importance of innovative universities, the quadruple helix introduces the perspective of the knowledge society and the democratization of knowledge. Instead of the development of society in the knowledge economy introduced by the triple helix, the innovation of the quadruple helix system requires the simultaneous development of the knowledge economy, the knowledge society and the knowledge democracy. The concept of the quadruple helix encourages society and the democratization of knowledge to support, promote and accelerate the production of knowledge (research) and the use of knowledge (innovation) (Carayannis and Campbell 2012). The concept of the pentacle helix in the entire innovation process brings with it environmental sensitivity. "The Pentacle helix supports the creation of a state of mutual benefit between ecology, knowledge and innovation, and the creation of mutual positive effects between the economy, society and democracy" (Carayannis and Campbell 2012). As a practical example to which the concept of the pentacle helix can be applied, the authors point to the issue of climate change.

Simultaneously with the concept of the quadruple and the pentacle helix, the concept of Mode 3 knowledge emerged. The concept of Mode 3 emphasizes the coexistence and joint development of different modes of knowledge and innovation. Compared with Mode 2, it emphasizes pluralism and the diversity of knowledge and innovation. Pluralism supports the processes of mutual learning using different types of knowledge, and thus enables the creation of various forms of integration between basic and applied research (Carayannis and Campbell 2012).

2.3 The Importance of Sustainable Innovation in the Innovation Process

Systemic thinking in innovation studies emphasizes the importance of interactions and feedback mechanisms among all innovation actors, including university researchers, industry developers, brokering organizations and end-users (Lipnik 2016). The concept is primarily used as a framework for describing and explaining the complexity of innovation systems, and is also used to propose a more systematic approach to innovation policies (Smits and Kuhlmann 2004).

The system is defined as a set of interconnected components that work towards a common goal and which consists of components, the relationships between them, and its attributes (Carlsson et al. 2002).

The perspective of the innovation system is used at different levels to describe the innovation system, but is linked to the consideration of the interactive nature of a successful innovation process (Edquist and Johnson 1997; Hessels and Van Lente 2008).

The 1990s marked the beginning of intense theoretical engagement with innovation processes and various innovation models. The traditional, linear model of innovation, the beginning of the innovation process was in basic research, which, through applied research and engineering development, transforms into a product/service. This process can operate on the basis of market pull or the suppression of science and is based on the first generation of innovation policies (Lipnik 2016).

In the 1990s, the traditional innovation model underwent changes with the emergence of a coupling model. The coupling model is a combination of both of the previously described models. The concept of the model asserts that research using new technologies and knowledge-based production, from below, as well as society and related market requirements, from above, have an effect on the realization of new products and services.

Innovation studies at the beginning of the twenty-first century brought in the concept of the "National Innovation System", which assigns a new role to both research and the market. These are seen not only as the main generators of the need for new products and services, but recognizes them as important actors in national economies—however, market need is still the main generator of innovation, together with other important factors such as fiscal policy, innovation support, promotion of entrepreneurship and mobility (Lipnik 2016). Under these conditions, however, through direct or indirect measures, the state is influenced through its institutions (Nabradi 2009; Kuret 2012; Lundvall 1988). The national innovation system (hereinafter NIS) is represent in Fig. 2.1.

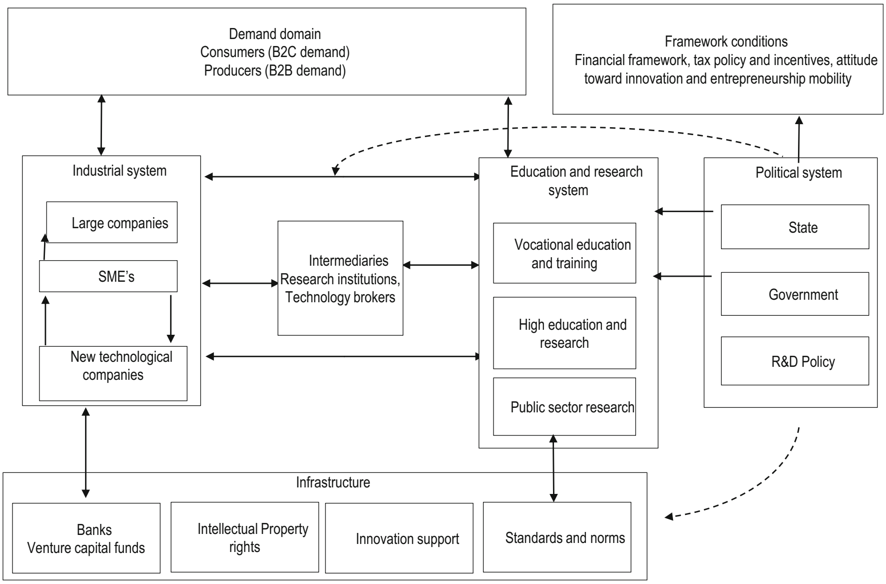

Fig. 2.1 National innovation system/scheme. Source: Kuhlmann and Arnold (2001)

An important change introduced by NIS is the conditions and incentives that the state determines in order for the innovation system to function properly and successfully (Chesbrough 2003).

Although the authors of the concept consider the national innovation system, individual authors argue that globalization, transnational connections, like the EU, and multinational corporations have, on the one hand, greatly diluted the role of the state in the innovation process; on the other hand, regional subsystems are becoming more important than the state, including individual regions, certain industrial quarters or "silicon valleys" (Freeman 2002).

Moreover, regional infrastructure, knowledge and skilled employees, specialized services, as well as mutual trust and personal connections play an important role on the regional level, and contribute much to the regional innovation system (Freeman 1995).

In this light, the authors distinguish between the narrower definition of NIS, which includes sources of innovation that have changed greatly over the centuries, from scientific academies in the seventeenth century, through the industrial revolution of the eighteenth century, to the growth of universities, scientific faculties and institutes. In the twentieth century, this narrower definition includes industrial research and the emergence of research councils, ministries of science and technology, as well as institutional networks (Lipnik 2016).

The broader concept of NIS understands that the sources of innovation are integrated into a far wider socio-economic system with a strong political and cultural impact on the innovation process; similarly, economic policy influences and to some extent determines the extent, direction and success of innovation activity (Freeman 2002). However, recent developments show the need to transcend the concept of NIS in order to address the challenges of a larger global society. This approach shows the need for a “Transformative Innovation Policy”, which divides innovation policies into three frames. Frame 1 refers to policies aimed at producing social benefits through R&D investment; Frame 2 refers to NIS; and Frame 3 is dedicated to the role of science, technology and innovation policy in the implementation of Global Sustainable Development goals, addressing questions related to global sustainability, poverty and inequitable income distribution (Schot and Steinmueller 2018). This concept does not ignore the importance of Frame 1 and Frame 2, but implies that both Frame 1 and Frame 2 have to be open to the emerging global challenges.

2.4 Definitions

2.4.1 Innovation

In any consideration of innovation systems, we are confronted with the concept of innovation. Waite (2014) pointed out that innovation is widely recognized as the main driver of industrial growth. Innovative companies achieve a competitive advantage, but the idea of a competitive national economy works to create a system that improves the competitiveness of the national economy as a whole. Countries try to achieve this by investing in innovation and, consequently, improving their own innovative ability (Porter 1990).

Mulej et al. (2008) suggest that innovation comes from an invention, which differs from it by the fact that someone has developed it to its point of utility, and that it has already found its customers and proved to be useful. Most innovations appear to build on “repurposing, improving or renewing existing ideas and practices” (Hines and Marin 2004).

According to OECD (2005), innovation is the use of a new or significantly improved product, service or process, new marketing or organizational methods, business practices, workplace organization or external relations. Innovation is the result of an innovation process, and this process can come about due to the demands of the market, users or scientific findings.

Charter and Clark (2007) point out that innovation is the successful exploitation and commercialization of new ideas. It is far more than the common perception that innovation is only about new ideas or research and development. Furthermore, they add that innovation can (ibid.):

- Cover all processes (technological, organizational and marketing) in the development and commercialization of novel products and services providing value to customers

- Occur at four main tiers or levels (technologies/products/services, process, organizational, business)
- Include, but is not limited to the ideas and research stages of the innovation cycle, or to novel technology alone, although these are core elements of innovation
- Include "low tech" and is not restricted to "high tech" technologies

The term innovation is often used interchangeably with other terms, such as a new or novel idea, radical change and creativity (Waite 2014). Creativity is considered in the generating of ideas as the front-end of the problem-solving process, while innovation is useful for implementing a solution as the back-end (Waples and Friedrich 2011).

2.4.2 Eco-innovation and Sustainable Innovation

There are several accepted definitions of eco-innovation. According to the European Commission (2007), eco-innovation is any form of innovation aiming at significant and demonstrable progress towards the goal of sustainable development, through reducing impacts on the environment or achieving a more efficient and responsible use of natural resources, including energy. Charter and Clark (2007) refer to eco-innovation as the creation of novel and competitively priced goods, processes, systems, services, and procedures designed to satisfy human needs and provide a better quality of life for all, with a minimal use of natural resources (materials, including energy and surface area) per unit output, and a minimal release of toxic substances. In general, these definitions emphasize that eco-innovations reduce the environmental impact that arises as a result of consumption and production activities, whether the primary motivation for their development or deployment is environmental or not (Carrillo Hermosilla et al. 2010). Eco-innovations can serve as relevant tool for wiring up the innovation system. They may contribute to the renovation of the whole innovation system, taking into account social, ecological and economic aspects. Thus, sustainability becomes a key driver of innovation (Carrillo Hermosilla et al. 2010). In recent years, sustainable innovation has been gaining increased attention from academia, industry and the government actors, but there is no precise or established definition of sustainable innovation, which reflects the more general difficulty in defining the concepts of sustainability and sustainable development (Charter and Clark 2007). Varadarajan (2015) pointed out that sustainable innovation is a company's implementation of a new product, process, practice or modification of an existing product, process or practice that significantly reduces the impact of the company's activities on the natural environment. Furthermore, Charter and Clark (2007) argue that just as with general innovation, there is an emerging sense of recognition that sustainable innovation involves not only new concepts but also the commercialization of technologies, products, services and entrepreneurship. It can also involve the adoption of new processes and systems at the societal level.

2.4.3 CASI-F Definition of Sustainable Innovation

One of the objectives of the CASI project was to develop a working definition of sustainable innovation. For this purpose, a comprehensive analysis of different SI principal actors was prepared using the quadruple helix approach. Principal actors involved in the process were environmental scholars, the European Commission (EC) environmentalists, sustainable innovators, citizens and Pan-European SI stakeholders. From the perspective of environmental scholars, the current definition of SI relates to innovations, which involve environmental improvements. These environmental improvements were addressed in a number of consecutive EU funded Framework programmes for R&D through different key actions, thematic priorities and societal challenges. In order to access SI innovation from innovators perspectives, over 500 SI initiatives were nominated and systematically mapped as part of the CASI project activities. EU citizens provided another source of SI perspectives as citizen panels organized in 12 EU countries identified 27 research priorities. Another rich source of SI perspectives in the CASI project was pan-European stakeholder consultations, conducted through stakeholders' workshops, policy dialogues, and via an online survey.

The analyzed results were used to construct the following definition of sustainable innovation: *"Sustainable innovation may be conceived as 'any incremental or radical change in the social, service, product, governance, organisational, system and marketing landscape that leads to positive environmental, economic and social transformations without compromising the needs, welfare and wellbeing of current and future generations"* (Popper et al. 2016a, b). This definition refers to seven types of innovations, which derived from a comprehensive desk research, and which served a framing purpose for the mapping and studying of SI initiatives in the CASI project (see Popper et al. 2017).

2.5 Environmental and Sustainable Challenges

Europe 2020, a strategy for smart, sustainable and inclusive growth sets policy priorities, which reflect global social challenges. Horizon 2020 (H2020), the EU's main financial research and innovation programme in the period 2014–2020 used this challenge-based approach by organizing its activities into the following seven Grand Societal Challenges (European Commission 2019):

- Health, demographic change and well-being
- Food security, sustainable agriculture and forestry, marine and maritime and inland water research, and the Bioeconomy
- Secure, clean and efficient energy
- Smart, green and integrated transport
- Climate action, environment, resource efficiency and raw materials
- Europe in a changing world—inclusive, innovative and reflective societies
- Secure societies—protecting the freedom and security of Europe and its citizens

The CASI project focused on Grand Societal Challenge 5 (SC5), i.e. Climate action, environment, resource efficiency and raw materials, the objective of which is "*to achieve a resource—and water—efficient and climate change resilient economy and society, the protection and sustainable management of natural resources and ecosystems, and a sustainable supply and use of raw materials, in order to meet the needs of a growing global population within the sustainable limits of the planet's natural resources and eco-systems*". SC5 is explicitly addressed in H2020 work programmes for the years 2014–2015, 2016–2017 and 2018–2020 and promotes a systemic and holistic approach in relation to technology, business models and economic organization, finance, governance and regulation as well as skills and social innovation (European Commission 2015, 2017, 2018; see also Table 3.3 in Chap. 3).

On a global scale, in September 2015, the United Nations (UN) adopted the 2030 Agenda for Sustainable Development, including the following 17 Sustainable Development Goals (SDGs):

- Goal 1. End poverty in all its forms everywhere.
- Goal 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture.
- Goal 3. Ensure healthy lives and promote well-being for all at all ages.
- Goal 4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.
- Goal 5. Achieve gender equality and empower all women and girls.
- Goal 6. Ensure availability and sustainable management of water and sanitation for all.
- Goal 7 Ensure access to affordable, reliable, sustainable and modern energy for all.
- Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.
- Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.
- Goal 10. Reduce inequality within and among countries.
- Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable.
- Goal 12. Ensure sustainable consumption and production patterns.
- Goal 13. Take urgent action to combat climate change and its impacts.
- Goal 14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development.
- Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.
- Goal 16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.
- Goal 17. Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development.

These goals are strongly interconnected, thus achieving them, with the inclusion of multiple stakeholders, would provide a rather holistic solution to global challenges. For this reason, a multi-stakeholder forum was assembled in order to identify and examine technological needs and gaps, including scientific cooperation, innovation and capacity-building (UN 2015).

2.6 Conclusions

A panoramic review of the innovation concepts highlighted the growing interdependence between the main players of the innovation system; multidisciplinarity, where science becomes collective and the focus shifts from the emergence of new knowledge to the use of such knowledge; and that wider participation of all relevant stakeholders becomes increasingly important.

Tracing the development of the innovation process demonstrates the growing importance of sustainable innovation. Such importance was recognized by policymakers and became an important part of political agendas and research programmes internationally, as it became evident that global challenges could be successfully addressed only through coordinated action of multiple stakeholders.

The multi-dimensional nature of sustainability was identified and addressed in the CASI project. The CASI-F Framework (a.k.a. CASI-F, see Popper et al. 2017) entails a multilevel and multi-actor approach to assessment and management of sustainable innovation, thus contributing to increased understanding of SI practices, outcomes and players, and how these could contribute to setting, and addressing, important national and global priorities.

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