Challenges and opportunities at the crossroads of *Environmental Sustainability and Economy* research

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Abstract: Cities occupy only nearly 3% of the world's land surface. However, they account for over 75% of global natural resource consumption and contribute to about 70% of greenhouse gas emissions (UNEP International Resource Panel). Thus, human activities in cities are drivers of multiple environmental challenges, which are likely to increase with an expected rise to 70-80% of the global urban population by 2050, and their effects extend over all the ecosystems of the world. Cities are human ecosystems where social, economic, biological and ecological components work together forming a system of feedback loops and interactions. These interactions in urban ecosystems are guided through human values, agency, and perceptions. An ecological understanding of cities can help conceptualize them as key socioeconomic and environmental "nodes" where great potential exists for sustainability-oriented innovations in resource management and the mitigation of pollutant emissions, climate change, and other negative externalities of resource consumption. For several decades now, the need for sustainable development has emerged across different systems working in human societies on a global level. However, the challenge remains to integrate the environmental, social and economic dimensions of sustainability. The focus of this Chapter is to read environmental sustainability through a socioeconomic lens. Towards this, the role of transition to innovative socioeconomic models and "metabolic" approaches has been explored here, learning from main insights from the chapters in this book.

Keywords: Urban metabolism; green economy; value chains; market; emissions; climate change

1. Introduction

In his masterpiece, *Faust*, the poet and writer Johann Wolfgang von Goethe examines the pathology of human society running in a ceaseless quest after fastest means of transport, the quickest and most powerful weapon and the largest and easily earned wealth, all of which are utilized to fulfil a succession of human desires but lead ultimately to the society's downfall.

Most global societies today are also suffering from the same pathology running after growth and development in a ceaseless quest, at the cost of most marginalized communities, unabated ecological destruction, and worldwide food crisis.

While urban populations are expected to reach 5.6 to 7.1 billion by 2050, the majority of urban population growth is expected to take place in small to medium-sized urban areas with lower levels of economic development (Karen C. Seto, 2014). Economic development has the potential to drive urban growth, innovation, socio-economic balance, healthcare and employment, as well as, air pollution, greenhouse gas emissions, waste production and socio-economic disparity, accessibility and availability of cleaner sources of energy (Fig. 1). This is not an exhaustive list, but it indicates the potential for economic development to be used in response to local priorities and needs. Prioritizing the application of sustainable measures lies at the core of the green economy concept.

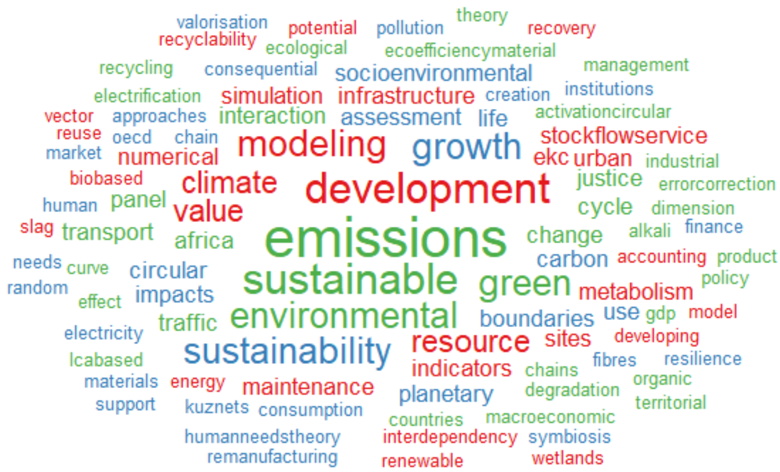

Figure 1. Word cloud image of author keywords from chapters in the book

1.1 Environmental sustainability and economy

According to the United Nations Environment Programme (UNEP 2011), green economy is defined as, "one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. In its simplest expression, a green economy is low-carbon, resource-efficient, and socially inclusive. In a green economy, growth in income and employment are driven by public and private investments that reduce carbon emissions and pollution, enhance energy and resource efficiency, and prevent the loss of biodiversity and ecosystem services".

Traditional economic practices are generally resource-intensive and do not give much regard to the environmental fallout in the form of degradation of ecosystems, disruption of biogeochemical cycles, waste production, and social equality, among many others. As opposed to the traditional practices in the economy, the green economy aims to extend the life cycle of natural resources basis by considering their sustainability over long periods of time in a holistic manner. The system working of natural fluxes of mass and energy are used to create economic benefits which should cause the least harm to environmental and economic systems and, potentially, increase their resilience. Knowledge of systems, their interactions and feedback loops, the impact of sustainable policies and socio-economic equality are essential in creating green economic models. However, often the socio-economic equality takes a back seat while designing green economy functions.

In a study by Glazyrina et al. (2015), it was reported that in forest use policy, the use of budgetary and socio-economic indicators was more effective in creating green practices than the traditional indicators of "felling, export and processing volumes". Political, socio-economic and cultural constraints should be considered (Brand 2012). A diversification in economic activities and priority on socio-economic indicators would help create green economic policies

(Zabortseva et al. 2017). The green economy requires a shift in assumptions about traditional economic principles and a restructuring of priorities, where accountability is included from the conception (Najam & Halle, 2010). At present, most of the countries worldwide follow the economic models set by the predominant economic powers. However, such development has happened at the cost of significant and, in some cases, irreparable environmental damage. As exposed by Rokstrom et al. (2009), the scale of human activities has influenced the global cycles to the point that the chances of a global scale environmental disruption are increasing. The planetary boundary concept is crucial for creating sustainable "growth within limits" (Crépin & Folke, 2015). They signify the biophysical limits of growth beyond which the global balance might tip permanently towards chaos, causing shifts in global biophysical processes. For example, four of the nine planetary boundaries had already been crossed in 2015, as reported by Stephen et al. (2015). These were climate change, loss of biosphere integrity, land system change, altered biogeochemical cycles (phosphorus and nitrogen). Out of these, climate change and biophysical integrity are considered core boundaries which have effects on multiple scales. It is essential to mention here that the same research drew on these results to conclude that such a change would have not only an impact on the environment but also on the economic status and human well-being (Stephen et al. 2015). Planetary boundaries may be considered as warning signs indicating a need to shift the current economic policies from GDP growth towards human well-being (Crépin & Folke 2015). A more recent analysis of tipping cascades suggested that a potential planetary threshold could occur at a ~2 °C temperature rise above preindustrial level (Steffen et al. 2018). A "Stabilised Earth Pathway" to maintain the Earth System within such limits would require fundamental change in humanity's relationship with Earth based on reorientation of human values, equity, behaviour, institutions, economies, and technologies. This evidence points to the need for an integrated approach of environmental sustainability and socioeconomic development.

Environmental sustainability is seldom practised in the supply chain of products and services, and the process towards integrating sustainability into the economic process is not always clear-cut, especially for developing countries (Suhi et al. 2019). Further, people directly involved in product chains are unsure about how to measure sustainability; there is a lack of indicators (Verma & Raghubanshi 2018; Suhi et al. 2019). This also affects the efficiency of economic processes. Certain indicators focus on the economic state only while others might deal with environmental impact. The concept of the circular economy is also essential in this regard as it has the potential to open pathways into reduced waste generation and increased efficiency of production processes. The recycling rate is one such indicator used to measure the circular economy; however, it fails to capture the environmental dimensions clearly (Haupt and Hellweg 2019). This Chapter essentially focusses on the current state of research into environmental sustainability and economic practices. It gives an overview of the subjects addressed within this book across four themes (*Environment and economy, Indicators and sustainability, Circular Economy and Urban Metabolism,* and *Market and Sustainability*), giving a background for each as well as proposing future directions for research in these fields.

2. Environment and Economy

2.1 State of the art

Economic activities drive urbanization and its associated impacts in the form of greenhouse gas emissions, land-use and land cover change and urban heat island effect, urban design and architecture, social structure and human health, resource management and sustainability, climate change or loss of ecosystem services and biodiversity (Verma et al. 2020). Economic, geographical drivers refer to the scale at which economic activities take place and their boundary in the global hierarchical structure of human settlements. The resulting trade and commerce, and the flows of material, energy and services that ensue, generate income which is generally measured as per capita GDP or Gross Regional Product (GRP) (i.e., the GDP normalized at the scale of human settlements), calculated either as an urban total, or normalized on a per capita basis (Seto et al., 2014). Urban areas have been called economic centres of energy consumption (Xia et al., 2015). Sustainability is inherently intertwined with urban growth since human activities converge in urban areas of high resource consumption. Sustainability is essential to be analyzed since the growth and development associated with human activities is set on a different course than the natural functioning of ecosystems. However, with the right policy measures, urban areas might embrace resilient and resource-efficient pathways for development, including a green economy model based on an understanding of different components of the environment (Verma et al. 2020). In the next section, we have discussed in brief the various components of this book aimed at describing the relationship between environmental sustainability and the economy.

2.2 Highlights from chapters relevant to the Environment and Economy theme

The transportation sector is closely associated with economic growth as it serves one of the essential functions of transporting resources and provides employment to a large number of people. However, the transport sector is also responsible for a significant impact on the environment. It was reported by the International Energy Agency (IEA) that in Organization for Economic Co-operation and Development (OECD) countries, transport is responsible for more than half of their energy consumption (Chapter 1). Air and rail transport contributes to higher GHG emissions; however, this impact is not uniform for developed and developing countries. This impact of the transport sector is a major concern for sustainability as it is an essential part of economic development as well as responsible for environmental impacts (Chapter 2). A major shift in transport technology and resource movement policies is needed to offset its environmental costs. The policy interventions to achieve energy sustainability along with economic growth requires the involvement of economic institutions. More consumption of resources leads to higher energy-related emissions necessitating decoupling of economic growth from energy consumption. The role of economic institutions in this respect needs more attention (Chapter 3).

Chapter 4 discussed the role of pollution, energy consumption and economic growth. Emissions from urban activities, transport sector and industries, energy generation and waste management constitute a number of pollutants and GHGs like NOx and SOx, methane and other. According to the Environmental Kuznets curve theory, during the initial stages of economic growth, the environmental pollution rises rapidly, reaches a stable state for some time and then decreases when more and more people start getting richer, forming an inverted U-shaped curve (Dasgupta et al. 2002). However, there are several concerns regarding this type of growth. First, the per capita pollutants may fall, but the total amount of pollution increases. Some developed countries have shown an N-shaped curve where, after reaching the U-shape, economic growth leads to much higher emissions. The role of particular pollutants was investigated in chapter 5. It remains an emerging challenge to assess the effect of economic growth on different types of pollutants. Chapter 19 dealt with the various aspects of using EKZ hypothesis in environmental research.

The impact of economic growth and human activities is now apparent at the global scale in the form of climate change. The Paris agreement towards reducing carbon emissions by 2030 to keep global average temperature rise below 2-degree Celsius introduced the concept of Nationally Determined Commitments (Rogelj et al. 2016). This has given governments the opportunity to take action to mitigate the effects of climate change. As discussed in Chapter 6, the role of governmental institutions towards formulating new strategies for mitigating the impact on the environment and, at the same time, sustaining economic growth, is crucial in this regard. However, it has been observed that it is becoming increasingly challenging to achieve sustainable development goals in many parts of the world. This problem was analyzed in

Chapter 7 for the Sub-Saharan Africa region. The major problem involves creating sustainable energy policies which can ensure environmental sustainability as well as economic growth in under-developed and developing countries.

Evidence-based policy decision is important to develop effective plans of action towards the uptake of environmental and socioeconomic sustainability principles. Integration of scientific knowledge into policy decision is a major challenge since both are traditionally considered separately (Moldan and Dahl 2007; Verma and Raghubanshi 2018). Integration of knowledge and knowledge co-production requires removal of the ambiguity of assumptions which may not be applicable uniformly across scientists, policy makers, and other stakeholder groups (Perrotti 2019). This requires a situation-specific production of knowledge (Brugnach & Ingram 2012). Apart from policy initiatives, another critical aspect of economic development is the resilience of the environment in the changing economic circumstances and use different ecosystems are put to. This has been dealt with in Chapter 12 in the context of wetlands and agricultural practices followed there. Wetlands contribute towards agricultural practices and livestock maintenance in many parts of the world (Rebelo et al. 2010). However, with changing economic circumstances, ecological components, like wetlands, are being increasingly put under pressure, also threatening their ecosystem services and biodiversity. In order to protect such ecological areas of strategic importance, their economic value in terms of their continued existence can be evaluated using both monetary and non-monetary metrics. In Chapter 12, the use of wetland vegetation in building materials is proposed as a means to enhance their value and promote a resilient and dynamic model of site maintenance.

Thus, there is a need to measure such complex ecosystem functions and explore related economic opportunities. Indicators and modelling approaches are needed to make sound scientific decisions from the perspective of an urban metabolism approach (Verma and Raghubanshi 2018; Perrotti 2020). In the next section, a brief account of discussions related to modelling and economic sustainability indicators is given, corresponding to the second theme of the book.

3. Indicators and Sustainability

3.1 State of the art

To measure the shift towards a circular and sustainable economy, the environmental, economic and social dimensions of such a transition need to be measured. Economic institutions are faced with the challenge of achieving sustainable development goals related to the environment, economic production or social equity. Clarity is needed to develop and select appropriate indicators in this regard which can be multidimensional and not solely focused on one aspect of sustainability. This struggle is often visible in manufacturing industries (Suhi et al. 2019). In the words of Peter Ducker quoted in Haupt & Hellweg (2019), "What gets measured get managed". Sustainable and circular economy brings forth the importance of this statement, making it important to have measurable targets and an indicator framework to support such development. However, widely used indicators do not always fully express environmental and economic sustainability in all its facets. This is, for example, reflected in the many critiques of the use of GDP to measure social progress (Haberl et al., 2019) and the growing discourse on the need to craft alterative indicators to assess the contribution of economic growth and material and energy consumption to improve human well-being (Millward-Hopkins et al. 2020). Moreover, apart from measuring, the impact of any approach devised to measure sustainability has to be regularly cross-checked for its suitability over time and in changing socioeconomic circumstances. The primary challenges towards developing such indicator frameworks to measure sustainability lie in lack of empirical studies and data especially in developing countries (Verma & Raghubanshi 2018). In a study of certain industries in Bangladesh, a best-worst method was proposed to assess the environmental measures for sustainability. Expert opinion was included in the evaluation of this indicator framework which helped in selecting the best indicators for environmental sustainability (Suhi et al. 2019). It was found that waste management was the most important indicator of environmental sustainability in industries. Another indicator system proposed for environmental sustainability made use of the fact that reuse, recycling, repair and remanufacturing hold certain environmental values which can be exploited (Haupt and Hellweg 2019). This indicator framework accounted for the end-of-life and life-cycle of the materials. The integration of socioeconomic aspects with ecological research is essential to creating such indicator frameworks. However, interdisciplinary approaches have several challenges especially when it is hard to identify clear research boundaries among disciplines and the "labelling" of research approaches is difficult or even artificial (Haberl et al. 2019). In some cases, the lack of organic linkages between different approaches in various disciplines can limit scholars' understanding of the nuances of interdisciplinary frameworks. A detailed description of indicator frameworks, the challenges and opportunities towards their development, is described in Verma & Raghubanshi (2018), Corredor-Ochoa et al. (2020) and Batalhão & Teixeira (2020). The next section describes the emerging aspects of measuring economic sustainability as discussed in chapters within this theme.

3.2 Highlights from chapters relevant to the Indicators and Sustainability theme

Production and consumption of goods create waste at different stages. Material recovery is an integral part of creating circular economies (Genovese et al. 2017). Recycling is a direct method of material recovery; however, a rational perspective reveals that it involves recovery at different stages of the product life-cycle. The potential for material recovery depends on multiple factors which have been described in Chapter 8. Thus, the economic reasons act as a push and pull factor for practical application of such an approach which involves maturity of recycling technologies, geographical proximity, scalability and existing marketplaces to minimize the cost and maximize the sustainability of the products. As discussed in Chapter 9, economic indicators can provide "early warning signs for future economic, environmental and social problems".

Further, sustainable economic development needs to move beyond measuring the economic and environmental impacts of economic growth towards a holistic form where the multidimensional aspects of sustainability, namely resilience, social progress, connections between the economic processes, environmental and social well-being, are considered. Thus, a rethinking is required in sustainability indicators of economic development. Such rethinking needs to account for disruptions in economic activities which have an impact on the environment. These can be as simple as disruption in the production line or as complex as road maintenance leading to traffic jams, increased travel times and more carbon emissions. These disruptions serve as sources of increased inefficiency and are challenging to include in modelling approaches. The subject of Chapter 10 deals with analyzing such modelling approaches where the authors have taken the example of road maintenance sites. Road maintenance leads to disruption in traffic flows.

The next section illustrates examples of alternative, holistic approaches to economic and environmental sustainability which draw from research into circular economy and urban metabolism, corresponding to the third theme of the book.

4. Circular Economy and Urban Metabolism

4.1 State of the art

Circular economy and urban metabolism are two interdisciplinary research fields that study the functioning of ecological, social and economic systems as influencing and influenced by a complex series of biophysical and socio-economic processes, including resource management and decision making. Circular economy research applied to the valorization of local waste flows is paramount to improve the performance of urban systems in the light of population growth and a variety of other socio-economic drivers influencing resource demand and waste generation. Recent progress in green economy and industrial ecology have substantially contributed to broadening the methodological spectrum of circular economy research; the number of works on the subject has grown exponentially over the past two decades, showing that the field is undergoing significant development in both science and policy (Schöggl et al. 2020). The growing scientific interest for circular economy frameworks and strategies has also resulted in higher scrutiny of the use of concepts and the narratives deployed as well as their differences and overlaps with other models in sustainability science and action (Reike et al., 2018; Korhonen et al., 2018). Other critical research questions in the field concentrate on the global impact and contribution of circular economy initiatives towards the UN Sustainable Development Goals (SDG), most notably the Responsible Production and Consumption Goal (SDG 12), and at least four others SDGs on water access, management and sanitation (SDG 6), affordability of renewable energy sources and energy efficiency (SDG 7), sustainable economic growth (SDG 8), and climate change adaptation and the mitigation of greenhouse gas emissions (SDG 13) (Geng et al., 2019; Schroeder et al., 2018).

The urban metabolism field investigates resource demand and emissions in cities through the quantification of energy, materials, water, and nutrient flows. Cities are studied as socio-ecological systems whose metabolism is the result of the interactions with other - close or remote - anthropogenic systems and the natural environment. The “metabolic” approach to urban sustainability rests on a wide spectrum of analytical tools and methods to assess the resource intensity of urban systems (and the associated waste and pollutant emissions) which bear great potential to inform resource management policy and action at the regional and local scale (Perrotti and Iuorio, 2019). The application of the concept of 'metabolism' to societies and cities has a strong interdisciplinary tradition (Haberl et al., 2019). At least three critical moments in the history of the concept as used across social, natural and engineering sciences are identified in the literature (Newell and Cousins, 2015). Borrowing from Moleschott's (1852) physiological materialism and chemist Justus von Liebig's (1842, 1859) idea of 'metabolic rift', Marx and Engels used the concept of 'metabolism' to describe the 'material exchange' relation between man and nature and the role of the human labour in it. The metaphor of metabolism was implicitly present almost from the outset of urban sociology in the 1920s, with the human ecology of the Chicago School studying the city as an ecosystem in analogy to natural systems (Burgess, 1925). However, it was the rise of environmental awareness and the increase in cultural acceptability of a critical view of economic growth in the late 1960s that brought forward a renewed interest in the idea of metabolism as applied to cities (Wolman, 1965). Finally, the late 1990s saw a rejuvenation of urban metabolic studies, with the becoming mainstream of the 'limits to growths' narrative in engineering, social and environmental sciences; this led to the recognition of urban metabolism as a well-established interdisciplinary theme in sustainability science resting on a rich collection of diversified analytical strategies and modelling tools (Kennedy et al. 2011). The field has known significant momentum over the last years through interdisciplinary contributions spanning from a broad range of disciplines in ecological science (Perrotti 2020) and a growing number of applications of "urban metabolism thinking" in spatial planning and design (Perrotti, 2019; Galan and Perrotti, 2019; Perrotti and Stremke, 2020).

Social ecology and urban ecology have produced among the most influential lines of research in metabolic studies. They can be described as 'archipelagos' of disciplinary islands and are influenced by a wide range of disciplines in the humanities and social sciences (human geography, political ecology, environmental history, ecological economics), the natural sciences (land-use science, ecosystem and landscape ecology), and engineering (industrial ecology and civil and environmental engineering) (Fischer-Kowalski and Weisz, 2016; Cadenasso and Pickett, 2013). Both fields have been most influential in bridging multi-disciplinary conceptual approaches to society–nature coevolution pertaining to history, current development and future sustainability transitions. They have catalyzed efforts to bridge the 'great divide' between engineering and the natural sciences, on the one hand, and the social sciences and the humanities, on the other hand, inevitable engendered by the conceptualization of society and nature as two separate entities in relation. Main directions for future research to advance urban metabolism discussed in the recent literature include: promoting continual dialogue between "metabolic" research communities to overcome conceptual and methodological silos and identify opportunities for epistemological and methodological coordination and synthesis; fostering a deeper understanding of the interdependence between biophysical and socio-economic aspects of urban material and energy balances; and strengthening the link between metabolic analysis and implementation of real-world solutions to stakeholders' concerns, including advanced design strategies (Perrotti, 2020).

4.2 Highlights from chapters relevant to the Circular Economy and Urban Metabolism theme

The processes by which "value systems" are generated and studied, as opposed to the more traditional conceptualization of "value chains", is one of the most critical frontiers in circular economy research (Babbitt et al., 2018). Only a few empirical studies to date focus on the generation of 'circular' value systems and, in most cases, they lack a comprehensive conceptual foundation. Chapter 11 has embraced the challenge of developing a novel framework through which social-ecological systems can be empirically studied based on their capacity to generate "circular" value. The proposed analytical framework provides a three-dimensional categorization system including agency (actors and their interactions), biophysical components (material and energy flows as well as spaces and artefacts) and framing elements (domains, scale and rules). Using a comparative lens, the framework is applied to three case studies relative to the sustainable management of three different types of urban material flows (excavated earth, urban wood, and coffee grounds) which are understood as multi-layered value systems. Through the discussion of the framework application, the Chapter has provided novel insights on value creation in circular economy initiatives, while bridging theoretical approaches and empirical shreds of evidence in metabolic research.

Chapter 12 has opened up novel pathways into the analysis and assessment of the processes underpinning the local cycling of natural resources and the generation of construction-material value chains. It presented a two-fold approach to study opportunities for the recovery of four different kinds of plant fibres from a protected wetland area in Normandy, France, and their use as an insulation material for construction purposes (earth-based composites). First, a range of strategies for generating novel value chains are assessed through the identification of territorial resources, agents and dynamics using "resilience thinking" as an overarching framework and an alternative to conventional approaches to natural resource management (Folke et al., 2010). Consideration of the ecological values of the studied wetland landscape (maintenance of the protected landscape and preservation of the ecosystem services this provides) are combined with the appraisal of socio-economic factors that can increase the viability of the use of the fibres for the local farms. Second, a characterization of the mechanical, physical and hygrothermal properties of the local wetland plants is conducted through experimental lab testing. The integrated approach allows for studying the circulations and reuse of locally-sourced bio-based materials based on their potential to leverage the resilience of the regional system from an environmental, socio-economic, and cultural perspective.

Finally, chapter 13 has addressed the limitations that traditional circular economy tools might bear when it comes to supporting decision making across environmental and economic policy areas. It made the case that, when aiming at replacing a traditional construction material with a more "sustainable" one, recycled options do not automatically lead to better overall sustainability; indeed, indirect effects on the market must also be considered when introducing a new product in a well-established industry sector. Traditional analysis tools to assess direct environmental impacts throughout a product's life, such as Life Cycle Assessment (or "attributional-LCA" ALCA), do not allow to take into consideration the consequences of a change in supply and demand chains (Vázquez-Rowe et al., 2013). The study has illustrated the limits of ALCA by concentrating on the environmental consequences and rebound effects occurring when substituting ordinary Portland Cement (responsible for 10% of global carbon emissions) with stainless steel-slag blocks (an alkaline residue from industrial processes). Consequential Life Cycle Assessment (CLCA) is employed as an alternative tool to ALCA and the Flemish construction industry, in Belgium, as an example. Two different markets affected by the stainless steel-slag blocks production (non-structural construction blocks and low-quality aggregates) are considered in parallel together with impacts on marginal suppliers. Moreover, the study has shown that, if environmental impacts are reduced through minimizing the use of concrete blocks, the new recycled product requires additional natural aggregates for low-value applications, adding to the complexity of policy support exercises toward "sustainable" decision-making. The next section discusses the several levels of intertwinement that exist between the role of the market and supply/demand chains and the sustainability of technologies, products and policies (corresponding to the fourth theme of the book).

5. Market and Sustainability

The mitigation efforts for the impact of climate have grown to encompass climate finance as its integral part. The inclusion of climate finance in the United Nations Framework Convention on Climate Change (UNFCCC 1992) stated the importance of Climate Finance arising out of a need for transnational and multi-institutional cooperation. Climate Finance refers to, "local, national or transnational financing—drawn from public, private and alternative sources of financing" (UNFCCC website) to mitigate the impact of Climate Change and develop adaptation strategies. Rapid development has given rise to megacities, and urban expansion has also resulted in the intensification of economic activities, consumption and waste production (Verma & Raghubanshi 2018). This has resulted in a number of challenges for the environment. From the perspective of sustainability, a clear institutional framework is needed, which can collate the biophysical components and the various processes of the earth. Urban areas contribute to about 70% of greenhouse gas emissions while covering only about 2.7% of the global land surface (UN-HABITAT 2011). The role of Climate Finance has garnered greater support due to the rapid urban growth, pollution and environmental destruction. The role of institutions in supporting sustainable development can bridge the gap between consumption and sustainability by creating new markets for sustainable technology, products and policies. One of the four themes addressed in this book consists in exploring the role of market mechanisms and finance for sustainable development.

5.1 State of the art

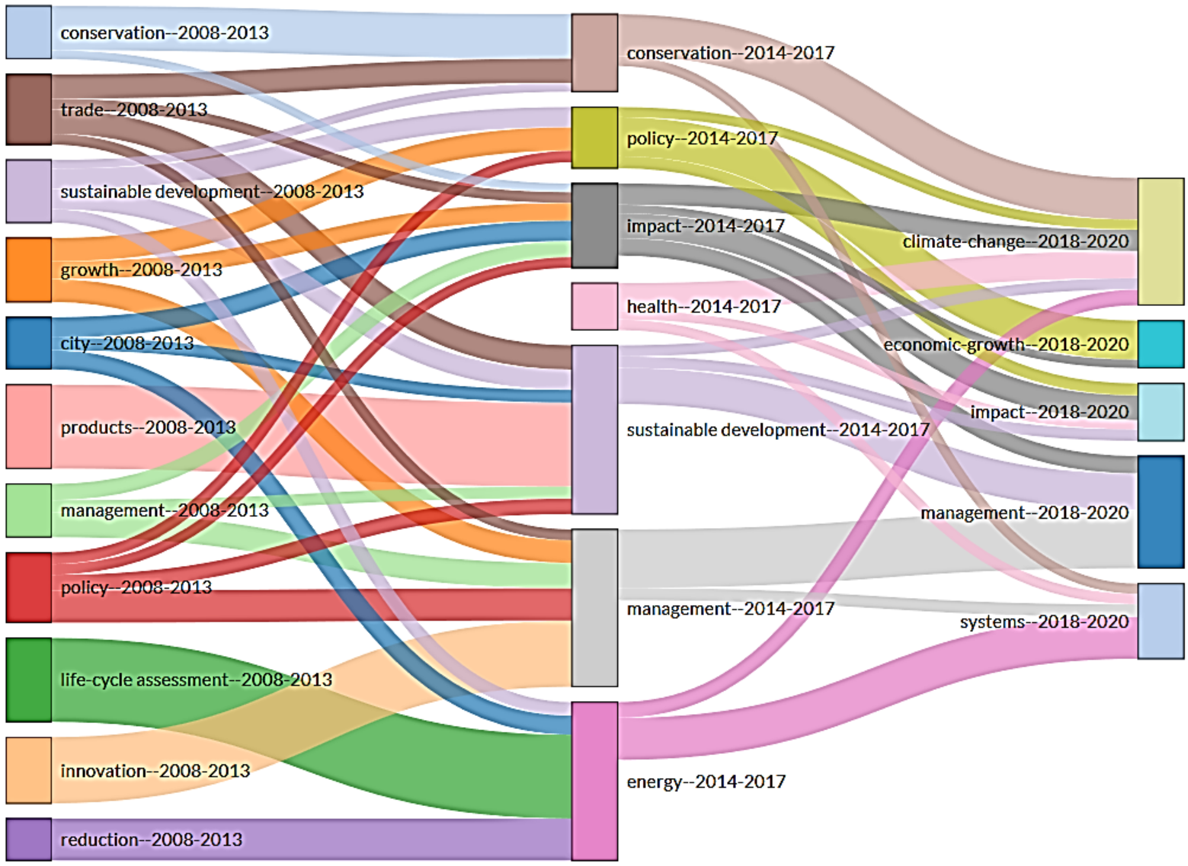

Figure 2. Thematic evolution of economic and environmental sustainability themes for the 2008 to 2020 time period

The market and sustainability concept has evolved from a number of components into certain broader thematic areas. From the year 2008 to 2013, various thematic areas like “conservation”, “trade”, “sustainable development”, “growth”, “city”, “products”, “management policy”, “life-cycle assessment”, “innovation” and “reduction” strategies diversified and recombined into much more focussed research fields in 2014 to 2017 (Fig. 2). The thematic evolution showed diversification of thematic areas of “policy”, “management”, “conservation”, “city”, “trade”, “sustainable development” and “growth”, whereas, “innovation” merged into “management”, and “life-cycle assessment”, and, “reduction” merged into “energy” during the 2008-2013 period. Some of the “conservation”-based studies also focussed towards “impacts” in 2014-

2017, whereas, the “conservation” theme focussed on adopting a systems approach in 2018-2020. “Trade” diversified into “conservation”, “sustainable development” and “impacts” in 2014-2017. The “sustainable development” and “policy” themes showed the largest diversification during the 2008-2017 period. In 2014-2017, the “conservation”, “policy” and “energy” themes were studied from the perspective of “sustainable development”. In 2018-2020, “sustainable development” was explored from the perspective of “climate change’, “impacts”, and “management”. This indicated evolution of the “sustainable development” theme was the focus of “management”, “impacts” and “climate change” studies. “Life-cycle assessment” and “reduction” themes were mainly focussed on “energy” in the 2014-2017 period, which further evolved into “systems” approach and studies on “climate change” 2018-2020. Studies encompassing the “policy” theme diversified into “impacts”, “sustainable development” and “management” in 2014-2017, apart from the “policy” theme. In the 2018-2020 period, studies on “policy” aspects of markets and sustainability was mainly approached from the perspective of “climate change”, “impacts” and “economic growth”. This was also very significant as it showed the evolution of “policy” studies into one of the most pressing problems in the world today, that is “climate change”. Another significant aspect of the thematic evolution was the emergence of the “health” theme in 2014-2017 period in the market and sustainability field. This showed the direction of economic growth and sustainability towards health. This theme further diversified into “climate change”, “impacts” and “systems”.

Further analysis of its components showed that the field was concerned with human health, the impact of pollution due to economic activities in different manufacturing industries, healthy environment and the impact of climate change on such activities. The emergence of “system” in the 2018-2020 period also indicated the maturing of this field and inclusion of different components into studies encompassing the economic and environmental sustainability. The thematic evolution showed that the number of themes has reduced and become more focussed, there are indications of the development of systems approach in analyzing the economic and environmental sustainability; various aspects of sustainable development are being integrated into economic mechanisms, and vice-versa, which would help in creating co-production of knowledge and integrated frameworks.

Co-production and integrative frameworks are deemed essential to generate knowledge which can be used to create sustainability practices (Verma and Raghubanshi 2020). Some of the most recent studies focussed on different aspects of environmental and economic sustainability are aimed toward created integrated mechanisms for real estate market analysis (Kauskale and Geipele 2017), studying the impact of rural development and sustainability practices (Cole and Ingalls 2020), various aspects of different industries like energy and natural gas (Yang 2018), power generation (Dong et al. 2019), multinational industries, corporate sustainability and emerging markets (Park 2018), emerging green markets, green entrepreneurship (Lofti et al. 2018), tourist market and sustainable travel (Kastenholz et al. 2018), and sustainable food markets like seafood and their impact on the social-ecological systems (Travaille et al. 2019).

5.2 Highlights from chapters relevant to the Market and Sustainability theme

Mitchell (2010) showed by empirical modelling that the Sustainable Market Orientation could help create corporate benefits when it focusses on the economic, social and ecological sustainability. The role of sustainable market supple chains is also very important. A shift in environmental economics and sustainability has been observed by Vermeulen and Seuring (2009) over four ways. They have stated that due to development of newer models of environmental politics, environmental policies are increasingly being embedded into sustainable development with producer’s responsibility towards the community as well as the distribution of economic benefits arising out of the resource utilization. They have also observed that the producers are increasingly being held responsible for the impact of economic activities on the society, and this responsibility is shared along the supply chain with the driving force in the form of government agencies and the direct consumers.

The role of governance, social awareness and lack of implementation of environment protection measures are a significant drawback in order to reduce the role financial institutions, and the Non-Governmental organizations have become very important. The role of financial mechanisms from the aspect of mitigating climate change impacts has been the focus of Chapter [ ]. Economic growth, along with sustainability practices, has been the focus of green growth practices. There is a need to create a shift in the conventional economic policies, especially in developing and developed countries, towards inclusive green growth. Thus was the focus of Chapter [ ]. The authors have examined the conventionally used macroeconomic instruments in green economy accounting and discussed the green economic policies practised in several countries from the European Union, Asia and the United States of America.

6. Conclusion and common challenges across the four themes

The book has explored multiple aspects of "Environmental Sustainability and Economy" from four complementary perspectives: *Environment and economy, Indicators and sustainability, Circular Economy and Urban Metabolism,* and *Market and Sustainability*. Several common challenges lie across economic, environmental and social dimensions to sustainability. For example, the markets can help in creating sustainability practices and understanding the impact of such policies on management and governance. However, there is a need for a broader view of economic strategies due to the adverse impact of economic activities on the ecological and socio-economic systems, such as the forest destruction in Amazon river basin, disappearance of Fisheries, the Union Carbide chemical plant disaster in Bhopal, India and many others (Mitchell 2010).

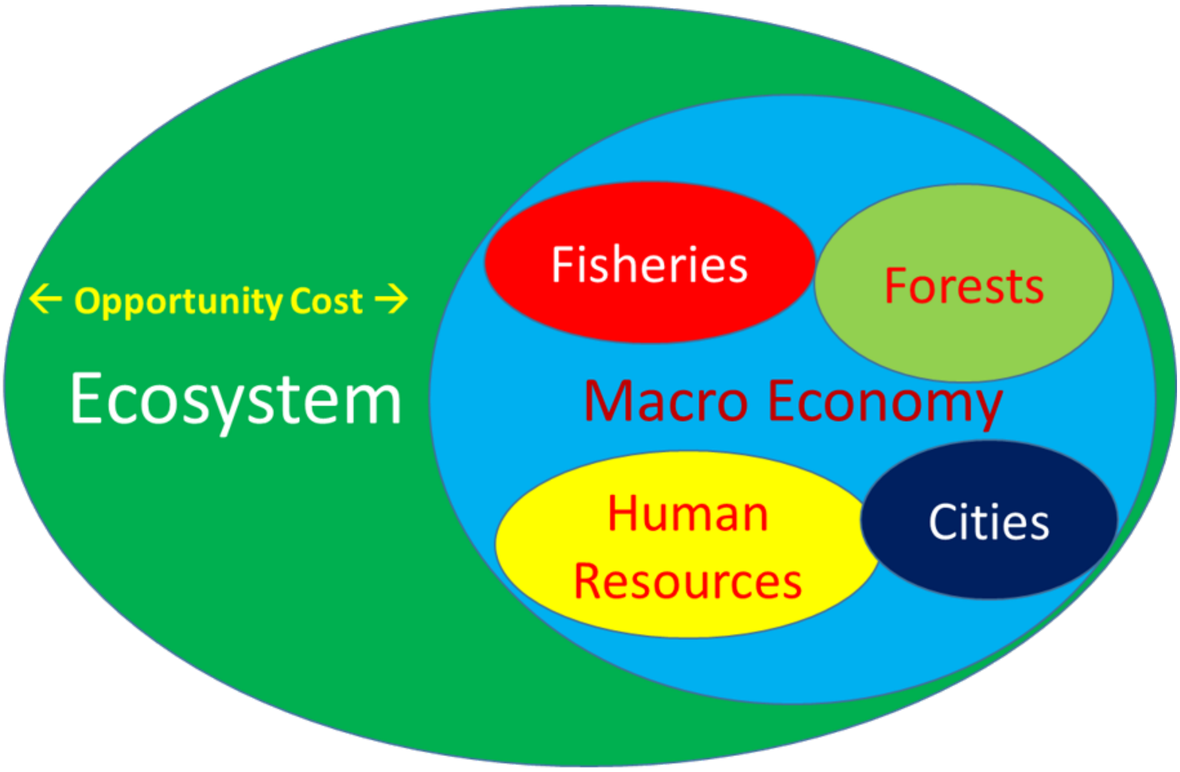

Figure 3. Challenges of Economic sustainability – integration of micro- and macro-economy within an ecosystem metabolism

Another challenge lies in the "opportunity cost" which arises due to lack of understanding and integration of the ecosystem and economic systems (Fig. 3). A considerable opportunity cost is incurred due to excessive exploitation of resources to fulfil short-term economic or social benefits. This lack of understanding arises due to differing perceptions of the ecosystems and the micro- and macroeconomies. When the macroeconomy is considered as the all-encompassing system, containing the microeconomies and the environmental and ecological components (natural resources and their supply chains), the value of the ecosystem is diminished thereby ignoring the ecosystems services and a large number of benefits provided by them. This opportunity cost can be recovered by the inclusion and application of sustainable development practices in economic policies. This integration needs to happen at different scales of supply chains, manufacturing, governance and social awareness. Future research should be directed towards a more far-reaching integration of the ecological, social and economic sustainability. This should be based on fine-tuned understanding the metabolic pathways of different human systems, their material and energy fluxes and impacts on the environment, as well as the cultural embeddedness of the heterogeneous forms of *oiko(household)-nomia(management)* embraced by societies across the world.

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