1. Introduction
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1.1 SETTING THE CONTEXT

This *Handbook* addresses the consideration of biodiversity and ecosystem services (ES) in impact assessment, by providing a critical analysis of some of the latest research and practice in this field. The book was written to support researchers and practitioners in the conceptual development and operational implementation of biodiversity and ES-inclusive impact assessment processes.

Impact assessment is the 'process of identifying the future consequences of a current or proposed action' (IAIA, 2009, p. 1). At its heart, impact assessment aims to provide information for decision-making. With this intention, the National Environmental Policy Act (NEPA) – signed into law in 1970 – introduced the process of Environmental Impact Assessment (EIA) in the United States of America. This Act represented the first legislation that formally established an impact assessment process to state the potential effects of actions prior to their approval (O'Riordan and Sewell, 1981). NEPA inspired the institutionalization of EIA as a decision-support tool all over the world (Canter, 1996). Currently, EIA is firmly embedded in the legislation of nearly all UN countries, as well as in international law (Morgan, 2012).

Even though the scope of EIA varies in different contexts, its focus (especially in early applications) has been on the biophysical aspects of the environment and on the project level of decision-making (Wood, 2003; Morgan, 2012). This has led to the development of other forms of impact assessment that expanded the scope, both thematically and across the decision spectrum. For example, Social Impact Assessment (SIA) (Esteves et al., 2012) and Health Impact Assessment (HIA) (Harris-Roxas et al., 2012) address in a more comprehensive way social aspects, and community and individual health issues respectively. Strategic Environmental Assessment (SEA) (Therivel, 2010) reflects the need to consider the higher levels of decision-making, such as policies, plans and programmes. More recently, sustainability assessment (Bond et al., 2012) has emerged to emphasize the analysis of the sustainability gains associated with any kind of decision.

The content of impact assessments is constantly evolving to reflect new

perspectives and emerging issues and concerns. The treatment of biodiversity is a case in point. Early legislation (e.g., Directive 85/337/EEC, the first European Union directive on EIA) described the biotic aspects to be included in impact assessment studies simply as 'flora and fauna'. This narrow scope is reflected in the findings of reviews of EIA practice in the 1990s and early 2000s (Treweek et al., 1993; Thompson et al., 1997; Atkinson et al., 2000; Byron et al., 2000). These reviews report a tendency to limit biodiversity and ecological analysis to individual species (e.g., iconic, endangered or protected species) and sites already designated for nature conservation, concluding that the majority of EIA did not discuss impacts on the different levels at which biodiversity occurs. Meanwhile, the Convention on Biological Diversity endorsed and popularized a broader definition of biodiversity, seen as 'the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems' (CBD, 1992, Art. 2).

More comprehensive approaches to address biodiversity in impact assessment were developed in the years that followed. For example, Treweek (1999) and Treweek et al. (2005) identified important principles to ensure that biodiversity considerations are appropriately addressed in EIA and SEA, respectively. These studies also illustrate key analysis to be performed in different stages of the EIA and SEA processes. Geneletti (2003, 2004) proposed methods to consider the spatial configuration of ecosystems in impact assessment, and to assess and compare their value using decision-support techniques. Geneletti et al. (2003) advanced the treatment of uncertainty factors in Biodiversity Impact Assessment (BIA). Balfors et al. (2005) set the foundations for landscape- and regional-level analysis of biodiversity in SEA. Gontier et al. (2006, 2010) applied innovative modelling tools to predict and assess impacts on biodiversity of projects and plans. Even though all these studies demonstrate a more systematic understanding of biodiversity and its complexity, they look at biodiversity from a nature conservation perspective, with limited (or only indirect) consideration of human development and well-being.

Two seminal works in 1997 reinforced the recognition that biodiversity underpins the delivery of ES that are fundamental for our well-being. Daily (1997) provided the first comprehensive account of the many services that nature offers to people, and the way in which we all depend on them. Costanza et al. (1997) estimated the overall economic value of the ES of the entire biosphere, stimulating a surge of interest in this topic. The Millennium Ecosystem Assessment (MA, 2005) and many subsequent studies documented the rate of degradation of many services, and the

associated negative consequences for human well-being (Nelson et al., 2013; Barnosky et al., 2014). The MA defines ES as the benefits human populations derive from ecosystems, such as goods and products (e.g., fresh water, fuel), regulation of natural processes (e.g., climate, flooding, erosion), and non-material benefits (e.g., recreation, aesthetic enjoyment). Over the last decade, the concept of ES has been widely taken up in both science and policy (Polasky et al., 2015). Publications in this field have grown exponentially (Braat and De Groot, 2012), and a number of international initiatives gained media and policy attention, such as The Economics of Ecosystems and Biodiversity (TEEB, 2010) and the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) (Díaz et al., 2015).

The field of impact assessment has been receptive to this widening in perspective. EIA and SEA guidance published after the MA (Slootweg et al., 2006; OECD, 2008), and subsequent academic work (Slootweg et al., 2010), proposed integrative impact frameworks that include the effects of development on ES and human well-being, along with more traditional biodiversity conservation issues. Geneletti (2013) has collected recent experiences and viewpoints in this area, and Rosa and Sánchez (2015) and Geneletti et al. (2015) have reviewed practice. Methods have been advanced to include ES in impact assessment for higher-level policies (Helming et al., 2013; Diehl et al., 2016), plans (Geneletti, 2011, 2015), projects (Landsberg et al., 2013), as well as for specific sectors (e.g., infrastructure development; Mandle et al., 2015). All these efforts show the emerging interest in this area, but also the many open challenges.

This *Handbook* presents state-of-the-art methodological guidance and discussion of international practice related to the incorporation of biodiversity and ES in impact assessment. As one of the series of *Research Handbooks on Impact Assessment*, the book provides a critical assessment of the research and thinking in this field, emerging from different parts of the world. The case studies presented in the chapters span the five continents, and a broad range of sectors and biomes. The *Handbook* is divided into four parts. Part I, described in Section 1.2, looks at how biodiversity and ES information can be mainstreamed in different impact assessment types to improve their salience and effectiveness. Part II (Section 1.3) presents a range of applications in key policy and planning sectors. Part III (Section 1.4) addresses selected issues and challenges in contemporary practice and research. Part IV (Section 1.5) concludes with a final chapter that summarizes the key messages and provides directions on the way forward.

1.2 PART I: MAINSTREAMING BIODIVERSITY AND ECOSYSTEM SERVICES IN IMPACT ASSESSMENT TYPES

Over the last decades, a number of impact assessment types have emerged in the literature and practice, raising concerns about their efficiency and effectiveness. Morrison-Saunders et al. (2014), after having identified more than 40 different specialist types of impact assessment, argue that this proliferation creates separate silos of expertise and undermines interdisciplinary practice. This *Handbook* endorses the integration of biodiversity and ES within existing impact assessment types, rather than via separate stand-alone processes. It acknowledges that these issues are inherently interdisciplinary and better addressed from broader perspectives, as already demonstrated by Geneletti (2011, 2015) and Partidário and Gomes (2013) in relation to SEA, and by Karjalainen et al. (2013) in relation to EIA. The chapters of Part I present innovative conceptual frameworks, and practical methodologies, to strengthen the consideration of biodiversity and ES in different types of impact assessment.

Lisa Mandle and Heather Tallis (Chapter 2) address EIA of projects, by proposing an approach for carrying out spatially explicit assessments of development impacts on ES. They argue that assessments of environmental impacts of projects have traditionally focused primarily on quantifying change on the basis of area, habitat quality or ecological processes, without linking clearly to people and their well-being. Hence, an accounting of impacts on ES – not just ecosystems – is needed to make the impacts on people transparent. With their approach, environmental impacts are not only quantified, but importantly also tracked between ecosystems and people to account for where and to whom the costs and benefits accrue. The flexibility of the approach is demonstrated with two case studies, in which free, open-source, science-based software tools and commonly available data are used to assess the impacts of mine and road development on ES in Latin America.

Chapter 3, by Davide Geneletti, shifts the focus from project-level to strategic-level decisions, by presenting a sequence of key analyses to mainstream ES information in SEA. These analyses include: building a conceptual framework for ES production and use in the study region; reviewing relevant regulations, plans and policies; determining priority ES and assessing their baseline conditions and trends; developing possible alternatives that enhance opportunities and reduce risks for ES, and assessing their impact. The analyses are illustrated through a variety of examples and short case studies in different contexts. The chapter demonstrates how

information of ES represents a valuable addition to the content of SEA by providing a means to translate unattended and unintended consequences of plans and policies implementation on human well-being, as argued by Kumar et al. (2013).

Pierre Horwitz and Margot W. Parkes (Chapter 4) examine the potential value of the ES concept as a framing device for Health Impact Assessment (HIA). Particularly, the chapter addresses the scoping stage of HIA. The authors identify overarching health issues, and associate them with relevant ES, which then enables estimation of health benefits when these ES are maintained or enhanced, and the consequences for health where these ES are disrupted. This provides a framework for the scoping phase in HIA, which can be used to promptly identify and negotiate trade-offs. A case study involving a resource development proposal (coal seam gas extraction in eastern Australia) is used to demonstrate the applicability of the proposed approach. The chapter concludes by discussing some of the remaining challenges and unanswered questions associated with the consideration of ES in the context of HIA.

In Chapter 5, Leena Karrasch discusses ways to match the ES concept with Social Impact Assessment (SIA). The author presents a framework to identify the links between ES and social impacts, accounting for the social preferences and needs of local decision-makers. The framework consists of three steps, starting with scientific-based input and moving towards intensive stakeholder engagement. The case study in regional development that is presented in the chapter shows that the framework could be used to assist planners and researchers in establishing a more integrated, participatory development process, particularly in relation to the consideration of complex interactions between nature and society.

The economic dimension is the focus of Chapter 6. In this contribution, Léa Tardieu presents the theory and practice of performing monetary evaluation of ES loss induced by transportation infrastructures. The chapter begins by reviewing the legal framework of transportation infrastructure projects in France, with the purpose of illustrating how the legal context influences the most appropriate way of incorporating ES. An application to a real case study (a high-speed rail project) is then presented. Finally, the advantages and challenges of integrating monetary evaluation into more traditional decision-support tools, such as EIA and cost–benefit analysis, are discussed.

In Chapter 7, Assumpció Antón et al. address the integration of biodiversity and ES in Life Cycle Assessment (LCA). The aim of LCA is to provide a quantification of the potential environmental impacts of goods and processes for the cycle of production from 'cradle to grave'. The first section of this chapter describes the environmental mechanisms affecting

biodiversity and ecosystems services and their quantification in LCA. The second section introduces the state of the art of the different impact indicator proposals addressing biodiversity loss and change in ES in the frame of LCA. The review focuses on the effects of land use and land use change as the key drivers of biodiversity loss. Finally, the last section addresses the main challenges in the quest for good and harmonized indicators to account properly for biodiversity and ES in LCA.

1.3 PART II: APPLICATIONS IN DIFFERENT SECTORS

Part II of the *Handbook* provides a collection of applications in a broad swathe of sectors. The purpose is to illustrate experiences and approaches that are relevant for different decision-making areas and levels, and discuss the associated challenges, solutions and opportunities. The following sectors are featured: urban development, spatial planning (both for terrestrial and marine areas), agriculture and forestry, hydropower, wind energy, and tourism. The different chapters in this part of the book were selected also to cover different key impact assessment issues (e.g., cumulative effects, impact trade-offs, consideration of stakeholders' perception), and a variety of ecosystem types, including agro-ecosystems and grasslands, urban green infrastructures, forests, marine and fluvial ecosystems, and coastal zones.

Berit Balfors et al. (Chapter 8) address the impacts of urbanization on biodiversity and the capacity of urban green areas to provide ES. A description of the role of biodiversity and ES is provided as a framework for a landscape approach in biodiversity assessments and for presenting the practical examples. Three different case studies in urban planning from the Stockholm region are presented and discussed, together with tools to predict and assess biodiversity impacts at a landscape level and to plan and manage urban green areas. The chapter concludes with lessons learned and key recommendations for best practice.

In Chapter 9, Christine Fürst et al. consider how to assess the impact of agricultural and forest management on biodiversity and ES. Agricultural and forest land management practices play a key role in affecting biodiversity shifts and sustaining natural capacities to provide a multitude of ES. This contribution presents a modelling and assessment platform – GISCAME – that was developed to connect planning and decision-making at different scales. The approach particularly supports the comparative analyses of combined land use and land management change scenarios to guide spatial planning processes. To demonstrate how the platform can be

applied, two applications in agriculture and forestry at regional level (in Germany and Chile) are presented.

The purpose of Chapter 10, by Leena Kopperoinen et al., is to present key issues related to including biodiversity and ES in impact assessment of spatial planning. First, a set of useful tools to support impact assessment is presented. This includes tools to assess ES at the local scale, to improve participatory mapping and to analyse the spatial configuration and connectivity of green infrastructures. The usefulness of these tools is then illustrated through three real-life spatial planning processes in Finland and Germany. The chapter concludes by providing a checklist for implementing impact assessment in practice.

Tara Hooper et al. examine marine spatial planning and impact assessment in Chapter 11. They argue that ES approaches to marine EIA have tended to consider only a small number of services, which is of limited use in project or strategic planning. The chapter then explores the process required for adopting an ES approach to EIA in marine systems, including the role of stakeholders in identifying ES and selecting assessment priorities. The need for appropriate indicators that permit the manageable measurement and reporting of ES is discussed. Modelling and spatial mapping are key tools for evaluating and communicating potential change, and methods for these are demonstrated using two case studies in the context of regional marine energy planning and marine protected areas, respectively.

In Chapter 12, David Newsome and Michael Hughes discuss the impacts of ecotourism on biodiversity, by providing a multi-scale perspective that considers the influence of people's perceptions and politics. They explore the complex spectrum within which ecotourism exists, ranging from mass tourism at one end to highly specialized niche tourism at the other. Positive and negative impacts are identified, acknowledging that the nature of such impacts is influenced by political and socio-economic factors that characterize the areas in which the biodiversity occurs. The chapter concludes with an exploration of the implications for impact assessment concerning the complex characteristics of ecotourism and their interaction with biodiversity. This is achieved via examining the case of the ecotourism–conservation nexus associated with iconic species such as gorillas in East Africa.

The last two chapters of Part II address the energy sector. Lea Bulling and Johann Köppel (Chapter 13) explore the trade-offs between wind energy and biodiversity conservation. They draw on the argument that the assessment of these trade-offs is bound to become more and more critical due to the expected increase in wind energy development, posing a great challenge to impact assessment processes. They provide an overview of

current conflicts between biodiversity conservation and energy generation, looking specifically at the species groups that are affected the most by wind energy development (birds and selected mammals). Then they consider potential solutions and present exemplary case studies that can pave the way for future best practices.

Finally, in Chapter 14 Asha Rajvanshi examines the hydropower sector. She first reviews the potential impacts of dams on biodiversity, and then presents the merits and challenges of conducting Cumulative Impact Assessment of dams for the identification of basin-wide effects that may cause aggregate, multiple and altogether new impacts on ecological systems. The chapter provides examples that reflect the contributions of Cumulative Impact Assessment to SEA for planning hydropower projects in locations that are least disruptive to key ecological processes, and operating them in ways that protect biodiversity and maintain key ecological services. Operational recommendations for successful assessment of the cumulative effects of dams are provided at the end of the chapter.

1.4 PART III: CURRENT ISSUES AND CHALLENGES

Part III of the *Handbook* addresses selected issues and challenges in contemporary practice and research related to the consideration of biodiversity and ES in impact assessment. The purpose is to advance new ideas and discuss possible solutions, as well as to identify priority directions for future research.

In Chapter 15, Dilys Roe and Davide Geneletti consider the interactions between biodiversity conservation and poverty alleviation in impact assessment. They start by presenting a conceptual framework to guide thinking about the interactions between different components of biodiversity and different dimensions of poverty. The framework recognizes that both biodiversity and poverty are complex, multi-dimensional concepts and, furthermore, that the interactions between the two are mediated by a wide range of factors. In particular, cross-cutting determinants, such as governance and policies on poverty and biodiversity, are critical in determining whether biodiversity leads to actual poverty reduction. They then review the existing evidence base on biodiversity–poverty linkages, drawing on a systematic mapping of the published and grey literature. The findings of the review are used to identify key issues that should be addressed in Biodiversity Impact Assessment of any planned development interventions, if the subsequent implications for poverty are to be taken into account.

The next two chapters discuss open challenges, and make innovative proposals, in relation to biodiversity and ES mitigation and offset measures. Susie Brownlie and Jo Treweek (Chapter 16) explore biodiversity offsets in the context of impact assessment processes. Particularly, they examine the role of offsets in achieving 'no net loss' or 'net gain' of biodiversity when development takes place. The chapter looks at offset practice around the world and considers how issues in offset design and implementation have been addressed. It then goes on to consider some of the aspects that need further consideration to allay fears that use of offsets might reduce the effectiveness of impact assessment and accelerate loss of biodiversity due to development. Challenges to effective offset design, and responses to these challenges, are discussed. Finally, some emerging trends in offset practice that might help to address the challenges are presented.

In Chapter 17, Heather Tallis et al. draw on the argument that we lack a unified conceptual framework and analytical precedent to guide the integration of ES into more commonly practised biodiversity mitigation contexts. They present a four-step framework that addresses key deficiencies in current biodiversity mitigation practice and recommend how ES can be included in the context of existing regulatory approaches. Within this framework, they address the conceptual and analytical advances needed to establish ES targets, delineate a spatial extent that captures ES supply and delivery, establish avoidance thresholds for services, quantitatively estimate impacts on services, consistently construct mitigation replacement ratios, and identify and design potential ES offsets. In each of these areas, they identify opportunities to embed ES alongside biodiversity in a single integrated framework.

Climate change is expected to be an increasingly important source of impacts on biodiversity and ES, both directly and in combination with other activities and phenomena. The potential of nature-based solutions is more and more acknowledged in the climate adaptation debate, because they offer the advantage of promoting 'no regrets' interventions, and potentially delivering multiple economic, social and environmental co-benefits (Jones et al., 2012; Munang et al., 2013). In Chapter 18, Davide Geneletti et al. address the role that impact assessment can play to promote nature-based solutions for climate adaptation in urban areas. They first analyse the current trends and gaps, and then illustrate a methodology to increase the evidence base that planners have at their disposal to develop and compare nature-based solutions. The application of the method is demonstrated for a case study related to impact assessment of urban planning in Italy. Finally, some conclusions and recommendations for directing future practice and research in this area are provided.

Richard T.T. Forman and Jianguo (Jingle) Wu round up Part III of the

Handbook with an analysis of the best places for the next billion people, based on environmental constraints (Chapter 19). The analysis is first conducted globally, and then downscaled to urban regions. The purpose is to identify the types of urban places where major population growth could be concentrated, in order to reduce the impacts on farmland and natural land. An array of urban-region solutions are then suggested to improve food-producing land, nature and built communities despite a new billion people. The authors acknowledge that no single overarching solution emerges. However, packages of specific solutions seem promising to address a number of problems and mould a better land ahead – a very relevant message for impact assessment practitioners and researchers.

1.5 PART IV: CONCLUSIONS

The overall conclusions of the *Handbook* are provided in Chapter 20. This final chapter summarizes the key messages that emerged from the contributions, and that are relevant across impact assessment types and planning and policy sectors. These messages are articulated into two parts, addressing impact assessment frameworks and impact analyses respectively.

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