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Double components, three domains of impact and three valuation languages for assessing the insurance value of Nature-Based Solutions

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Summary

Despite growing interest in Nature Based Solutions (NBS) and recent application of the concept of the Insurance Value (IV) to underline their multifunctional and multidimensional benefits, theoretical understanding of these concepts is limited. A better understanding is essential to increase their implementation. What do we mean by IV of NBS? How are these concepts valued and operationalized? This paper proposes a conceptual framework for the analysis and measurement of the IV of NBS. It is aimed specifically three objectives. First, we examine some general definitional issues related to the concepts of NBS and IV. This allows for providing a conceptual background to clarify these concepts. We highlight three characteristics and their associated benefits for defining NBS. Secondly, we review resilience theories from the perspective of analysing how the characteristics of NBS affect the resilience of the socio-ecological system. We show that NBS have a double IV, both ecological and social. Thirdly, we review the literature on plural valuation in order to propose an integrative framework to assess the double IV of NBS. We conclude by summarizing some limitations of our work and point to areas of improvement in relation to our framework.

Key words: Nature Based Solutions, Insurance Value, Integrative assessment, plurality of values

JEL Codes: Q57, Q2

Introduction

In less than a decade, the concept of Nature Based Solutions (NBS) has become part of the policy agenda, due largely to the increased need to build resilience and sustainability. The growing consequences of natural hazards shed light on the vulnerability and non-resilience of the Socio-Ecological System (SES) suggesting the need for more concerted efforts and innovative solutions to cope with the ongoing process of climate change and the increasing risk from natural hazards. The concept of NBS is at the interface between practice, policy and science and refers to the synthesis and accumulation of prior ecosystem-based experience (Albert et al., 2019; Eggermont et al, 2015). The notion was proposed in 2008 by the International Union for Nature Conservation (IUCN) (Eggermont et al., 2015). It has quickly taken up and promoted by the European Commission (EC) in its Horizon 2020 research and innovation programme (Eggermont et al., 2015; Nesshöver et al., 2017; Maes & Jacobs, 2017). Since 2015, it has become widespread in science with "4, 21 and 62 papers published on NBS in 2015, 2016 and 2017 respectively" (Albert et al., 2019 p.13). NBS is seen as an alternative to grey solutions, which "are designed and managed to be as simple, replicable and predictable as possible" (Eggermont et al., 2015, p. 243). NBS are complex solutions to address complex problems posed by climate change and associated sustainability and resilience issues (Eggermont et al., 2015; Nesshöver et al., 2017; Maes & Jacobs, 2017; Raymond et al., 2017; Albert et al., 2019). Their aims are primarily at reducing risk (Andersson et al., 2017) and providing multiple co-benefits to humans and biodiversity. In this context, the societal importance of NBS can be examined in terms of its Insurance Value (IV) (Andersson et al. 2017 ; Green et al., 2016). However, we have limited theoretical understanding of the IV of NBS. What do we mean by the IV of NBS? How are these concepts valued and operationalized? To our knowledge, Andersson et al. (2017) is the only attempt to define the IV of NBS and there are no studies that explain how the IV of NBS can be assessed. The present paper tries to fill this gap by analysing how NBS affects the resilience of the SES, how the IV of NBS can be framed and identifying an appropriate unit of analysis.

Addressing these questions is not straightforward for several reasons. First, although several authors (Eggermont et al., 2015; Nesshöver et al., 2017; Maes & Jacobs, 2017; Albert et al., 2019) have proposed definitions of NBS in the scientific sphere, the concept remains vague and remains a 'catch-all' concept with multiple definitions. It relates to or overlaps with other ecosystem-based concepts. Second, the benefits of NBS are diverse. NBS reduce risk and provide Ecosystem Services (ES) and advantages for both humans and biodiversity. For example, the involvement of stakeholders, one of the characteristics of NBS, provides “substantive”, “instrumental” and “normative” benefits (Nesshöver et al., 2017, p.1221), while their use of nature provides ES and enchances ecological functions (Cohen-Shacham et al., 2016; Eggermont et al., 2015). Third, the diverse nature of the benefits of NBS means that any assessment of NBS must take account of the plural dimensions of values, individual lexicographic preferences and multiple rationalities (Arias-Arévalo et al. 2018; Pascual et al., 2017; Spash 2015; Kallis et al., 2013). Some of the benefits are tradeable in the market (e.g., provisioning ES), some are public goods (e.g., food security, biodiversity) and some have socio-cultural value (e.g., biodiversity). This highlights the need for different methodologies to assess the multiple benefits induced by NBS.

The main objective of this paper is to develop a conceptual framework that can be used to assess the IV of NBS, because it is important that these values are incorporated in decisions to support the scale up NBS implementation. We address three issues. First, we examine the general definitional issues and propose a definition of NBS. We identify three important characteristics and associated benefits related to their definition. Second, we review therories about resilience, focusing on how the characteristics and benefits of NBS affect SES resilience. We demonstrate the ecological and social components of the IV of NBS. Thirdly, we review the literature on the plural valuation of nature to propose an integrative framework to assess the IV of NBS. This framework distinguishes three beneficiaries of the effect of NBS on the SES. It has natural benefits for ecological diversity while individuals benefit from impact on ES provision. Local/national authorities benefit from the impact on risk management processes via a flexible and open system, co-production and the sharing of knowledge and social learning. In addition, the framework articulates the value domain, value meanings and the value provider.

The paper is organized in four main sections: (1) definitional issues, (2) theoretical foundations of the IV of NBS, (3) proposed conceptual framework for assessment, (4) discussion and conclusions.

1. Concept clarification

Assessment of the IV of NBS requires clarification of the concepts of 'insurance', 'value' and 'NBS', which are interpreted differently in the literature.

1.1. NBS or not

The concept of NBS is complex because it has multiple definitions and is related to different ecosystem based concepts (see Annex 1) In this paper, we propose a definition of NBS that can be used in a general framework and identifies three important characteristics and their associated benefits (Table 1). The first characteristic is the targeted risk which use of NBS helps to mitigate. The context in which the concept of NBS was introduced, that is, finding solutions to climate change is important. Indeed, climate change effects (e.g., extreme weather) increase the risk of "abrupt and, in some cases, irreversible environmental changes detrimental to human development" (Eggermont et al., 2015, p.243). Andersson et al. (2017) consider that risk reduction is a primary target for NBS. Risk is fundamentally complex and linked to uncertainty about the future. It refers to an unpredictable or unknown event with negative and undesirable consequences for something that humans value (Aven, 2016). It includes natural hazards and disasters (e.g., droughts, floods and tropical storms), natural resources management, resource scarcity and environmental variability (e.g., mangrove forests, declining water quality and water scarcity) and social change and development issues (e.g., policy and institutional change, migration and economic crisis and uncertainty). In contrast to alternative grey solutions (Kabisch et al., 2016; Raymond et al., 2017), which "are designed and managed to be as simple, replicable and predictable as possible" (Eggermont et al., 2015, p. 243), NBS are complex solutions which address complex problems (i.e. risk) posed by climate change and the associated objectives of sustainability and resilience (e.g., Nesshöver et al., 2017; Albert et al., 2019).

The second important characteristic is 'use of nature' (even partly), which refers to self-regulation of ecological functions. For example, Maes and Jacobs (2017) point to the use of renewable natural processes while Nesshöver et al. (2017) discuss use of ES and adaptation of the natural functioning of ecosystems to reach a target ecosystem with preferably biological and/or endogenous inputs. For Albert et al. (2019), NBS must fulfill ecosystem process utilization. Eggermont et al (2015) suggest that NBS design should be related to species diversity if this is not counter-productive. They suggest, also, that "clones from one or very few plant species could increase the risk of biological invasion and lead to poor resistance and resilience to future extreme events” Eggermont & co-authors (2015, p. 245). These studies hightlight that the use of nature benefits both society through the provision of ES and biodiversity.

The third important characteristic is the involvement of stakeholders. In contrast to related concepts (Annex 1), Eggermont et al. (2015) maintain that NBS have the potential to adress ethical, intellectual and relational challenges. Stakeholder involvement allows the mapping of the different dimensions of risk and consideration of multi-interests and conflicts; hence they provide “substantive”; “instrumental” and “normative” benefits (Nesshöver et al., 2017 p.1221). Stakeholder involvement is essential to design, value, implement and manage appropriate efficient and socially acceptable NBS. Indeed, adoption of NBS requires viable business models and governance (Albert, et al., 2019). People's perceptions of NBS and their management is a determinant of their survival over time (Andersson et al., 2017). The management of NBS needs to be flexible and open-ended (Andersson et al., 2017, Raymond et al., 2017, Kabisch et al., 2016). To be considered a NBS, the measure must fulfill all three characteristics simultaneously. Hence, we define NBS as risk mitigation actions using nature, which are co-designed and co-managed with participation from stakeholders.

Table 1: Characteristics and benefits defining NBS

NBS characteristics	Type of benefit	Benefits
Target risk	Primarily benefit	The reduction of targeted risk (e.g. extreme heat, flooding and drought)
Use of nature	Co-benefit	Biodiversity (e.g. ecological functions, ecosystems)
		Bundle of other ES (e.g. natural pest control, water quality regulation, erosion control)
Involvement of stakeholders	Co-benefit	Substantive benefit
		Instrumental benefit
		Normative benefit

1.2. The Insurance Value of NBS: from risk to resilience

A definition of the IV of NBS can be drawn from the definition of the concepts of insurance and value. ‘Insurance’ commonly means “an action or institution that mitigates the influence of uncertainty on a person's well-being or on a firm's profitability” (Baumgärtner & Strunz, 2014, p.24). This implies the notion of risk mitigation should stress reduction of an undesirable change in the future. In turn, ‘value’ refers to the importance or worth of something (Arias-

Arévalo et al., 2018) and represents "how much something is needed or preferred" (Tadaki et al., 2017, p.2).[1] Considering the definition of NBS proposed in section 1.1, we can define the IV of NBS as the importance of using of nature and involving stakeholders in risk mitigation. Numerous scholars have highlighted that one way to mitigate risk is to increase resilience since this reduces the 'non-measurable' probability of an undesirable transition (e.g., Baumgärtner and Strunz 2014, Folke et al., 2010). In ecology, the concept of the IV is associated explicitly to resilience and sustainability and refers to the stability of a system over time (Loreau et al., 2002; Yachi & Loreau, 1999; Tilman et al., 2005). Scholars increasingly are drawing on the idea of IV to investigate the societal importance of ecosystems and biodiversity for buffering shocks and sustaining resilience (Baumgärtner & Strunz, 2014; Green et al., 2016; Andersson et al., 2017). Hence, to propose a better definition of the IV of NBS, we need to understand the concept of resilience.[2]

Scholars refer to the resilience of what, to what. The 'to what' suggests the risk at stake (e.g., Walker et al., 2010; Folke, et al., 2010). In relation to the 'resilience of what', we observe that the concept of resilience has been applied to three different systems: ecological systems, the social system and the "embedded SES". So-called "engineering resilience" described by Holling (1973) and Pimm (1984) is related to ecological systems (Walker et al., 2004).[3] Another approach is related to the social system and emerged from the social and health sciences literature (Maclean et al., 2014). This literature highlights that social resilience is characterized mainly by the ability of people to adapt and cope with change, whether social, cultural, health, environmental or disaster risks. The third approach is applied to the SES representing a system composed of ecosystems and human society with reciprocal links and feedback (Folke et al., 2010). There are three dimensions to SES resilience. The first corresponds to the persistence of ecological functions (Folke et al., 2010; Keck and Sakdapolrak, 2013) and refers to its ecological resilience. The second and third dimensions are adaptability and transformability of SES resilience (Walker, 2004). Adaptability refers to "the collective capacity of the human actors in the system to manage the resilience", while transformability refers to "the capacity to

[1] The value concept encompasses three types of values namely transcendental values (principles associated to a given worldview), contextual values (preferences or opinions about the importance of something) and value-indicators (measure) (Kenter & co-authors, 2015; Pascual & co-authors, 2017).

[2] Although resilience and sustainability are conceptually different in their priorities (e.g., process vs outcomes), they "share many objectives and elements in their drive to understand system dynamics and enhance strategic competencies" in order to achieve the maximum good for society and the environment (Redman, 2014). NBS purse the objectives of resilience and sustainability and for this reason, here, we adopt the perspective that merges these two concept.

[3] Admiraal et al. (2013) note that Holling's (1973) approach is the most often adopted in practice.

create a fundamentally new system when ecological, economic, or social (including political) conditions make the existing system untenable" (Walker et al., 2004, p.6-7). Both dimensions are closely related to social resilience. The two literature streams on resilience are often treated separately, but here both are mobilized to define SES resilience.

NBS are aimed at increasing increase resilience and sustainability and, in that sense, they have IV. To analyse this IV, we adopt a SES resilience approach because NBS are embedded in SES (Andersson et al., 2017; Nesshöver et al., 2017) and require a good understanding of their potential impacts on both the ecological and social systems. The next section discusses the characteristics of NBS that influence the resilience building process.

2. From the dual functions of NBS to the double insurance value

This section demonstrates that NBS have a double IV: an ecological IV and a social IV.[4] The notion of double insurance allows a better understanding of the complexity of the system in which NBS are embedded. Therefore, we analyse ecological IV and social IV.

2.1. Ecological IV of NBS

2.1.1. Determinants of ecological resilience

In ecology, biodiversity is at the core of resilience theories (Finger & Buchmann, 2015). Eppink and Bergh (2007) show that the concept of biodiversity is multidimensional and includes four levels - genetic, species, function (or natural production processes) (Tilman et al., 2005) and ecosystem. Several authors point out that species, function and ecosystem are relevant levels for studying resilience. Tilman et al. (2005) suggest that "the ecosystem becomes more temporally stable as diversity increases even though, on average, the individual species in it become less temporally stable" (p. 415). A review of the theoretical and experimental work on the relationship between diversity and stability is provided in Loreau et al. (2002). Their study confirms the insurance effect of diversity on ecological resilience.[5] Hence, we prefer the term

[4] The idea of the double insurance value of NBS was advanced first by Andersson et al. (2017) who include both external and internal components.

[5] We acknowledge that there are some limits to reliance on ecological theory to define this component of the IV of NBS. Indeed, Loreau et al. (2002) note the scarcity of experimental studies of the influence of species diversity on the resilience of ecosystem functions and the lack of robustness of their results. The authors note, also, that the relationship between ecological system diversity and stability is still the subject of debate among ecologists. Therefore, to disentangle the different components of the IV of NBS, the analysis in this paper should be regarded as providing a general overview.

‘ecological diversity’ which emphasizes the different dimensions (species diversity, function diversity and ecosystem diversity) of biodiversity for resilience.

Further, ecological diversity acts as a natural insurance in the provision of ES (Baumgärtner 2007; Landers and Nahlik, 2013). It acknowledges both the contribution of nature to human wellbeing and health via the provision of ES and demonstrates the dependence on the resilience of the biosphere (McPhearson et al., 2015; Green et al., 2016; Folke et al., 2016). Since the Economics of Ecosystem Services and Biodiversity and the Millennium Ecosystem Assessment was launched in 2000s, interest in ES assessment has gained huge attention (Gómez-Baggethun & Martín-López, 2015). This was boosted by the implementation in 2012 of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). Because of the part played by ES in linking planning, designing and governing ecosystems in urban areas, ES provision as considered one of the cornerstones of resilience. ES increases adaptative capacity and sustains human well-being (McPhearson et al., 2015; Green et al., 2016).

2.1.2. NBS and ecological resilience

The NBS typology proposed by Eggermont et al. (2015), highlights clearly that provision of ES and ecological diversity are the main characteristics of NBS. They point out that NBS have impacts on ecological diversity via use of nature. They state that NBS provide “biodiversity benefits in terms of diverse” (Eggermont et al., 2015, p. 243). Similarly, other studies put the provision of ES and ecological diversity at the heart on NBS (Kabisch, et al., 2016; Nesshöver & co-authors, 2017; Raymond, et al., 2017; Albert, et al., 2019). The IUCN’s definition of NBS (Annex 1) emphasizes the benefits for biodiversity of using nature. Also, several studies stress that provision of ES represents one of the key co-benefits of NBS (Cohen-Shacham et al., 2016; Maes & Jacobs, 2017; Nesshöver et al., 2017; Gulsrud et al., 2018; Albert et al., 2019). Indeed, it represents a direct and perceived impact of the use of nature for solving problems. Gulsrud et al. (2018) and Green et al. (2016) provide examples of cities using urban green infrastructures to build resilience through delivery of ES. These NBS are mitigating such risks as urban flooding, urban heat waves and wild fires, and are having an impact on provision of ES such as ground water replacement, water purification, biodiversity and species habitats and ecotourism.[6]

Thus, by affecting ecological diversity and the provision of ES, we assume that NBS have an ecological IV. More specifically, based on Eggermont et al.'s (2015) NBS typology, we hypothesize that the lower the degree of biodiversity and the number of ES targeted, the lower is the ecological IV. Hence, we consider that the ecological IV of NBS type 1 is lower than NBS type 2 and 3 (Table 2).

2.2. Social IV of NBS

2.2.1. Determinants of social resilience

The framework of Olstrom (McGinnis & Ostrom, 2014) has been applied widely in several empirical studies, to understand and diagnose the combinations of variables that determine the capacity of the social system to manage resilience. Keck and Sakdapolrak (2013) and Saja et al. (2018) point to three attributes of social resilience: coping, adaptive and transformative capacities. Coping capacity refers to individual's reactive capacities to restore, in the short term, the present level of well-being following a critical events (Keck and Sakdapolrak 2013). Adaptive capacity refers to individuals' proactive capacities to establish a learning process and adjust solutions according to experience and knowledge, towards incremental changes to social structures and securing future well-being (Folke, et al., 2010; Keck & Sakdapolrak, 2013). Transformative capacity refers to individuals' proactive capacities involving the creation of fundamentally new systems (Walker et al., 2004; Folke, et al., 2010). It requires radical changes to the social structure (Keck and Sakdapolrak 2013).

Keck and Sakdapolrak (2013) also highlight three keys set of variables for determining social resilience. The first is the social relations and network structures referring to social capital, which includes "the bonding (social ties and place of attachment) the bridging (external networks) and the linking (interaction between social groups, governing authorities, and non-state local institutions)" (Saja et al. 2018 p.868). Social capital is influenced by: (i) the type of social network; and (ii) the tenor and nature of the social relations. The type of network needed for social resilience is a network of "institutional entrepreneurs that make innovative processes happen" (Keck and Sakdapolrak, 2013, p.11). Change towards a desirable system requires

[6] Nesshöver et al. (2017) stress reliance on the concept of ES to provide a common framework for evaluating the consequences of different NBS.

innovation and, hence, flexibility is an important feature of the network structure. In addition, informal social relations such as trust, reciprocal mutual support, are crucial elements that affect the meaning and content of social capital and contribute to the building of social resilience.

The second set of variables are the institutions and power relations, which refer to individuals' access to resources and involve equity, justice and power issues. Saja et al. (2018, p.878) suggest that increasing equity and social justice are core to building social resilience. Lovell and le Masson (2014) demonstrate that equitable allocation of resources has a significant effect on people's capacity for adaptation in the face of a disaster risk. The third set of variables are knowledge and discourses. People's perceptions of risk, risk experience, beliefs, values and attitudes comprise the set of capacities required to build social resilience (Keck and Sakdapolrak, 2013; Saja et al 2018).

2.2.2. NBS and social resilience

We hypothesize that NBS has social IV because they help to build social resilience through a flexible and open-ended network structure and the co-production and sharing of knowledge. The involvement of stakeholders is an important characteristic of NBS and provides three types of benefits (Section 1.1) for the process of risk management (Nesshöver et al., 2017). Here we adopt a normative definition of stakeholders (Colvin et al., 2016): they are the actors, including individuals and groups, with an influence (direct, indirect, intentional or unintentional) on risk (Walker et al., 2004; McGinnis & Ostrom, 2014). The participatory approach in NBS allows flexible and adaptive bringing together of different SES actors such as practitioners, scientists, NGOs, policymakers and citizens in the decision-making process. Enhancing the flexibility of the social system is considered fundamental for risk mitigation in the context of rapidly changing global environments (Paolisso, et al., 2019; Saja et al., 2018; Ostadtaghizadeh et al., 2016; Moench et al., 2007). The capacity of the social system to learn from and live with risk is as important, if not more important to reduce the impacts of extreme events. This governance mode ensures the capacity of NBS to adjust to changes and, therefore, improve social resilience.

This type of governance contributes, also, to the co-production and sharing of knowledge, which can simulate a process of dynamic social learning. Numerous scholars highlight that stakeholder involvement is aimed at connecting and integrating diverse knowledge system to promote mutual learning, co-creation of knowledge and adaptive capacity (Paolisso, et al., 2019; Gulsrud et al. 2018; Djenontin & Meadow, 2018; Raymond et al. 2017). Each actor in the SES can contribute to the knowledge needed to design and implement an appropriate, efficient and socially acceptable NBS. A participative approach is essential to fill caps in the knowledge about the design, implementation and effectiveness of NBS for risk reduction (Kabisch et al., 2016; Andersson et al., 2017). The co-production and sharing of knowledge allow co-definition of the problem and co-development of scenarios (Raymond, et al., 2017; Albert, et al., 2019). For instance, they allow the mapping of different risk perception and experience and, in that sense, increase the social resilience of SES.

In this paper, we assume that the degree of social resilience differs depending on the type of NBS (Eggermont et al., 2015) (Table 2). Type 1 corresponds to definition of better use of natural resources to resolve a critical problem. It involves a low level of change in the social structure in the short-term and requires coping capacity. Types 2 and 3 are built on more inclusive involvement of stakeholders, individuals and groups (Walker et al., 2004; Folke, et al., 2010) because their respective objectives are to develop a sustainable and multifunctional managed ecosystem and to create a new ecosystem or restore a heavily degraded or polluted one (Eggermont et al., 2015). These types imply respectively incremental and radical changes to the social structure in the long-run and correspond respective to the adaptive and transformative perspectives. In contrast to transformative actions, aimed at increasing the flexibility of the system via the introduction of new dynamics, adaptive actions are relatively conservative and aimed at maintaining or returning the system to the previous order or to something very similar to it, and require modest and incremental changes (Redman, 2014). Hence, the need to look beyond the "usual suspects" (Colvin et al., 2016) and to consider people’s preferences, values, beliefs and perceptions. The underlying rationale is that public support is essential for social acceptance, especially for types 2 and 3. Environmental management can be highly contentious because it affects people in diverse, complex, conflicting and antagonistic ways (Soma & Vatn, 2014; Tadaki et al., 2017). For instance, it can affect people’s well-being and values. In addition, individuals have a dual role in relation to NBS: they are simultaneously affected by them and are actors of change in relation to these solutions. Thus, the greater the involvement of stakeholders in types 2 and 3, the greater the co-production and sharing of knowledge compared to type 1. Hence, we consider that the social IV of NBS type 1 is lower than NBS type 2 and 3 (Table 2).

Table 2: The components of the insurance value of NBS

Double IV of NBS	Components of the IV of NBS/Attributes of SES resilience	Type of NBS		
		Type 1“better use of natural or protected ecosystems”	Type 2 “sustainable and multifunctional managed ecosystems”	Type 3 “design and management of new ecosystems”
Ecological	Attributes of SES resilience	Persistence	Persistence	Persistence
	Ecological diversity	Low	Medium	High
	ES provision	Low	Medium	High
Social	Attributes of SES resilience	Coping	Adaptability	Transformability
	Flexible and opened system	Low involvement of stakeholders with no change	Medium/High involvement of stakeholders with incremental change	High involvement of stakeholders with radical change
	Co-production and sharing of knowledge/ social learning	Low	Medium/High	High

3. Assessing IV of NBS

The question that emerges from identification of the IV of NBS is how it can be valued? Quantifying or qualifying the importance of NBS is one step in the scaling-up of risk mitigation. However, valuation is highly controversial because it is not neutral for decision making (Tadaki et al., 2017; Pascual & co-authors 2017; Sagoff, 1998). Indeed, environmental decisions affect people in diverse ways (Tadaki et al., 2017) and a valuation perspective stress on a particular way that predetermines the "policy objectives, as well as policy instruments" (Pascual et al., 2017, p.9). Given the double IV of NBS, which implies multiple values, we need to identify what perspectives of assessment are relevant?

3.1. Single vs plural valuation?

There is a consensus in the literature on the existence of plurality of values (e.g., Gómez-Baggethun & Martín-López, 2015; Kenter et al., 2015; Tadaki et al., 2017; Arias-Arévalo et al., 2018). However, the point of contention among scholars is related to valuation of the system of values. This debate has two levels. The first refers to the concept of the value itself and is aimed at reducing the plural dimensions of value to a single dimension so that the goals reflected by some of these dimensions are incommensurable and cannot be trade-offs (Gómez-Baggethun & Martín-López, 2015).[7] The main criticism of this notion is that individuals hold lexicographic preferences, which lead them to perform ordered rankings in which some things are absolutely more important than others, according to their ethical positions (e.g., intrinsic value, rights and virtues) (Spash, 2015). In addition, people adhere to rationalities other than utilitarianism, which guide their choices (Kallis et al., 2013). The second critique refers to the individual approach to valuation. Valuation exercises based on individual approaches capture shared values poorly (Sagoff, 1998; Kenter et al. 2015, 2016). According to Kenter et al. (2016, p.358) "valuation that focuses only on individual values evades the substantial collective and intersubjective meanings, significance and value from ecosystems… and may undermine the legitimacy of decisions based upon them".

Economic valuation figures at both levels of debate (e.g., Sagoff, 1998) and has split ecological economists into those who consider monetary valuation to be a pragmatic choice and those who

[7] Incommensurability and trade-offs are the foundations, also, of the strong and weak positions in the sustainability debate (Missemer, 2018).

reject it on methodological, ethical or political/governance grounds (Gómez-Baggethun & Martín-López, 2015; Missemer, 2018). To try to answer the question of which perspectives of valuation matter, we consider each component of the IV of NBS has the same weight (Brouwer & Ek, 2004) and propose a plural valuation framework, which could be used in future work.

3.2. Framework for integrated valuation of the IV of NBS

An economic valuation of the IV of NBS is based on the strong assumption that the different impacts of NBS on the SES occur within the instrumental domain (Arias-Arévalo et al., 2018). Although a plural valuation approach would seem relevant for valuing the IV of NBS based on its components outlined in Section 2, this raises the important question of double counting. People's values are interlinked (Steg et al., 2005) as are ecosystem functions and ES (Pascual & co-authors, 2010). There are numerous arguments in this context. The first is related to the incommensurable characteristics of the values in the intrinsic, fundamental and eudaimonistic domains versus the lexicographic preferences of indiviuals. An economic valuation can capture only the values within the instumental domain even though they may be linked to values in the other three domains. The second and perhaps most important argument is based on individual perception of the role of ecological diversity. Individuals generally do not observe the causal relationships between ecological diversity and resilience due to the complexity, stucture and scale (spatial and temporal) of the ecosystem at which this relationship emerges (Eppink & Bergh, 2007; Pascual et al., 2015). Admiraal et al. (2013, p. 117) highlight this misperception and the failure of total economic value to capture the importance of ecological diversity due to "lack of information concerning the amount of perturbation an ecosystem can withstand before a shift to another state occurs". Moreover, Pascual et al. (2010, 2015) describe the non-linear behaviour of ecosystems with critical thresholds and uncertainties as challenging the assumption of a linear relationship inherent in economic valuation and the requirement of proof of the biophysical functioning of the ecosystem.

Table 3 presents a pluralism valuation approach to asssess the IV of NBS. Starting from the ecological diversity of the IV of NBS, we consider that nature is the direct beneficiary. We suggest that this component is valued within the intrinsic value domain by relying on human values, judments and behaviours (Dietz et al. 2005). The biophysical modelling of ecosystem functioning is non-anthropocentric (Admiraal et al., 2013) and guarantees the intrisic characteristic of the valuation. Harrison et al. (2018) and Jacobs et al. (2018) propose an overview of biophysical modelling methods and a guide to selection of the most appropriate one. However, if biophysical modelling is impossible or too costly because of the uncertainty related to predicting ecosystems and biodiversity dynamics, then the precautionary principle and safe minimum standards can be applied (Pascual & co-authors, 2010) and the concept of "value as contribution to a goal" can be incorporated (Tadaki et., 2017). For example, experts and practitioners, can define ecological goals and indicators (e.g., species composition, rarity, richness), and the contribution of NBS to these goals can be monitored and documented.

Regarding the provision of ES, this component benefits indivuals through its more perceptible impact on individuals. Numerous ES fall within the instrumental value domain and, in our view, should be valued within the Total Economic Value (TEV) framework which values only "the output of ecosystems at one point in time and space and not on the state of ecosystems" (Admiraal et al., 2013, p.116). For an overview of applied economic valuation methods for each type of ES see De-Groot et al. (2012) and Grizzetti et al. (2016).

Finally, we posit that social resilience benefits local or national authorities responsible for risk management. The aim is to capture the benefits of NBS related to the process of building social resilience. This complements the "static" dimension of social resilience (Admiraal et al., 2013; Saja et al., 2018) benefits to the social system, captured by ES valuation. The valuation of social IV of NBS within the relational value domain, on the one hand, highlights the impact of NBS on the meaningfulness of the relationships among individuals (Pascual et al. , 2017) and on the other hand, highlights the notion of "living with nature" (Arias-Arévalo et al., 2018) and the dynamic process of social learning allowing individuals to "live/coexist with hazards" (Ostadtaghizadeh et al., 2016, p.1855). In practice, this valuation might focus on integration of local and analytical meanings of risk by allowing individuals, practitioners, experts and scientists to share knowledge and experience (Paolisso, et al., 2019). Because of the dynamic and complex nature of this component of the IV of NBS, we suggest a holistic approach using a SES framework (McGinnis & Ostrom, 2014) to evaluate the social impacts on the risk management process, risk perception and risk awareness. Alternatively, the contribution of NBS to the social resilience could be monitored. The Community Disaster Resilience (CDR) framework is another holistic approach to measure resilience, which focuses on resilience to natural risk in particular. It can be mobilized to establish a baseline for the monitoring. For an overview of CDR tools and social resilience indicators for measurement of the initial level of social resilience, which could be re-evaluated after a period of time of the NBS implementation, see Sharifi (2016), and Saja et al., (2018).

Table 3: Integrated valuation framework of the IV of NBS

NBS		Benefit		Value domain	Value meanings	Value provider	Valuation framework	Example of indicators/ models outputs
Double IV	Components of IV	Temporal scale	Beneficiary					
Ecological resilience	Ecological diversity	Long-run	Nature	Intrinsic	Value as contribution to a goal	Expert, practitio-ners	Biophysical modelling	¬ Surface runoff ¬ Sediment yield ¬ Evapotranspiration ¬ Organic N, P ¬ Species distribution ¬ Species richness, ¬ Communities.
							Biophysical Monitoring	¬ Biodiversity richness. ¬ Species and stage class of invasive. ¬ Ecological state. ¬ Connectivity.
	ES provision	Short-run	Individuals	Instru-mental	Value as magnitude of preference	Individuals	TEV	¬ WTP ¬ Avoided damages ¬ Provision of forests products ¬ Carbon sequestration
Social resilience	Flexible and opened system/ Co-production and sharing of knowledge/ Social learning	Long-run	Local/ national authorities	Relational	Values as relations	Individuals/ social groups	SES framework	¬ Number of actors ¬ Knowledge of actors ¬ Monitoring and sanctioning processes
							CRA	¬ Risk perceptions, experiences and awareness ¬ Being in the pressure ¬ Community stresses, mental disorders

4. Discussion and conclusion

From practitioners to scientists via politicians, we have seen a rise in interest in NBS and their benefits and, particularly, their IV. However, we lack a clear definition of NBS and its IV and concrete valuation to support decision-making. Our paper provides three novel contributions: (1) it reviews the growing body of work on NBS and identifies three important characteristics defining NBS, that is, targeted risk, use of nature and involvement of stakeholders; (2) it outlines resilience theories and how they affect the characteristic and benefits of NBS and their impact on SES. We demonstrated the two components of the IV of NBS, namely the ecological and social IV. We highlighted that NBS affect ecological resilience through their effect on ecological diversity and ES provision, affect social resilience by means of their flexible and open system and co-production and sharing of knowledge, which allow social learning in the process of risk management; (3) we reviewed the literature on plural valuation of nature to assess the IV of NBS and proposed an integrative valuation framework which includes value domain, value meanings and value provider.

The integrative framework proposed to assess the IV of NBS has two advantages. First, it considers all the benefits of NBS highlighted by scholars without double counting. We argue that the incommensurability characterizing values in intrinsic, fundamental and eudaimonistic domains (Arias-Arévalo et al., 2018) and the lexicographic preferences of indiviuals (Spash, 2015), render plural valuation possible and relevant. Furthermore, people's misperception of the role of ecological diversity (Eppink & Bergh, 2007; Pascual et al., 2015), coupled to the long-term impact of stakeholder involvement on risk management, support this approach. We distinguished three different beneficiaries of NBS. Nature which benefits from the impact on ecological diversity; individuals which benefit from the impact on ES provision; local/national authorities which benefit from the impact on risk management via flexible and open systems, and the co-production and sharing of knowledge and social learning. Since it has been shown that biospheric and altruistic values structure individuals' core priorities (Arias-Arévalo et al., 2017; Steg et al., 2005), we consider that the impact of NBS in the intrinsic and relational value domains should be valued similarly to instrumental values. Second, our framework is aligned to the principles of ecological economics valuation perspectives by accommodating plurality of (i) values among individuals and social groups, (ii) valuation language across multiple disciplines, (iii) qualitative and quantitative methods, and (iv) practitioners', experts' and individuals' knowledge sources (Gómez-Baggethun & Martín-López, 2015). It includes citizens' and experts' participation in decision-making and addresses normative concerns about equity and power (Tadaki et al., 2017).

Nevertheless, our framework has some shortcomings which should be addressed in future research. The weight of each component of IV in decision-making remains an open question which requires more investigation. Albert et al. (2019) underline the importance of viable governance for the implementation of NBS, allowing appropriate actions to become solutions. Are NBS governed by market values and norms? On the one hand, monetary valuation is useful to calculate economic gains and elaborate business models to realize and sustain NBS over time (Albert et al., 2019; Andersson et al., 2017). Depending on the institutional context, this would require combination of different available financial options to secure an "economic insurance" for NBS (Albert et al., 2019; Andersson et al., 2017). According to Kabisch et al. (2016), demonstrating the cost-effectiveness of NBS could promote new investment and public-private arrangements because alternative grey solutions might be more cost- or space-efficient (Albert et al., 2019). On the other hand, people' perceptions as well as political and public acceptance play critical roles in the persistence of NBS over time (Andersson et al., 2017). We posit that the fundamental challenge for NBS governance is to arbitrate between the long-term/processes and short-term/output benefits of NBS. We believe that the relative importance of these benefits is context dependent and, hence, deserves more attention from empirical research.

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Annex 1: Definition of NBS and related concepts

Concepts	Definition	Examples of measures
Nature-Based Solutions (NBS)	The IUCN defines NBS as “actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits” (Cohen-Shacham, 2016, p.5). The EC defines NBS as “actions inspired by, supported by or copied from nature; both using and enhancing existing solutions to challenges, as well as exploring more novel solutions, for example, mimicking how non-human organisms and communities cope with environmental extremes” (Nesshöver & co-authors, 2017, p.1217).	¬ Riparian and wetlands restoration. ¬ Sustainable agricultural practices. ¬ Reconnect rivers and floodplains. ¬ Allow for meandering. ¬ Enhance water retainment. ¬ Extensity agricultural land use. ¬ Transform fields into grassland. ¬ Replacement of fossil fuel and fertilizer input by natural processes and jobs in agriculture. ¬ Green roofs, pockets of nature, or sustainable urban drainage systems in city
Natural Systems Agriculture (NSA)	“NSA is predicated on an evolutionary-ecological view of the world that is featured by an ecologically sound perennial food-grain-producing system where soil erosion goes to near zero, chemical contamination from agrochemicals plummets, along with agriculture’s dependence on fossil fuels” (Jackson, 2002, p. 111).	¬ Polycultures of perennial grain crops ¬ Plant community ¬ Soil community
Natural Solutions	“Natural solutions refer to the use of protected areas to deal with the climate crisis. “Protected areas are geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long term conservation of nature with associated ecosystem services and cultural values” (Dudley, et al., 2010, p. 8)	¬ Protected areas management ¬ Protected areas development
Ecosystem based Adaptation (EbA)	“EbA integrates the use of biodiversity and ecosystem services into an overall strategy to help people adapt to the adverse impacts of climate change” (Colls et al., 2009, p. 1)	¬ Sustainable management of river ecosystems; grasslands and rangelands; protected area systems ¬ Restoration of coastal habitats ¬ Conservation agriculture systems
Ecosystem Approach (EA)	EA is “a strategy for decentralised, participatory and systemic natural resource management.” (Nesshöver & co-authors, 2017, p. 1219)	¬ Multi-stakeholder systemic Management
Green infrastructures	“Green infrastructure is an interconnected network of green space that conserves natural ecosystem values and functions and provides associated benefits" to human populations” (Benedict & McMahon, 2002, p. 12)	¬ Network of parks and wildlife refuges; ¬ Network of waterways, wetlands, woodlands, wildlife habitats ¬ Network of farms ; ranches; forests ¬ Ecological corridor or greenways

Ecological engineering (EE)	"EE is defined as the design of sustainable ecosystems that integrate human society with its natural environment for the benefit of both" (Mitsch, 2012, p. 5)	¬ Restoration of river systems, minelands, prairies. ¬ Wetlands creation. ¬ Agro-ecological engineering ¬ Wastewater wetlands ¬ Bio-manipulation ¬ Soil bioremediation ¬ Solar aquatics ¬ Biosphere 2
Catchment Systems Engineering (CSE)	"CSE is an interventionist approach to altering the catchment scale runoff regime through the manipulation of hydrological flow pathways throughout the catchment". (Wilkinson et al., 2014)	¬ Bunds, ¬ Drain barriers ¬ Runoff storage features ¬ Large woody debris dams, ¬ Buffer strip management, ¬ Willow barriers.
Ecosystem Services (ES)	"ES are the aspects of ecosystems utilized (actively or passively) to produce human well-being." (Fisher et al., 2009, p. 645)	¬ Landscape management ¬ Environmental education ¬ Protected areas management
Natural Capital (NC)	"NC is the sum of exhaustible resources, renewable resources, and what are called today regulating ecosystem services" (Missemer, 2018, p.90)	¬ Terrestrial ecosystems (e.g. forests, landscapes) ¬ Aquatic ecosystems (e.g. river and marine systems) ¬ Maintenance of the composition of the atmosphere ¬ Hydrological cycle regulation ¬ Waste assimilation, recycling of nutrients, generation of soils, pollination of crops. ¬ Scenery of the landscapes.