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Stakeholder Mapping to Co-Create Nature-Based Solutions: Who Is on Board?

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Abstract: Nature-based solutions (NBS) are inspired and supported by nature but designed by humans. Historically, governmental stakeholders have aimed to control nature using a top-down approach; more recently, environmental governance has shifted to collaborative planning. Polycentric governance and co-creation procedures, which include a large spectrum of stakeholders, are assumed to be more effective in the management of public goods than traditional approaches. In this context, NBS projects should benefit from strong collaborative governance models, and the European Union is facilitating and encouraging such models. While some theoretical approaches exist, setting-up the NBS co-creation process (namely co-design and co-implementation) currently relies mostly on self-organized stakeholders rather than on strategic decisions. As such, systematic methods to identify relevant stakeholders seem to be crucial to enable higher planning efficiency, reduce bottlenecks and time needed for planning, designing, and implementing NBS. In this context, this contribution is based on the analysis of 16 NBS and 359 stakeholders. Real-life constellations are compared to theoretical typologies, and a systematic stakeholder mapping method to support co-creation is presented. Rather than making one-fit-all statements about the "right" stakeholders, the contribution provides insights for those "in charge" to strategically consider who might be involved at each stage of the NBS project.

Keywords: ecosystem-based; natural hazard mitigation; participative planning; co-design; polycentric governance; living labs; societal resilience; sustainable development goals

1. Introduction

Nature-based solutions (NBS) are acknowledged by the European Union as a potential opportunity for mitigating hydro-meteorological risks, such as flooding, landslides, coastal erosion, and heatwaves. After decades of anthropogenic modification of ecosystem functions, scientists have cautioned that we are gradually approaching a point where the collapse of ecosystems and the services that they provide is inevitable, e.g., for river system in Wantzen, et al. [1]. In the past, large-scale engineering measures have been implemented in riverine and mountain areas to mitigate the potential destruction of property and loss of life caused by natural hazards as a result of hydro-meteorological risks. Unfortunately, these massive interventions can have negative impacts on the natural environment [2], as well as not being capable of completely mitigating risks but rather transferring risks to other geographical areas, and in some cases, increasing or creating new risks and vulnerabilities for biodiversity and communities [3].

Since the late 1980s, nature itself is increasingly being perceived as a means to mitigate risks. In 2009, the ecosystem-based landscape planning and resource management flourished, and in 2011, the term "green infrastructure" was well-established to define the network of natural and semi-natural areas, which contribute to ecosystem health and benefits for human. NBS is an umbrella term for solutions based on natural processes and ecosystems solving societal challenges [4]. NBS are understood as 'solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social, and economic benefits, and help build resilience. Such solutions bring more and more diverse, nature, and natural features and processes into cities, landscapes, and seascapes, through locally adapted, resource-efficient, and systemic interventions.' [5]. NBS are 'nature-friendly' solutions with high biodiversity requirements [6].

Nature-based solutions are green and blue solutions but may integrate engineering elements, too [5]. While gray solutions are mostly mono-functional, NBS can serve as multi-purpose and flexible alternatives for various objectives, address multiple goals, and create co-benefits, such as risk reduction, enhancement of cultural uses, improvement of ecological quality standard, and green economy reinforcement [7,8]. The European Union (EU) is positioning itself as a leader in 'innovating with nature' [5] and has set NBS design, implementation, and monitoring at the top of its political agenda. This has resulted in the funding of a large number of research projects [5,9], such as NATURVATION (www.naturvation.eu), RECONECT (www.reconect.eu/), PHUSICOS (www.phusicos.eu/), and ThinkNature (www.think-nature.eu). The goals of the current EU research and innovation policy agenda on NBS are based on major strands of knowledge and build on results from the past EU framework programs. Many of the H2020 EU funded action projects follow a similar strategy, namely to optimize and upscale NBS using EU financial support and providing governance support to enhance collaborative planning, including co-creation processes. Furthermore, recent studies have identified that partnerships and collaborative governance models are crucial for successfully implementing NBS [10,11] and that missing intersectoral collaboration causes bottlenecks when implementing measures [12].

Nature is considered as a public good that historically cannot be managed or sustained solely by private or market actors. Consequently, stakeholders with governmental power have aimed to control nature using a top-down approach to governance [13]. However, observations from federal or decentralized systems, such as in the US, have shown that solutions to cross-jurisdictional problems can be addressed more efficiently through decentralized and contractual agreements [14]. In recent years, environmental governance has shifted from a top-down approach to collaborative planning [15]. Polycentric governance structures have evolved and are described as systems in which decisions are taken through formally independent decision-centers [16]. Polycentric governance structures, which include a large spectrum of stakeholders, are assumed to be more effective in the management of public goods than traditional top-down approaches to governance [17,18]. Furthermore, NBS governance analysis already indicates that NBS implementation has successfully resulted from such a co-creation with a large diversity of stakeholders [19]. However, observations of cases have shown that the "the more, the better" principle cannot be applied to increase success in participative planning [20]. Inter-sectorial communication needs to be efficient [12], and the relevant stakeholders have to be on board [21,22].

In the EU, the Parliament and the Commission are currently strongly encouraging—at least as part of the research funding policies—innovative models for collaboration, such as Living Lab, to create solutions, and the involvement of stakeholders and end-users in the design and implementation of NBS has an important role to play [5]. Based on Leminen's definition in 2013 as cited in Fohlmeister, Zingraff-Hamed, Lupp and Pauleit [21], "A Living Lab is a physical region and interaction space, in which stakeholders form a quadruple helix innovation network of companies, public agencies, universities, users, and other stakeholders in the pursuit of collaborating for the creation, prototyping, validating, and testing of new technologies, services, products, and systems in real-life contexts" [23]. The efficiency and the legitimacy of the participatory process are critical for the quality of the resulting solutions. Stakeholder participation can take many forms, ranging from information and consultation to partnership and collaboration to citizen power [24–26]. While informative and participative planning can help to reach acceptance, co-creation also aims to achieve multiple benefits for society by involving a broad spectrum of stakeholders not only in the planning but also in the design, implementation, monitoring, and evaluation as well as the maintenance stages of projects [16,21].

To ensure a well-functioning co-design process and to deal with potential conflicts, issues, and constraints that may arise, identifying and addressing stakeholder values, interests, and knowledge is a crucial step in the NBS process [27]. While some theoretical approaches request certain stakeholders and their perspectives can contribute the most [28], other approaches strive to involve more different groups continuously during all phases equally [29,30]. Innovative approaches to achieving co-creation, such as the quadruple helix innovation networks or Living Lab approaches [23], provide methodologies for bringing together core stakeholder groups. However, while the number of projects using co-creation increases, and "good" practices related to co-creation have been described, limited attention has been focused on identifying the specific stakeholders needed for the planning, design and implementation, monitoring and evaluation, and maintenance of nature-based solutions [21]. Often considered self-evident in the literature (Reed et al., 2009), stakeholder-enhanced processes mostly result from self-organization [31,32] or from windows of opportunities directly after a disaster event has occurred [33], rather than from strategic decisions. A lack of process for identifying and involving stakeholders often leads to a very long initiating process and significant delays in implementation. For example, in the case of the Isar river restoration in Munich, it was more than 30 years [34]. Systematic methods to identify relevant stakeholders seem to be crucial to enable higher planning efficiency, reduce bottlenecks and time needed for planning, designing, and implementing NBS.

According to literature, characterizing stakeholders is useful in order to understand the power relationship between them and their specific interest in the project to avoid pitfalls and failures of such processes [35]. Some stakeholder typologies exist, [36], but are based on psychological evaluation of the stakeholders and have a limited potential to support the initialization of a collaborative planning process. These stakeholder characterization methods are more efficient for an ongoing project as a tool for the project manager. Furthermore, while these typologies based on psychological aspects help to identify the role of stakeholders in terms of attributes, knowledge, source of information, and roles in the action arena, they are not specific for NBS for natural hazard mitigation.

In this context, this contribution intends to answer the three following research questions:

- Which stakeholders and stakeholder types are or should be part of the collaborative planning process that leads to NBS co-design and implementation?
- Do these real-life constellations reflect theories on the ideal structure of co-creation?
- How does a systematic stakeholder mapping method support the initiation of participative planning?

The objective of the research is to reflect upon stakeholder constellations, as observed in two H2020 projects, namely PHUSICOS and RECONECT, and the relative methods developed to identify and initiate collaborative planning to co-design NBS. While the PHUSICOS stakeholder selection procedures rely on the quadruple helix innovation networks theories, the RECONECT method relies on the influence of actors perceived by the core stakeholders. The authors have asked that who has the power to influence decisions for NBS and/or is affected by the risks at stake. We stress that this analysis is not meant to generalize conclusions about favorable stakeholder constellations because they are largely case-specific [19,37]. However, we wish to draw general conclusions on stakeholder mapping methods and to stimulate the debate on the use of systematic methods to strategically identify relevant stakeholders and initiate co-creation.

2. Materials and Methods

The methodological approach is composed of seven steps (Figure 1). In order to answer the research questions, we apply inductive and explorative methods for the case study analysis to generate an in-depth, multi-faceted understanding of a complex issue in its real-life context [38,39]. In this context, we first identify the case study sites, then collect data on the stakeholders potentially involved in the collaborative planning process. We then apply explorative clustering analysis to map the stakeholders according to the variables identified and assess the mapping procedure according to the theories applied in both research projects.

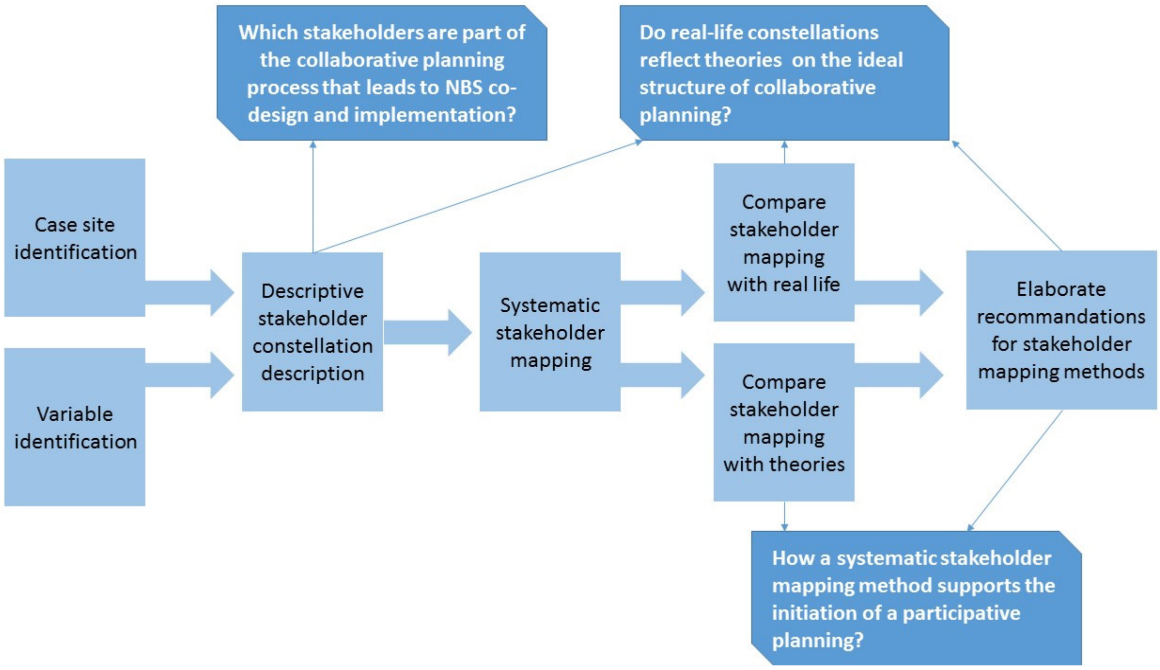

Figure 1. Methodological approach.

2.1. Case Sites

The cases' sites include sixteen NBS (Figure 2 and Table 1) for hydro-meteorological risk reduction, which is investigated in both ongoing H2020 projects—PHUSICOS and RECONECT. All cases of the data pool are located in Europe, and NBS has been or is being implemented to manage hydro-meteorological risks, such as flooding, droughts, erosion, avalanches, or landslides. The six cases of PHUSICOS represent five case study sites and two NBS implementation locations in the Pyrenees. Ten cases of the RECONECT have been integrated into the data pool, namely the demonstrator cases that are been established, validated, or monitored during the RECONECT project lifetime. The 15 RECONECT collaborator cases have been excluded from the data pool for the purpose of this article because the degree of implementation is still largely undefined at the time of writing.

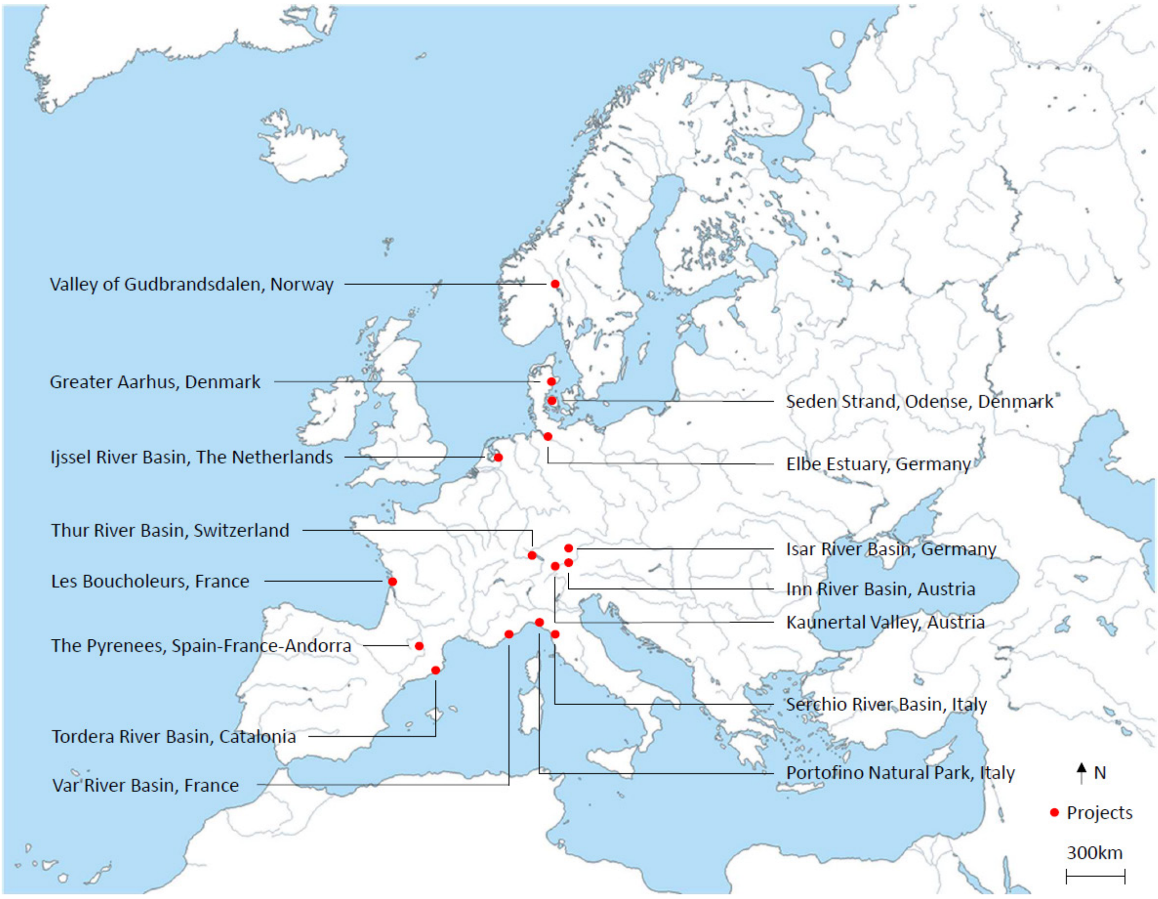

Figure 2. Localization of the case study sites.

Table 1. Overview of the case study sites.

Case Label	Risk	Country	Related Research Project	Description
Greater Aarhus	Coastal flooding	Denmark	RECONECT	Lystrup is at risk of flooding due to its vicinity to the river Egå catchment and the Lake Egå, a shallow lake surrounded by grassland. The NBS was initiated after an extreme rain event in 2012, which flooded critical infrastructures (i.e., the highway) and private properties. The planned NBS is a wetland recreation space at Lake Egå, reducing the flood risk while also reducing the nitrogen supply to Aarhus Bay, thereby improving the health of the natural environment in and around the Egå valley and providing a recreational area to residents and tourists.
Bargèse Forest	Rockfall, landslides, avalanches, pluvial flooding	France	PHUSICOS	The location faces two risks induced by extreme rain events: flooding from the Bastan River and rockfalls due to erosion. Hydro-meteorological risks are particularly severe, impacting critical infrastructure by blocking road access to the village and skiing resort of Barèges. The NBS uses reforestation of the catchment area and in-stream measures to mitigate hydro-climatic extreme events by reducing the hazard intensity. Reforestation is also expected to provide co-benefits by increasing the storage of carbon dioxide as well as supporting biodiversity.

Table 1. *Cont.*

Case Label	Risk	Country	Related Research Project	Description
Les Boucholeurs	Coastal flooding	France	RECONECT	A large storm called Xynthia occurred in 2010. This storm caused 6-meter high waves, killing 6 people, flooding 600 homes, and affecting the local economy through the disruption of the local oyster farms. The storm resulted in policy changes. Flooded areas were reclassified, prohibiting new dwellings but conserving existing buildings. Local municipalities (Châtelaillon-Plage, Yves, Aix, and Fouras) came together to implement a flood risk management strategy. The NBS, in this case, comprised a mixture of gray and green measures. Existing flood walls were reinforced and raised, but no new gray measures were built. Instead, green measures were identified to help manage the residual risk. Specifically, the oyster farms were converted into retention areas for river and groundwater flooding. The retention capacity of marshland was also increased and protected by being designated as a Natura 2000 protected area.
Elbe Estuary	Coastal and pluvial flooding, drought	Germany	RECONECT	The site is at risk of both droughts and floods. On the one hand, flood intensity and frequency have increased, resulting in high water levels and floods along the river Elbe and the North Sea. On the other hand, rainfall has decreased, and this causes drought, which places pressure on the water infrastructure, which services the city. This NBS focuses on the development and implementation of water retention areas located at the Dove/Gose Elbe to address both the risk of flooding and drought. The hope is that both risks can be dealt with by using the same measures by providing innovative, smart water management practices.
Ijssel River Basin	Pluvial flooding	Netherlands	RECONECT	The NBS was funded as part of the "Room for the River" Programme ("Ruimte voor de Rivier"-PKRR 2006). The NBS consisted of roughly 300 ha of vegetation along approximately 130 km of the river. The aim of the project was to remove vegetation from the river's summer bed in order to increase the velocity of the water traveling from the mountains to the sea. The project began in 2014 and was completed in 2018. Specifically, the aim was to remove 70% of the vegetation within the project area.
Inn River Basin	Pluvial flooding	Austria	RECONECT	The overall catchment (~5700 km^2) comprises of the two streams, which flow into the Inn River, the Geroldsbach (12 km^2), and the Marbach (1.2 km^2). The aim of the NBS is to complete the upstream part of the Geroldsbach to avoid flood in the municipality of Götzens. This case comprises different types of NBS, which are currently being installed or have already been completed in this area since the early 1950s. The NBS includes afforestation of high-altitude areas, buffer strips and hedges along watercourses, greening, and forest management.

Table 1. *Cont.*

Case Label	Risk	Country	Related Research Project	Description
Isar River Basin	Pluvial flooding	Germany	PHUSICOS	The Isar River is one of the main rivers in Bavaria and is a tributary of the Danube River. It drains part of the Karwendel Mountains in the Alps, and heavy rain events in the years of 1999, 2005, and 2013 led to major flood events. Climate change is predicted to increase extreme rain in summer, leading to higher flood risks. The Isar River restoration aims to increase flood protection, recreational uses, and ecological quality.
Kaunertal Valley	Erosion, landslide	Austria	PHUSICOs	The 'Gepatschferner' glacier is a fast-melting glacier, and its rapid retreat has resulted in unconsolidated open sediments without vegetation cover, causing a decrease in the stability of the mountain slopes and an increased risk of rockfall, debris flows, and landslides. These risks threaten roads and critical infrastructure, such as a reservoir lake. The NBS aims to achieve slope stabilization through the planting of mountainous species that have improved soil retention capacities by bacteria and fungi.
Seden Strand, Odense	Coastal flooding	Denmark	RECONECT	Approximately 300 people reside in the 142 houses and three farms at this site. With the exception of farming, there are no other commercial or industrial activities at this site. However, critical infrastructure, such as electricity and wastewater, operate in the area. The site is at risk of coastal flooding, which is occurring more frequently in the past decades, causing large amounts of damage. This risk is predicted to increase in the future due to climate change. High tides combined with strong winds from the north can result in flooding of properties and the surrounding agricultural land. The NBS here is to deconstruct the old gray dyke at the shore and to reconstruct it in a greener way and lower inside the island while compensating farmers for allowing their land to flood frequently. This NBS is aimed at protecting the settlement of Seden Strandby from flooding, and at the same time, creating the co-benefits of increasing biodiversity, improving the recreational opportunities in the area, and securing the open coastal landscape by avoiding technical installations, such as large coastal dikes.
Portofino Park	Coastal storms, flash flooding, and erosion/landslides	Italy	RECONECT	As a result of the increasing frequency of extreme weather events over the last ten years, efforts have been made to reduce those risks through NBS. The NBS is located in a newly proposed national park. Due to the national park status of the site, NBS is perceived as a promising alternative to gray measures. The NBS focuses on the restoration of ancient agricultural terraces and reforestation in order to mitigate erosion and storm damage.
Portalet Forest	Rockfall, landslides, pluvial flooding, avalanches	France, Spain	PHUSICOS	The road connecting France and Spain is highly exposed to rockfall, landslides, and also flooding. Systematic reforestation of the slopes and the catchment areas, as well as further structural NBS, will reduce these risks to critical infrastructures, such as settlements, roads, and high power lines.

Table 1. *Cont.*

Case Label	Risk	Country	Related Research Project	Description
Serchio River Basin	Pluvial flooding and erosion	Italy	PHUSICOS	While the drought risk at Massaciuccoli Lake has been addressed through the design and implementation of a diversion channel, NBS measures are planned in order to mitigate the effects of climate change and, at the same time, create the co-benefit of increased biodiversity, a reduction in nutrient and soil runoff from agricultural land, and the improvement of water quality. The NBS also includes restoration and revegetation efforts, the inclusion of buffer strips and sediment retention basins, as well as reforestation through multiple vegetation layers to reduce the risk of landslides and runoff-induced erosion.
Gudbrandsdalen valley in Skjåk	Pluvial flooding, landslides	Norway	PHUSICOS	During recent years, a number of severe weather events have triggered landslides and flash floods. The goal of the Living Lab process is to find nature-based solutions, which include riverbank restoration and/or reduction in erosion and sediment transport. This is to reduce the risk of flooding for the settlements and infrastructure, as well as create the co-benefits of enhanced ecosystem biodiversity, protection of fish stocks, and the increase of recreational potentials.
Thur River Basin	Pluvial flooding	Switzerland	RECONECT	In 2012, federal law required river revitalization in Switzerland. Several projects have been implemented along the Thur River. The NBS combines gray structural measures with green measures, such as river restoration, to enhance flood protection while achieving the co-benefits of restored ecological functions and reduce erosion of the riverbed.
Tordera River Basin	Pluvial flooding	Spain	RECONECT	Blanes and Malgrat de Mar are located on the opposite side of the Tordera River mouth and are both at risk of storm surges and river flooding. Since 2016, campsites located on both sides of the river and are at extremely high risk to the point that they are no longer allowed to be located in the designated risk area. Outside this area, protection measures to protect campsites for the 500 years return period flood need to be implemented if they are to remain in this location. The focus of the NBS is mainly water storage areas and the setback of levees for reconnecting rivers and floodplains. The Tordera River Basin management plan also includes the restoration of Tordera River tributaries located in the municipality of Tordera to enable water diversion from the main river in case of flooding to reduce flood risk of housing areas.
Var River Basin	Pluvial flooding	France	RECONECT	The Var valley is exposed to several types of risks like floods, forest fires, earthquakes, and landslides. The implemented NBS is a combination of gray, blue, and green infrastructure, e.g., "green dikes" create a floodplain, which also promotes wetland habitats. Inside the green flood protection infrastructure, the river runs freely and creates biodiverse habitats.

2.2. Stakeholder Identification

Stakeholder identification conducted in both projects (RECONECT and PHUSICOS) has followed a similar procedure, i.e., case representatives are interviewed, and interactive and structured worksheets are used to document existing and potential stakeholder involvement in the co-creation process. Despite the few slight differences related to the timeline of the data collection, the comparability of the collected data is high because they follow the same methodology.

The RECONECT research group performed the stakeholder identification between November 2018 and April 2019 by visiting case sites that are at different steps of the design, implementation, and monitoring procedure of the NBS. At each of the case sites, the official partners of RECONECT (e.g., representative of municipalities, water authorities, or universities) are interviewed. Interviewees are asked to complete a number of interactive worksheets in order to capture a range of information about existing and potential stakeholders involved in the co-creation process. Interviewees are asked to identify stakeholders by using a pre-prepared list of stakeholder groups as a way to guide and encourage conversations and reflection as well as ensure the comparability of results. The results of these interviews are documented in a report that is validated by the representatives of the demonstrator sites.

The PHUSICOS research team performed the stakeholder identification shortly after the research project started in April 2018. In order to provide comparable data with the RECONECT cases, the PHUSICOS team performed a second round of stakeholder identification in May and June 2020 by following, as far as possible, the RECONECT methodology. Potential stakeholders are listed based on available information from the different sites with the aid of relevant documentation, including support letters and available protocols from meetings with stakeholders at different sites. The structured worksheets produced by RECONECT serve as a template to collect information on the PHUSICOS cases. At each of the case sites, the official partners of PHUSICOS (e.g., representative of municipalities, water authorities, or universities) are asked to fill in the worksheets using the prepared list of stakeholder groups as a guide. After the interviewees fill in the worksheets, the PHUSICOS researcher in charge of the social science-related work package contacts each partner to validate the results.

2.3. Stakeholder Characteristics

Each stakeholder is characterized according to the five categories of variables (Table 2):

- Belonging: this variable describes the case study site the stakeholder belongs, their institution, as well as which stakeholder group the stakeholder represents. Stakeholder groups represent different sections of society: governmental authorities, political representatives, civil society, private sector, academia and research sector, media, and international and transnational organization. Each stakeholder can only represent one group at a time.
- Role of stakeholders: Each stakeholder can have different roles [40]. The decision-makers make and execute decisions. The implementers are responsible for the execution or implementation. The facilitators coordinate a variety of actors for the design, implementation, and monitoring of measures. The providers of expert knowledge are mostly consultants, universities, insurance companies, as well as local informants from civil society. The funders or sponsors can be private, governmental, or non-governmental, and finance activities and measures. The lobbyists refer to stakeholders or group representatives who attempt to influence decision-making. The mediators or facilitators mediate and facilitate communication between different stakeholders. While stakeholders can only represent one group, it is possible for them to have several roles. Stakeholder roles vary across contexts.
- Planning stage: this variable describes the different NBS project steps. The importance of various stakeholders in different steps from design, planning, implementation, monitoring, and evaluating, as well as regular maintenance, can vary. Even when striving for broad involvement of different stakeholders during all phases, this evaluation can help to determine and better understand participants varying motivation to participate and resulting potential different levels of willingness

to engage and act, their relative power, influence, and interests during the different stages of such a co-creation process.

- Relation to the hazards: It is also important to look at the relation of stakeholders to NBS, different NBS planning processes, and potential offsets and trade-offs. This category aims to differentiate between stakeholders who are affected by natural hazards and those who are affecting natural hazards. For example, stakeholder groups are affected in different ways, and property owners can, for example, be threatened by floods [41]. On the other hand, individual stakeholders can have the ability to reduce or mitigate natural hazards (e.g., forest owners and their forest management) [42].
- Relation to the NBS: While some stakeholders might be affected by a selected solution to reduce risks, others might not benefit from a measure (e.g., a landowner being expropriated to build a retention basin to protect a village downstream or farmer asked to change land use to enable regular flooding) [42]. This analysis also helps to determine the ability of different stakeholders to influence the decision on potential NBS or traditional grey engineering solutions. Besides, some stakeholders might not have the power to influence all of the phases but might be influential in the implementation phase, intervene, and halt the implementation of NBS.

Table 2. Documented stakeholder characteristics.

Category	Variables	Modalities
Belonging	Case	Case label (see Table 1)
	Stakeholder group	Governmental authorities (SH1) Political representatives (SH2) Civil society (SH3) Private sector (SH4) Academia and research sector (SH5) Media (SH6) International and transnational organization (SH7)
	Institution	free text
Role of Stakeholders	Decision-makers	Yes or No
	Implementers	Yes or No
	Coordinators	Yes or No
	Providers of expert knowledge	Yes or No
	Funders/Sponsors	Yes or No
	Lobbyists	Yes or No
	Mediators	Yes or No
NBS project stage	Assessment and planning	Yes or No
	Design	Yes or No
	Implementation	Yes or No
	Operation and Maintenance	Yes or No
	Monitoring	Yes or No
	Evaluation	Yes or No
Relation to the hazards	Affected by natural hazards	Least, Moderate, Most
	Affecting natural hazards	Least, Moderate, Most
Relation to the NBS	Affected by NBS	Least, Moderate, Most
	Affecting the NBS	Least, Moderate, Most

2.4. Analysis

According to our methodological approach (Figure 1), we first describe the potential stakeholder using descriptive statistical methods on qualitative variables. The link between variables is investigated using chi-squared contingency table tests and goodness-of-fit tests [43,44].

In order to identify which stakeholders are part of the collaborative planning process that leads to NBS co-creation (first research question), we first perform a descriptive statistical analysis on the variable collected. In order to investigate which parameter influences the role of the stakeholder in the planning process and at which stage the stakeholder is involved, we extend the analysis to a multiple factorial analysis (MFA). MFA is an explorative method that enables to analyze simultaneously sets of variables (continuous or categorical) and linkage between them.

We finalize the statistical stakeholder typological analysis by performing a clustering analysis based on k-means methods [45–47].

An original contribution of this paper is to statistically investigate the stakeholder constellation existing in NBS and to compare statistical results to theories on the stakeholder structure of NBS co-creation. The analysis is expanded to qualitative discussion on the role and potential of stakeholder mapping tools, especially to answer both remaining research questions: Do real-life constellations reflect theories on the ideal structure of co-creation? How does a systematic stakeholder mapping support the initiation of co-creation?

3. Results

3.1. Overall Stakeholder Constellation Description

The stakeholder identification results, in a listing of 359 stakeholders for the 16 cases, roughly indicating about 22 stakeholders per case (mean number of stakeholders), are involved in the NBS planning, design, implementation, monitoring and evaluation, and maintenance. Most of the stakeholders are authorities (30%) and representatives of the civil society (23%) (Figure 3). However, great diversity between the sites exists. For example, the number of stakeholders ranges from 11 to 38, with the case Serchio River Bassin counting up to 52 stakeholders identified due to many different authorities and different departments involved in the process (N = 20) and a comparatively high number of NGOs and divisions (N = 12) being involved.

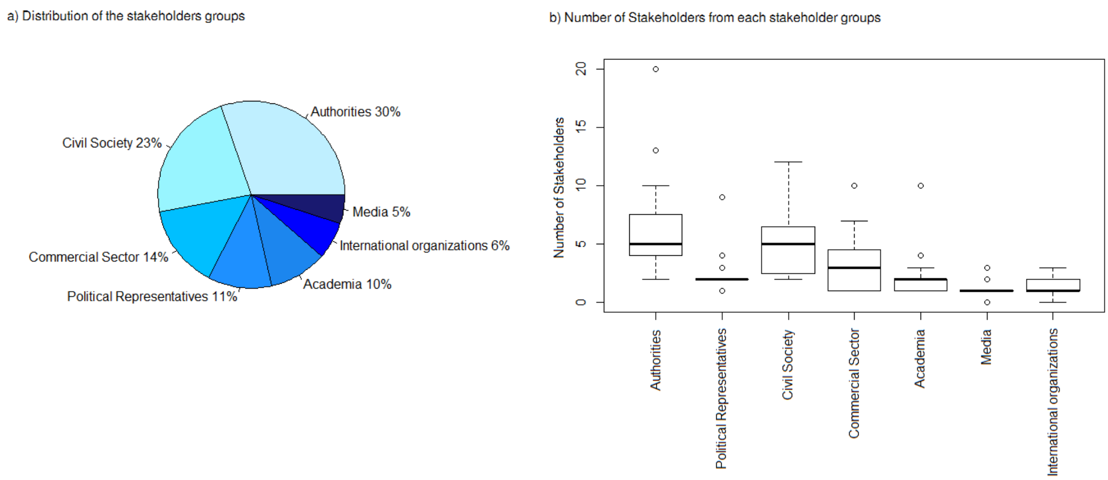

Figure 3. Profile of the stakeholder constellation for nature-based solutions (NBS) planning, design, implementation, and monitoring, illustrating (**a**) the overall distribution of the stakeholders' groups into the stakeholder constellation and (**b**) the number of each stakeholder in each stakeholder group.

3.2. Role Distribution between the Stakeholder Groups

The roles of the stakeholder differ between the stakeholder groups (Figure 3). The authorities are mostly the funder of the NBS (80%), coordinator of the process (70%), and decision-makers (70%). The civil society is an important provider of knowledge and plays a crucial role as a lobbyist (59%), mostly acting as advocacy groups. The commercial and private sector takes a share in the implementation (18%) but also as neutral mediators (25% of the cases). Interestingly, the provision of knowledge relies on many stakeholder groups, namely 41% from the authorities, 23% from the civil society, only 17% from academia, and also only 15% from private experts from the commercial and private sector, and 4% from international and transnational organizations that play a role providing advice on specific topics. The authorities play a dominant role in their proportion (Figure 3), and in their role (Figure 4), they are followed by representation from civil society.

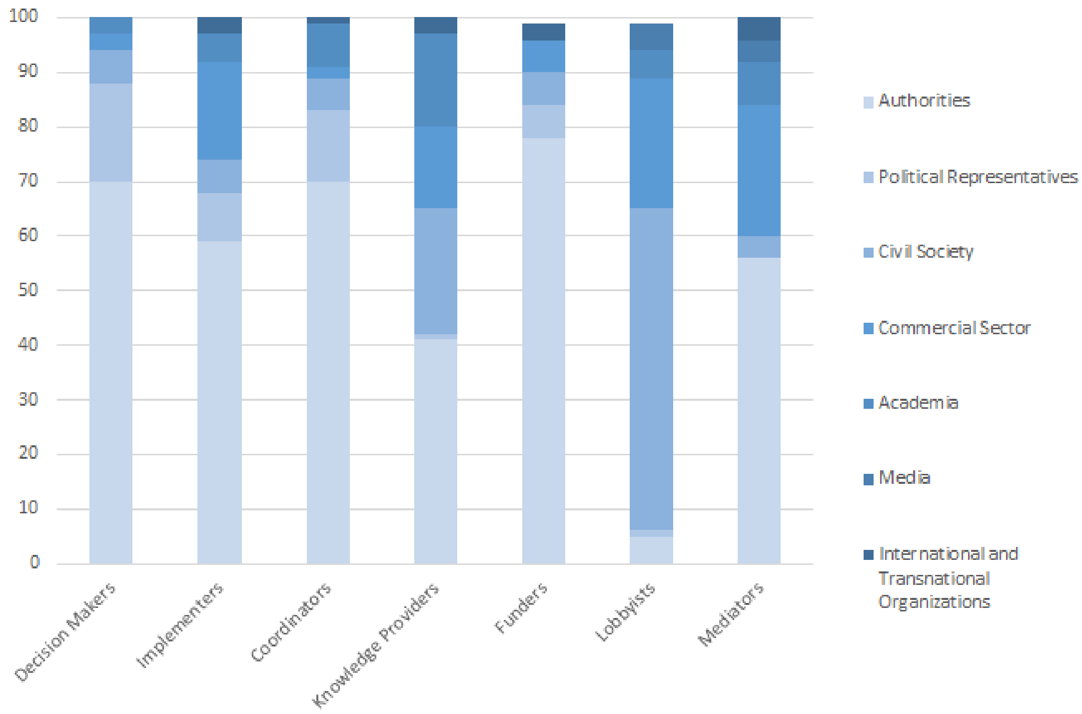

Figure 4. Distribution of the roles between the stakeholder groups.

3.3. Relationship between Stakeholders Role and Implication, and Their Relation to the Hazards and the Solution

The MFA can explain 40% of the data distribution according to three main dimensions. The first dimension is particularly strong and explains 20% of the information. The representation of variables shows that two variables are highly correlated to the first dimension (Figure 5): stakeholders "affecting the NBS" ($R2 = 0.56$) and stakeholders "affecting the hazards" ($R2=0.44$). Stakeholders affecting both the solution and the hazard are distributed positively on the x-axis. The second and third dimensions are explained by the variable "affected by the hazards" ($R = 55$); the stakeholders the most affected by the hazards are positively distributed on the y-axis, and the stakeholders who are moderately affected by the hazards and the solution are positively distributed on the z-axis. Interestingly, the groups' representation of the MFA (Figure 5) suggests a linkage between two variables: the relation that the stakeholders have with the hazard, namely if they are affected by or affecting the hazard, and the stage of the NBS project process they will be part of, namely if they are part of the planning, design, implementing, monitoring and evaluation, and maintenance of the NBS. Similarly, two other variables are linked, namely the relation that the stakeholders have with the solution and their roles in the planning process, e.g., decision-maker, funder, coordinator, lobbyist. Linkages between the roles of the stakeholders and the planning stage and their relation to the hazard and the solution are summarized in Table 3. The role of the stakeholders is particularly linked to how he/she is affecting the solution and less if he/she is affected by the solution. Interestingly, most of the stakeholders, who are participating in the solution design, are the least affected by the hazard (74%). Sixty-five percent of the stakeholders, who are the most affected by the solution, participate in the design of the solution. Seventy percent of the lobbyists are the stakeholders who are least affecting the hazard. Seventy-eight percent of the knowledge providers are the stakeholders who are the least affected by the hazards.

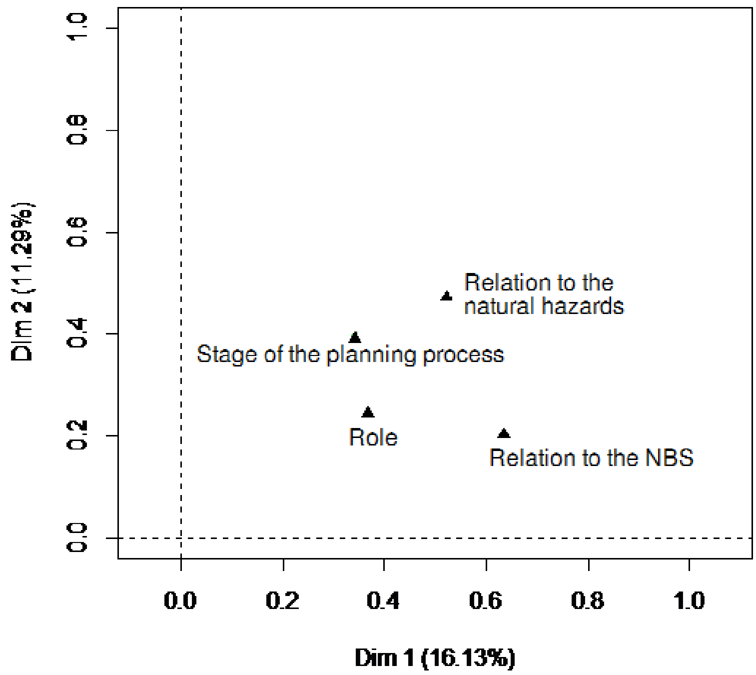

Figure 5. Groups representation of the Multiple Factorial Analysis.

Table 3. The linkage between the role of the stakeholder and stakeholder implication in the NBS stage, and the stakeholder relation to the hazard and the solution (p-value < 0.05).

	Relation to the Hazard		**Relation to the Solution**	
	Affected by the Natural Hazards	**Affecting Natural Hazards**	**Affected by the Solution**	**Affecting the Solution**
		Role of the Stakeholder		
Decision-makers (25% the SH)	50% are SH the least affected by the hazards	22% are SH the most affecting the hazard	NS	50% are SH the most affecting the NBS
Implementers (26% of the SH)	NS	50% are SH the least affecting the hazard 25% are SH the most affecting the hazards	NS	NS
Coordinators (17% of the SH)	NS	40% are SH the least affecting the hazard	NS	43% are SH the most affecting the solution
Knowledge providers (46% of the SH)	78% are SH the least affected by the hazards 30% are SH the most affected by the hazards	60% are SH the least affecting the natural hazards	NS	60% are SH the most affecting the NBS
Funders (10% of the SH)	NS	40% are SH the most affecting the hazard	NS	50% are SH the most affecting the NBS
Lobbyists (25% of the SH)	NS	70% are SH the least affecting the hazard	40% are SH the most affected by the NBS	30% are SH the most affecting the NBS
Mediators (8% of the SH)	NS		NS	40% are SH the least affecting the NBS

Table 3. *Cont.*

	Relation to the Hazard		Relation to the Solution	
	Affected by the Natural Hazards	**Affecting Natural Hazards**	**Affected by the Solution**	**Affecting the Solution**
NBS Project Stage				
SH participating at the Preliminary Assessment and Planning (54% of the SH)	NS	NS	NS	77% are SH the most affecting the solution
SH participating at the Design (45% of the SH)	74% are SH the least affected by the hazard	NS	65% are the most affected by the solution	70% are SH the most affecting the solution
SH participating at the Implementation (40% of the SH)	NS	60% are SH the most affecting the hazard	NS	NS
SH participating at the Monitoring (27% of the SH)	NS	NS	NS	22% are SH the least affecting the NBS
SH participating in the Evaluation (41% of the SH)	71% are SH the least affected by the hazard	NS	NS	60% are SH the most or moderately affecting the NBS
SH participating at the Maintenance (18% of the SH)	NS	50% are SH the least affecting the hazard	NS	40% are SH the most affecting the NBS

Notes: For example, the first cell reads as follows: "50% of the decision-makers are stakeholders who are least affected by the hazards". Not statistically significant (NS). Stakeholders (SH).

3.4. Stakeholder Types

The hierarchical analysis of the variables "role", "involvement in the different NBS phases", "relation to the hazard", and "relation to the solution" shows that the stakeholder can be clustered into five groups (Figure 6). We add a label for each type to ease understanding their characteristics (Table 4).

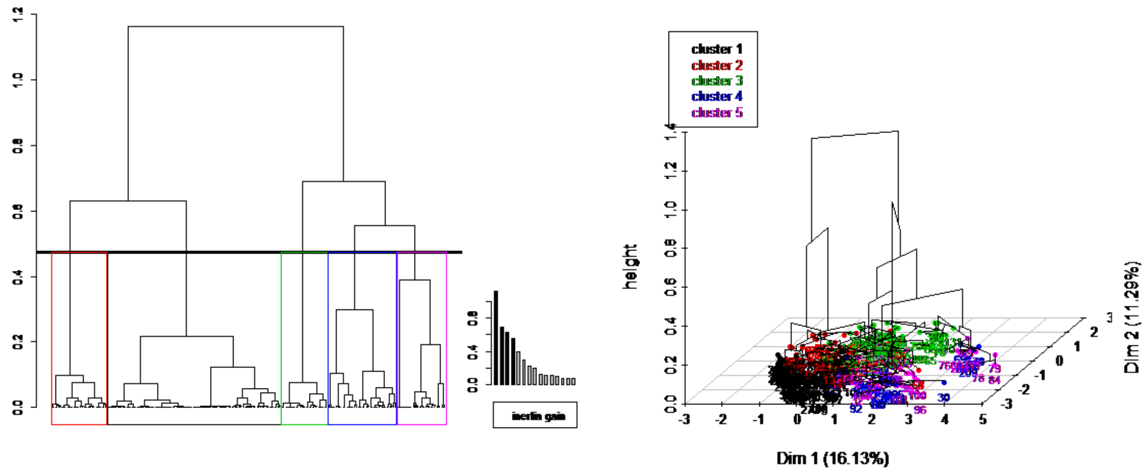

Figure 6. The hierarchical tree of the clustering procedure.

Table 4. Table describing the type of stakeholders defined by the clustering procedure (note: For instance, the first line reads as follows: 68% of the stakeholders of Type 1 are stakeholders who are the least affected by the hazards. This 68% represents 99% of the stakeholders the least affected by the hazards).

Types	Characteristics of the Type		Characteristics of the Stakeholders
	. . . composed the type.	**They represent . . .**	**. . . of the Stakeholder that are . . .**
1: Observers	68%	99%	The least affected by the hazards
	67%	94%	The least affecting the hazards
	68%	88%	The least affected by the solution
	67%	74%	The least affecting the solution
	87%	87%	Not decision-makers
	96%	48%	Not funders
	100%	NS	Media and international or transnational organizations
	75%	NS	Academia
2: Officials moderately concerned	95%	87%	Moderately affected by the hazards
	42%	36%	Moderately affected by the solution
	NS	91%	Not involved in the maintenance
	NS	82%	Not involved in the design
	22%	51%	Authorities
	32%	NS	Political representatives
3: Silent stakeholders	72%	92%	The most affected by the hazards
	47%	84%	The most affected by the solution
	24%	82%	Not knowledge providers
	20%	94%	Not involved in the implementation
	20%	98%	Not coordinator
	20%	86%	Not involved in the monitoring
	22%	62%	Not involved in the planning and the design
	28%	42%	Civil society
	27%	26%	Private sector
4: Wise and active stakeholders	40%	77%	Moderately affecting the hazards
	25%	97%	Knowledge provider
	24%	97%	Implementer
	30%	75%	The most affected by the solution
	30%	80%	The least affecting the solution
	20%	94%	Involved in the planning and the design
	22%	47%	Lobbyist
	NS	42%	Civil society
5: Stakeholders in charge	81%	100%	The most affecting the hazards
	27%	78%	The most affecting the solution
	26%	77%	Authorities
	NS	100%	Lobbyist
	24%	52%	Implementer
	34%	30%	Funders
	22%	47%	Decision-makers
	17%	69%	Involve in the implementation
	16%	75%	Involve in the planning
	16%	72%	Involve in the design
	17%	47%	Involve in the monitoring

Type 1 can be referred to as “observers” and can be assigned to 20% of the stakeholders. These stakeholders, gathered in the first cluster, are the least affected by the hazards, the least affecting the hazards, the least affecting the solution, and the least affected by the solution. These stakeholders are neither decision-makers nor funders. Academia, media, and stakeholders from the international and transnational organization are type 1, with around 32% of the authorities being part of the NBS co-creation process.

Type 2 can be identified as “officials moderately concerned” and concerns 42% of the stakeholders. These stakeholders are typically not originating from academia, media, or from international and transnational organizations. They are mostly authorities or political representatives. Their main characteristics are that they are moderately affected by the hazards as well as by the solution and are not part of the design or maintenance. For example, in the case in the Pyrenees, the regional police department and the regional juridical department, or in the case of the Serchio River Basin, a community district.

Type 3 can be addressed as "affected silent stakeholders" and comprises 14% of the stakeholders. The stakeholders are mostly from civil society or from the private sector and are stakeholders who are the most affected by the hazards and/or the solution. They are rarely involved in planning processes, but often their help or support is required for the implementation.

Type 4 can be described as "wise and active stakeholder" and covers 12% of the stakeholders. The stakeholders are knowledge providers and are involved in all phases of the planning process. They are moderately affecting the hazard but the most affected by the NBS. They are usually not political representatives but often part of the civil society and are likely to be lobbyists for environmental protection.

Type 5 can be labeled as "stakeholders in charge" and concerns 12% of the stakeholders. The stakeholders are mostly authorities and are affecting the hazards as well as the solution. They are coordinators, implementers, and funders, and ultimately, decision-makers.

The 2D display of the stakeholders, according to the most important variables, namely if the stakeholder is affecting the NBS and/or affected by the hazard (Figure 7) using a 3 value scale, enables to identify the stakeholder type distribution more easily than the common tree display (Figure 6).

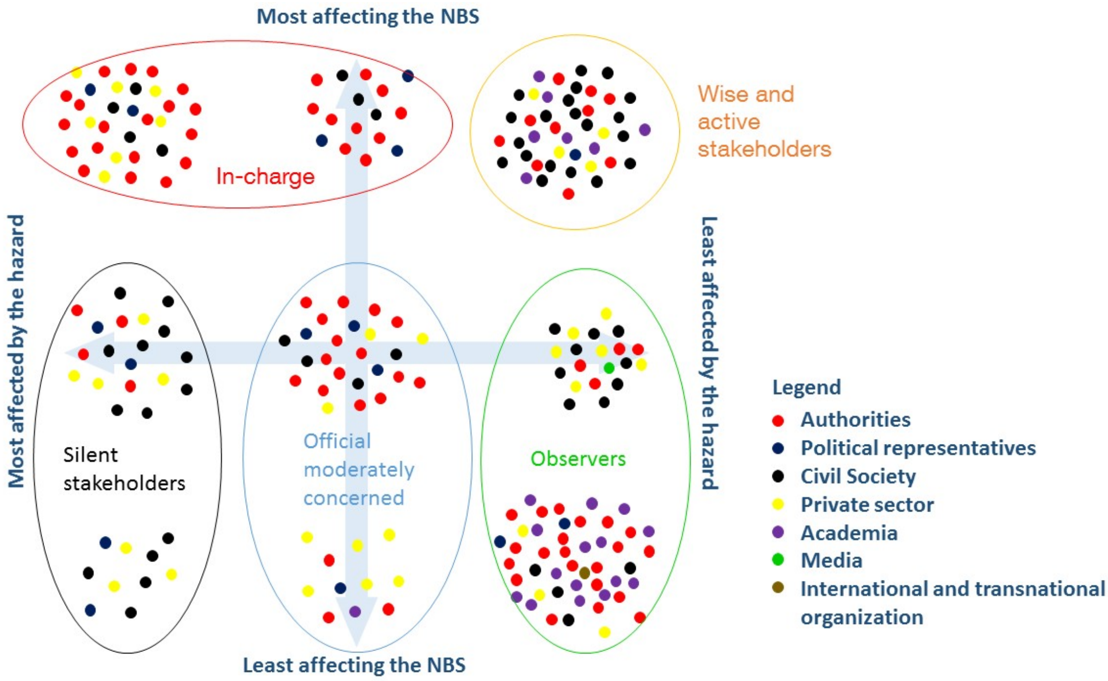

Figure 7. Distribution of the stakeholder using only two of the most significant variables and displaying the type of stakeholder.

4. Discussion

4.1. The Stakeholders Involved in Collaborative Planning of NBS

We first provide an overview of the stakeholders that are identified as either being involved or could be involved in the co-production of NBS. We have found, as mean value, that around 22 stakeholders may be involved in the planning, design, implementation, monitoring and evaluation, and maintenance of an NBS. In our dataset, we have an outlier with the SRB that engages 52 stakeholders. While some investigated cases are at an early stage and the stakeholder list could be seen more like a wish-list than an effective list of stakeholders actively participating in the planning of the NBS, other cases like the SRB case are ongoing projects with a participative approach that started years ago. The high number of stakeholders involved can be explained by the large-scale of the solution designed and by the nature of the SRB case, which addresses both measures at water bodies as well as changes in agricultural land-use practices. According to a previous study on stakeholder constellation analysis [19], we have found that the mean number of participants can serve only as an orientation for recruiting stakeholders for a co-creation process. While the quantity of stakeholders to be involved is of importance, it seems more relevant to involve the "right" stakeholders. Our results also show that all stakeholder roles are represented in all of the 16 case study sites. The literature highlights the value of the coordinator to trigger the collaborative process [21,22]. We have found that for the design, implementation, and monitoring phases of NBS, the role of the coordinator is mostly attributed to the stakeholder groups "public authorities" as staff of planning or water agencies. Literature provides descriptions of the "best coordinator", but interestingly do not consider the institutional background of that person or organization, but rather focuses on the coordinator's social competences [48–50]. Our results have highlighted that in practice, coordinators are decision-makers. This result is in line with the theoretical identification of the coordinator made by Ståhlbröst, et al. [51] and Leminen, et al. [52]. They mentioned that the coordinator should have enough legitimacy to ensure the planning and implementation of the design. Consequently, we can recommend for the setting of a new collaborative planning process that the coordinator should be an authority; however, it is not a golden rule. For example, in the Portofino case, the national park office and national research agencies, actors connected to the state, are the drives of implementing the NBS. But these coordinators are no authorities in the sense of having the power to exercise implementation against the will of veto players. In Portofino, the national park authority really took over the umbrella function, like in our definition for the coordinator, and especially convinced many businessmen and house owners who were afraid that the NBS implemented would not reduce the risk from landslides as grey infrastructure had in the past.

Regarding the groups of stakeholders who are involved at different stages of the NBS co-creation, the results show that almost all the stakeholder groups are for each case represented (except media). Interestingly, the number of the members of the civil society participating in the phases of the design, implementation, and monitoring of the NBS is very high, and this stakeholder group is the second most represented. Previous studies have presented the shifting from a top-down to a co-creation or even bottom-up governance model in the last 40 years for sustainability transition [15]. However, previous research has shown that apolitical grassroots initiatives are rare in food, energy, and recycling management [35]. In the cases presented in this study, civil society participation is mostly driven by pragmatic goals, the aspiration to challenge the political regime and strengthen relationships between policy-makers and common people. Further study should investigate civil society's motivation to participate in NBS co-creation to better understand and involve those who may be relevant stakeholders but are not reaching the collaborative planning procedures yet.

It is interesting to find that the role of "knowledge providers" is sourced from all stakeholder groups. This result shows how it might be crucial to have all relevant stakeholders on board to ensure knowledge transfer. This result is in line with an end-user-based co-design approach as the Living Lab approach. The application of the Living Lab theories is supposed to provide a broad spectrum of different knowledge actors and specialist competencies to solve complex issues [50], but do real-life stakeholder constellations reflect theories on the ideal structure of stakeholder participation and co-creation?

4.2. Mapped Stakeholder Constellations and Collaborative Planning Theories

In the 16 cases, we have investigated, a broad spectrum of stakeholders has participated in the planning process. However, the clustering analysis has enabled us to identify five core types of stakeholders that can be labeled as the "stakeholders in charge", the "wise and active stakeholders", the "affected silent stakeholders", the "officials moderately concerned", and the "observers". Different typologies of stakeholders already exist, especially in the sector of technology innovation and marketing, but such a typology has yet to be developed for environmental and social issues. In comparison to other typologies found, the one presented in this paper is inductive, meaning based on the real-life case rather than on theories, and based on facts that do not require psychological analysis, and is in this sense of great potential in terms of usability for stakeholders who intend to initiate a co-creative process. As mentioned before, these are often members of agency staff and are rather chosen for their planning and technical competence rather than social capabilities. However, this method should not replace in-depth analysis of the social profile of the stakeholders, their backgrounds, interest and attitudes towards a project, potential conflicts and coalitions between stakeholders, how they are shaped by power constellation (i.e., access to resources, political influence over the project, intensity of involvement, proximity, and legitimacy, as well as scale of influence) [53]. For example, in the marketing sector, Nystrom, Leminen, Westerlund and Kortelainen [36] identified the social role of actors in the Living Lab. The most important actors mentioned are the following. The "webber" initiates network connections and decides who is contacted or not to participate in a process. The "instigator" tries to influence the decision-making processes of actors. The "gatekeeper" possesses relevant resources or knowledge and can influence decisions by providing them or not. The "advocate" is someone who is spreading positive information. The "entrant" focuses on protecting its perspective by interfering. The "compromiser" tries to balance out to avoid conflicts. Other authors have classified the stakeholder considering their power (high vs. little), their attitude (positive vs. negative), and their interest (high vs. low). In addition, Murray-Webster and Simon [42] suggested three basic but important dimensions to identify stakeholder roles: (1) Power or ability to influence, e.g., position, power over resources, credibility, (2) Interest in the topic or issue, meaning if these play an active or passive part, (3) Positive or negative attitudes towards the project or issue, the extent of supporting or blocking potential work or possible outcomes. The typology is based on three variables, namely stakeholder power, interest, and attitude, and results in eight participant types: "Saviour" (powerful, high interest, positive attitude or influential, active, backer of a process), "Friend" (low power, high interest, positive attitude), "Saboteur" (powerful, high interest, negative attitude), "Irritant" (low power, high interest, negative attitude), "Sleeping Giant" (powerful, low interest, positive attitude), "Acquaintance" (low power, low interest, positive attitude), "Time Bomb" (powerful, low interest, negative attitude or an influential, however, passive blocker), "Trip Wire" (low power, low interest, negative attitude). However, these typologies cannot be applied prior to collaborative planning since crucial parameters to be considered, e.g., the attitude toward the solution, cannot be estimated as long as the solution is not yet identified. These methods are more efficient for ongoing projects as tools for the project manager. Moreover, this concept and terms are judging on stakeholders in an explicit and, also in some cases, potentially negative manner and, therefore, seems unsuitable, especially when performing a stakeholder mapping task in a core circle or leading to the exclusion of stakeholders with assigned undesired characteristics. Furthermore, this classification helps to identify the role of stakeholders in terms of attributes, knowledge, source of information, and roles in the action arena, but they are not specific for natural hazard mitigation. Moreover, they give little information for planning processes, namely where and when actors are needed the most to drive co-planning/co-design processes forward.

The advantage of our inductively-derived classification is that it provides a more in-depth look and a better understanding of the roles in co-designing processes and its different stages. For example, the group "stakeholders in charge" shares many features with the "Saviour" group, though our model also can demonstrate that those pushing and implementing a process most are not lobbyists as implied in the model of Murray-Webster and Simon (2006). Besides, the "silent stakeholder" group draws a very different picture than previous typologies. Instead of being characterized by its attitude, as "friend", "acquaintance", or "irritant", our analysis rather reveals that this group is most affected by the natural hazard or the solution but barely has a voice or being heard in traditional planning processes. A closer look at this group shows that they are mainly the civil society, which includes citizens or businesses threatened by the hazards or, in a few cases, authorities with different responsibilities or local policy-makers on the municipal level with little power to influence decisions made on other levels.

4.3. Systematic Stakeholder Mapping Method to Support Collaborative Planning Initiation

The success of co-design processes is based on strong commitment and sharing of common key interest [20,40,54–57]. Reed [54] observed that, for environmental management projects, the nature of the participatory process is decisive for the quality of the resulting solution. Naumann and Kaphengst [58] suggested the establishment of the stakeholder involvement right from the project's outset as a decisive feature to achieve the integration of local and scientific knowledge. Key success factors, according to these authors, are a systematic representation of relevant stakeholders and the institutionalization of the related participatory processes. Stakeholder mapping can, therefore, support the facilitators of such processes to best include stakeholders. In PHUSICOS, as in RECONECT, the same stakeholder-mapping method has been used to support collaborative planning initiation, but the theory supporting collaborative planning is applied in different ways. The method developed in both projects has already shown positive results, and this method can be refined as a result of the clustering procedure presented in this paper. Such a process is especially relevant for identifying and avoiding the omission of potential veto players.

The PHUSICOS project has applied the concept of Living Lab with the quadruple helix participation model [21]. It demands that different stakeholder groups continuously collaborate to form an innovation network [50] by intertwining their competencies from four sectors—the public organizations, private companies, users (or end-users), and knowledge institutions (academia) consistently. Stakeholder mapping can help to systematically identify participants from all four of these groups. The result of the analysis shows that focusing only on the quadruple helix participation concept, the stakeholders selected to co-create the solution can be only from the type "observer", and they may not have the power to implement the solution. The literature describing this type of Living Lab suggests the identification of a core group of stakeholders, which will participate in the whole process, especially if project goals are ambitious [59]. Reflecting on our results, the groups from the public organization, companies, end-users of a solution, and academia in practice might not be able to contribute equally or drive a co-creative process for all phases of the NBS with the same intensity. Our analysis suggests that throughout the process, stakeholder groups will have varying interests in different stages, providing expertise or being decisive or productive only in certain phases of the co-design process. Depending on the co-design strategies with either approach to work with a core group at certain phases or having a broader inclusive approach, stakeholder mapping helps to determine the actors for the different phases around a core group. If the facilitation of such a process strives for continuous involvement of all actors, the mapping helps to understand varying interests throughout the co-planning, co-design, and co-implementation phase and allows developing strategies to keep actors motivated or involved at all stages.

The project RECONECT follows a theoretical approach of advocating participatory processes, motivated by the norm that this will increase the legitimacy and efficiency of NBS or of transformation to sustainability in general. This approach is called social innovation or co-creation and suggests inclusive, proactive participation all over the project time. Very important is, therefore, to integrate potential powerful veto players early enough. The stakeholder mapping approach might have missed these, very unlikely but theoretically, as in the first step, we interview project partners, involved and ambitious stakeholders, which might not want to point us in the direction of potential barriers to not give us the impression the NBS might be at risk, especially if these stakeholders are silent and not on the radar from the very beginning. Not very likely as well, but we might have missed active and wise stakeholders, but if our partners interviewed are competing with other supporters of NBS, e.g., for specific funding, it might be the case that these other active and wise stakeholders are not mentioned in the mapping round, but will be discovered later on.

Oftentimes, the design and implementation phases of an NBS are not within the frame of a research project. Instead, the stakeholder constellations usually result from windows of opportunities [33] and self-evident stakeholder selection (Reed et al., 2009), which lead to very long initiating processes and significant delays in implementation [34]. Having not the most relevant stakeholders on board or, even worse, missing a crucial stakeholder for the planning and implementation may lead to the intrusion of unexpected veto players, which blocks implementation at the last final step after years of hard work [60]. Systematic methods to identify the relevant stakeholders seem to be crucial to a) enable higher planning efficiency and b) reduce bottlenecks and time needed for planning, deciding, and implementing NBS. Future studies should also focus on the role of policy on the stakeholder constellation to co-create NBS.

5. Conclusions

This study has explored the stakeholder constellation of 16 NBS implemented in Europe. It identifies which stakeholders and stakeholder types are part of the collaborative planning process that leads to NBS co-creation, discusses real-life constellations with theories on the ideal structure of co-creation, and provides a hands-on typology of stakeholders as a systematic stakeholder mapping method to support the initiation of participative planning. The systematic stakeholder mapping, as presented in this contribution, can help explain how different stakeholder groups can be involved in co-planning processes and to have the needed stakeholders on board or ensure the necessary level of involvement throughout the process. Rather than identifying the "right" stakeholders to be on board, the presented stakeholder mapping provides a methodology for encouraging those "in charge" to consider strategically who might be involved at each stage of the co-creation process and which role stakeholder will have. This publication offers preliminary guidance to the local coordinator or initiator or facilitator in the setting-up and steering of their collaborative planning process in order to co-create an innovative solution that will mitigate natural hazards and provide many co-benefits and results from fruitful knowledge exchange.

With the ongoing project and progress, it will be interesting to analyze from a retrospective view how identified stakeholders in reality work, cooperate, involve, and intertwine with each other and if they follow the full lifetime of a co-creation process through all its phases. Further investigations addressing this collaboration can provide insights for concepts for stakeholder involvement and to better design processes and having the right stakeholders on board for NBS co-design tasks.

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