

# PHUSICOS

## According to nature

Deliverable D5.1

### **NBS in-depth case study analysis of the characteristics of successful governance models**

Work Package 5 – Governance Innovation

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Systems Analysis (IIASA)  
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## Summary

PHUSICOS is an Innovation Action project funded by the EU Horizon 2020 research and innovation programme (Grant agreement No. 776681). The main objective of PHUSICOS is to demonstrate that nature-inspired or nature-based solutions (NBS) for reducing natural hazard risk of extreme weather events in rural mountain landscapes are technically viable, cost-effective, and implementable at regional scale. Experience shows, however, that technical viability and cost-effectiveness alone do not ensure the successful realization of NBS. On the contrary, the NBS process will depend critically on the legal, institutional, social, political, and financial conditions—that is, the governance framework—enabling the NBS policy process (Bernardi et al., 2019).

PHUSICOS Work Package 5 addresses governance innovation, where governance goes beyond government to involve a network of state and non-state actors (e.g., business, civil society, expert communities) in the process of deciding on and implementing NBS policy. This deliverable (D5.1) provides a comparative overview of governance frameworks that have enabled the initiation, planning, design and implementation of NBS across three successful NBS cases: i) mitigating flood risk through the restoration of the Isar River in Munich, Germany; ii) halting deforestation and encouraging afforestation as measures to reduce flood/landslide risk in the Wolong Nature Reserve, China; and iii) reducing landslide risk with natural measures in Nocera Inferiore, Italy. All case studies address two main questions:

- How do public authorities and other stakeholders view the success of implemented NBS in terms of their main benefits and co-benefits?
- What pre-existing conditions (external to the project) and new and potentially innovative factors helped enable the NBS?

The methodologies for exploring these questions include i) a literature review (publications, reports, media, web sites, etc.) and ii) targeted open-ended interviews (telephone and face-to-face) with stakeholders.

In each of the three cases, the interviews confirmed the success of the NBS measures and revealed interviewees' views on their benefits in terms not only of disaster risk reduction but of multiple ecological and social-economic co-benefits. Delving into the governance factors that enabled the implementation of the NBS, we distinguish between those factors in place before the NBS initiation (i.e., preconditions) and those that emerged post-initiation. In all cases, funds for disaster risk reduction (DRR) were in place (or promised) by the public authorities at the initiation of the NBS policy process (in the Nocera Inferiore case the budget was insufficient for a grey solution which paved the way for an affordable NBS), meaning our cases focus largely on administrative governance. Market actors were absent in all cases.

Notwithstanding differences in the European and Chinese political systems, as well as differences in the NBS implemented, the governance enablers were in many ways similar. A major flood/landslide event or in the Isar River case smaller events coupled with a model that simulated a major future event, opened a window of opportunity for

already existing environmental groups or supportive state authorities to advocate for a nature-based or hybrid green–blue–grey solution. In all cases political will developed (although to different degrees) in the public administration, reinforced by individuals that championed innovative nature-based policy options. Even in the absence of formal procedures such as an environmental impact assessment, inclusive participatory processes emerged that shaped the outcome toward an NBS or in China toward a more effective incentive system for assuring monitoring of an NBS. Finally, wide-scale stakeholder opposition to grey measures, or in China to a sanction-based enforcement regime, catalyzed the NBS policy process. The cases thus illustrate *governance innovation* in three critical areas:

- *Polycentric governance*: In all cases novel arrangements emerged in the public administration that dispersed decision authority across multiple organizations that included not only flood and landslide protection, but also nature conservation, urban planning, water quality, waste management, tourism, and recreation, among others.
- *NBS co-design*: All cases illustrate novel stakeholder participatory processes that influenced the eventual shape of the NBS. In Nocera Inferiore the process was particularly exemplary in that it coupled stakeholders and experts in the co-design of a compromise solution for risk mitigation that fostered the NBS adoption.
- *Financial incentives*: In the Wolong case, local authorities in unprecedented consultation with villagers designed and implemented novel incentives for households to monitor illegal logging in a nature reserve.

The cases also illustrate the prominence, almost inevitability, of hybrid solutions. Governance involves finding compromises that can resolve the interest and value conflicts underlying the green–grey divide. In the Isar-Plan case the compromise was a hybrid solution that piggy-backed the restoration of the river onto a "hidden" grey flood protection; in China, although there were few overt tradeoffs, the national government combined the large-scale forest conservation NBS in Wolong with grey flood protection measures in lower reaches of the Minjiang, the source branch of the Yangtze river; and in the Nocera Inferiore case the NBS was coupled with a plan for complementary grey infrastructure.

Importantly, the implemented NBS in each case had co-benefits reaching beyond disaster risk reduction (DRR) that added significantly to their rationale, appeal, and eventual adoption. Indeed, a major insight from the case studies is the importance of merging agendas. NBS can contribute to transformative global agendas, including disaster risk reduction as agreed in the 2015 Sendai Framework, as well as climate adaptation (2016 Paris Agreement), biodiversity (European Biodiversity Strategy), and sustainable development (2015 UN Sustainable Development Goals). The transition from grey solutions to NBS is not only in many instances cost-effective and viable, but also necessary and urgent.

The target audience of this deliverable includes:

- PHUSICOS project partners and Living Lab participants and facilitators, who are implementing demonstration or concept cases and exploring governance regimes for upscaling;
- The PHUSICOS Policy-Business Forum (D5.3) which is exploring innovative legal, financial, institutional, and other measures that can accelerate the uptake of NBS;
- National, European, and international administrators who can influence institutional and policy reforms needed for enhancing NBS governance regimes; and
- A broader audience of scientists, policy makers and NBS practitioners.

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## Glossary

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### KEY CONCEPTS, ABBREVIATIONS, AND DEFINITIONS

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**Adaptation:**

An adjustment in ecological, social or economic systems in response to observed or expected changes in climatic stimuli and their effects and impacts in order to alleviate adverse impacts of change or take advantage of new opportunities (Adger et al., 2005)

**Advocacy group (interest/pressure group):**

Formally organized groups outside of the government system yet seeking to exert influence on the function or composition of government and its outputs (adapted from Berry & Wilcox, 2018).

**Co-design, co-creation, co-production:**

Co-design, co-creation or knowledge co-production can be defined as innovation process that involves end-users as “actors” instead of solely “factors” in all phases of the design process, and the actors have genuine influence in the overall design and outcome of the policy process, unlike traditional top-down linear design thinking where end-users may only be responsible for reviewing or giving feedback on the design process (adapted from Voorberg et al., 2014; Evans et al., 2017).

**Co-benefits:**

The various benefits that are (intentionally or unintentionally) provided by an NBS simultaneously over a certain period (Jiang et al., 2016).

**Ecosystem-based Adaptation:**

The use of the range of opportunities for the sustainable management, conservation, and restoration of ecosystems to provide services that enable people to adapt to the impacts of climate change (CBD, 2009:41).

**Ecosystem-based Disaster Risk Reduction (Eco-DRR):**

The sustainable management, conservation, and restoration of ecosystems to reduce disaster risk, with the aim of achieving sustainable and resilient development (Estrella and Saalismaa, 2013:30).

**Ecosystem-based management:**

An approach to maintaining or restoring the composition, structure, function, and delivery of services of natural and modified ecosystems for the goal of achieving sustainability (MEA, 2005).

**Ecosystem Approach:**

A strategy for the integrated management of land, water, and living resources that promotes conservation and sustainable use. An ecosystem approach is based on the application of appropriate scientific methods focused on levels of biological organization, which encompass the essential structure, processes, functions, and interactions among organisms and their environment. It recognizes that humans, with their cultural diversity, are an integral component of many ecosystems (CBD, 2004).

**Ecosystem Services:**

The direct and indirect contributions of ecosystems to human well-being (MEA, 2005).

**Ecosystem Governance:**

Ecosystem governance is an approach that merges different disciplines to explore ways that human can protect the environment and maintain activities in a sustainable manner (IUCN, 2019).

**Environmental governance:**

The set of regulatory processes, mechanisms and organizations through which political actors influence environmental actions and outcomes. Governance is not the same as government. It includes the actions of the state and, in addition encompasses actors such as communities, businesses and NGOs (Lemos and Agrawal, 2006).

**Governance:**

How society or groups within it, including government, businesses, civil society organizations, among others, organize to make policy decisions. The important distinguishing features include i) who has a voice in making decisions, ii) how the decisions are made, and iii) who is accountable. (adapted from Institute on Governance, 2019)

**Green infrastructure:**

A strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services (Baró et al., 2016).

**Living Lab (LL):**

A physical area 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 collaboration for the

creation, prototyping, validating and testing of new technologies, services, products, and systems in real-life contexts (based on Leminen, 2013).

**Natural Capital:**

Natural assets in their role of providing natural resource inputs and environmental services for economic production (OECD, 2005).

**Nature-based solution (NBS):**

Living solutions inspired by, continuously supported by and using nature. They are designed to address various environmental challenges in a resource efficient and adaptable manner and to provide simultaneously economic, social and environmental benefits (EC, 2015:4).

**Polycentric governance:**

A governance system in which multiple governing bodies interact to make and enforce rules within a specific policy arena or location (Biggs et al., 2015)

**Resilience:**

The capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance, responding to or reorganizing in ways that maintain their essential function, identity and structure, while also maintaining the capacity for adaptation, learning and transformation (IPCC, 2014).

**Social justice:**

The fair and equitable distribution of the benefits and costs arising from societal processes amongst all groups in society; this includes inter alia issues of equality between genders, and for ethnic, religious and socio-economic groups (Kretsch & Kelemen, 2016).

**Stakeholder:**

All persons, groups and organizations with an interest or stake in an issue, either because they will be affected, simply interested, or because they may have some influence on its outcome. This includes individual persons, companies, economic, environmental and public advocacy groups, government bodies and experts (Ridder et al., 2005:2).

## 1 Introduction

There is growing recognition that using nature's own attributes can help provide viable and cost-effective solutions to a broad range of societal and environmental challenges (Cohen-Shacham et al., 2016; Maes et al., 2017; Keesstra et al., 2018). Nature-based solutions (NBS) are defined by the European Commission as “actions which are inspired by, supported by or copied from nature (...) to turn environmental, social and economic challenges into innovation opportunities” (European Commission, 2015). NBS seek to provide society with multiple co-benefits, such as ecological resilience, economic growth, and health (Raymond et al., 2017). Only recently emerging as a term on its own right (Eggermont et al., 2015; Davis et al., 2018), NBS was first introduced in the context of climate change mitigation (World Bank, 2008), and has emerged as an umbrella term that covers a variety of ecosystem-related approaches, such as ecosystem-based adaptation and green infrastructure (IUCN, 2019). NBS are increasingly being adopted as complements or alternatives to traditional "hard" or "grey" infrastructure solutions that exclusively involve structural features (Davis & Naumann, 2017; Faivre et al., 2017; Toxopeus & Polzin, 2017; Davies & Laforteza, 2019).

NBS have also emerged as promising strategies for reducing disaster risk (European Commission, 2011; Emilsson et al., 2017; Calliari et al., 2019; Ozment et al., 2019). Among others, NBS have been proposed for mitigating the impacts of coastal floods (Morris et al., 2018), heatwaves (Kabisch et al., 2016), droughts (Kalantari et al., 2018) and landslides (Ozment et al., 2019). This deliverable addresses NBS for reducing flood and landslide risks in or downstream from mountain regions, which are particularly at risk due to their steep topography and resulting fluctuating hydroclimates (Slaymaker, 2010).

Extreme weather events in many mountainous areas impose high risks on human lives as well as infrastructure, goods, and assets (Accastello et al., 2019). The cost of mitigation measures and emergency costs in European alpine countries has been estimated to range between 44 and 216 €/year per capita (Pfurtscheller & Thieken, 2013). This is exacerbated by mass tourism in many mountain regions and the rising intensity and frequency of natural hazards associated with a changing climate (Zimmermann & Keiler, 2015; UNISDR, 2015). While most NBS research and implementation are focused on urban environments (e.g., Kabisch et al., 2016; Raymond et al., 2017; van der Jagt et al., 2017; Davis et al., 2018; Ozment et al., 2019), there is great potential for NBS to reduce the risks of natural disasters in rural mountain areas. Examples of the types of NBS that can be used to minimize risks from extreme weather events in mountain areas are given in table 1.

*Table 1: Examples of NBS that can reduce the risk of extreme weather events in mountain areas*

Extreme weather event	NBS description	Reference
<b>Floods</b>	Peatlands, wet grasslands and other wetlands for water retention	Javaheri & Babbar-Sebens 2014
	Buffer strips and buffering zones to reduce erosion and contain flood water	Jackson et al., 2008
	Widening the riverbed to allow the river to use a larger part of its former floodplain	Rijke et al., 2012
	Riparian forest afforestation and restoration for water retention	Dixon et al., 2016
<b>Drought</b>	Creation of marshes, lakes and floodplains that release water slowly	Wilson et al., 2010
	Rainwater harvesting	Fischborn & Herr, 2015
<b>Landslide</b>	Vegetating slopes (e.g., afforestation) to increase soil retention	Dorren & Schwartz (2016)
	Log terracing to stabilize slopes	ADB, 2016
	Vegetated and stone gabions to retain soil	Vaciago et al., 2011
	Seeding of slopes to increase soil retention	Albaladejo Montoro et al., 2000
<b>Avalanche, Rockfall</b>	Forestation of slopes ('protection forests')	Moos et al., 2018; Brang et al., 2006

PHUSICOS (“According to nature” in Greek), funded by the European Union Horizon 2020 Program, demonstrates how NBS provide robust, sustainable, and cost-effective measures for reducing the risk of extreme weather events in rural mountain landscapes. The project recognizes the importance of meaningful participation of regional, national, and local stakeholders (people who have a “stake” in what is happening in their community, country, or region) for successful implementation and acceptance of NBS, and it thus aims to engage diverse stakeholders through a so-called Living Labs approach. Living Labs are a methodology through which stakeholders are involved in the creation, prototyping, validating, and testing of new technologies, services or products in real-life contexts (Almirall et al., 2012; Leminen, 2013). Work Package 5 (WP5; Governance innovation) is dedicated to exploring policy instruments to enhance the effectiveness of the design and implementation of NBS.

Understanding the factors that have characterized successful NBS governance models is essential for advancing policy instruments and institutional reform that can better enable NBS implementation and up-scaling. Despite this, research on the enablers of and opportunities for NBS implementation is sparse, with studies and reports primarily focusing on urban NBS (e.g., Raymond et al., 2017; Ershad Sarabi et al., 2019; Somarakis et al., 2019), their barriers (e.g., Schmalzbauer et al., 2018) or their potential for climate change adaptation (e.g., Kabisch et al., 2017; Kuban et al., 2018). Additionally, governance criteria are underrepresented in NBS assessment frameworks (Sekulova & Anguelovski, 2017), and little research has been conducted on the factors required for successful NBS design and implementation for DRR in mountain areas (Accastello et al., 2019).

In this deliverable, we describe and compare the institutional, legal, social, and economic factors—in short, governance frameworks—for initiating, planning, designing, and implementing NBS in three selected case studies (Fig. 1):

- i) Flood risk on the Isar River in Munich, Germany (Isar-Plan case);
- ii) Flood and landslide risk in Wolong National Nature Reserve, China (Wolong case); and
- iii) Landslide risk in Nocera Inferiore, Italy (Nocera Inferiore case).

The case studies were chosen because of their widely acknowledged success in implementing NBS and, more specifically, their governance innovation in three critical areas: public administration and stakeholder involvement (Isar-Plan), co-design of NBS policy options (Nocera Inferiore), and financial incentives for enabling NBS (Wolong). Importantly, the NBS implemented in each case had substantial co-benefits reaching beyond disaster risk reduction (DRR) that added significantly to their rationale, appeal, and eventual realization.

Table 2 provides a brief description of the case studies.

*Table 2: Selected characteristics of the case studies*

Case study	Isar-Plan (2000-2011)	Wolong National Nature Reserve (2000-present)	Nocera Inferior (2015-2019)
Location	Munich, Germany	Sichuan Province, China	Campania, Italy
Main reason for NBS implementation	Flood protection	Flood and landslide protection	Landslide protection
Main co-benefits	Ecological restoration, recreation	Biodiversity conservation, socio- economic development	Recreation, environmental awareness
Approximate Cost	€35 million	€1 million/year (2019)	€637,000
Main implemented NBS	Widening of riverbed (room for the river)	Forest conservation and afforestation	Natural remediation measures (e.g., gabions)



*Figure 1: The three selected case studies (Sources: Pin by Yo! Baba from the Noun Project; Illustration 107207656 © Miceking—Dreamstime.com, Design: Juliette Martin.)*

In each case study, we begin with an exploration of the literature and stakeholder views on the success of the NBS measures in terms of their DRR benefits and co-benefits. We then turn to examining the factors that led to their successful implementation. Recognizing the problems of generalizing from only three case studies with different socio-political contexts, and the difficulties in transplanting practices from one country to another, our aim is not to provide a recipe for realizing NBS across the world, but to draw lessons that can provide insights for designing or reforming governance institutions and procedures that better enable NBS. This report also intends to inform and enhance NBS implementation within PHUSICOS' demonstrator and concept sites (Work Package 2 - Case study sites). While recognizing the importance of considering barriers to NBS implementation when assessing enablers, the enabling factors of NBS design and implementation and barriers to them will form the subject of a more in-depth analysis in T5.2 (Scoping study of opportunities and barriers to NBS). Additionally, barriers were not addressed in detail in this report as the included case studies represent success stories of NBS realization. As such, they exhibit no unsurmountable 'barriers', rather challenges, limitations and hurdles, which are briefly discussed in sections 3.6.3, 4.6.3 and 5.7.

## 2 Concepts and methods

In this report, concepts and methods are based on the European Commission’s (2015:4) definition of NBS (“living solutions inspired by, continuously supported by and using nature”). As shown in figure 2, this definition implies a continuum of grey-green infrastructure elements that define NBS. Green and grey infrastructure elements are often combined to form hybrids, as is the case with many existing structural measures that are subsequently greened (e.g. rooftop gardens) (Naylor et al., 2017; Fig. 2). Accordingly, NBS include different degrees of engineering – from grey-green solutions, which incorporate green elements into grey infrastructure, to prompted recovery, where natural processes are restored. Hybrids, which combine both natural and manmade infrastructure elements, are thus encompassed in this definition.

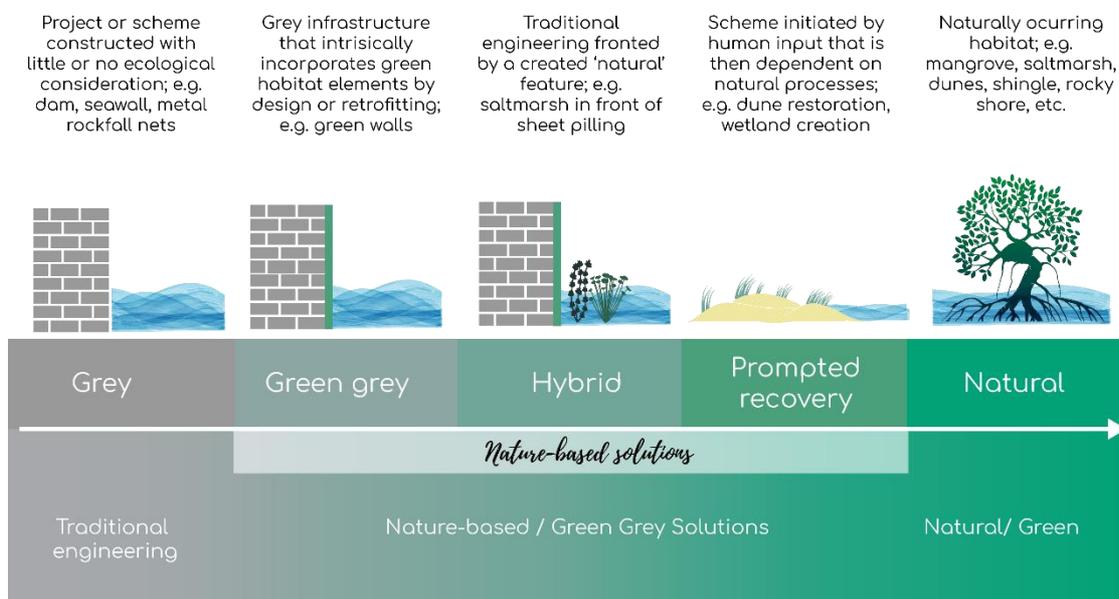


Figure 2: The grey-green continuum of grey to green infrastructure approaches (Adapted from: Naylor et al., 2017; Sources: Mangrove by ruliani, wall by AlyaNafisa dunes by Daan, sea plant by Agne Alesiute, Seaweed by Vladimir Belochkin from the Noun Project; Design: Juliette Martin)

To identify successful governance models for NBS, a first step of this analysis was to identify the different (subjective) interpretations of ‘success’ in each case study. Thus, as shown in figure 3, we differentiate between NBS governance **enablers** and NBS **benefits and co-benefits**.

For each case study, two main research questions are addressed:

- How do public authorities and other stakeholders view the success of implemented NBS in terms of their main benefits and co-benefits?
- What pre-existing conditions (external to the project) and new and potentially innovative factors helped enable the NBS?

Enablers are factors that play a positive role in the eventual implementation of the NBS at different stages of the policy process:

- i) preconditions that are in place before the project is initiated and are thus external to the NBS project; and
- ii) factors that emerge after the project is on the political agenda until the project completion.

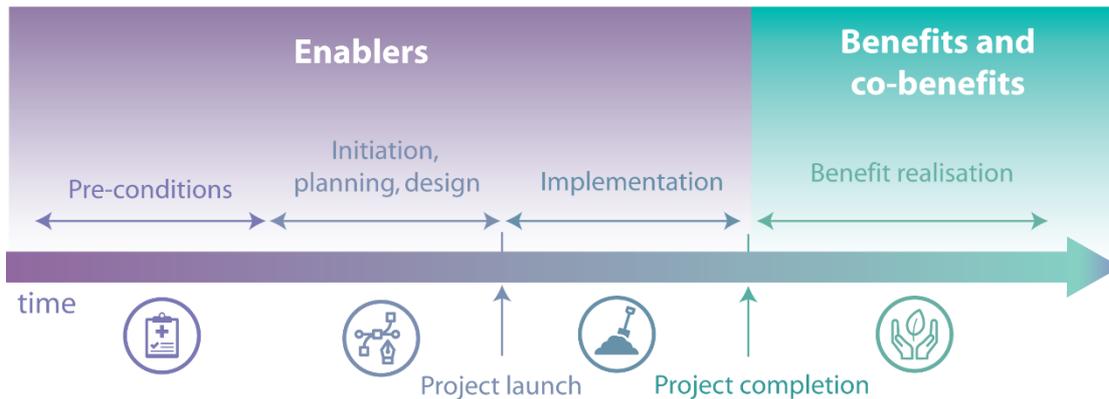


Figure 3: The NBS lifecycle (based on Kerzner, 2014; Toxopeus & Polzin, 2017. Sources: Icons by sahua d, Adrien Coquet and Line Icons Pro from the Noun Project, Design: Juliette Martin)

While recognizing that NBS are also enabled by bio-physical and environmental factors, these are outside the scope of PHUSICOS WP5 and form the basis of WP4 (focused on technical innovation and on the development of a framework to evaluate and verify NBS performance through indicators). We therefore focus our analysis on governance enablers - that is, on the contextual pre-conditions, policy processes and institutions that proved helpful or even essential for the initiation, planning, design and implementation of the NBS. To document stakeholder views on NBS enablers, the typology shown in figure 4 was developed based on existing work on governance and/or NBS indicators (Kabisch et al., 2016; Raymond et al., 2017; Baha et al., 2018; Huthoff et al., 2018; Schmalzbauer, 2018; Somarakis et al., 2019). Table 3 provides the definitions used for these different categories, although depending on the case-specific findings, enabler categories were merged where appropriate. The identification of benefits and co-benefits, also illustrated in figure 4, was based on the ambits developed under PHUSICOS D4.1 (Autuori et al., 2019).

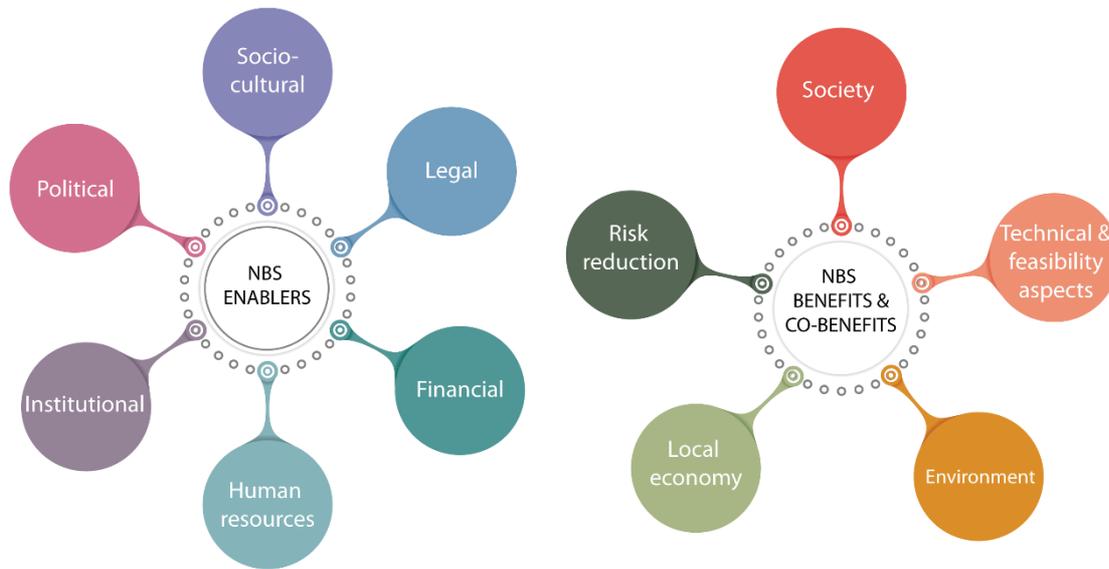


Figure 4: The typologies used to classify enablers (left) and benefits and co-benefits (right) of the case studies

Table 3: Definitions and examples of the typology used for NBS enablers

Enabler category	Definition	Examples
Political	Factors relating to the political landscape in which the NBS was implemented.	Local champion
Socio-cultural	Factors relating to the diverse customs, values, worldviews and social behaviors of a society.	Interests/pressure groups
Financial	Factors relating to trade, industry and finances.	Favorable funding conditions
Human resources	Factors relating to human expertise and knowledge.	Expert knowledge and expertise
Institutional	The internal and structural attributes of a particular organization or group.	Cross-sectoral collaboration
Legal	Factors relating to rules, laws, policies and their frameworks.	Existing legal basis

The case studies report on NBS enablers and NBS benefits and co-benefits as elicited with semi-structured stakeholder interviews as well as from peer-reviewed and grey literature, documentaries, and legal documents. The experience of PHUSICOS project partners and demonstrator sites has further informed this research. The case-specific research methodologies are described in further detail in sections 3.2, 4.2 and 5.2.

### **3 Green is the new grey on Munich's Isar River - Innovative nature-based solutions boost ambitious flood protection scheme**

#### **3.1 Case-study overview**

Munich's Isar River, which rises in the Austrian Alps, has often been described as a "lifeline" for Munich's cultural heritage, identity, and urban recreation (Kropp, 2000; Bäumler, 2018b). Only two decades ago, however, the Isar was contained within a narrow concrete "corset," having been channelized in the 18<sup>th</sup> century to facilitate its hydropower exploitation. This case study reports on the restoration of the Isar in 2000–2011 (referred to as the Isar-Plan project), during which an 8 km long stretch of the Isar in Munich was "re-naturalized" using nature-based solutions (NBS). The measures implemented included the widening and deepening of the riverbed, the addition of natural material to reduce the river's flow speed and enhance the quality and connectivity of fish habitats, and the reinforcement of existing levees to preserve vegetation and fulfill the water authorities' main goal of protecting Munich from extreme floods. With the entry of environmental and residential stakeholders, the aims of the project became threefold: environmental restoration, recreation and most importantly, flood protection. Thus, while flood protection is generally viewed as the principal benefit of the project and also as the rationale for financing the approximately €35 million cost of the Isar-Plan, its co-benefits—ecological restoration and recreation—are also widely portrayed and perceived as being important contributors to the project's overall success.

This study identifies the key governance factors that enabled the restoration of the Munich stretch of the Isar making use of both nature-based and grey measures. The analysis is based on a review of the grey and published literature, combined with extensive face-to-face and telephone interviews with the responsible authorities, environmental groups, residents and other actors throughout the 15-year Isar-Plan process. The Isar-Plan process offers many lessons for enabling NBS. Our results show how important strong advocacy groups and innovative governmental approaches were for designing and realizing the ambitious Isar-Plan. Indeed, the Isar-Plan was a pioneer in terms of its participatory approach, actively engaging environmental NGOs, residents, and other stakeholders in the co-design and implementation of NBS. Furthermore, being jointly implemented by the State of Bavaria and the City of Munich, the Isar-Plan demonstrated unprecedented multi-scale and cross-sectoral collaboration. Although stakeholders were for the most part united in their overall vision for the Isar, the transformation was enabled by creating space for expert and stakeholder deliberations and "clumsy" compromises—sometimes called the Isar Living Lab (LL).

This case study is organized as follows: first, the history and context of the Isar-Plan are reported, and the stakeholder landscape is then depicted. Secondly, the perceived benefits and co-benefits of the Isar-Plan are described. Thirdly, an analysis of the different enablers according to the project's key stakeholders, is carried out. This is

followed by a discussion of the perceived challenges and limitations involved in the project. The case study concludes with the key "lessons learned" on governance models for designing, financing, and implementing NBS.

## 3.2 Research design

In this case study analysis, two main research questions are addressed:

- How do Isar-Plan authorities and stakeholders view the success of the implemented NBS in terms of their main benefits and co-benefits?
- What pre-existing conditions (external to the project) and new and potentially innovative factors helped enable the Isar-Plan?

The case study describes the distinct and sometimes opposing stakeholder views of success of the Isar-Plan, both in terms of enablers of NBS (i.e. key catalysts throughout the entire cycle of the implemented measures) and its benefits and co-benefits.

The research methodologies included a review of peer-reviewed and grey literature, documentaries, and legal documents. To gather expert input on the Isar case study, e-mail correspondence and semi-structured interviews were carried out with key stakeholders (N=15) (see Appendix A for the interview protocol). As the initiation of the Isar-Plan dates back to the 1980s, the number of stakeholder interviews was limited, as many of the stakeholders have retired or moved on. Only stakeholders who were involved in most or the full duration of the Isar-Plan (roughly 1995–2011) were selected for interviews. While small sample sizes do not allow for statistical analyses, they help foster close associations with respondents and provide information on social contexts and worldviews (Crouch & McKenzie, 2006). Nevertheless, all the main stakeholder groups, as identified by DÜchs (2014), were represented in the sampling. Interviewees were identified through expert consultation and snowball sampling (Birnacki & Waldor, 1981). Interviews were transcribed using naturalized transcription and analyzed using NVivo version 12.4.0. A quantitative content analysis of the interview transcripts was performed to assign codes to ideas that emerged from the transcribed text (Corbin & Strauss, 2015), and aggregated into clusters. In order to identify participants while preserving their confidentiality, each interviewee in this report was assigned a number (e.g., Interviewee 1, 2, etc.). The socio-demographics of the interview participants are summarized in Appendix B.

## 3.3 The Isar restoration in Munich: Context and history

### 3.3.1 The Isar River: Geographical characteristics

The Isar is a 295 km long river originating in the Austrian northern limestone Alps and joining the Danube in Bavaria, Germany, after flowing through Munich (Böhm &

Wetzel, 2006). This alpine river is characterized by braided streams, mobile gravel bars, and extreme hydrologic regimes dominated by orographic rainfall (Böhm & Wetzel, 2006) (Fig. 5). Due to the resulting large and varying river discharge, the Isar is subject to frequent floods. During one of the most important Isar floods in 1899, several bridges in Munich collapsed (Böhm & Wetzel, 2006).



*Figure 5: Left: Aerial view of the Isar flowing to the Sylvenstein Lake near Garmisch Partenkirchen (Source: Illustration 99124083 © Vladvitek - Dreamstime.com) Right: Aerial view of the Isar between the Sylvenstein reservoir and Vorderriß (ca. 80 km south of Munich), showing the river's alpine character (Photo by: Franz Speer, 1996)*

The Isar played a central role in the foundation of Munich as a city in the 12<sup>th</sup> century and its economic development; human modifications to the river date back to medieval times (Requena et al., 2017). With the urban expansion of Munich starting from the 18<sup>th</sup> century, however, major alterations were made to "tame" the Isar by straightening and channelizing it (Requena et al., 2017). Weirs and dams were also constructed once the hydropower industry started to expand (Winiwarter, 2016), with the most important morphological modifications occurring in the 20<sup>th</sup> century (Scheuermann, 1998). Until then, the Isar was still largely considered a wild alpine river with hardly any built-up riverbanks (Binder, 2010) (Fig. 6).

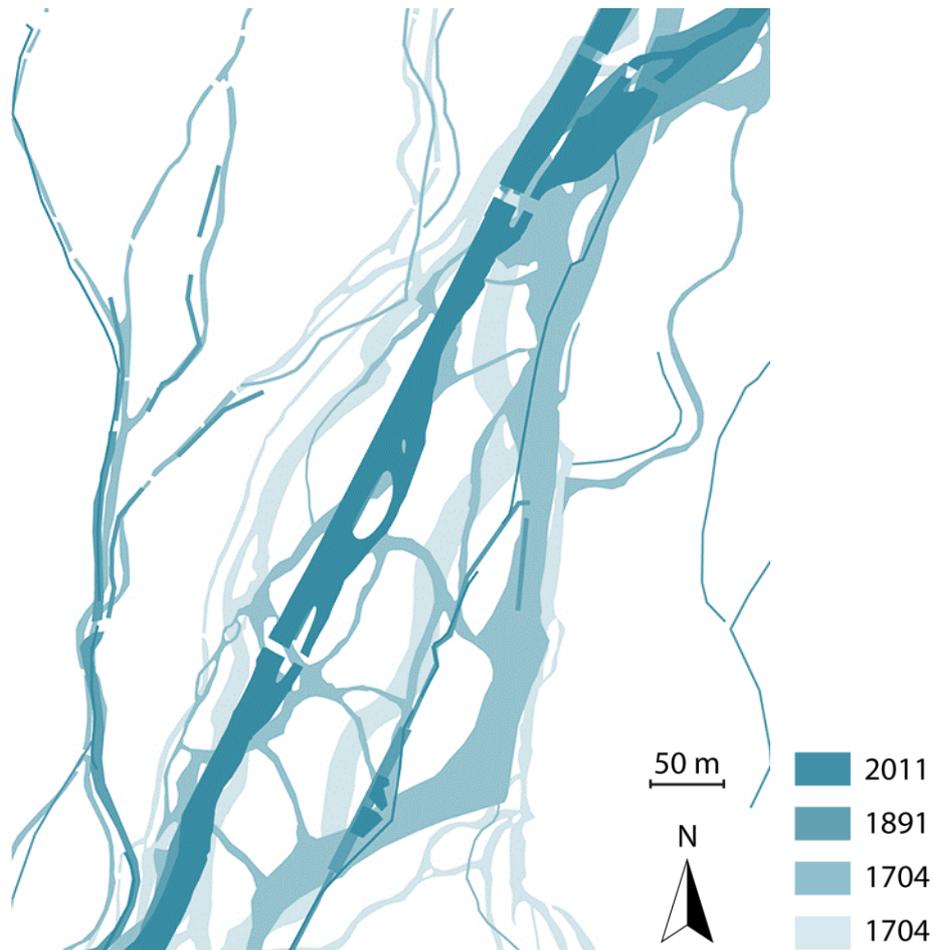


Figure 6: The Isar’s course in Munich in 1704, 1808, 1891, and 2011 (from light to dark blue) after completion of the Isar-Plan (Adapted from: Rossano, 2016)

Coupled with the city’s industrial growth and geographic expansion, these modifications resulted in the degradation of riverine habitats (Döring & Jochum, 2006), a decrease in its recreational potential and, most importantly, insufficient flood protection for Munich at the end of the 20<sup>th</sup> century (Wasserwirtschaftsamt München and Landeshauptstadt München, 2011).

### 3.3.2 The Isar-Plan context and storyline

Although plans for the restoration of the Isar date back to the 1960s (Grüne Liga, 2016), with a first expert colloquium organized in 1978 to discuss the Isar re-landscaping (Düchs, 2017), the Isar-Plan project was first initiated in 1995 and implemented in 2000–2011 (Landeshauptstadt München et al., 2012). The focus of the Isar-Plan was an 8 km long stretch of the Isar within and to the south of Munich City, from the Grosshesseloher Bridge to the Cornelius Bridge in the center of Munich. A far cry from the recreational oasis it now represents (Fig. 7), prior to the Isar-Plan, the river was often described as a ‘sewer trickle’ in Munich (Bäumler, 2019).



Figure 7: Crowds gathering along the Isar in Munich during summer 2015 (Source: Illustration 56419303 © Glacyer - Dreamstime.com)

The project was headed by Munich's Water Agency (*Wasserwirtschaftsamt München*) in collaboration with the city of Munich's Construction- (*Baureferat*), Planning- (*Planungsreferat*) and Health and Environment Divisions (*Referat für Gesundheit und Umwelt*) (Landeshauptstadt München et al., 2012). The Isar-Plan project was jointly funded by the State of Bavaria and the City of Munich, covering 55% and 45%, respectively, of the total cost of around €35 million (Wasserwirtschaftsamt München and Landeshauptstadt München, 2011). Although the budget was originally targeted only at flood control, with the entrance of environmental groups and other stakeholders, the original aims of the Isar-Plan project evolved to include:

- Flood protection;
- Enhancing the river's ecological status through restoration; and
- Improving its recreational use (Wulf & Schaufuss, 2013).

Figure 8 shows the Isar-Plan timeline of main events, starting from the construction of the Sylvenstein reservoir in 1959 to the completion of the river restoration project in 2011.

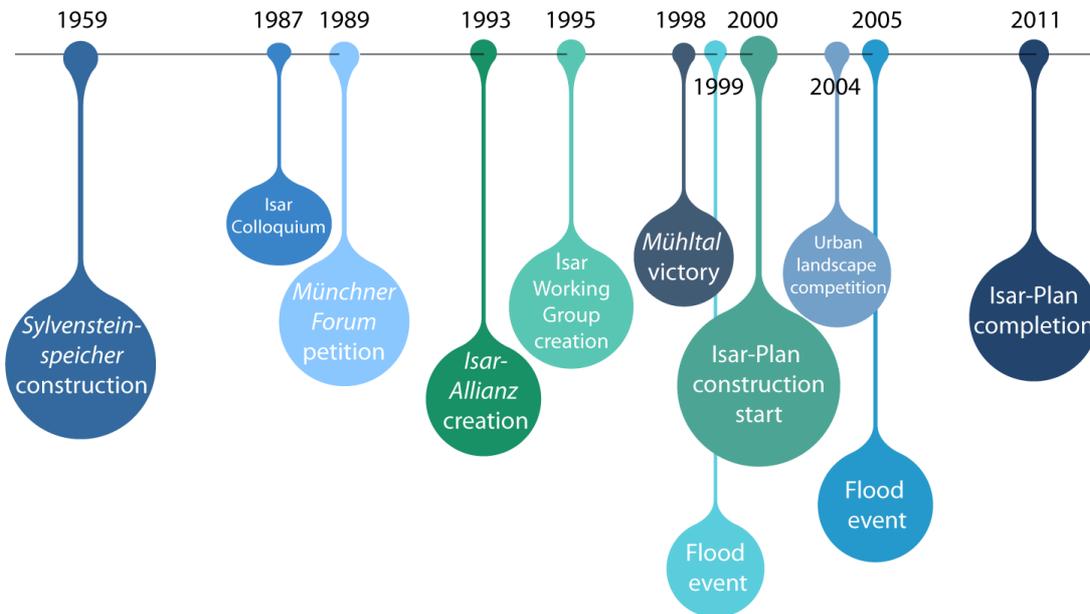


Figure 8: Timeline of the Isar-Plan and related key events

In the 1970s the idea of a restored wild Isar was introduced (Bäumler, 2019) as part and parcel of Munich’s environmental movement, with citizen and environmental groups alike lobbying for the conservation of green spaces in and around Munich (Interviewees 4, 5). A crucial event was a petition launched by a local citizen association, the *Münchner Forum*, in 1989, which consulted 10,000 residents on their ideal vision for the Isar in the future (Bäumler, 2019). Results showed that the *Flaucher* area of Munich (Fig. 9) combined many of the traits that citizens associated with a more pristine and wilder riverine habitat, including alternating pools and shallows, rapids and gravel banks. This remained the common reference point and vision of the Isar-Plan for the entire project.



Figure 9: The Flaucher area in Munich, used as a baseline reference for the NBS measures implemented through the Isar-Plan (Photo by: Juliette Martin, March 2019)

In the early 1990s an important event that catapulted the river restoration onto the political agenda was the end of the concession for the *Mühlthal* hydropower plant south of Munich, to which most of the Isar's water was being diverted (Düchs, 2014). The renewal process of the concession was used as an opportunity by environmental groups, which rallied under the *Initiative Mühlthal*, to demand a higher discharge for the Isar, synonymous with higher ecological quality. Their voices were heard, and the Isar's residual water was increased in 1998 (Sartori, 2012). Members of the *Initiative Mühlthal*, or *Mühlthal* Group, created the *Isar Allianz* in 1993, a coalition group which brought together the major environmental NGOs in and around Munich.

Probably the most important factor at the very root of the Isar-Plan project was a model developed in the 1990s that showed Munich to be at risk of floods. Munich's flood protection did not conform with European standards (Wasserwirtschaftsamt München and Landeshauptstadt München, 2011). Although Munich had not experienced major floods at that time (Sartori, 2010), hydrological models run by Munich's Water Agency (*Wasserwirtschaftsamt München*) showed that the city was at risk from a 100-year flood event (Interviewees 1, 2, 4, 10, 12) despite the construction of the *Sylvenstein* Reservoir south of Munich, which had significantly reduced the risk of flooding in Munich. The Munich Water Agency's budget for flood protection, renewed every 10–15 years (Interviewee 4), was available to fix this issue, yet the question still remained as to how this would be done.

To help answer this question, a multidisciplinary Working Group (the Isar-Plan Working Group) with representatives from the Munich Water Agency and relevant city divisions

was created in 1995. This Working Group, which was set up by young, forward-thinking members of the Water Agency, played an essential role in catalyzing change from within the administration. This Group embraced the idea that flood protection can be achieved in different ways, including through NBS.

The Isar-Plan was unique in its participatory approach, integrating stakeholder views in all major stretches of the project through ad hoc meetings, public talks, and round tables organized by the Working Group and consultations between citizen associations. Despite all stakeholders agreeing on the project's three main aims, their prioritization differed due to the various and sometimes conflicting demands of different stakeholders—the “how” and “where” were extensively discussed, for example, to decide which NBS should be implemented where. However, the stakeholders did agree on a common vision of a more pristine (“*naturnahe*”) Isar. Stakeholders' varying views will be further discussed in the next section.

In 2004, to decide on the design for the last urban stretch of the Isar-Plan before Museum Island, a landscape architecture competition was launched (Sartori, 2010). The winner of the first prize envisaged an urban design with straight lines, but this faced heavy criticism from the public. The public favored the second-prize winner, who proposed curving lines and river islets, and was thus considered to be more “nature-based.” A compromise solution integrating both designs was eventually adopted.

### 3.3.3 Overview of the implemented measures

The combination of measures implemented along the Isar in Munich varied from section to section of the river stretch. The main measures implemented included (Fig.s 10, 11):

- The excavation and widening the riverbed from 50 m up to 90 m;
- The removal of concrete steps in the river, which obstructed the upstream movement of aquatic species;
- The restructuring of riverbanks which were flattened and graveled;
- The reinforcement of existing levees using concrete inserts (“mixed-in-place” method), allowing trees on the riverbanks to remain standing (used over approximately 2 km of the entire Isar-Plan stretch);
- In areas with reduced levee safety, new levees were filled in front of the old ones (air-side);
- The planting of indigenous plants on riverbanks, some of them transferred from neighboring conservation areas;
- The addition of boulders, for example, providing a “fish ladder” that created stepping stones and corridors for fish and resting places for juvenile fish; and
- The addition of driftwood to create biodiversity refugia (Wulf & Schaufuss, 2013).

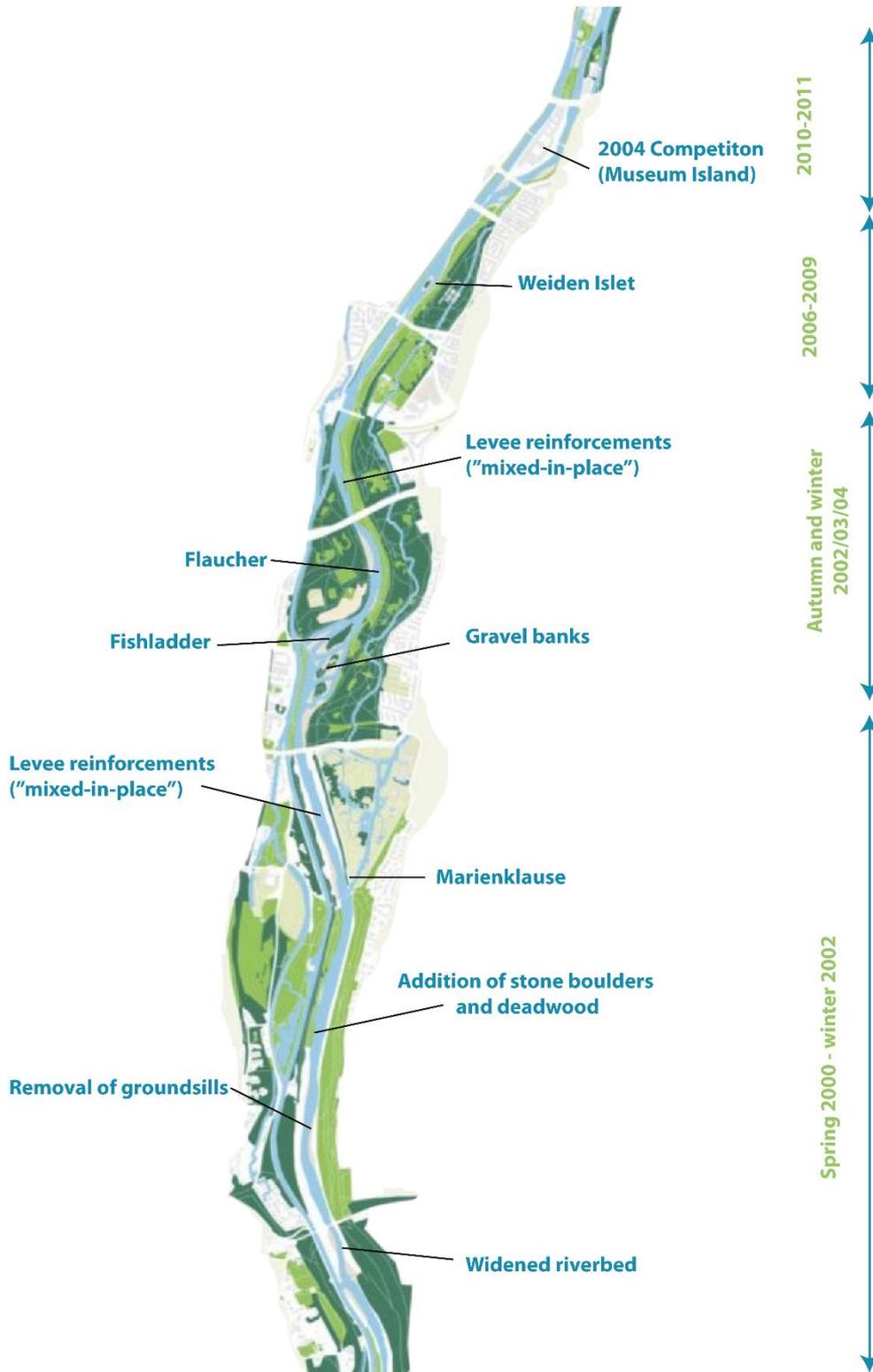


Figure 10: Map of the Isar-Plan and its main features, sections, and implemented NBS (approximate locations) (Adapted from: Wasserwirtschaftsamt München and Landeshauptstadt München, 2011; Requena et al., 201. Design: Juliette Martin)



*Figure 11: The Isar before (2001) and after (2004) the Isar-Plan implementation at the Brudermühl bridge (Source: Mahida, 2012)*

### 3.4 Stakeholder landscape and positions

We identified five clusters of stakeholders involved in the Isar-Plan: the City of Munich and its associated divisions, the State of Bavaria, citizens, environmental groups, and experts (Fig. 12). Together, these include the ‘quadruple helix’ of stakeholder groups (the private sector, public sector, civil society and expert community/academia) characterizing living labs (Fohlmeister et al., 2018). These clusters are based primarily on legal and administrative boundaries. Clusters based on how stakeholders frame and prioritize the issues—or their worldviews—are explored below.

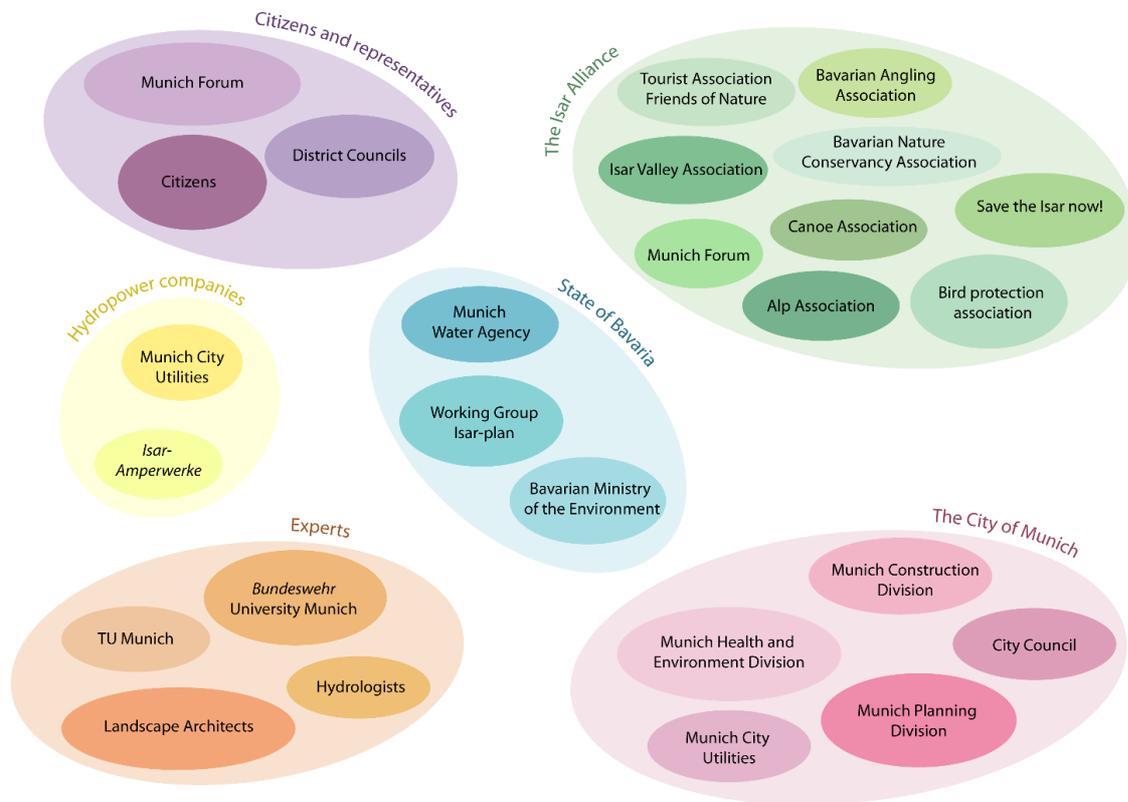


Figure 12: The main stakeholder clusters and their representatives involved in the Isar-Plan project: State of Bavaria, City of Munich, citizens and representatives, hydropower companies, Isar Alliance and experts (Design: Juliette Martin)

### 3.4.1 State of Bavaria

In Germany, the states have primary responsibility for river management and flood control. The Munich Water Agency is a Bavarian state authority that is responsible for so-called type I rivers (classified by their size) such as the Isar (Bayerische Staatskanzlei, 2010). The Agency describes its current goals as follows:

*To protect water as a component of the natural environment and as a habitat for animals and plants; to allow people to use water responsibly; to protect people from the dangers of water (Source: Bayerisches Staatsministerium für Umwelt und Verbraucherschutz, n.d.; translated by the author)*

Flood protection is one of the Agency’s key mandates, and in the Isar case, the Agency controlled the budget for what began as a project to reduce the risk of flood to Munich. The Water Agency’s position was clear: as models had shown that Munich was at risk of a 100-year flood event, it was their responsibility to protect the city and its inhabitants (Interviewee 2). In the words of an interviewee from the Munich Water Agency:

*The main reason [for the initiation of the Isar-Plan] was flood protection of the City of Munich. We had checked the [current] flood protection, taking into account the Sylvenstein reservoir. The results showed that the existing protection was not sufficient south of Munich (Munich Water Agency; translated by the author, clarification added)*

When the Isar-Plan was drafted and implemented, the Water Agency's primary concern thus remained the city's flood protection. Indeed, the Agency did not compromise on its mission to provide Munich with protection against a 100-year flood, although it did recognize that nature-based or "green" solutions could effectively complement the grey infrastructure that was also needed.

*I think the most important aspect was that the responsible actors realized that there is a new form of flood protection, which also consists of restoring nature (Isar-Plan journalist and author; translated by the author)*

While the project's co-benefits in terms of esthetics, ecology, and recreation were welcomed as an addition, they were not seen as essential aims of the project, but rather as attractive collaterals (Interviewees 2 and 3). Ironically, however, the co-benefits were considered by many as the most important factors for the success of the project. This might be explained by the fact that flood protection became a less visible outcome, as some of the structural measures were buried underground (Binder, 2010).

To facilitate the project's smooth progress, based on a 1987 City Council resolution taken at an expert colloquium, the Water Agency also created the Isar-Plan Working Group (henceforth, Working Group), consisting of permanent representatives from relevant public institutions (including selected divisions of the City of Munich) and guests that were brought in from relevant areas of expertise (such as ecologists, hydrologists, and engineers) (Landeshauptstadt München et al., 2012).

### 3.4.2 City of Munich

Munich's municipal government was represented in the Isar restoration by three administrative divisions: the Planning, Construction, and former Health and Environment divisions. Like the Munich Water Authority, the City's main interest was flood protection, closely followed by the wish to create a recreational area within an urban context (Interviewees 1, 8, 9).

*There were two elements that played a role: there was a win-win situation. The first element was the interest of many residents in Munich, and therefore of the City council, the administration, and the district councils, to design the Isar in a way that is closer to nature and makes it accessible to people. The second element, which was the State's and Water Agency's main interest, was probably to increase flood protection (City of Munich Planning Division; translated by the author)*

The City also bore the responsibility for the failure or success of the implemented NBS, meaning that in the case of an accident caused by the implemented measures, the City was liable (Interviewees 9, 10).

*Of course, the keyword "responsibility" is very important. In the end, this is what we always had to fight for, among other things, with our partners. We constantly had to debate how much freedom we could give the river, and how much safety is needed (Munich Water Agency; translated by the author)*

Through its different divisions, the City of Munich brought extensive expertise in urban planning to the table, which was widely appreciated by the more technically oriented Water Agency (Interviewees 10, 12). Likely influenced by the political climate at the time, the City emphasized the environmental aspect of the Isar-Plan rather than its flood protection measures, which although less visible to the public became more prominent after the floods that took place from 2002 onwards (Interviewee 8).

### 3.4.3 Residents and their representatives

Citizens were represented through various stakeholder groups, including the Munich Forum (*Münchner Forum*) and councils from all the districts (*Bezirksausschüsse*) bordering the Isar in Munich, such as the *Isarvorstadt-Ludwigsvorstadt*. The *Münchner Forum* involves citizens in city matters and thus worked closely with these district councils. While views on the Isar-Plan changed over time, it seems that the very initial reaction to the project by residents living along the river was opposition to the proposed changes and potential construction noise (Landeshauptstadt München et al., 2012; Interviewees 2 and 7). Once the first section of the Isar-Plan was completed and covered in springtime vegetation, public opinion of the project shifted from mild opposition to strong support (Landeshauptstadt München et al., 2012).

Before the Isar-Plan, the river was less accessible to Munich's inhabitants and partially unsafe for swimming due to the high concrete banks within which it was confined (Interviewees 1, 2). Once the first results of the project became apparent, this view quickly shifted, intensifying the public demand to make the Isar accessible to Munich's residents (Interviewees 4, 6, 7).

*There was an increasing demand [from the public] to be able to use and enjoy the Isar more (Isar Alliance; translated by the author).*

Although not captured in official documents, a grey alternative to the Isar-Plan was briefly envisaged that included raising the existing levees; this would have been quicker and less costly to implement (Landeshauptstadt München et al., 2012). This plan was, however, quickly abandoned when potential public opposition became clear. Calls for a more sustainable solution were too strong to ignore, and it was recognized

that trying to do so would lead to the project failing (Interviewee 2). Environmental movements were already gaining traction when the Isar-Plan was first proposed. The citizen groups already in existence could exploit this open window of opportunity by demanding a solution that would allow public access to the river within the city and, incidentally, be more environmentally friendly (Bäumler, 2019; Interviewees 4, 5). Thus, the recreational use of the river within the city was a major request, sometimes voiced as demands for a green solution. As a member of the influential Munich Forum put it:

*In this area, the Isar is a lifeline. It has a central role. Therefore, it was society's duty to bring it to life again (Münchner Forum; translated by the author).*

#### 3.4.4 Isar Alliance

As an ecological corridor for alpine fauna and flora species, the Isar and its riparian zone host many protected areas, including over 100 km<sup>2</sup> of Natura 200 sites (Rehklau et al., 2017). The presence of the City of Munich disrupts the connectivity of these sites and their habitats, including fish migration (Binder, 2010). Nature-interested NGOs, rallying under the Isar Alliance, saw the Isar-Plan as an opportunity to restore the river's ecological value. The Isar Alliance was created in 1993 from former members of the *Mühltal* group and numbers nine member organizations (Sartori, 2010). With the Isar being an urban and highly altered river, its ecological status had suffered due to the limited water flow to it, and a general lack of resting and breeding sites for fauna, for example, gravel bars (Binder, 2006). The Isar Alliance had four key aims: widening the riverbed to increase wilderness and habitat quality, improvement of water quality, restoration of the flood plain, and increase in fish migration corridors (Sartori, 2011). This stakeholder group mainly had a lobbying and advisory role in the Isar-Plan (Sartori, 2011). It voiced its overarching aim as restoring a more "natural" and pristine ecosystem by allowing the river to meander freely and regain a "wilderness character" (*Wildflusscharakter*) (Kangler et al., 2014; Binder et al., 2015). The Alliance gained considerable visibility throughout the process, including a presence in major stakeholder consultation forums, as well as press coverage. Local newspapers highlighted the ecological co-benefits of the project with headlines such as: "The Isar will flow again" (*Süddeutsche Zeitung*, 1998).

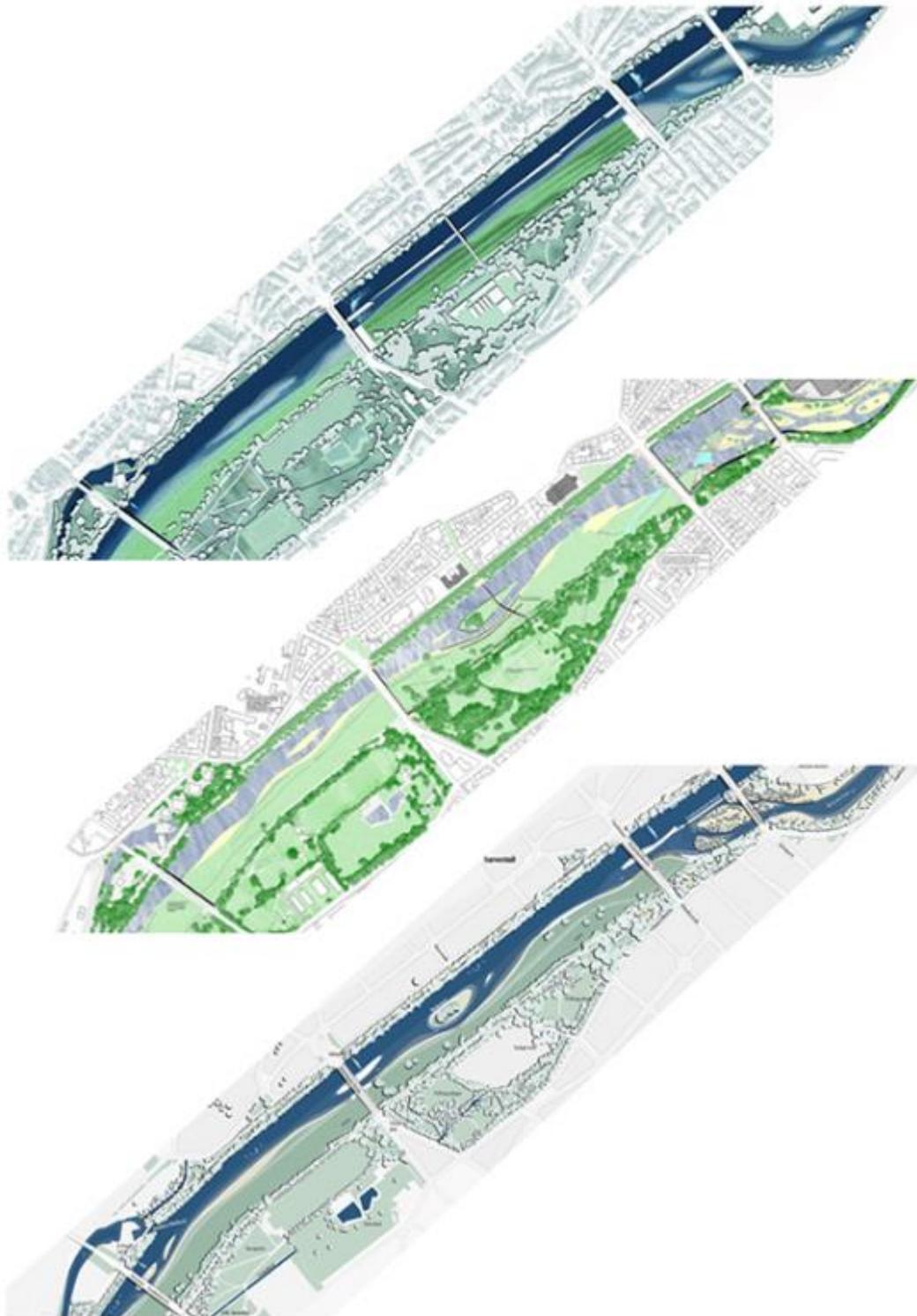
#### 3.4.5 Landscape architects

In 2003–2004, the design of the last 1.6 km stretch of the Isar-Plan was put out for competitive bid through a landscape design competition (Rossano, 2016). This stretch was the most urban of the project, extending from the *Eisenbahn* Bridge downstream to Museum Island. Probably due to its location, this section was also the most debated part of the Isar-Plan (Interviewees 3,7). A landscape architecture firm (Bureau Irene Burdhardt) was publicly presented with first prize in the competition, only to see citizen and environmental groups rejecting the chosen design and demanding that elements of

the submission that won second prize (deemed more ecological) should be integrated into it (Rossano, 2016; Interviewees 3,5,7,9). In the end, a compromise between the two designs was found; for instance the islet (*Weideninsel*) proposed by the second-prize winners was preserved (Fig. 13). A mediator was hired to facilitate this process (Sartori, 2012).

The landscape architects' role was to provide a design that would meet the criteria of their clients (the Munich Water Agency) for combining urban design and flood protection. The functionality of the design was therefore the Agency's main interest, and NBS were accordingly perceived as a way of "romanticizing grey infrastructure" (Zingraff-Hamed et al., 2019). Additionally, flood protection was particularly important in this section of the Isar-Plan. Indeed, compared to the southward limit of the Isar-Plan, the riverbed progressively becomes more confined with higher volumes of water (Interviewee 3). Building a sustainable solution (i.e., a structure that was not going to be immediately washed away) was thus all the more important. Therefore, the landscape features of this section were seen as an illusion of what is perceived as "nature-based," as they had to be kept within the limits of the site's hydrological and urban reality and, moreover, possessed a clear underlying structural purpose.

*The Isar in Munich is a built structure. One tries to build it in a way that is as close to nature as possible (...). But the river is entirely constructed. It is a completely controlled situation* (Landscape architect; translated by the author).



*Figure 13: Isar competition, 2003–2005: from top to bottom: first prize (by Burckhardt/SKI), second prize (by Jerney/EDR), and the final compromise (Source: Rossano, 2016).*

### 3.4.6 Hydropower companies

One voice that is rarely represented in literature on the Isar-Plan is that of the hydropower companies, which played a significant role in shaping the history of the Isar. There were two publicly owned hydropower companies along the Isar-Plan stretch of the river: the Munich City Utilities (*Stadtwerke München*, which still exists today) and the former *Isar-Amperwerke*. While the Isar-Plan was praised for its great success for nature and people, the decrease in water flow was against the interests of the hydropower companies that used the water to produce electricity. The Isar-Plan thus represented a potential loss in electricity production and revenue for these public utilities making them one of the rare initial "losers" and potential opponents of the Isar-Plan (Interviewee 15). Although there was little mention of this by the interviewees, it also raised the tradeoff of renewable energy versus the ecological benefits of renaturation. To address this conflict, a compensation scheme was drawn up during the Isar-Plan, which allowed Munich City Utilities to increase their water intake in the Isar side-channel by  $10\text{m}^3/\text{s}$  (water levels permitting) to make up for the profit lost through the Isar-Plan (Referat für Gesundheit und Umwelt, 2007). This compromise helped avoid any major potential conflicts.

*We had to find a compromise [between nature and hydropower], which hurt both a little, but with which we could both live (Munich City Utilities; translated by the author)*

Additionally, in 2010, the City of Munich financed part of the renovation of two power plants in Munich, whose productivity was hence increased by up to 30% (*Stadtwerke München*, 2017).

### 3.4.7 Sources of expertise

Multidisciplinary expertise was brought in from three main groups:

- The different experts (e.g., engineering, ecology, horticulture, hydrology) which were convened in the Water Agency's Working Group (*Landeshauptstadt München et al.*, 2012);
- Hydrological models run by the Water Agency (Interviewees 1, 2) and academia (*Neisch et al.*, 2012); and
- Real-life downscaled models of the Isar (Fig. 14), conducted by Munich's Technical University (TUM) and the Bundeswehr University Munich (Interviewee 10; *Bechteler & Nujic*, 2000).



Figure 14: Experimental hydrological model of the Isar in Munich, carried out by TUM (downscaled 1:20) (Source: WWA München, n.d.)

### 3.5 Benefits and co-benefits

In what follows, we distill the elements that contributed to the Isar success story as reported by the 15 stakeholders that were interviewed. One notable outcome of the interviews is that, without exception, the environmental groups, Munich and Bavarian authorities, and citizens/residents unequivocally agreed that the Isar-Plan was successful in terms of its three main aims: flood control, ecological restoration, and recreation (Interviewees 1–15). There was thus no highly "contested terrain" (Gallie, 1955; Ney, 2009; Verweij, 2011); yet, the stakeholder discourses put different emphases on each of the three aims (Interviewees 2,4,5). Table 4 summarizes the key benefits and co-benefits identified by the interviewees.

Stakeholders were asked to identify the main accomplishment of the Isar-Plan (see Appendix A). It is important to note that what, to some, was a perceived "benefit" of the Isar-Plan, to others was a "co-benefit." Table 4 thus identifies different versions of what the 'co-' in 'co-benefits' stands for in stakeholders' eyes. Note that the absence of a benefit or co-benefit does not always mean that the NBS did not exhibit this attribute, but that it was not mentioned by the stakeholders.

Table 4: The main perceived benefits and co-benefits of the Isar-Plan

Views expressed by interviewees	
<b>Category and type of NBS benefit/co-benefit</b>	
<b>Risk reduction</b>	
Reduced risk from floods	The Isar-Plan did significantly reduce the risks from extreme flood events, as confirmed by the 2005 flood.
<b>Technical feasibility aspects</b>	
Cost effectiveness	The projects costs (€35 million) were low relative to the flood reduction and co-benefits achieved.
<b>Society</b>	
Recreation	The Isar has become a primary urban recreational hub in Munich.
Inclusiveness and equity	The Isar is now accessible to urban residents and accessible by public transport, rather than being exclusive to car owners.
Social cohesion	The Isar in Munich brings together people from all walks of life and different generations.
Esthetic value	The Isar in Munich has an increased scenic and landscape quality.
Cultural heritage value	The Isar has become a cultural trademark of Munich and represents a "wild" urban river.
Environmental awareness	The Isar-Plan had a catalyst function by inspiring further NBS projects (nationally and internationally).
Nature accessibility	The Isar became safe to access within Munich (before the Isar-Plan, the river was contained in high, concrete river banks)
<b>Environment</b>	
Biodiversity	The Isar-Plan has increased the ecological status of several fauna and flora species.
Habitat connectivity	The implemented fish ladders have increased fish habitat connectivity.
Wilderness	Despite being an urban river, the Isar regained an alpine character.

The interviewees generally recognized that the multiple benefits and co-benefits of the implemented measures spanned risk reduction, social cohesion, and multiple other ecosystem services (TEEB, 2009)—a central characteristic of NBS (Raymond et al., 2017).

As a major interest of the responsible authorities, **flood risk reduction** was highlighted by many (Interviewees 1, 2, 8, 10) as a central benefit. As a member of the Munich Water Agency summarized:

*Every city has to offer its inhabitants protection (...). Anything that goes beyond that, as was done in the Isar-Plan, for example, improved ecology and increased social and recreational function—to reconcile all of that was secondary. Flood protection was the priority (Munich Water Agency; translated by the author)*

Likewise, the **environmental benefits** of the Isar-Plan, for example, fish ladders for increasing fish habitat connectivity (Interviewee 2) and improved habitat quality (Interviewee 9) were especially highlighted by environmental stakeholders:

*The Isar has become much more natural—for recreation, but it also offers fish a much better habitat (Fisheries Association/Isar Allianz; translated by the author)*

Yet, stakeholder responses show the clear dominance of the project's **societal benefits**, which were mentioned by all interviewees, regardless of which stakeholder group they belonged to. Many stakeholders shared the view that the Isar-Plan first and foremost benefits people:

*Good environmental status [under the Water Framework Directive] also encompasses social function. If I aim for a good status, this must serve not only nature, but also humans (Münchner Forum; translated by the author)*

*The biggest success was that people got a river they can use in a city of millions. Although ecological aims were fulfilled, the social success, i.e. the restored accessibility of the river for people, surpasses that (Save the Isar now! /Isar Allianz; translated by author)*

The restoration of the Isar, a river that was often referred to as a sewer before the Isar-Plan, had a clear cultural value, encompassing, among other things, recreational, emotional, spiritual, esthetic, and social equity benefits. Although the importance of cultural services is widely recognized (TEEB, 2009; Chan et al., 2012; Daniel et al., 2012) these remain difficult to explicitly characterize and quantify, a challenge that was noted by an interviewee from the Bavarian Ministry of the Environment:

*For recreation and leisure purposes the River Isar in the city of Munich of course represents a natural resource that goes way beyond what can be monetarily quantified. There is an important emotional aspect that explains the great success of the project (Bavarian Ministry of the Environment; translated by the author).*

The increased accessibility of the river for all and the associated social equity aspect were also highlighted:

*It is an atmosphere of liberality and generosity, and of friendship. That's in fact what's beautiful about it. And we have this in the middle of the city (Isar Alliance; translated by the author).*

The interviews also alluded to a strong sense of ownership of the Isar restoration, translated as pride at having been part of Isar-Plan:

*This urban green space which runs along the Isar is globally unique. In that sense you would have a hard time finding a city where the unity between landscape and river is so harmonious. But it should not be taken for granted—this was a fight and struggle by Munich's citizens, for their Isar,*

*for their central recreational spaces (Münchner Forum; translated by the author).*

Despite the total costs of the Isar-Plan being far from negligible, they were widely perceived as cost-effective in relation to what was achieved and the scale of the project (Interviewees 1, 2, 3).

*In comparison with other measures it cost hardly anything when taking into account the success (...) It was solved in a clever way. What you can see is the restoration, but in fact that wasn't that expensive, but everyone finds it great, it looks good, it's great to use (City of Munich Planning Division; translated by the author).*

Finally, the Isar-Plan is thought to have had a positive impact on raising awareness about NBS in Germany and beyond.

*I do think that successful projects like this have increased the acceptance of such nature-based solutions. Green infrastructure was also more or less invented as a term to emphasize the importance of green vs. grey infrastructure (City of Munich Planning Division; translated by the author).*

### 3.6 Enablers of the Isar-Plan success

#### 3.6.1 Preconditions

For the Isar-Plan to catapult onto the political agenda and emerge as a major policy issue, a number of pre-existing conditions had to be in place. These are factors that were external or exogenous to the Isar-Plan process, yet contributed to it getting off the ground. Table 5 summarizes the preconditions that were voiced by the interviewees.

Table 5: Pre-existing conditions that enabled the Isar-Plan in the view of the interviewed stakeholders

Category and type of NBS precondition	Views expressed by interviewees
<b>Socio-cultural</b>	
Environmental awareness	Green movements were on the rise and "en vogue." The City's mayor was from the Green Party.
Interest/pressure groups	The <i>Mühltal</i> group, consisting of environmental stakeholders, had been formed to advocate increased water for the Isar in the early 1990s.
Risk awareness raised by event/model	Through a hydrological model, the Water Agency realized that flood protection of Munich was insufficient in the case of a 100-year flood event.
<b>Legal/institutional/political</b>	
Sufficient space	The riverbanks in the Southern sections of the Isar-Plan were not built up, allowing the river to be widened.
Favorable public property rights	The land along the eastern riverbank of the Isar, where the river basin was to be widened, was owned by the City of Munich.

Category and type of NBS precondition	Views expressed by interviewees
Mandate and authority	The Munich Water Authority and the City of Munich both had the mandate to protect the City from floods.
Existing legal basis	Existing legal documents, including the Bavarian Constitution and German Federal Water Act, contained paragraphs favoring the restoration of rivers.
<b>Human resources</b>	
Expert knowledge and expertise	Both the City and the Water Agency of Munich had relevant experience and expertise in flood control and landscape planning, respectively.
Previous risk control (residual risk)	Thanks to the construction of the <i>Sylvenstein</i> reservoir in 1959, flood risk had already been reduced, leaving only residual risk (losses in the event of a 100-year flood) to be addressed by the Isar-Plan.
<b>Financial resources</b>	
Available funds	A budget had been earmarked to increase flood protection.

As shown in table 1, the Isar-Plan was enabled, according to the interviewees, by a wealth of pre-existing geographic, social, political, legal, financial, and human-capital factors. In combination, these were powerful drivers of NBS uptake and suggest that synergies are important for NBS catalyzation.

### 3.6.1.1 Socio-cultural context

Helping to prepare the socio-political climate prior to the Isar-Plan was the non-compliance with the 1975 European Bathing Directive (76/160/EEC) (EEC, 1975). Indeed, in the 1980s, the Isar was not declared as “bathing water” by the State of Bavaria - supposedly due to its cold temperature – despite the large numbers of people swimming in the Isar during the hot summer months (Bäumler, 2019). Citizens reported this to the European Commission in 1986, and measures to disinfect the wastewater produced by Munich’s sewage plants using ultraviolet light treatment were introduced from 2005 onwards (Dikloh, 2006). The result was a significantly improved water quality, with sometimes thousand-fold reductions in bacteria levels (Münchner Stadtentwässerung, 2005). After treatment the Isar was declared up to official EU bathing water standards. The citizen engagement triggered by this Directive thus helped pave the way for the Isar-Plan by raising **environmental awareness**.

*At the time, the Water Framework Directive did not exist (...) The Bathing Directive had a signal function (Münchner Forum; translated by the author).*

Later, after the victory of the *Mühlthal* Group in increasing the Isar’s residual water from 5 to 15 m<sup>3</sup>/s in 1998 (Sartori, 2012), the calls for a restored Isar in Munich grew stronger still, supported by a green government and general trend in environmental movements at the time (Interviewees 3, 10). Indeed, in the view of many, Munich’s residents were perhaps the most influential drivers of the Isar-Plan (Rossano, 2016; Bäumler, 2019; Interviewees 2, 4, 5, 6).

Stakeholder participation in the restoration of the Isar can be traced back to well before the start of the Isar-Plan. In 1987, a colloquium gathering representatives of the City of Munich and relevant experts was organized by the City Council to discuss the different options for the future Isar (Düchs, 2014). A key enabler was the creation of the aforementioned *Mühlthal* Group (which later became the *Isar Allianz*), which can be seen as an early **interest/pressure group** for the Isar-Plan (Sartori, 2010). The *Mühlthal* Group, which rallied environmental stakeholders sharing a common vision for a revitalized and more "nature-based" Isar, was therefore an essential precondition for the Isar-Plan. As stakeholders with a common interest were already gathered under this umbrella group, they could build on the already established traction:

*An important element was that the Isar Alliance already had a track record of success. We had already achieved a lot through the renewal of the concession for the Mühlthal hydropower plant (Isar Alliance; translated by the author).*

### 3.6.1.2 *Legal, institutional and political context*

While it is not possible with hindsight to put the identified enablers in any order of priority or to determine which were the most essential, a few can be considered as prerequisites for success, such as the **availability of space** to widen the riverbed:

*A huge advantage for the Isar-Plan to happen in Munich in the first place was that we had space. Other cities just don't have that (Fisheries Association/Isar Alliance; translated by the author).*

This was largely facilitated by the lobby of an important NGO, the Isar Valley Association (*Isartalverein*), who fought for the protection of the Isar Valley from urban expansion (Düchs, 2017).

The legal landscape in which the Isar-Plan is nested consists of multiple "levels" or scales of governance. Based on stakeholder interviews and literature, the relevant legal documents are summarized in figure 15. The most important legal and policy frameworks for the introduction of the Isar-Plan are discussed in more detail below.

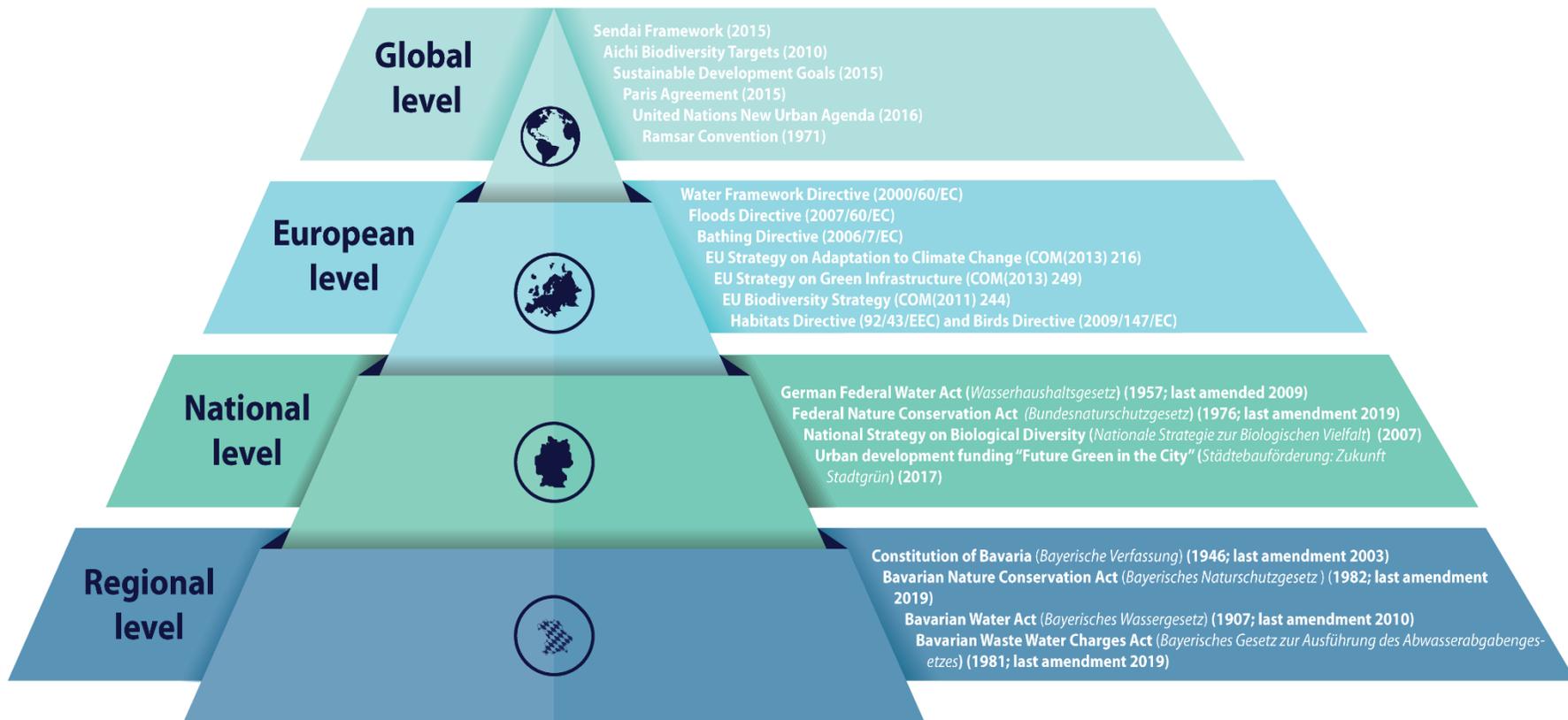


Figure 15: The legal framework and policies (date of adoption in brackets) relevant to the Isar-Plan implementation at the global, European, national, and regional levels (non-exhaustive list) (Sources: Earth by Randomhero; Europe by anbilero adaleru; Germany by Sascha Elmers; Bavaria flag by Bence Bezeredy from the Noun Project; Illustration 63198447 © PixMarket - Dreamstime.com; Design: Juliette Martin)

Although global frameworks helped set the stage for the Isar-Plan, they were not mentioned by the stakeholders who were interviewed. For example, climate change did not appear to play an important role in the Isar-Plan stakeholder deliberations, although it likely played a role in the flood risk scenarios that were modeled. In Bavaria, since 2004, flood protection planning must allow for a 15% addition to a 100-year flood to account for climate change (Bayerisches Landesamt für Umwelt, 2018).

At the European level, besides the aforementioned 1975 European Bathing Directive (76/160/EEC) (EEC, 1975), the Floods Directive (2007/60/EC) played an important role in giving the Munich River Authority the **legal basis and mandate** to act:

*The law existed—a municipality of this size had to be protected* (Munich Water Agency; translated by the author).

Later, the Water Framework Directive (2000/60/EC) provided much more detailed guidelines on how rivers should be managed to achieve a Good Ecological Status (Interviewee 10). At the national level, the German Federal Water Act (BGBl. I S. 1110) represented a further **legal basis**, favoring the natural development of rivers:

*(...) natural waters which have not been developed in a near-natural way should be returned to a near-natural state as far as possible, except if predominant reasons for the welfare of the general public do not allow this<sup>1</sup>*  
(Article 1, § 6) (Bundesamt für Justiz, 2009; translated by author).

At the regional level, the Isar-Plan and the ideologies behind it were also anchored in existing legal documents. In particular, Article 141 of the Constitution of Bavaria (GVBl. S. 991, 992) was one of the first to advance the idea of an Isar restoration (Bäumler, 2018a). Similarly, Article 26 of the Bavarian Conservation Act (GVBl. S. 82) lists the "right to enjoy nature and recreation" (Bayerische Staatskanzlei, 2011). Both articles were readily cited by environmental groups to support their cause (Sartori, 2012).

*State and municipalities are obliged to keep (...) rivers and other scenic places accessible for the general public and, if necessary, to make them accessible by restricting property rights and to create hiking trails and recreation parks<sup>2</sup>* (Article 141, § 3, Sentence 3) (Bayerische Staatskanzlei, 1998; translated by the author).

Furthermore, the amendment of the Bavarian Water Act in 1987 created the legal basis for increasing the minimum flow in the diverted reach of the Isar (Bäumler, 2019). Thus, the upsurge in environmental movements since the 1970s resulted in the development and amendment of important environmental legislation in Bavaria and Germany.

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<sup>1</sup> (...) nicht naturnah ausgebaute natürliche Gewässer sollen so weit wie möglich wieder in einen naturnahen Zustand zurückgeführt werden, wenn überwiegende Gründe des Wohls der Allgemeinheit dem nicht entgegenstehen.

<sup>2</sup> Staat und Gemeinden sind verpflichtet, der Allgemeinheit die Zugänge zu (...) Flüssen und sonstigen landschaftlichen Schönheiten freizuhalten und allenfalls durch Einschränkungen des Eigentumsrechts freizumachen sowie Wanderwege und Erholungsparks anzulegen.

Finally, the Isar-Plan was enabled by **public property rights** relating to the Isar in Munich. The Isar and its riverbanks count as property of the City according to the German Land Register (*Grundbuch*) (Bäumler, 2014). Therefore, the riverbanks were free of private properties, meaning that the City could easily convert land upstream to widen the riverbed:

*This area was simply available to the Munich Water Agency and the City of Munich (...) No intervention in the legal land ownership relationships was necessary. That was the condition* (Landscape architect; translated by the author).

### 3.6.1.3 Financial and human resources

The construction of the *Sylvenstein* reservoir south of Munich in 1959 had significantly reduced the risk of flooding in Munich prior to the Isar-Plan implementation, meaning that the Isar restoration project only needed to reduce **residual risk**. As the quote below suggests, an NBS may depend for political support on the pre-existence of grey measures—in this case the upstream reservoir and reinforced levees.

*[During the 2005 floods] without the Sylvenstein reservoir, Munich would have been flooded. The combination of Sylvenstein reservoir plus Isar-Plan prevented that* (Munich Water Agency; translated by the author).

Awareness raised through a flood **risk model** and routine checks on levees, both commissioned by the Munich Water Agency, was another key driver of the Isar-Plan. Once it became clear that Munich was at risk of a 100-year flood event, funds were mobilized for flood protection.

**Available funds** were perhaps the most essential enabler of the Isar-Plan. The Water Authority receives a state budget every 10–15 years to implement its multiple goals of providing habitat for fauna and flora, the responsible use of water by people, and protection against water hazards. The Agency has discretionary power over the use of its budget, which was important for budget allocation to the broadly defined goals of the Isar-Plan; yet, the main rationale for justifying project costs remained flood protection (Interviewee 4).

*If you want money, then you have to tell politicians that you need flood protection. And every 10–15 years there is a flood protection budget* (Munich Water Agency; translated by the author).

The Isar-Plan costs were approximately €35 million, consisting of €28 million for building costs and €7 million for the disposal of dangerous waste left over from World War II (Wasserwirtschaftsamt München and Landeshauptstadt München, 2011). The unanticipated disposal costs were the only cost overrun compared to the initially estimated budget (Süddeutsche Zeitung, 2010). Like most NBS (Sekulova &

Anguelovski, 2017; Ecologic Institute, 2018), the Isar-Plan was publicly funded (Landeshauptstadt München et al., 2012). An even split of costs between the State and City is common for these types of project in Germany, with more specific cost-sharing being decided on a case-by-case basis (Interviewees 1, 2). With the State of Bavaria being responsible for flood protection in Munich, and the City having more of an interest in the recreational and environmental co-benefits of the project, the State paid 55% of the total costs, which was slightly more than the City. This was seen as a fair split between the two main beneficiaries of the project (Interviewees 1, 2, 3, 9, 12). A less widely known fact is that the European Commission contributed a further €4 million of support to the project (Bäumler, 2019).

*Financing was a crucial issue. Therefore, it was certainly very important that the two [funding] partners, City and State, had common goals that could be pursued (Munich Planning Division; translated by the author).*

### 3.6.2 Enablers that emerged from project initiation to implementation

This section reports on the emergent factors that contributed to the success of the Isar-Plan. Based on coding of themes that emerged in our 15 stakeholder interviews, key enablers were identified for the various phases of the NBS initiation, planning/design and implementation. Table 6 summarizes these enablers, which are subsequently discussed in more detail.

Table 6: Main perceived enablers of the Isar-Plan during its initiation, planning, and implementation

Category and type of enabler	Views expressed by interviewees
<b>Socio-cultural</b>	
Risk awareness raised by event	Large floods occurring during the project construction (in 1999 and 2005) helped increase the awareness of the NBS' benefits and renew funding.
Interest/pressure groups	The former <i>Mühltal</i> group formed the Isar Alliance in 1993, which rallied different environmental NGOs in support of the Isar-Plan.
Stakeholder engagement	Stakeholders were consulted on each section of the Isar-Plan and were able to co-design implemented NBS.
Trust relationship between stakeholders	The long-lasting collaboration between stakeholders (over 15 years) resulted in a trust relationship.
<b>Legal/institutional/political</b>	
Local champion	The Mayor at the time (Hep Monatzeder) was in favor of the project.
Clearly defined goals	Throughout the Isar-Plan, the 3 goals of the project (recreation, flood protection, ecology) prevailed and guided the Water Agency and city representatives.
Common vision	All actors were in favor of the Isar-Plan and associated with at least one of its three goals (recreation, flood protection, ecology).
Cross-scale collaboration	The Isar-Plan Working Group was created by the Munich Water Agency and included representatives from the State of Bavaria and the City of Munich.
Cross-sectoral collaboration	The Isar-Plan Working Group brought together members from many different disciplines.

Category and type of enabler	Views expressed by interviewees
<b>Intellectual and economic resources</b>	
Expert knowledge and expertise	The City and the Water Agency of Munich had experience and expertise in flood control and landscape planning, respectively.
Communication strategy and platforms	An intensive communication strategy was put in place to inform stakeholders about what was implemented where.

### 3.6.2.1 Socio-cultural enablers

The Isar-Plan’s **stakeholder engagement**, unique and innovative for its time, was widely perceived as one of the most successful aspects of the project. While the importance of stakeholder engagement in NBS design and implementation is increasingly recognized (e.g., Eggermont et al., 2015; Faivre et al., 2017) it was much less common when the Isar-Plan was launched (Interviewee 5). Consequently, stakeholder involvement was not straightforward from the onset. What started out as a more tentative approach to defining a common vision for the Isar later evolved into more systematic and organized ways of consulting stakeholders (Interviewees 2,5,10). Very much in line with the living lab concept, the Isar-Plan was experimental and based on "learning by doing" (Interviewee 10).

The Munich Water Agency, which had overall responsibility for the project, was receptive to engaging the Isar Alliance, district councils, and other stakeholders in the planning and design of the project. A participatory process was not mandated (as it later was by the Water Framework Directive) and thus the Water Agency was remarkable in its persistent and open approach to outside interventions. Their approach was necessarily ad hoc and experimental. In the words of an interviewee from the Water Agency:

*We did not have any clear rules or guidelines for stakeholder involvement—but we had to keep everyone informed, and of course NGOs and other interested participants always had their own ideas on how to proceed. But I think it was very important for the success of the project that a kind of participation and stakeholder involvement was continuously established or, in other words, that a kind of change in culture was developed. In the end this is the only way to realize such large projects (Munich Water Agency; translated by the author).*

Once the advantages of integrating different views into the project were recognized and a relationship was formed with many stakeholders and stakeholder groups, participation was actively sustained throughout the project (Interviewees 4,10). However, relationships between stakeholders were not taken for granted and had to be constantly maintained and renewed.

While no formal co-design of the implemented NBS was undertaken, stakeholder views were integrated on an ad hoc basis and for each larger section of the project (Interviewees 2, 5, 9). Although the two leading agencies were fully aware of the importance of stakeholder engagement (Interviewee 10), they were also conscious of the

fact that consulting stakeholders on every detail of the project would be unfeasible and counter-productive (Interviewee 2). A balance thus needed to be struck.

A further innovative aspect of the stakeholder engagement process was avoiding the administrative burden of conducting a full plan-approval procedure (*Planfeststellungsverfahren*), through which stakeholders each have to provide a statement to the proposed project (Interviewees 8,9). Instead, as stakeholders had already been consulted at an early stage of the project (Interviewees 8,9), a shorter approval procedure (*Genehmigungsverfahren*) could be undertaken.

One setback to the relationship of trust established between the stakeholders was the competition held regarding the last section of the plan, the result of which precipitated uproar from environmental NGOs and nearly caused the abandonment of the project (Interviewee 10). The conflict was overcome by hiring a facilitator to settle the issue, which was in turn only possible through the willingness of the first- and second-prize winners to find a compromise solution (Interviewee 10).

As the successor of the *Mühlthal* Group, the Isar Alliance represented a crucial coalition or **interest/pressure group** from the project initiation, exerting pressure on politicians to restore the Isar:

*The members of the Isar Alliance stood up for the Isar restoration. This was picked up by the politicians. Munich's mayor at the time then also supported this* (Fisheries Association/Isar Allianz; translated by the author).

Individual members of the Isar Alliance were regularly invited to the Water Agency's Working Group meetings and consulted on ecological aspects of the Isar-Plan (Interviewees 4, 5, 9, 14). The Isar Alliance accordingly had a central role in the co-design of the NBS that were implemented. This task was facilitated by the fact that the Alliance rallied different environmental interests. In the words of an interviewee:

*[The Isar Alliance] brought together people with the same interests. This was also much easier for the City, because you could speak with the Alliance instead of each individual NGO* (Isar Valley Association/Isar Allianz; translated by the author).

Finally, as there had been no major floods in Munich at the time the Plan was first suggested (Interviewee 2), flood protection was initially not a public concern. This perception shifted after the major flood in 2005, **raising awareness** about the flood protection function of the Isar-Plan (Interviewee 9) and helping authorities to continue to justify the need for the project (Interviewee 10).

### 3.6.2.2 *Legal, institutional and political enablers*

At the very heart of the Isar-Plan stood strong **political support** for the project, as well as several "**champions**," such as Munich's then mayor, who strongly backed the Isar restoration:

*Another success factor back then was certainly the favorable political constellation. In fact, at that time the Bavarian Minister of the Environment and the mayor, Hep Monatzeder, (who was one of the well-known green politicians in the City of Munich) agreed to jointly carry out the project (Bavarian Ministry of the Environment; translated by the author)*

The same legal documents which served as a **legal basis** for introducing the Isar-Plan later helped during its initiation and planning phases:

*There were the Bavarian Constitution and Nature Conservation Act. What we did was covered by the law. That way, even if someone in the administration was not happy about [the Isar-Plan], they could not say anything against it (Isar Alliance; translated by the author)*

To enable the project planning process, the three **clearly defined goals** and **common vision** embodied by the *Flaucher* area were deemed key (Interviewees 1,2,3,10).

*Everyone always had the same goal in mind—that's why it worked (Landscape architect; translated by the author).*

*There was a clear work assignment, so that we all worked in a structured way (Munich Planning Division; translated by the author).*

In 1995 the creation of the interdisciplinary Isar-Plan Working Group marked a critical milestone in the Isar story (Düchs, 2014). Although the Working Group was composed of experts representing both the City of Munich (through the City's relevant Divisions) and the State of Bavaria (through the Munich Water Agency), stakeholders from various other fields (e.g., ecologists, hydrologists, and representatives of different NGOs) were regularly invited to discuss specific issues or sections of the plan (Interviewees 1,2,4). One of the group's aims was thus to resolve conflicts before they could escalate (Interviewee 2).

*The different solutions were always weighed up. The Isar-Plan Working Group served to discuss challenges amongst various experts (...). We said we will develop what we want to build in Munich together. This was the first time that such a Working Group had been created (Munich Water Agency; translated by the author)*

Another tacit aim was to create a broad-based support group across the relevant authorities. This Working Group, created by a group of forward-thinking members of the Water Agency, represented great innovation by catalyzing change from within the administration:

*The Isar-Plan was the ideal solution—but it wasn't a given, and could only be realized through this generation change within the Water Agency in Munich (Münchner Forum; translated by the author)*

*The "concrete faction" in the Water Agency had retreated. Young engineers and landscape planners were the ones in charge now (Isar Alliance; translated by the author).*

An important and emergent characteristic of the Working Group's institutional framework was its polycentricity (Zingraff-Hamed et al., 2019), which denotes a system in which decisions are taken at different jurisdictional levels and scales (e.g., national, regional, global) through sometimes formally independent decision-centers (Ostrom, 1999). Indeed, as the Isar River in Munich falls into several overlapping jurisdictions and their legal mandates—mainly at the State (Bavaria) and City (Munich) scales—this created the need for **cross-scale and cross-sectoral coordination and cooperation**, embodied by the Isar working Group. This collaboration was a key enabler for the Isar-Plan (Interviewees 2, 10, 4).

*Without the cooperation between the City of Munich and the State of Bavaria, (i.e., the Working Group), [the Isar-Plan project] would not have been achieved. (Munich Construction Division; translated by the author)*

*The essential reason for success was this: the City administration and Bavarian State worked together (Münchner Forum; translated by the author).*

The **relationship of trust**, thus established, was expressed by an interviewee from the Munich Water Agency:

*The State and City basically worked together for 15 plus years. Of course a trust relationship had been established and a good collaboration. This was certainly an important basis, among others, to get along in difficult times during the project (Munich Water Agency; translated by the author).*

### 3.6.2.3 Enablers related to financial and human resources

Through their complementary institutional knowledge, both the City of Munich and the Water Agency provided important **expertise** for informing the Isar-Plan. While the City had extensive experience in urban planning, the Water Agency had more technical expertise regarding flood protection (Interviewees 10, 12).

Complementing the above-mentioned stakeholder engagement, the **communication strategy** developed by the City of Munich and Water Agency were important enablers. During the implementation of the first section of the Isar-Plan, many citizens asked builders about the Isar-Plan (Interviewee 2). Consequently, an intensive outreach

strategy was put in place by the Water Agency and the City of Munich. For each section of the Isar-Plan, citizens were informed about what was going to be done, and why, through large information boards installed next to the river (Wulf & Schaufuss, 2013).

*We realized how important public outreach is. We weren't aware of that at first (Munich Water Agency; translated by the author).*

The strategy further included guided tours, an information point, public lectures and presentations, educational trails, and information boards along the Isar to inform the public about the measures being implemented (Interviewee 2). As a popular topic to report on, the positive press coverage of the Isar-Plan also raised citizen satisfaction (Interviewee 10). Additionally, citizens initiatives such as the *Münchner Forum* and the district councils were central **communication platforms** which gave citizens a voice in the matter (Interviewees 1,4, 5).

*A further important prerequisite for the success of the project was that we communicated intensively not only with NGOs but also with representatives of the city districts (Bavarian Ministry of the Environment; translated by the author).*

### 3.6.3 Hurdles and challenges

One of the main issues pervading the mainstreaming of NBS into disaster risk reduction (DRR) policy practices is the **difficulty of quantifying the economic benefits of NBS** in comparison with grey solutions. While methodologies for estimating the economic benefits of flood protection are well documented and include measures such as probabilistic catastrophe models (Amendola et al., 2012) and risk benefit analyses (Mechler et al., 2014), it is far more complex to estimate benefits from the other co-benefits identified, such as increased ecological status and biodiversity or cultural values. In the case of the Isar-Plan, however, there were no quantitative estimates of flood risk protection; rather, arguments were put forward that Munich should be protected (at zero risk) from a 100-year flood event and that, without the implementation of the NBS, the large flood in 2005 would have caused significantly more damage and flooded parts of the City (Schaufuss, 2015). Although these damage costs were never estimated, they are thought to be well over the costs of the project (Interviewee 2). This concept of "avoided cost," despite providing only a very simplified estimate of the benefits of flood risk reduction, is commonly used for ecosystem service valuations (de Groot et al., 2002; Liu et al., 2010). A clear challenge is therefore to establish consistent **monitoring protocols** to assess the benefits and co-benefits of NBS.

In terms of **financing NBS**, it appears that ecological co-benefits alone would not have been enough to justify the project costs. This implies that NBS are harder to fund without a DRR aspect.

*[The authorities] primarily portrayed it as an Isar restoration, but it was also a big flood protection measure. Otherwise it wouldn't have been financed at all (Isar Allianz; translated by author).*

A further limitation is the **increased use pressure** to which the restored Isar is now exposed and the accompanying **maintenance costs** (Interviewees 2,5,8,10) (Fig. 16), which were underestimated during the planning process. While in the southern parts covered by the Isar-Plan, maintenance is minimal, it gradually increases towards Munich's center (Interviewees 1, 2, 3). The underestimation of maintenance costs represents a major barrier to future NBS implementation, particularly when these count as discretionary services (Schmalzbauer, 2018). Every year, the City of Munich bears significant costs to remove rubbish along the Isar, estimated at €240,000 in 2015 (Wetzel, 2016). Nevertheless, these costs were never compared to the maintenance costs of a pure 'grey' solution (Interviewee 14). The increased human presence has also affected local fauna and flora (Zingraff-Hamed et al., 2017; 2018). The **enforcement** of environmental protection rules (e.g., designated grill sites, protection of bird nesting areas) was mentioned as a further problem, as continuous patrolling of the entire river stretch would be too costly to undertake (Interviewee 4). Although existing legislation in favor of NBS played an important role in enabling the Isar-Plan, Munich's 1976 **Tree Protection Act** (*Baumschutzverordnung*), prohibiting the felling of any tree with a diameter at breast height above 80 cm (Landeshauptstadt München, 2015), was also seen as a challenge (Interviewee 14). Indeed, as trees could not be removed or flooded, this Act was the main reason why the mixed-and-place method had to be applied near Munich Zoo (Interviewee 2). Furthermore, the Isar Valley Association opposing to the relocation of the Zoo was a further argument for the more structural approach chosen in this part of the Isar-Plan (Interviewee 14).

In general, **use conflicts** are still a limitation of the Isar-Plan, as the river attracts many different activities that are not always compatible. A major discord persists between hydropower usage and environmental concerns—especially as climate change policies in Europe call for greener energy production, such as hydroelectricity (Interviewee 14). In addition, as hydropower plant concessions along the Isar will run out in 2020, this is a key window of opportunity for environmental groups to achieve higher water discharges in the Isar in Munich (Interviewee 5).

As a more general challenge, NBS are currently only sparingly addressed in European law, with most references being made to green infrastructure (Davis et al., 2018). Despite the International Union for the Conservation of Nature currently developing global standards for NBS (IUCN, 2019), the absence of specific **building and quality standards** for practitioners and planners results in a lack of liability and accountability when it comes to the success or failure of NBS. Yet, the recently published International Organization for Standardization's standard for climate change adaptation (ISO/CD 14090) (ISO, 2019) might be a first step towards NBS standards, which will greatly help build the business case for them.

*Today we talk more about green infrastructure, but less is done. In the past, many measures were implemented, but we didn't call them green infrastructure [or NBS] (Landscape Architect; translated by author).*



Figure 16: Crowds gathering along the Isar in Munich in July 2015 (Source: Illustration 74661921 © Glacyr - Dreamstime.com)

### 3.7 Summary and key messages

This study complemented a literature review with stakeholder interviews in order to elicit insights into two research questions:

- How do Isar-Plan authorities and stakeholders view the success of the implemented NBS in terms of their main benefits and co-benefits?
- What pre-existing conditions (external to the project) and new and potentially innovative factors helped enable the Isar-Plan?

We summarize our results in what follows:

### 3.7.1 Views on the success of the Isar-Plan project

Based on the stakeholder interviews and literature, the Isar-Plan can be considered a success in terms of its ecological, social and flood-reduction benefits, as well as its inclusive process of stakeholder involvement. Although the Isar-Plan was initially conceived as a flood protection project, its recreational and social benefits were those voiced most prevalently in stakeholder responses. This is noteworthy, especially as social value, particularly cultural heritage, intrinsic, and spiritual values, is difficult to assess in formal benefit-cost analyses, and thus less represented in NBS research (Josephs & Humphries, 2018). The environmental and ecological benefits of the Isar-Plan project were stressed mainly by the Isar Alliance of environmental groups, which were well organized and vocal, yet which represented fewer voices among the public.

What is also noteworthy in the Isar process was the small amount of contention and conflict—to a large extent, all stakeholders were able to realize their vision of the Isar: the public authorities were assured that Munich was protected against an extreme flood event through "hidden" grey infrastructure; the Munich public gained a pristine area for swimming and recreation; environmental activists saw progress towards a "wild river" with the return of the Isar's fauna and flora. While compromises were negotiated throughout the 15-year process, there were few strongly contentious issues (with the possible exception of the first-prize-winning architectural design for the urban stretch of the project). All stakeholders could claim victory.

*There was no competition, no judgement, instead we all worked towards the common goal to revive the Isar (...). Because the City would not have managed it alone. The citizens would not have managed it alone either. And the citizens would not have managed it even with the City, if the State of Bavaria had not been on board (Munich Forum; translated by the author).*

It is important to emphasize that this "common Isar victory" was possible only with a hybrid solution. Munich's flood risk had been significantly reduced by the upstream reservoir and was further reduced by the strengthening of the levees in the Munich reach of the river. Importantly, the concrete and steel levee strengtheners were invisible—thus, the voices against grey measures were dampened. The Isar-Plan's overall success was thus a product of interlinked hybrid measures.

### 3.7.2 Preconditions and emergent enablers

The project's main enablers in terms of engagement of stakeholders and public authorities, as well as catalyzing external events, are summarized in figure 17.

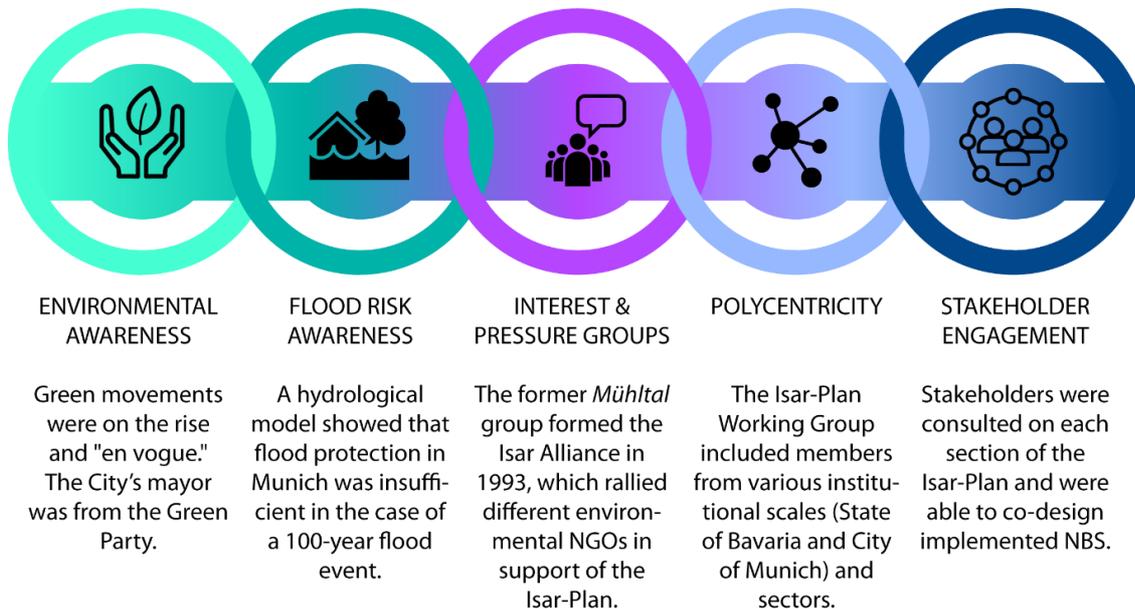


Figure 17: Stakeholders' views of the main enablers of the Isar-Plan (Sources: Illustration 143908448 @ Lobov227878 - Dreamstime.com, Participation by Vectors Market, Network by Anna Sophie, Flood by Hea Poh Lin, from the Noun Project; Design: Juliette Martin)

The preconditions of the Isar-Plan were marked by what could be called a perfect storm of events. These included the ending and subsequent renewal process of the hydropower concession, opening the way for diverting water to the Isar to increase its discharge, as well as the commissioning of a hydrological model that showed an unacceptable inundation risk to Munich. Interestingly, the model appears to have substituted for a serious flood event in opening a window of opportunity for a major flood protection project. The preconditions were also marked by a transition in the socio-political environment, with the rise of an environmental movement and two formidable advocacy groups (*Mühlthal* and later Isar Alliance) campaigning for a more natural Isar and opposed to large-scale grey flood defenses. Not least, the Munich Water Agency and City of Munich were in control of a budget that, although earmarked primarily for mitigating flood risk, could be allocated for the Isar NBS project, given the Water Agency's broad mandate that included social wellbeing and ecological objectives.

Beyond the preconditions, two governance features emerged and stand out as particularly important enablers of the Isar-Plan, namely, the formation of the interagency Isar Working Group and the involvement of interest/pressure groups, particularly the broad-based Isar Alliance (representing environmental groups) and the Munich Forum (representing mainly Munich residents). The Isar Working Group with its young bureaucrats signaled a significant transition in the operating culture of the Munich Water Agency—from a focus on grey infrastructure for flood protection to a more holistic and nature-based approach. The Working Group platform was strengthened by coalitions advocating for an ecological approach (Isar Alliance) and social innovation (Munich Forum). This "common vision" cleared the way for an ambitious, although ad hoc, approach based on the involvement of stakeholder groups.

The Isar-Plan process was progressive and innovative in its approach to stakeholder participation. Although there is significant emphasis in Europe on stakeholder engagement in environmental policies, landscape planning, and (as specified in the Water Framework Directive (2000/60/EC)) water resource management (CEC, 2001; Conde & Lonsdale, 2003; Newig et al, 2014), there was little experience with involving stakeholders when the project started (Interviewee 5). The stakeholder process evolved over the lifetime of the project and was facilitated by extensive outreach led by the Isar Working Group and other responsible authorities, as well as the diverse platforms through which the public could voice their opinions, such as the Munich Forum and district councils. Many interviewees referred to a climate of trust among the public authorities and private citizen groups. Although the process was not formally structured, the goodwill on the part of the Munich authorities made it possible not only to hear the voices of the stakeholders, but in one phase of the project (the revision of the first architectural design), to include them in the project's co-design.

What appears missing from the Isar-Plan narratives is any focus on the pre-project estimates of the costs and benefits of this ambitious project. Although a model showed that a 100-year flood would cause a risk of property loss in Munich, there were no calculations of the probabilistic losses (formally called a probabilistic loss-exceedance estimate). This can perhaps be explained by the existence of an earmarked budget (meaning there was no need to recruit the funds) and the early expansion of the project to include social and economic benefits far beyond the prevention of flood losses, which were difficult to estimate. Many interviewees commented on the cost-effectiveness of the project, taking informal account of the extensive social, ecological and flood-risk-reduction benefits. Still, many countries would have required a detailed benefit-cost analysis for a project of this size.

Finally, perhaps the most powerful enabler of the Isar restoration was the merger of political agendas. As emphasized throughout this case, funding for the Isar restoration was mobilized mainly for flood protection rather than the ecological or recreational rationales alone. Flood protection was thus the major driver for funding:

*If there hadn't been a problem with flood safety, ecology alone unfortunately would not have sufficed to motivate the redesign (Landscape architect; translated by author).*

The Isar restoration "piggy-backed" on more conventional investment in grey flood-control infrastructure; and, in so doing, the Isar case flags an important opportunity for merging the DRR agenda with those addressing urgent challenges, such as biodiversity loss and climate change. This merger can potentially mobilize more resources for all three agendas than proceeding separately. Indeed, the environment and public stakeholders exploited the political will of the Bavarian and Munich authorities to spread the funding across the broad aims of the project. Moreover, in the end, this merged agenda mobilized additional funding. The Isar Working Group was instrumental in this merger by assimilating the relevant expertise across otherwise autonomous and

disconnected authorities. The collaboration across different jurisdictional scales and sectors—polycentric governance—was unprecedented for a project of this size and played a key role in the successful implementation of the Isar-Plan.

In conclusion, the Isar-Plan project is exemplary for its innovative approach to combining separate but synergistic agendas for fulfilling economic, social, and ecological priorities. The Isar story has lessons that extend far beyond the City of Munich. It shows how NBS can contribute to the urgent transformations needed to meet the world's Sustainable Development Goals (SDGs) by merging priorities across multiple global aspirations. As cases in point, the Sendai Framework (2015) calls for increased investment in disaster risk reduction rather than relying primarily on post-disaster response and recovery (UNISDR, 2015). As the Isar case has so strongly shown, the synergies in flood protection, climate mitigation and adaption, as well as biodiversity, can be exploited if the DRR community embraces a transformation from grey infrastructure to green-grey NBS.

## **4 Carrots and sticks for conserving the forest - A Nature-based Solution for Wolong Nature Reserve**

### **4.1 Case-study overview**

To address extreme hazard events, especially the 1998 floods that struck several of China's major rivers (e.g., Yangtze River, Nen River, Songhua River, Pearl River) and recurrent sandstorms that swept northern China in the late 1990s, China implemented a sequence of national policies on nature-based solutions (NBS) for disaster risk reduction (DRR). One of the most ambitious is the Natural Forest Conservation Program (NFCP), which is massive in its scale as well as its unprecedented budget and potential ecological and socioeconomic impacts. The NFCP aimed to conserve natural forests mainly through logging bans and afforestation. While the overall ecological and DRR impacts of China's NBS programs have been positively evaluated at national scale (Ouyang et al., 2016; Viña et al., 2016; Xu et al., 2006), opinions are mixed about the cost effectiveness and socioeconomic impacts of the NFCP implementation across China's thousands of counties (Yin et al., 2010).

This study reports on the implementation of a nature-based solution to flooding and landslides that was carried out in upstream tributaries of the Yangtze River in the Wolong Nature Reserve (WNR). The WNR is located in the Western Sichuan mountains, a flagship protected area of China, a global hotspot for biodiversity, as well as hazards such as earthquakes, floods and landslides. The multiple motivations for the large-scale project included multi-hazard risk management, conservation, and economic development that would be achieved by reducing/minimizing deforestation and continuously monitoring, evaluating, and maintaining healthy forest ecosystems. A major innovation in this project was the introduction of a forest management concession contractual system - the 'carrot and stick' approach - for local households to monitor illegal logging. Based on literature and stakeholder interviews, the study identifies the key governance factors that enabled the NFCP at WNR for effective forest conservation and recovery, focusing on the period 1999-2001 when the NBS program was initiated, planned, designed and implemented.

The results show the importance of inclusive stakeholder involvement and cross-scale and cross-sectoral collaboration, or polycentric arrangements, in designing, implementing, monitoring and maintaining NBS. In the context of Western China's rural mountain areas, the NFCP at WNR was a pioneer in terms of engagement with local communities in negotiating the co-design of an innovative concession contractual system. The resulting 'sticks and carrots' system effectively changed government-owned forests from open-access resources to common-pool properties of household groups, so that long-term forest conservation and recovery could be maintained. The NFCP process at WNR demonstrates that strong multi-scale and cross-sectoral collaboration can take place in a rural Chinese administrative governance system to produce innovative financial arrangements and implementation rules to effectively manage NBS.

This case study is organized as follows: In section 2 we report on the research design, and in section 3, on the natural (ecological) and disaster history of the Wolong Nature Reserve. This is followed in section 4 with a description of the stakeholder landscape. In section 5 the observed and perceived benefits and co-benefits of NFCP at WNR are elaborated followed in section 6 with an analysis of the preconditions and enablers of the NFCP, as well as the challenges and limitations, as gleaned from stakeholder interviews. We conclude in section 7 with the key findings on the Wolong governance model for planning, designing, financing, implementing, and maintaining NBS.

## 4.2 Research design

In this study, we examine the initiation, planning, implementation, and the subsequent monitoring, evaluation and maintenance processes involved with a large-scale national NBS program, the Natural Forest Conservation Program (NFCP) in Wolong Nature Reserve (WNR), China. Substantial data, information and knowledge on WNR and the NFCP were drawn from a long-term social-ecological research program (LTSER (Angelstam et al., 2019; Haberl et al., 2006)) on the WNR as a coupled human and natural system (Liu et al., 2007; Liu et al., 2016).

New data and information were collected in 2019 through primary data sources involving in-depth interviews with selected stakeholders, including reserve managers, community residents, and researchers (see Appendix C) and secondary data sources, including government documents, grey literature, and academic publications in both English and Chinese. All interviewees experienced the NFCP full process, and generally have in-depth knowledge on the WNR.

Two main research questions are addressed in this study:

- What are the main benefits and co-benefits of the NFCP in the WNR, including how they are viewed by stakeholders?
- What pre-existing conditions (external to the program) and new and potentially innovative factors helped enable the NFPC in the WNR?

## 4.3 NBS in Wolong Nature Reserve: context and history

### 4.3.1 Case study area

#### 4.3.1.1 *Wolong Nature Reserve*

Wolong Nature Reserve, home to the world's largest wild population (ca. 140) of Giant Panda (*Ailuropoda melanoleuca*) (Schaller, et al., 1985; Wolong Administration Bureau, 2004) is China's most known protected area. Located along the eastern boundary of the Tibetan Plateau with extremely high-relief topography (i.e., the elevation increases by 5,000 meters across a horizontal distance of ~50 km from east to west, Figure 18), the reserve is also part of a global hotspot area for disasters, such as earthquakes, floods, and landslides (Viña et al., 2011). On May 12<sup>th</sup>, 2008, it was struck by the devastating magnitude-8.0 Wenchuan Earthquake with the epicenter at WNR's eastern boundary.

Climbing from 1,150 m to 6,250 m in elevation (Figure 4), the reserve hosts hundreds of mammal and avian species and thousands of higher plant species, making it part of the Southwestern China Mountains biodiversity hotspot at the global level. The reserve is an important head water area for the Minjiang River, the main source of the Yangtze River.

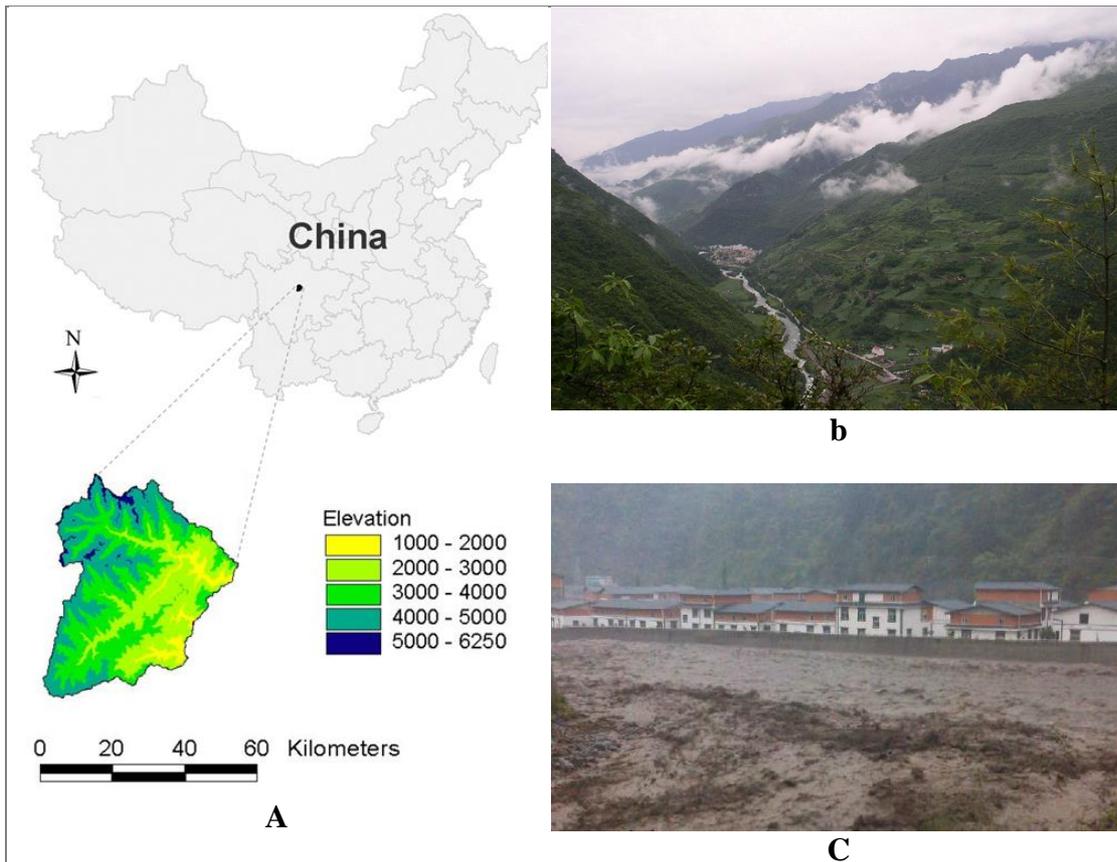


Figure 18: (a) Location of Wolong Nature Reserve (bottom) in China (top) with indication of elevation; (b) Mountain landscape in WNR, showing Wolong township, sloped cropland, and forests; (c) Flood after an extreme rain fall in summer 2013. (Photo credits: Wei Liu)

There are two townships in the reserve, Wolong Township and Gengda Township. In each township there are three villages, each of which is composed of a number of (up to 7) hamlets (i.e., the lowest level of organization in rural China). Between 1975 and 2018 the human population in WNR almost doubled to around 5,000 and the number of households tripled to more than 1,300. Most local people belong to Tibetan and Qiang ethnic minorities but can speak fluent Mandarin Chinese in a local dialect. Since their first arrivals in the region in the 17-18<sup>th</sup> century the local communities had mainly a subsistence-based livelihood, relying heavily on natural resources from the forests, especially the timbers for fuelwood and construction needs.

The reserve was established in 1963 and expanded to its current size of 2,000 km<sup>2</sup> in 1975. In 1979 the reserve became one of China’s first of three UNESCO biosphere reserves (Li & Zhao, 1989), from which time it has received extensive attention both domestically and internationally. In 1980, the first internationally collaborative wildlife conservation and ecology research project in China was initiated in the Reserve by the Chinese Ministry of Forestry and WWF, later leading to the establishment of the Chinese Conservation and Research Center of Giant Pandas (CCRCGP), now the world’s largest research and breeding facility for pandas and their natural habitat. In 1983 the Chinese central government designated the reserve as the nation’s first special district for nature conservation. Since then the reserve has been managed by two administrative units – the Wolong National Nature Reserve Administrative Bureau (WNNRAB) and the Wolong Special District Administrative Bureau (WSDAB) (Fig. 19).

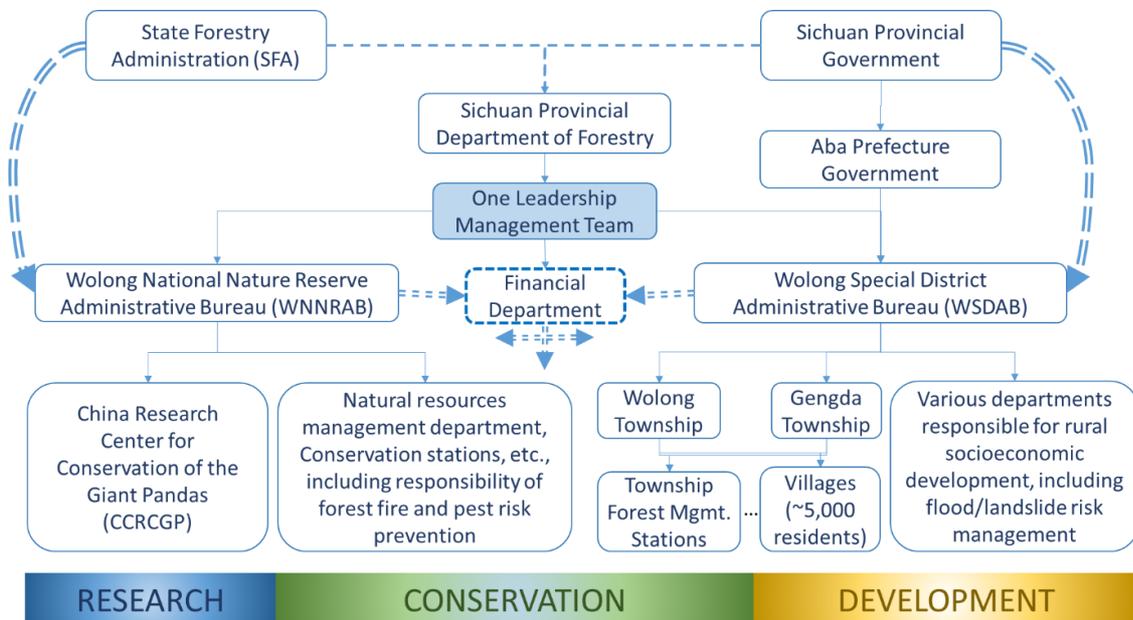


Figure 19: The hierarchical structure of the management of WNR.

The WNNRAB and the WSDAB continue to be led by a management team under the supervision of Sichuan Provincial Department of Forestry, as designated (single dashed lines on the top in Fig. 19) by the State Forestry Administration and the Sichuan Provincial Government, both of which provide direct funding (double dashed lines on two sides in Fig. 19) to WNR. The reserve’s three main functions (research, conservation, and socioeconomic development, as shown at the bottom panel in Fig. 19) were fulfilled by different departments. For instance, managing flood and landslide disaster risks that mainly threaten people and assets are usually responsibilities of local government (WSDAB and the two townships), while managing forest fires and pest risks (i.e., threat to ecosystems) is the duty of the reserve (WNNRAB and the Natural Resources Management Departments). Lacking a specific government unit exclusively dealing with disaster risk, this special “One team, two plates” system, unique in China’s

protected areas, gave WNR's management team relative independence in deciding and coordinating their conservation and development activities.

#### 4.3.1.2 *Natural hazards in WNR*

Located in a global disaster hotspot region, the WNR is prone to risks from multiple natural hazards, such as flood, landslides, mudslide and rock fall. The average annual precipitation is ~900 mm, and precipitation from May to September accounts for ~70% of the total annual precipitation (Wolong Administration Bureau, 2004). Landslides, debris flow and torrential floods are common in summers, and the area has experienced recurrent natural disasters throughout its recorded history. For example, a compound disaster in 1812, composed of torrent flood, landslides and debris flow, led to the death of more than 60 people. The direct impact lasted for almost half a year and the resulted sand/soil deposition become a flat area named Sandy Bay (沙湾 in Chinese) where the WNNRAB and WSDAB headquarters are currently located. In the 1960's, the area was connected to the outside by a road along the main river that flows through the reserve center. The road was inundated by torrential flood and extensive mudslides in 1964, resulting in 78 deaths, 48 days of road block, and extensive cropland (>150 ha) losses and damages. A detailed list of major disaster events, including types and losses and damages, can be found in Appendix D.

On May 12<sup>th</sup> of 2008, a devastating (8.0 Mw) earthquake struck the reserve and the surrounding area in Sichuan province, causing mortalities of more than 80,000. In the WNR area the earthquake and its associated landslides caused the death of more than 100 people and extensive damages to the reserve's forest ecosystem (c.a. 15% of canopy cover was lost) and infrastructure (Viña et al., 2011). A series of reconstruction programs were implemented to restore the ecological, social and economic systems in the reserve. During a decade long reconstruction period, the WNR was frequented by secondary disasters as a result of a weakened geological and ecological system due to the earthquake. Torrential floods and mudslides devoured newly built roads twice between 2010 and 2014 and led to the decision to construct ~70% of the roads in tunnels. Most recently in August 2019, a mudslide following an extensive rainfall led to the death of 12 and loss of several houses in the Gengda township. The road was blocked for over a week. Appendix F shows one photo of this recent disaster.

#### 4.3.2 The NBS programs in WNR

Despite being China's flagship protected area with worldwide fame, deforestation persisted in WNR throughout the 20<sup>th</sup> century, caused by agriculture expansion in the early decades, followed by authorized timber harvest in the 1960s and 1970s, and later due to illegal logging and local consumption with increasing human population and household proliferation as a root driving force. Local households were required to harvest wood only for meeting local needs, but by the end of the century deforestation still resulted in severe destruction of forests and wildlife habitat, including the giant pandas, as well as severe natural hazards such as landslide and floods (An et al., 2002; Li et al., 1992; Liu et al., 2001b; Liu, Ouyang, Taylor, et al., 1999).

#### 4.3.2.1 *The (unsuccessful) early NBS programs*

Since the establishment of the Reserve, forests in Wolong had been turned to almost all government-owned, while local households were allowed to use timber and non-timber forest products (e.g., mushrooms, herbal medicines) for their own use. Since the 1970s, pressure of excessive local use, especially illegal logging and poaching of wildlife, had been increasing. One important purpose of the establishment of the Wolong Special District in the early 1980s and the “One team, two plates” system was to mitigate the conflicts between the needs for development (e.g., income and job creation, natural disaster risk reduction) and conservation (e.g., reduction of illegal logging to stem forest ecosystem degradation) through more integrated solutions. With support from both international and national sources, a number of NBS programs were planned and implemented to conserve and restore the forest ecosystems for both disaster risk reduction and biodiversity conservation in the 1980s. To address deforestation problems, the following measures were put into practice:

- Strict rules on local forest uses for local subsistence consumption only, including punishment for illegal logging and poaching;
- Government funded afforestation and reforestation in degraded forest land; and
- World Food Programme funded cropland reforestation program (~113 ha in 1983) coupled with relocation of households near primary forests (a pilot of ~50 households from Wolong township were supplied with new housing in Gengda township).

However, the rules and restrictions were usually not effectively executed due to insufficient capacity to monitor and enforce. Forests in WNR thus were effectively open-access resources, and local people could appropriate the wood, or even sometimes clear the trees for cropland. This inevitably led to the so-called “tragedy of commons” phenomenon (Dietz et al., 2003; Hardin, 1968), and deforestation was common in natural forests and reforested areas. The cropland reforestation and household relocation pilot project above also failed due to lack of livelihood opportunities, and the reforested areas were largely reclaimed into cropland.

Throughout the late 20<sup>th</sup> century, WNR’s management body and local communities were often in conflict. Because the authorities had mainly “sticks” but with little resources for monitoring and enforcement, Interviewee 3 describes the situation as a “cat and mouse game” and recalls that the locals often referred to the government forest patrollers as “mountain-chasing dogs”. The annual deforestation rate in WNR almost doubled in the period 1985-1990s as compared to that in the period 1975-1984, and Interviewees 2, 3, and 10 all mentioned the potential relationship of the deforestation to China’s introduction of a new market-based forest policy in the mid-1980s (Richardson, 1990). Illegal timber harvesting for sale to outside markets instead of local use became the main cause of deforestation, which was acknowledged in official publication by WNR researchers, one of whom became the Director of WNR in 2002. They described the illegal practices as “abnormal leakage of wood to the outside” (Zhang & Zhang, 1994).

Interviews were conducted in 2008 on illegal logging in the WNR with a purposeful sample of 32 government and local residents. From this sample the top reasons for deforestation included the following: lack of alternative income to locals (72%), the poor institutional structure for forest management (66%), lack of labor for forest management (44%), and the lack of funding for forest management (28%) (Liu et al., 2011). Interviewee 3 explains the situation in a slightly different way:

*“Many reserve managers and patrollers were born and grew up locally and had complex kindred relationships with local villagers, making it very hard for them to enforce punishment and confiscation when illegal logging happens, and sometimes they could also be bribed ..... no one wanted to be the bad man and be hated by locals, especially those who could barely survive with subsistence-based agriculture livelihoods.”*

#### *4.3.2.2 Natural Forest Conservation Program (NFCP) policy at national and provincial levels*

China is a disaster-prone country, especially in its vast mountainous regions that cover ~2/3 of its land. Partly due to increasing exposure of population and economic assets, disaster-induced losses and damages increased steadily in the second half of 20<sup>th</sup> century, from 48 billion Yuan/Year in the 1950s to more than 100 Billion Yuan/Year in the 1990s (both in 1990s prices, and the latter number did not include losses from the 1998 floods, which was at least three times the average annual loss in the 1990s) (CCIRDNR, 1998). China’s forestry policy played an important role in the worsening hazard situation, especially in mountainous regions. By the late 1990s, a half-century policy of forest exploitation and monoculture in China had led to devastating consequences nationwide, including extensive degradation of forests and ecosystems, severe loss of biodiversity, unacceptable levels of soil erosion, and catastrophic disasters, especially flooding (Liu et al., 2008 ; Ouyang et al., 2016; Zhang et al., 2000). Both the total area and unit-area stocking of natural forests declined by more than 2/3, including the upper reach of the Yangtze River, where WNR is located. China’s forestry sector had faced stagnation for almost a decade, especially the state-owned forestry bureaus with large bodies of under-employed loggers, and the public authorities actively looked for opportunities to transform away from the past logging-based regime.

In 1997, the Chinese Committee for the International Decade for Natural Disaster Reduction drafted the *National Disaster Reduction Plan (1998-2010) of the People's Republic of China*, which was approved by State Council in April 1998. The Plan specifically pointed out that in China’s rural areas, disaster risk reduction should “..... *be mainly based on soil and water conservation and eco-environment improvement; continue the implementation of ..... mid- and upper stream Yangtze river protection forest program, .....; enhance the integrated management of biological disasters, sandstorms, and forest and grassland fire disasters, .....*” (CCIRDNR, 1998), or in other words, NBS was considered a main tool for rural DRR in China at that time.

Coincidentally, the year of 1998 was an El Nino year. In that summer a series of flooding events struck the Yangtze River, the Nen River and Songhua River in Northeast China, and the Pearl River in Southern China, killing more than 4,000 people, rendering more than 13 million homeless, and causing more than U.S. \$36 billion in direct economic losses (Ye & Glantz, 2005). These massive disasters posed high political pressure and prompted the central government to create one of the world's largest NBS programs, the Natural Forest Conservation Program (NFCP), aiming to reduce natural disaster risk by restoring forest ecosystems upstream of the major rivers, especially those in Western China where a severe development gap and relatively rich forests still existed. A new agency, the Center for Natural Forest Conservation and Management (CNFCM, <http://www.forestry.gov.cn/sites/trlbh/trlbh/>), was established under the State Forestry Administration (SFA) to manage NFCP across the country.

CNFCM applied a mixture of policy instruments to achieve their objectives. Dedicated new funding from Chinese government bonds was provided from Ministry of Finance. The *Natural Forest Conservation Program Financial Management Regulation* was published by the Ministry of Finance in 2000, and subsequently updated in 2006 and 2011. Since 2001 a flat rate of ~10 EUR/ha was allocated, and this rate increased to ~20 EUR/ha by 2017. By the end of 2018, a total of 50 Billion EUR had been invested into NFCP from the central government's financial and budgetary provisions (State Council of China, 2019).

Sichuan province, where the largest upper tributary of the Yangtze River is located, was the first to respond to the national NFCP policy to a large extent because of the stagnant forestry sector. Immediately after the 1998 Yangtze river floods, a provincial natural forest resources conservation meeting was organized targeting the state-owned forest bureau's logging activities and businesses. It was later decided that commercial logging in Sichuan would be immediately banned. In Nov. 1999, the Sichuan People's Congress approved the 'Sichuan Provincial Natural Forest Conservation Regulation', the first of its kind nationally. This marked an important step in recognizing the value of an NBS to protect against flooding. In 2000, the NFCP was expanded to the whole province, including WNR.

#### 4.3.2.3 NFCP in WNR

The NFCP in the WNR focused primarily on forest conservation through more effectively enforced monitoring and management to minimize deforestation, targeting all the 120,500 ha forest (and shrub) land (Fig. 20), in order to enable the recovery and maintenance of forest ecosystem's functioning and regulating services (e.g., soil conservation, water absorption for flood control).

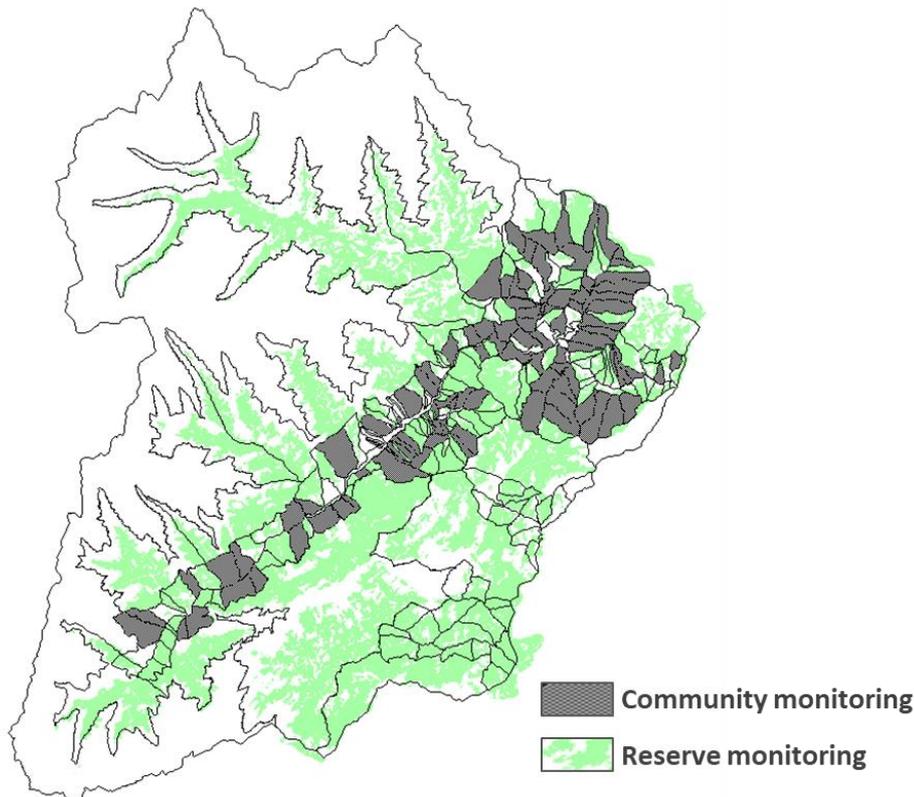


Figure 20: Spatial planning of NFCP monitoring scheme in WNR – grey parcels for local households monitoring and all other parcels monitored by the WNR (green color denotes forests based on Vina et al., 2001).

The full implementation process of NFCP, including some supporting measures, in WNR took place from 1999 to 2002. Table 7 summarizes a series of key events. More details are given in the following sections.

Table 7: Time line of NFCP initiation, planning, implementation, monitoring & evaluation in WNR

Year	Month	Events
1998	June	Approval of the first <i>Wolong National Nature Reserve Master Plan</i>
	Summer	Devastating floods across rivers in China, including Yangtze river
	Winter	National policy announced & Sichuan among the first batch of pilot provinces
1999	July-Nov.	Visits by top national leaders to Sichuan and WNR, including Prime Minister ZHU Rongji, with NFCP policy investigation as a main objective
	Nov.	Approval of <i>Sichuan Provincial Natural Forest Conservation Regulation</i>
2000	Summer – Fall	<b>NFCP preparation</b> – land and forest resources survey and mapping, and satellite image based forest map of WNR created by Forest Inventory and Planning Institute of Sichuan Province, providing necessary spatial information
	Nov.	<b>NFCP initiation</b> – Formation of NFCP Planning and Coordination Committee
2001	Jan.-May	<b>NFCP planning and pilots</b> – community consultation, spatial planning, monitoring area delineation with local households
	April	Publication of an article on ecological degradation in WNR on the academic journal <i>Science</i> drew international and domestic media attention to WNR
	May	NFCP of WNR in media of China Central Television (CCTV)
	July	<b>NFCP full implementation</b>

Year	Month	Events
	Oct.	Completion of WNR forest resources census by the Forest Inventory and Planning Institute of Sichuan Province
		<b>Monitoring, evaluation, and subsidy payment</b> semi-annually
2002	Jan.	NFCP committee chair, former deputy director, was appointed as the Director of both the WNNRAB and the WSDAB
	Apr.	Completion of rural electricity grid upgrade, ensuring local community's reliable access to electricity supply (i.e., alternative energy source to fuelwood)
	May	Completion of the new Wolong Eco-Hydropower Plant to meet increasing need for electricity by local households
	Sept.	The establishment of Wolong Forestry Police Squad to help enforcement of forest monitoring and conservation
2011	Jan.	Starting of the <b>second round (2011-2020) of NFCP</b>

While the stage was set for implementing the NFCP by the ban on commercial logging in the province, the initiation of the special brand of NFCP in the WNR can be attributed to a number of visits by top national leaders, including Prime Minister ZHU Rongji. NFCP soon became a top priority for the WNR management team, with the Department of Natural Resources Management (DNRM) as the main responsible department. In 2000, the DNRM led the efforts in conducting resource surveys and preparing resource maps for NFCP spatial planning. Due to lack of accurate information on forest area and structure, the WNR received NFCP funding for only ~70,000 ha of forest land for the first round of 2001-2010, a total of ~350,000 EUR/Year (1 EUR = 7.4 Yuan in 2001). Official *initiation* took place in Nov. 2000, when an inter-departmental NFCP Planning and Coordination Committee was formed, led by one deputy director of Wolong National Nature Reserve Administrative Bureau (WNNRAB) and coordinated by the DNRM. The NFCP committee later contracted the Forest Inventory and Planning Institute of Sichuan Province to conduct the first reserve-wide forest resources census, which concluded in fall 2001 (Wolong Administration Bureau, 2004).

The *planning* stage occurred mainly in the first half of 2001. The first major decision that the committee achieved was to allocate a major proportion (later decided to be ~45%) of the total NFCP budget to fund monitoring and management activities by local communities. The forest land was divided into parcels of varying sizes. As shown on figure 3, about one third of the total area (40,100 ha), mostly those relatively near the main road of the WNR, was allocated to be monitored by local communities. This was carried out with a forest management concession contract, which the interviewees generally called “contractual conservation” in Chinese. The contract essentially rewarded households for monitoring illegal logging in designated areas (carrots) and sanctioned households (either singularly or collectively) if illegal logging took place (sticks). The rest of the NFCP area, mostly further away from road, was allocated to be monitored by professional forest guards (mainly from the DNRM, conservation stations, and township level forest stations), supported by the Wolong Forest Police Squad that was later established in 2002.

In an unparalleled action, the NFCP committee instituted a broad *consultation* process with potential local stakeholders, especially government units at lower levels (e.g., forest stations, conservation stations) and local communities. A number of teams were established, each led by at least one deputy director of the Reserve, to conduct ‘town

hall' consultation meetings in all six villages of the two townships. Villages in WNR are comprised of 2-7 hamlets, and usually one meeting was held at each hamlet. The main purpose of the meetings was to collect information on local residents' initial responses to community-based forest monitoring with the 'sticks and carrots' concession plan, and on the stricter logging ban.

One village was selected from each township to **pilot** the new decentralized forest management concession system. A first pilot was initiated in the Gengda township with the initial idea to delineate and allocate small forest parcels to each household. Interviewee 4 (Date: July 2019) was involved in this pilot and indicated that -

*“We tried to get every household clear about where they should monitor to ensure the intactness of the forests, but soon found it close to impossible to make clear of boundaries of every forest parcel on our paper maps. Some local people also complained to us. .... We had to stop and discuss again how to proceed.”*

Difficulties encountered in the first pilot in Gengda township informed the second pilot in a Wolong township village. This time the DNRM Director suggested to lump neighboring households together to monitor a larger forest parcel, which largely increased the efficiency of the spatial planning and allocation process and was welcomed by the pilot village households. Following the consultation and pilots, a full strategy was **designed**, including an innovative forest management concession contractual system between WNR and local actors, mainly the more than 100 neighborhood household groups who were each allocated a forest parcel to monitor. These groups were paid ~120 EUR per household per year, covering ~1100 households, >95% of all in WNR at the time. Local households who manages a forest parcel jointly in a group were given the right to freely devise and decide on their own rules of management, especially on when, how and who to monitor. One common tactic was to combine monitoring with the collection of tree branches and grass for fuelwood and fodder, especially for those who live near their monitored parcels (Yang et al., 2013a).

The ***WNR NFCP Forest Management Evaluation Scoring Measures*** was the 'stick' designed in the form of a point system that deducted NFCP payment in the case of violations by local households, ranging from a small payment reduction up to the household being removed from the system. In this new arrangement, the households of persons found illegally logging would lose full or partial NFCP subsidy. If no appropriators could be identified, then all group members are sanctioned according to a detailed point accounting system that was widely publicized, depending on the seriousness and context of the forest damage, which also includes damage to forest wildlife. Sanctions are generally determined by the DNRM with the presence of affected households, and in extreme situations the Forest Police Squad will be involved in enforcing the sanctions or higher level of punishment according to *Sichuan NFCP Management Regulations* and other forest laws and regulations.

By late June 2001, the NFCP was fully **implemented** in the WNR, when the first payment of 60% of the annual allowance to households were dispersed in cash (the remaining 40% would be dispersed by the end of the year). Local households had come up with various levels and ways of collective monitoring, and the overall effectiveness has been satisfying (Yang et al., 2013a). Intensive semi-annual evaluations were conducted by DNRM and associated local government and village committee actors at the end of the second and fourth quarters of each year before payment, which later changed to bank transfer in the mid-2000s. In 2011, the NFCP was renewed for a second round of another ten years (2011-2020). This time WNR received ~1.15 Million EUR annually for all its 120,000 ha of forest land. As the national government gradually increased the financial rate per ha of forest land, and the total funding later increased to ~2.3 Million EUR/year by 2017.

Finally, it should be noted that NFCP was not the only NBS implemented in WNR. **Two other NBS programs**, the Sloping Land Conversion Program (SLCP) and the Grain-to-Bamboo Program (GTBP), were implemented mainly for reforestation from 2000-2003. They were much smaller in terms of spatial coverage in WNR (~467 ha, less than 0.4% of the total area under NFCP) and total budget, and have both been terminated recently. Their direct contribution to DRR was minor, therefore we did not include them in this study.

#### 4.4 Stakeholders landscape of NFCP in WNR

As described in the above section, the initiation, planning, implementation, monitoring and maintenance of NFCP at WNR since the early 2000s involved a wide range of stakeholder groups, including public administrators (mainly), public scientific and technical organizations, universities and village committees. Figure 21 shows a schematic diagram of the landscape of the main stakeholders involved in WNR's NFCP policy processes.

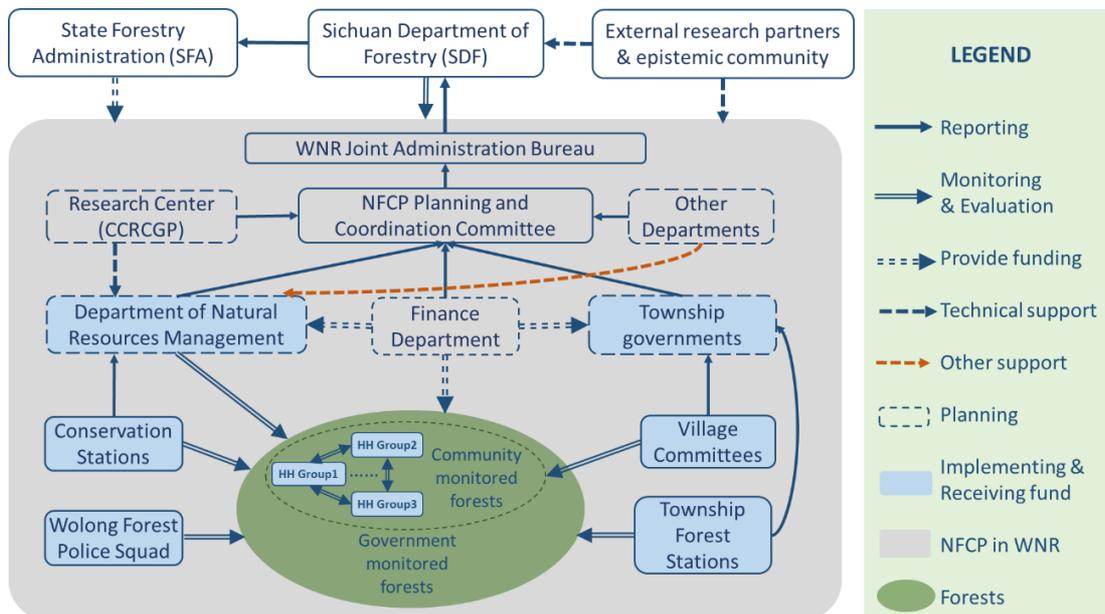


Figure 21: Landscape of stakeholders directly involved in the NFCP process at WNR

In general, The State Forestry Administration (SFA), through its Center for Natural Forestry Conservation and Management, provided the direct funding for NFCP at WNR. The Sichuan Department of Forestry (SDF), whom WNR reports to directly, officially monitors and evaluates the effectiveness of NFCP implementation. Both the SDF and WNR were supported by scientific and technical organizations and other expert communities, such as government institutes (e.g., Forest Inventory and Planning Institute of Sichuan Province), domestic universities (e.g., Peking University, Sichuan College of Forestry), international universities (e.g., Michigan State University), and international organizations (e.g., WWF China).

The inter-departmental NFCP Planning and Coordination Committee was formed in WNR in winter 2000, led by one reserve-level deputy director. The Natural Resources Management Department (DNRM), Finance Department, and two township governments were core members of the committee, while the research center and other departments provided technical and other support.

Only stakeholders, including local communities, who were directly involved in implementing, monitoring and maintaining the NBS were legally allowed to receive direct funding from the SFA. The Department of Finance played a key role in managing direct NBS funding and other funding that might be indirectly related to the NBS programs. Besides the novel forest management concession and participatory monitoring scheme that involved groups of local households to monitor the NBS, a number of agencies (e.g., conservation stations, village committees) also conducted monitoring activities and helped evaluate performance of community monitoring.

There were no private sector or civil society organizations playing active roles in NFCP of the WNR during the period of 1999-2002, thus the stakeholder landscape in 1999-

2002 was fully comprised of agencies from multiple government levels (from national to provincial and local) and local governmental sectors, and local communities (village, hamlets, households, etc.).

## 4.5 Benefits and co-benefits

Adopting the ambits identified by Autuori et al., (2019) as a typology, table 8 summarizes the key benefits and co-benefits of NFCP in WNR based on both published literature and interviewee responses. The confidence level is the author's judgement.

*Table 8: The key benefits and co-benefits of NBS in WNR*

Category and type of NBS benefit/co-benefit	Description	Confidence level	Source of information
<b>Risk reduction</b>			
Reduced flood risk	Reserve-scale risks from extreme flood events reduced, mainly due to increase of forest & vegetation cover and reduced soil erosion	Medium	Interview responses
Reduced landslide /mudslide risk	Reserve-scale risks from landslide/mudslide reduced, mainly due to increase of forest & vegetation cover and reduced soil erosion	Medium	Interview responses
Reduced potential additional earthquake damage	Increase of ecosystem integrity caused by the NBS may reduce ecological damages and degradations from the 2008 earthquake and the secondary disasters in the following years	Medium to high	Interview responses, Vina et al., 2011
Reduced rock fall risk	Recovered forests and reforested parcels stopped falling rocks during and after the 2008 earthquake in areas near local houses, saving lives and assets	High	Field survey; Interviewee responses
<b>Local economy</b>			
Job creation	Subsidy payment to all households and more labor from agriculture became available for off-farm job opportunities	High	Liu et al., 2012
Tourism	Improvement in ecosystem and reduction in disaster risk provide a favorable environment for continued tourism development	High	Liu, 2012
<b>Society</b>			
Esthetic value and recreation	Increase of vegetation cover improved esthetic values, especially in areas near roads where tourists and local residents frequent	High	Liu, 2012, Liu et al., 2012, Liu et al., 2015
Inclusiveness and equity	Broad community consultation and economic benefits from the NBS subsidies covering all households at various levels	Medium	Chen et al., 2010, Liu et al., 2016
Environmental awareness raising	Reduction of tree harvest and hunting in local communities	Medium	Liu et al., 2012a, Yang et al., 2013
<b>Environment</b>			
Vegetation cover	Both field survey and remote sensing imagery analysis showed significant increase in forest and vegetation cover across the reserve	High	Vina et al., 2011, Yang et al., 2013
Biodiversity	Field survey and advanced spatial modelling confirmed gains in wildlife habitat (quantity and connectivity), wildlife populations, and biodiversity in general	High	Liu, 2012, Tuanmu et al., 2015

Category and type of NBS benefit/co-benefit	Description	Confidence level	Source of information
Habitat quality	Field survey and advanced spatial modelling confirmed gains in wildlife habitat (quantity and connectivity), wildlife populations, and biodiversity in general	High	Liu, 2012, Tuanmu et al., 2015
Soil conservation	Increased vegetation/forest cover improved soil conservation	Medium to High	Qiao et al., 2014; Zhang et al., 2014

In the following sections, we elaborate on the benefits and co-benefits. The main focus is on reduction of disaster risks; other positive effects are considered as co-benefits (from the perspective of this case study). Because the DRR benefits are primarily achieved through improvement in environmental and ecological conditions, we begin with the environmental and ecological effects of NFCP in WNR.

#### 4.5.1 Environmental and ecological effects

##### 4.5.1.1 Forest cover increase

Forest cover maps have been developed for seven years: 1965, 1974, 1987, 1994, 1997, 2001 and 2007 (J. Liu et al., 2001; A. Viña et al., 2007; A. Viña et al., 2011) making use of data acquired by remote sensing imageries combined with field-collected ground-truth data. The results show that forest cover in WNR reduced from ~106,000 ha in 1965 to ~70,000 ha in 2001 (an average reduction of almost 900 ha/year). By 2007, seven years after the implementation of the NBS programs, forest cover in WNR increased to ~80,000 ha, close to that in the early 1990s (Fig. 4). Yang et al., (2013) estimated that in the absence of NBS programs, the forest cover would have reduced to ~68,000 ha. This net gain of ~12,000 ha is composed of three parts – natural recovery, avoided deforestation, and reforestation (mostly through SLCP and GTGP, merely ~450 ha in total) (Figure 22). The increase in forest cover and overall vegetation conditions were well recognized by stakeholders in past studies (Liu 2012, Yang et al., 2013) and in the 2019 interviews. All interviews mentioned the damage of the 2008 earthquake, which caused extensive forest losses with a size equivalent to the gain achieved during 2001-2007 ((Viña et al., 2011), Appendix E), and five Interviewees (1, 2, 9, 10 & 11) expressed the view that the earthquake limited the potential ecological benefits of the NBS programs.

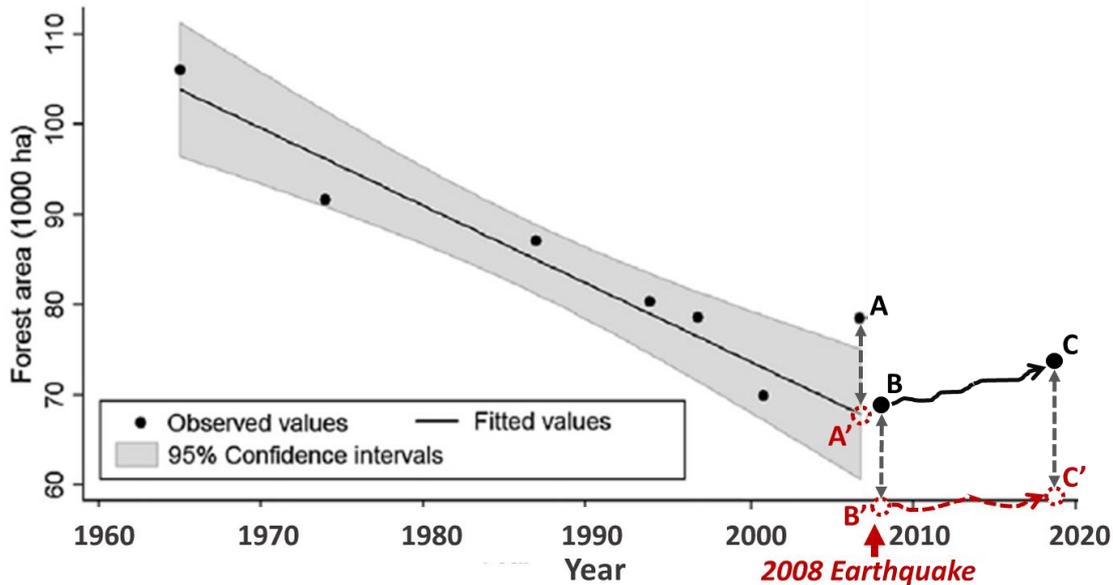


Figure 22: Observed forest change (in black dots) in WNR and hypothetical non-NBS scenario of forest change (in red open circles). The figure is partially adapted from Yang et al., 2013.

#### 4.5.1.2 Ecological functions

Tuanmu et al. (2016) utilized a satellite-based habitat model and spatial autoregressive analyses to assess giant panda habitat change in WNR, and confirmed significant improvement in both quantity and connectivity. Liu (2012) coupled an individual-based model with satellite-based habitat model to assess giant panda population carrying capacity in WNR, and also concluded an increase. This is generally consistent with the WNR's regular wildlife survey assessment, as confirmed by interviews in 2019. In fact, significant increase of population and habitat range of ungulates, especially wild boar, was also reported by local residents (Liu et al., 2012; Yang et al., 2013a), to the extent that this has led to increased crop-raiding (Yang et al., 2018; Yang et al., 2013b).

#### 4.5.1.3 Soil conservation

A positive relationship between vegetation cover increase and soil conservation is well established and has been previously documented in WNR (Fu et al., 2004). Most interviewees recognized a strong contribution of the NBS programs to decrease in soil erosion, but interviewees (Interviewees 1, 9, 10) pointed out that the exact contribution cannot be easily assessed, due to 1) the lack of field assessment, and 2) the damage caused by the 2008 earthquake disrupted the recovery process after 2008. Recent field studies (Zhang et al., 2014, Qiao et al., 2014) confirmed significant vegetation recovery in WNR after the earthquake. Interviewee 4 mentioned NFCP's potential positive effect on water quality in WNR, mainly reducing turbidity in the main river, but no supporting data is available.

#### 4.5.2 Disaster risk reduction

Increase in vegetation cover and condition and better soil conservation usually contribute to reduction in flood, landslide, and mudslide risks. This was largely confirmed in a survey of >200 local households in 2007, most reported observed benefits on improved environmental quality, and prevented water and soil erosion, landslides (Yang et al. 2013a).

The interviewees in 2019 had more mixed views. While recognizing the potential DRR benefits of NFCP, interviewees from within WNR (Interviewees 2-4, 6, 9) indicated that they were not sure, especially after observing recurrent and intensive floods and landslides in the decade following the 2008 earthquake, whether the recovery could really make a contribution to DRR. Only three Interviewees (Interviewees 1, 10, 11) considered that forest recovery since NFCP could have had a detectable effect on disaster risk reduction at the reserve scale within the relatively short amount of time. Interviewee 11 (researcher) believed that the net benefit of NBS on disaster risk reduction could be more significant when considering a counter-factual non-NBS scenario (A' in Fig. 18), in which earthquake would strike the forests at WNR at a more degraded state (i.e., forest area at 680,000 ha instead of 800,000 as shown in Fig. 4), the hypothetical earthquake damage (B-B' in Fig. 18) would have been larger than the observed damage (A-A' in Fig. 18). Furthermore, the indirect post-quake flood, landslide and mudslide damages and degradations could also have been larger than what was observed afterwards. As a result, post-earthquake recovery situation could be worse (i.e.,  $C-B > C'-B'$  in Fig. 18) if NFCP had not been implemented.

#### 4.5.3 Local economy and society

The reliance of local residents on forests for many generations changed since the implementation of the NBS, triggering not only environmental effects but also social, economic and cultural effects. The NFCP subsidy provided an important additional income source for the local households, initially equivalent to 20% of the average household net annual income (Yang et al., 2013). On average, total household income doubled by the end of 2001 compared with 1998, and had quadrupled from 1998 to 2007, based on a long-term panel data on household socioeconomics in WNR (Liu et al., 2016). In a household survey in 2007, almost 90% interviewed households reported that overall the NFCP had brought more benefits than costs to them, especially through the direct subsidy payment and promotion of tourism development. Tourism was promoted as an important alternative economic development method in WNR (Liu 2012). Improved ecological condition and scenic views, especially along the roads and near human settlements and major tourism infrastructure in WNR, induced more recreational uses by tourists as well as locals.

At community level, there was a good sense of inclusiveness according to feedback from local households (Yang et al., 2013a) mainly due to the broad community consultation during the NBS planning and implementation periods and wide coverage of economic benefits from the NBS subsidies of all households at various levels. Environmental

awareness and behavior change were also observed in past studies after NFCP, including reduction of tree harvest and hunting in local communities and a shift in the use of alternative energy sources (i.e., from fuelwood to electricity). The amount of electricity consumption per household doubled, while the amount of labor force spent in collecting fuelwood almost halved after NFCP implementation (Yang et al., 2013a).

## 4.6 Enablers of the NBS programs in WNR

### 4.6.1 Pre-conditions as enablers

A number of pre-existing conditions at higher political levels or at WNR but before the NBS programs were key in making the NBS programs possible. These are factors that were external or exogenous to the NBS programs, yet contributed to its initiation. Table 9 summarizes those pre-conditions that were identified in existing publications and/or by interviewees.

Table 9: Pre-existing conditions that enabled the NBS in WNR

Category and type of NBS precondition	Description
<b>Socio-cultural</b>	
Shared social norms	Strong local social/kinship network and the shared social norms among local households
Interest/pressure group	Integrated Conservation and Development Program (ICDP) and science-based planning advocacy by international NGOs
<b>Legal/institutional/political</b>	
Public property rights	Almost all forests in the WNR are government-owned.
Existing mandate and authority	The Wolong Special District Administrative Bureau, as the government body, has obligation to protect communities from disaster risks.
Existing legal basis	The First Master Plan of the Wolong Nature Reserve required nature-based solutions for synergy between DRR and conservation
Regional policy umbrella	Increased monitoring capacity and enforcement efforts on illegal logging at provincial level under NDCP
<b>Financial and human resources</b>	
Awareness raised by events	Massive disasters in the 1990s triggered the introduction of new national and regional NBS & DRR policies
Available funds	Unprecedented funding level from national NFCP fund, which was later renewed at increasing rates
Expert knowledge and expertise	Rich knowledge on forests and complexities of conservation-development conflicts, and awareness of the effects of deforestation and forest degradation on disaster risk
New economic development programs	Cash crop and nature-based tourism gaining in importance and government investment in local infrastructure, especially rural electricity network

#### 4.6.1.1 Socio-cultural context

WNR is located in Western Sichuan mountains, where over 75% of the local population are descendants of Tibetan and Qiang ethnic minorities (Liu et al., 1999). By the late 1990s, the traditional pastoralists had mostly changed into sedentary peasants. Most had lived together in small communities for generations, and cooperating, building and maintaining trust played an important part in their daily livelihoods, from constructing

together local roads and temples to helping each other build houses. An experimental game (Ultimatum Game) conducted in 2007 showed that local subjects made decisions heuristically based on relatively simple fairness norms (Song et al., 2012) and had strong antipathy to selfishness and greed (described as “heavy heart” in the local dialect). Chen et al., (2019) also suggested that social norms can be used to leverage participation in the SLCP NBS program at WNR. In general, such strong social/kinship networks and the shared social norms among local households in WNR were typical of China’s rural communities.

The strong social conventions were leveraged in designing the forest management concession contractual system. Chen et al (2009) and Song et al., (2012) both showed that strong social norm might play important roles in facilitating NBS up-scaling in WNR, as the limited monetary subsidy alone could not explain the cooperative commitment of the local households (Wu Yang et al., 2013) if they were only self-regarding. NFCP success inspired the need for policy design that better takes into account the active local social norms. Recently, China announced the ‘Natural Forest Conservation and Restoration Policy Plan’ (CCCPC & SC, 2019), a major update of the NFCP before the launch of its third period of ten years. Innovative enablers of NFCP in WNR almost 20 years ago was very well echoed in the Article 20 of the Plan –

*“Natural forest conservation should be a long-term, multi-generation effort with strong public participation, co-production and benefit sharing. Non-structural measures, such as formulating locally adapted rules, ..... should be encouraged in order to cultivate new ecological ethics and behavior norms for sustainable forest management. .... “*

Such community cohesion can be a double-edged sword. It contributed to the notorious illegal logging problem in the past. Some pressure groups, such as Worldwide Fund for Nature’s (WWF) China program in the 1990s saw community cohesion as a potential source of innovation for conservation and development. WWF played a key role in the initiation of nature conservation in WNR and China, and by 1990s, the community-based Integrated Conservation and Development Program (ICDP) (McShane and Wells, 2004) was among their priorities. However, top leaders of WNR in the 1980s-1990s favored fence and fine model (Schaller, 1994) to address deforestation challenges much more than softer but often more complicated, as perceived, measures such as People-Centered Conservation and Development (a synonym of ICDP). Interviewee 9 participated in many trainings and projects organized by international partners like WWF and academic partners in 1980s-1990s. He reported the importance of these partners in bringing new technologies such as GIS, GPS and remote sensing in making science-based spatial planning of forest ecosystem management, and also mentioned that -

*“..... in the mid- to late 1990s, we received a lot of criticism from international partners, especially from Dr. Z from WWF and P University, for not giving local communities enough opportunities to participate in decision making related to conservation and development,*

*to the extent that they moved to another panda reserve in Sichuan to implement their ICDP projects, with great success later.”*

Nevertheless, pressure groups such as WWF, and later other international and domestic partners, through their continuous collaboration and interactions, planted important seeds of new NBS governance ideas in the WNR system, or at least triggered some to think of alternatives, sometimes through conflicts (Schaller, 1994).

#### 4.6.1.2 *Legal, institutional, and political context*

As introduced earlier, WNR enjoyed a special institutional status of being a Special District and the leadership group had the mandate and authority for promoting conservation and development (see Fig. 19), with full property rights to almost all land except about 2-3 km<sup>2</sup> of cropland that is communally owned by villages. Limited funding forced them to explore more integrated solutions for synergies between DRR and NBS (i.e., reducing both disaster risk and deforestation simultaneously). This was further legitimized by the approval of the first *Master Plan of the Wolong Nature Reserve* by the SFA in 1998, a major outcome of almost a decade of planning mainly by the government with support from national and regional experts. WNR is also one of only three national nature reserves (all having large panda populations) directly funded by State Forestry Administration. The 1998 Master Plan included both specific conservation and DRR objectives and also related targets for financial support from the SFA.

An important external pre-condition was the strong enforcement of NFCP at the provincial level. The Sichuan province was the first to legislate a provincial NFCP regulation, and subsequently it has substantially increased monitoring capacity and enforcement efforts on illegal logging, including more strictly managed wood checkpoints along major transportation routes across the province. This was mentioned by Interviewee 1 (Date: July 19, 2019):

*“Illegal logging is a national and provincial level problem. Wolong alone cannot solve it unless the surrounding areas all work together in enforcement of checking, confiscating, and punishing illegal logging, including the timber market. After NFCP, the legal and transaction cost of illegal logging increased substantially in Sichuan. This also indirectly helped reduce deforestation pressure in Wolong.”*

#### 4.6.1.3 *Financial and human resources*

While the strong cause-effect relationship between deforestation and increasing disaster, especially flood, risks is rarely doubted, it was the increasing frequency and intensity of disaster events that substantially increased such awareness at all levels in China (e.g., the 1998 floods for the national leaders, and series of events in WNR in the 1990s for managers). This increase in awareness, coupled with recognition of development gap in Western China, triggered the creation of new national funding dedicated to NFCP

(Ouyang et al., 2016; Viña et al., 2016; Xu et al., 2006). The program initially targeted sensitive regions that had been severely degraded since the 1950s, especially headwater and other upstream regions of major rivers, such as WNR.

Locally in WNR, early on at the founding of the Wolong Special District Administrative Bureau (WSDAB), Li et al., (1983) suggested that, considering the geo-hydro-meteorological hazards impacting WNR, DRR should be given at least equal emphasis as conservation. While WSDAB has obligations in managing disaster risk, there is a severe lack of DRR related expertise. Neither did they have sufficient funding for hard infrastructure construction to mitigate flood and landslide risks. Interviewee 1 (Date: July 19, 2019) explained that many staff in the WSDAB and WNRAB graduated from national forestry universities or provincial forestry schools; while DRR was not their top priority and main expertise, reforestation and enhancing natural recovery of vegetation (i.e., NBS) was considered by them effective ways for local disaster risk management –

*“... honestly there was little that we could do with large-scale disasters, especially at the level such as the [2008] earthquake. .... but on the other hand, I do think that making sure forests are well protected should be at the core of any DRR plan of Wolong.”*

The role of alternative and new socioeconomic development opportunities cannot be underestimated either. At community level cash crops (e.g., cabbage, turnip) were introduced to WNR since the mid-1990s, to replace corn and potato that were dominant in the subsistence-based agricultural system. At WNR level tourism was developed to generate funds for conservation and to provide alternative income sources for local communities. The successful breeding of in-captive pandas in 1990s at the CCRCGP and the completion of a provincial highway in 1999 made it possible for tourism to boom since the early 2000s (e.g., tourism participating households increased from 4% in 1998 to 28% in 2007 (Liu et al., 2012). Tourism is becoming an even more important sector after the earthquake, with >90% of local households in the Gengda township turning their houses into small hostels for recreationists in summers, keeping local residents busy from excessive natural resources extraction activities.

#### 4.6.2 Enablers during the NBS processes

This section reports on the factors that enabled or facilitated the initiation, planning, implementation, monitoring and maintenance of the NFCP at WNR. While many technical conditions needed to be in place, this discussion focuses mainly on governance conditions, which comprise all of the processes of governing – whether undertaken by the government of a state, or by non-state and market actors (Bevir, 2012). Governance enablers were identified based on literature and interviews. Table 10 summarizes these enablers, which are subsequently discussed in more details.

Table 10: Key enablers of the NFCP in the WNR during its initiation, planning/design and implementation

Category and type of NBS enabler	Description
<b>Socio-cultural</b>	
Awareness raised by disaster events	Recurrent local disaster events since the late 1980s, such as relocation of a whole hamlet due to landslide risk, further exacerbated existing conflicts between conservation and development in WNR
Stakeholder engagement	Unprecedented consultation with local communities
<b>Legal/institutional/political</b>	
Political pressure, will and support	Visits of national leaders, especially Prime Minister Rongji Zhu to WNR in 1999; international and national media attention on WNR following a Science magazine research article on ecological degradation in WNR
Local champion	Two experienced government officials played pivotal roles in coordinating and planning the NBS programs in WNR
Cross-scale collaboration	Collaboration across hierarchical levels within WNR, from reserve level, to township, village, hamlets, and neighboring household groups designated specifically for NFCP
Cross-sectoral collaboration	Strong collaboration across different departments within the government systems, including the formation of the NFCP Planning and Coordination Committee and the introduction of the Wolong Forest Police Squad
Innovative design of incentive structure	From mainly “sticks” mechanisms to a novel combination of “sticks and carrots” mechanism
<b>Financial and human resources</b>	
Expert knowledge and expertise	Research on vegetation and ecosystems and introduction of new technologies (e.g., GIS, remote sensing) by local research team and domestic and international partners
Additional funding sources	Mixed sources ensured both the quantity and flexibility of funding

#### 4.6.2.1 Socio-cultural enablers

##### 4.6.2.1.1 Awareness raised by disaster events

The period 1988-1992 was characterized by frequent local disasters in WNR (Appendix E). When revisiting this history, three interviewees (Interviewees 2, 6, and 7) mentioned that one village group, Zoumalin, a hamlet in Gengda township, was completely relocated due to the landslide threat. Interviewees 9 and 10 (Researchers) suggested that there was strong association between the disasters and increased deforestation since the mid-1980s and resulted soil loss, especially along the slopes of the main road/river, where local people slide big logs. These disasters further exacerbated the conflicts between conservation and development, as well as between local communities and the Reserve’s management body, and put extensive pressure on the management body, as reflected by the interviewees, to find integrated solutions to the multiple challenges from poverty, disasters and ecosystem degradation. Interviewee 6 (Date: Sept. 15, 2019) stated that –

*“Wolong, being also a special district, is unique in China’s protected areas. We are not only a reserve, but also a government. While conservation and pandas are always of highest priority for us, we had no*

*choice but to find solutions that may help us address development and disaster issues in synergy with conservation. .... 'Lucid waters and lush mountains are invaluable assets' [A recent quote from President Xi Jinping of China], degradation, disaster and poverty together is a trap that we wanted to get out of. We needed more integrated solutions, .... which would require strong government financial input, and new economies such as ecotourism."*

#### 4.6.2.1.2 Community engagement

Almost all interviewees mentioned that the level of participation and stakeholder engagement during the planning and implementation of the WNR's NBS programs in the early 2000s were unprecedented in its history and unparalleled in the surrounding areas. Interviewee 2 pointed out that during initial discussions, there was a general consensus that the NBS programs could not be successful if they did not sufficiently involve local communities and address their development challenges.

*"Under NFCP we need ensure logging is strictly banned and no more deforestation and ecological degradation. This would have been impossible if the majority of local residents were not willing to support. Voluntary participation was impossible, but with funding, we might be able to pay them in exchange for their service to help monitor and manage the forests together".*

During the initiation and planning period, for the first time in history, small teams of Reserve staff, often led by Reserve-level officials or Department heads, visited all villages during the planning process, meeting not only rural elites (e.g., village committees) but also local families. Interviewee 3 indicated that for the first time he was confident about approaching village heads and local households because they would be paying everyone, instead of punishing anyone, and the attendance was very well, likely because *"some heard about the potential cash payment in the NFCP"*. The broad attendance of the consultation process was also confirmed by Interviewee 7 (Date: July 2019) -

*"I came to Wolong by marriage in the early 1980s from the nearby Xiaojin county. Before NFCP, I had never in my life seen so many high-level [reserve/county level] officials coming to my village and seriously talk with many families; neither in Xiaojin, nor in Wolong. .... We did not want to destroy our eco-environment, but the Reserve put a lot of limitations on how we could use natural resources, without any compensation. With the NFCP, for the first time we were paid with cash for conservation work."*

Feedback collected during the consultation and pilot processes substantially shaped the final design of NFCP. Many rules in the NFCP forest management scoring system were decided and/or modified based on suggestions from local residents, such as allowing

local households' uses of tree branches, dead trees and litter in forests monitored by them.

#### 4.6.2.2 *Legal, institutional, and political enablers*

##### 4.6.2.2.1 Political pressure, will and support

The 1990s marked a breakthrough period for WNR in terms of its *ex situ* conservation achievement (i.e., success in breeding pandas in captivity in the CCRCGP). This success enabled the national government to send two pandas from CCRCGP to the San Diego zoo as part of a new cooperative breeding and conservation program between China and the USA. Many high-level officials, often ministers or even vice prime ministers, visited WNR during this period. A major highlight was the visit of the then Prime Minister Rongji ZHU in Sept. 1999, when the NFCP and SCLP were at their initiation stage. It was recorded that Zhu pointed to one area of mountain forests in WNR and said that “the ultimate goal of NFCP is to make our land look like this” (Wolong Administration Bureau, 2004). To meet the high expectation from the top level of the Chinese government, WNR managers were determined to make WNR “a model for NFCP implementation” (Interviewee 2, Date: July 18th 2019).

One unexpected event happening during the NFCP planning stage likely played a role in the NFCP policy process. In April 2001, an article *Ecological Degradation in Protected Areas: The Case of Wolong Nature Reserve for Giant Pandas*, jointly authored by researchers from Michigan State University, Chinese Academy of Sciences, and Wolong Nature Reserve, was published in *Science*, one of the most prestigious academic journals. The article had a controversial (Shen 2002) conclusion that deforestation inside WNR region had become worse than that of outside the reserve after the designation of the reserve status. Given its flagship status in China's protected area system, WNR unexpectedly was on newspaper headlines internationally and later domestically. The management body became then under unprecedented pressure. Later in May, China Central Television (CCTV), China's predominant state television broadcaster, together with Sichuan Provincial Television, visited WNR to investigate the progress of NFCP. Interviewee 6 (Date: Sept. 15 2019) memorized the event –

*“Immediately after the Science paper, media put us in big criticism for not protecting our forests and pandas well, and causing ecological disasters. While disagreeing with the paper's conclusion, we could not change what had been published. .... But what we could do was to show that we can protect our forests through the NFCP.”*

##### 4.6.2.2.2 Local champions

At least two champions were instrumental in the success of NFCP at WNR, the NFCP committee chair (later Director of WNR from 2002) and the Director of DNRM. The former, as described by Interviewee 6 (Date: Sept. 15<sup>th</sup>, 2019), was the first “*scientist director*” in the Reserve's history, with 20 years of research and working experience at

WNR, and a “*special charisma to unite people around him*”. The latter, a forester by training, also had ~15 years of experience working at WNR by the late 1990s. Both had solid science backgrounds and rich experience (and lessons) in working with local communities. The DNRM director addressed Prime Minister Zhu during his visit and headed the NFCP committee with representatives from all major relevant departments and the two township governments (see Fig. 21). It was widely acknowledged by most of the interviewees (Interviewees 1-6) that it was the DNRM Director who initially proposed the idea of the forest management concession, including the suggestion to distribute a major proportion of the NFCP budget to local households, and later in the implementation stage suggested to form groups of households for monitoring. There were objections from other departments, but the DNRM Director’s plan was fully supported by the committee chair. Interviewee 6 called this “*a brave decision*”, as there was no precedent, and the decision makers might face risks of being accused of abuse of public fund. He further mentioned that during a later examination of the financial status of the NBS programs the examiners did question the legal basis for such subsidy payment to local households, but were convinced that this did not constitute a violation as the fund was used to pay households for monitoring and not (controversially) for paying households not to engage in illegal behavior.

#### 4.6.2.2.3 Innovative (and flexible) design of incentive structure

Trinomics & IUCN (2019) identified two major ways of financing and implementing NBS projects – (a) the public authorities finance and implement NBS projects or maintain existing NBS directly (especially on public land), or (b) the authorities encourage and incentivize other actors (e.g. residents, businesses) to implement NBS or to contribute to the maintenance of existing NBS in the public domain. Since past experience had shown that direct public monitoring of deforestation had not worked sufficiently, WNR managers (primarily the director) chose to incentivize households not to illegally log. This was a major innovation in the design of a forest management concession contract between public (the Reserve) and other actors, especially the local communities. Concessionaires, in this case local household groups, township forest stations, and others were granted limited use rights (e.g., collecting tree branches and dead trees) and were required to undertake monitoring activities and ecological protection.

The seminal work on the governance of the commons by the 2009 Economics Nobel Prize laureate Elinor Ostrom showed that the so-called “tragedy of commons” (Hardin, 1968) was not unavoidable (Ostrom, 1990). Through synthesizing myriads of case studies on how communities from around the world manage their common-pool resources (e.g., forests, fisheries, water, etc.), Ostrom first pointed out that it was in fact the tragedy of the open-access, then showed that common pool resources (i.e., resources exhibit characteristics of rivalry but not excludability) may be sustainably managed if the management rules respect a number of general design principles (Cox et al., 2010). The innovation of the NFCP contractual and management rules developed by the WNR managers, led by the Director of DNR, who had no knowledge of Ostrom, were largely consistent with Ostrom’s design principles. Table 11 summarized some details of the

concession scheme and how they correspond to Ostrom's design principles. In NFCP, while the forests remain state-owned, the WNR established a new contractual relationship with local residents and communities. In this new contract, local households, often in groups, took the responsibility to monitor and ensure the integrity of designated forest parcels (mostly near the main road, thus prone to illegal extraction activities) in exchange for annual NFCP payment. This design turned most of those forests from open-access resources to group-managed common-pool resources.

This was accomplished with incentives and sanctions, or 'carrots' and 'sticks'. Before 2000, the management body mainly had small sticks (particularly monetary sanctions) and struggled to govern the open-access forests. With the generous funding and new institutional arrangements in NFCP they had new sticks (e.g., as made possible by the Sichuan NFCP Regulation and the new Forest Police Squad with more legal capacity in pursuing forest and wildlife crime) and carrots (e.g., the NFCP payment and jobs to support government monitoring) making effective governance of the NBS programs much more likely.

Table 11: Rules in NFCP design that correspond to Elinor Ostrom’s design principles for sustainable management of resource commons

No.	Ostrom’s Design Principle	Designed rules of NFCP governance in WNR
1	Clearly defined boundaries of both the common property resource system and the membership in a group	The boundary of each forest parcel was mostly well defined (e.g, by ridges rivers, roads etc.) and the members of each group, also clearly defined, were reasonably clear about the boundaries and their rights to withdraw resource units from parcel were well defined.
2	Congruence between appropriation and provision rules and local conditions	Considering the local people’s basic needs for fuelwood and livestock fodder, the policy didn’t ban them from collecting branches, dead trees and understory grass.
3	Collective-choice arrangements: Most individuals affected by the operational rules can participate in modifying the operational rules.	The group of households who manages a forest parcel jointly devise and decide on their own rules of management, especially on when, how and who to monitor.
4	Effective monitoring: Monitors are present and actively audit CPR conditions and appropriator behavior and are accountable.	Neighboring group members could effectively monitor each other, per-household monitoring effort was generally smaller in groups, and plentiful additional monitoring by other groups.
5	Graduated sanctions for appropriators who violate the rules.	WNR NFCP Forest Management Evaluation Scoring Measures were designed with a point system that associate deduction of NFCP payment with various possible violations, from small payment reduction up to the household being removed from the system.
6	Conflict-resolution mechanisms: Appropriators and their officials have rapid access to low-cost local arenas to resolve conflicts.	Strong social network and the shared social norms among local households in WNR, typically found in China’s rural communities, played important roles in resolving conflicts, and DNRM provides an official channel for additional conflict resolutions needs.
7	Minimal recognition of rights to organize: The rights of appropriators to devise their own institutions are not challenged by external governmental authorities.	Each individual group’s right to devise its own rules was not challenged by the WNR management body.
8	Governance activities are organized in multiple layers of nested enterprises.	Broad involvement of and collaboration across local households and township/village level stakeholders in a multi-level nested polycentric government system of WNR (see next section).

#### 4.6.2.2.4 Cross-scale and cross-sectoral collaboration

The NFCP process in WNR was characterized by close collaboration across hierarchical levels, from national and provincial to reserve level, and lower township, village, and groups (Fig. 4). The funding was provided at the national level for the main purpose of flood protection; yet, the funds were administered jointly by provincial and nature-reserve departments with broader agendas that included conservation and economic development. Most notable was the formation of the inter-departmental NFCP Planning and Coordination Committee, led by a deputy director of the nature reserve administration (WNNRAB) and coordinated by the DNRM – both champions of NBS. This committee coordinated across departments, brokered scientific knowledge on NBS by commissioning independent evaluations (including by this author) and was instrumental in involving village households. The cross-sectoral collaboration was strengthened by the introduction of the Wolong Forest Police Squad to add the necessary legal enforcement capacity.

With significant funding for the NFCP, DNRM successfully convinced relevant departments to allocate roughly half to community monitoring by providing subsidies to nearly all local households. Initially, all government departments were included in the beneficiary group receiving funding for monitoring the remaining forest. This was corrected after the first SFA and SDF evaluation such that only departments and stakeholder groups directly related to forest monitoring would receive funding (Fig. 4). Two interviewees (Interviewees 2 and 4, July 18, 2019) indicated that the initial plan of broad sharing of NFCP funding across departments, which was implemented for three years, might have helped reduce the chance of objections.

#### 4.6.2.3 Intellectual and economic enablers

##### 4.6.2.3.1 Expert knowledge and expertise

WNR is nationally and internationally recognized as as China's ambassador protected area and attracts worldwide researchers, many who collaborate with the CCRCGP in WNR, China's largest research institute for pandas, including topics on forest ecosystems. Wolong was the first panda reserve where the new technologies of GPS, GIS and remote sensing were introduced by the Chinese Academy of Sciences and the WWF. In late 2000, the first state-of-art satellite image-based forest map for WNR was produced by the Forest Inventory and Planning Institute of Sichuan Province, providing necessary spatial information for the planning of NFCP. From this experience, it was also recognized that data from WNR's only forest survey carried out in the 1960s was dated and a new forest resources survey was initiated and funded by SFA. The survey confirmed that 120,000 ha of forested land in WNR met standards, a finding that subsequently supported the planning of the second round of NFCP for the period of 2011-2020.

Besides technical readiness, the WNR's core NBS program team (mainly the Committee and the Department of Natural Resources Management, See Fig. 5), led by the two

champions mentioned above, were highly knowledgeable of the local situations, especially the complexities of conservation-development conflicts and disaster events. The Director of the DNR explained why state-owned forests are open-access resources and with limited funds, it was impossible to monitor all forests at all times. At least three government official interviewees (Interviewees 2, 3, and 6) referred to the adage, “[forests] owned by government means that it’s owned by no one”. The interviewees stressed the importance of local households having responsibility, and thus a sense of ownership, of the forests, and necessary monetary income directly from the forests as incentives. This was mentioned as a major reason for the decision to allocate a proportion of NFCP subsidy to local households.

#### 4.6.2.3.2 Financial support

NFCP in WNR received substantial funding, including but not limited to the large sums directly from SFA, that ensured both the quantity and flexibility of funding for the implementation, monitoring and maintenance. Interviewee 2 (Date: July 18, 2019) indicated that –

*“Among all the factors, I would say that the financial capacity was the most important one. We had never had such level of funding, not mentioning that it was ensured for ten years and later further increased by almost one order of magnitude. Suddenly, a lot of what we wanted to do but could not do was possible.”*

An important indirect funding source was revenue from small hydropower plants owned and operated by a local public company, one of which was specifically built and finished in 2001, with funding from SFA. Due to fuelwood shortages resulting from the NFPC logging ban, it was expected that local electricity demand would increase. To further facilitate the switch from fuelwood to electricity, thus reducing the pressure on forests, a local electricity subsidy was devised, a 25% reduction (from 0.04 USD per kilowatt-hour to 0.01) was applied for all local household electricity use (Wolong Administration Bureau, 2004). Additional government funds were also secured to update the rural electricity network to ensure the stability of electricity supply and to appease residents’ complaints about living cost increases during the community consultation process.

### 4.6.3 Challenges and Limitations

Because of the unprecedented spatial and budgetary scale of the Wolong NBS program combined with a very short time horizon (1-1.5 years) from preparation to initiation, planning, design and implementation, there were inevitably limitations and challenges.

First, despite innovative and broad consultation, the design of NFCP was not immune to caveats. The membership in NFCP in the first round was on a household base, and only households officially registered before June 30th of 2001 qualified. Moreover, household size was not considered in the subsidy payment design, and larger households

raised this as an equity issue. What's more, newly formed households were not included in the program after 2001 and by 2007, this had accumulated to >100 local non-NFCP households. A large percentage of non-NFCP households was considered a threat to its effectiveness (Yang et al., 2013b).

Interviewee 2 (Date: July 18<sup>th</sup>, 2019) responded to these issues –

*“You probably cannot imagine how much work we needed to do at that time, on top of our regular mandate. We were literally rushing every week. .... The NFCP fund was dedicated to enhance forest management, thus our rationale is that only households with laborers [18-60 years old] should qualify, and such variation across households was not very high. .... In fact, we gave those households with only old people above 60 a partial payment, and they did not have to do anything for that money.”*

Nevertheless, in the second round of NFCP, the payment scheme was changed to be individual based, and every three years, all newborns would be added as beneficiaries. As Interviewee 7 (Date: July 20<sup>th</sup>, 2019) pointed out:

*“Many old people in Wolong are very healthy. In fact, the older ones used to do a lot of work in mountains, thus monitoring NFCP forests would be a piece of cake for them. .... I like the later arrangement. It is fairer.”*

Second, despite the substantial benefits and co-benefits of the NFCP in WNR, there were also (in the view of interviewees) negative unintended consequences. To anticipate the stricter logging ban in 2000, many local households conducted a round of intensive logging in winter to stock enough wood for up to 5-10 years (Liu et al., 2011). Some also complained that traditionally used natural resources (e.g., collection of non-timber forest products such as mushrooms) were too restricted under the NFCP (Yang et al., 2013a). The most negative impacts came from drastically increasing human-wildlife conflict because of uncompensated damage to crops and livestock from wildlife. Interviewee 8 (Date: July 20<sup>th</sup> 2019), a village committee member, reported that –

*“Crop raiding was extensive after NFCP, and even worse when many local households moved to low-land residence areas after the earthquake and left their cropland largely unattended. For some households, nowadays the NFCP payment was barely enough to cover their crop losses. .... we have conducted a series of fencing projects to mitigate threats from wildlife such as wild boar and changed cropping to fruit trees not favored by boars, but recently monkeys became a new threat. .... This should be considered in the next round of NFCP or other related policies.”*

Third, the devastating 2008 Earthquake created a major challenge for NFCP. The direct impact cancelled out the NFCP achievements (Viña et al., 2011), and indirect impacts

are still threatening lives and assets. The social and economic structure of local communities, including shared social norms, changed substantially during the post-quake construction. As more households switched to electricity and stopped raising pigs, the need to collect natural resources dropped. It was reported that household-based forest monitoring also declined after the earthquake (Yang et al., 2013b), as well as a result of more livelihood options (e.g., from tourism). Despite NFPC subsidy increases, for many local households, its relative percentage in total household income is declining. While there is no recently reported deforestation, achieving high functionality in DRR of the Wolong forests remains a challenge given the early anthropogenic degradation and recent earthquake damage.

## 4.7 Summary and key messages

Based on literature and interviews this case study complemented a long-term social-ecological research program in the Wolong Nature Reserve, a global disaster and biodiversity hotspot, for the purpose of investigating two research questions related to the Natural Forest Conservation Program in the Reserve:

- What are the main benefits and co-benefits of the NFPC in the WNR, including how they are viewed by stakeholders?
- What pre-existing conditions (external to the program) and new and potentially innovative factors helped enable the NFPC in the WNR?

In the following we summarize the main results.

### 4.7.1 Success in terms of benefits and co-benefits

The interviews and literature on the Wolong experience reveal three interrelated views or narratives on the benefits of the NFPC; flood and landslide protection; conservation; and economic well-being. Although scant quantitative evidence exists for assessing NFPC's effect on reducing flood and landslide risk, by improving soil conservation its DRR effect was largely acknowledged by local communities (Yang et al., 2013a) and interviewees. More pronounced were the perceived benefits of nature conservation. It was generally agreed that the NFPC played a pivotal role in reverting deforestation in the WNR resulting in substantial gain in forests and their ecosystems in a mere seven years. Another widely acknowledged benefit is the NFPC impact on the local economy and community well-being. It provided direct income to most local households, and the program enhanced the ecological infrastructure necessary for developing nature-based tourism. Most local households, as shown in early studies, reported that overall the NFPC had brought them more benefits than costs. This was further strengthened by the improvement in local communities' pro-environmental behaviors, such as reduction in wood collection and wildlife hunting.

In contrast to many cases where the NBS ‘piggy backs’ onto a more prominent DRR agenda, in this case it appears that the DRR agenda – although it had received huge funding – was piggy backed onto the responsibilities of administrative bodies with core interests in forest conservation and to some lesser extent economic tourism development. The importance of merged agendas – where the benefits and co-benefits are constructed depending on mandates and interests – is discussed in more detail below.

#### 4.7.2 Pre-conditions and enablers

NFCP at WNR was catapulted onto the government’s policy agenda by an enabling event - extensive floods in summer 1998 - which opened a window for government officials to advocate for forest protection programs. Recognizing the urgency of flood protection, China’s national government accelerated its plan to reform its forestry sector with unmatched political and financial resources. The Sichuan province, where WNR is located, was the most active province in implementing NFCP with regional policy design and enforcement. The special status of the WNR as both a protected area with its own management body and as part of the local government with direct financial access to the State Forestry Administration provided a unique level of independence in designing locally adaptive solutions. With its fame as the “Home of Giant Pandas”, two decades of collaboration with international and domestic expert communities also prepared WNR with the requisite knowledge and ideas for making use of the unparalleled government funding. Socio-economic trends, including road and electricity infrastructure upgrade, tourism development, and rural livelihood changes, also enabled the introduction of measures to curtail illegal logging.

The renown of the Wolong nature reserve was an enabler in that it engendered strong political support as was symbolized by the visit of Prime Minister Rongji ZHU in 1999. Moreover, the publication of an article in the prestigious *Science* magazine in early 2001 focused international attention on WNR’s deforestation. Dedicated to making use of NFCP as an opportunity to simultaneously tackle the intertwined disaster, conservation, and development problems, a wide range of administrative bodies at township and lower levels were involved in the initiation, planning, design, implementation, monitoring & evaluation processes. Support across the government’s administrative bodies was assured by the formation of a cross-department NFCP committee, led by two champions in the government with rich local knowledge and experience and supported by state-of-art technical expertise from research and practical partners. The resulting polycentric governance arrangements (see Liu, 2019; Marshall, 2015; Pahl-Wostl & Knieper, 2014) have proven to be critically important in the realization of China’s ambitious NBS.

An equally critical enabler of NFCP success lies in its innovative engagement of local communities through broad consultation. The coverage of local households in terms of both consultation and monetary benefit were unprecedented, including broad consultation in the planning stage and information sharing in the later monitoring and maintenance stages. In many ways the forest management concession contractual system - the ‘carrot and stick’ approach - was enabled by strong pre-existing social

norms and trust in the communities, which laid the ground for their mutual cooperation. At the same time, the ‘sticks and carrots’ system encourages neighbors to monitor each other and imposes collective sanctions on households if trees are logged. This can further jeopardize the traditional trust relationships in a period when rural China is increasingly influenced by market economy. Still, it is the social norms that some feel will enable a scaling up of the monitoring systems as the subsidies become less abundant. Recently, China announced the *Natural Forest Conservation and Restoration Policy Plan* (CCCPC & SC, 2019), a major update of the NFCP before the launch of its third period of ten years. Innovative enablers of NFCP in WNR almost 20 years ago was very well echoed in the Article 20 of the Plan:

*“Natural forest conservation should be a long-term, multi-generation effort with strong public participation, co-production and benefit sharing. Non-structural measures, such as formulating locally adapted rules, ..... should be encouraged in order to cultivate new ecological ethics and behavior norms for sustainable forest management. .... “*

Finally, the scale of recent NBS programs in China is unparalleled around the world in human history. An in-depth case study on a local success in China to understand its complex mechanisms and a mixture of DRR, conservation, and economic wellbeing benefits is not only important for China, but also of strong relevance to further mainstreaming and upscaling NBS in other countries and regions, especially in the developing world.

## 5 Co-designed nature-based solutions for landslide risk mitigation in Nocera Inferiore: The grey versus green battlefield

### 5.1 Case study overview: landslide risk and NBS in Nocera Inferiore



Figure 23: Map of Italy and Campania region

In 2017 the town of Nocera Inferiore had 45,796 inhabitants (municipality website). It has an area of 20.8 km<sup>2</sup>. The municipality is located at 43 m above sea level (a.s.l.) on the Agro-Nocerino-Sarnese plain in the hinterland of the Campania region of southern Italy (Fig. 23). This is a farming area, especially well-known for the San Marzano tomato, the basic ingredient of the famous “Pizza Napoletana.”

Many industrial activities are related to the cultivation of this tomato, and the area of the Agro-Nocerino-Sarnese has about 13,000 firms and 50,000 employees. Notwithstanding these industrial activities, the unemployment rate in Nocera is fairly high – more than 20 percentage points higher than the national average.

Nocera Inferiore is exposed to several natural hazards, among which are earthquakes, floods, and landslides. The most dangerous landslide sources are the Monte Albino and Monte Sant’Angelo di Cava mountains (around 1075 m a.s.l.). The area of Monte Albino has a surface of approximately 4 km<sup>2</sup>, corresponding to 20% of the municipal area. The area is also popular with residents and tourists alike because of the well-known Mount Albino sanctuary, which is visited for religious reasons and because of the beautiful landscape (Pucci et al., 2015).

On 4 March 2005, at 4.00 pm, a landslide was triggered by heavy rainfall on the northern slope of Monte Sant’Angelo di Cava, located upslope of the town of Nocera Inferiore (Box 1; Pagano, 2009). This was a severe event involving a slip surface area of 24,600 m<sup>2</sup> on an open slope with a soil mass of 33,000 m<sup>3</sup>. After the slope failure, the rapidly moving soil mass impacted houses, destroying them and causing the deaths of three people. Several other houses were destroyed or damaged, and four families were unable to return to their homes and properties after the event. Other families were affected by damage and claimed public compensation. Several minor events of this kind have occurred between then and 2019.

### Box 1: The 2005 landslide event at Nocera Inferiore



Figure 24: Landslide and quarry in Nocera Inferiore

On 4 March 2005, following an intense rainfall event (80 mm in 4 hours; (Schiano et al., 2009), a landslide occurred on the Monte Sant'Angelo di Cava on an open slope with an average gradient of 35–40°. The source area, located at 390 a.s.l. above an access road to a quarry, extends for about 100 m<sup>2</sup>. In this area, the pyroclastic soil cover does not exceed a depth of 1.5 m, and during the triggering stage a soil volume of about 150 m<sup>3</sup> was mobilized. This volume then increased following an M2 mechanism (Ferlisi et al., 2015) due to: i) the impact of the soil covers located below the access road; and ii) further erosive and transport

phenomena affecting the area (up to a 35° gradient) where the pyroclastic covers and the vegetation were completely removed by the force of the landslide. On the whole, this pseudo-triangular shaped phenomenon extended for 25,000 m<sup>2</sup> and had a volume of about 33,000 m<sup>3</sup> (Pagano, 2009). As far as the propagation stage was concerned, the velocity of the displaced mass reached a value ranging between 10 – 20 m/s, with the velocity attaining the highest value on the left side of the landslide-affected area where the flowing mixture channelized in a gully ending in an urbanized area with many masonry and reinforced concrete buildings. The impact of the flowing mass caused the destruction of a masonry building located at 105 m a.s.l. and the deaths of three people inside it. Another person in the same building suffered a brain trauma, but recovered within a few weeks. Several other houses were destroyed or damaged. The 1,350 people evacuated from the area sought refuge at relatives' or friends' houses or in municipal buildings (*Ordinanza* n. 8822, 4 March 2005) (Prot. N. 156/09).

On 8 March 2005, the municipality issued an official request to the Council of Ministers for the declaration of a “state of emergency” (*Deliberazione* n. 86, 8 March 2005). The municipal technical officers carried out a first damage estimation of public and private properties, which came to €10 million (Pagano, 2009). In 2011 (sentence n. 1359/11) the owner of the quarry above the landslide (see Fig. 24) was found guilty of contributing to the landslide with his activities (especially the building of a path/road without permission). He was sentenced to three years in prison and ordered to reimburse the families of the victims.

After the event, the townspeople and local authorities launched several initiatives. For example, the residents set up a landslide victims' committee to speed up reimbursements. In Italy, there is no insurance available for events like this, and the state usually covers all the reimbursements. The municipal council also opened a forum in the local "Agenda 21" for environmental sustainability to discuss landslide risk management together with representatives of the River Basin Authorities, the Regional Civil Protection, the Regional Department of Soil Defence, the Forest Ranger Corps, and the victims' committee, several local associations etc. (the stakeholder landscape, including a brief description and key actions is presented in section 5.4). The Municipality of Nocera Inferiore and the Salerno-based Authority “*Genio Civile*”

Engineering Corps” built essential and urgent structural works in the most at-risk areas. The costs were €328,688 for the municipality (later reimbursed by post-event provisions of the President of the National Ministries Council Decree, *Ordinanza* OPCM 3849/2010) and €178,000 for the Genio Civile. Although the latter was directly funded by the regional authorities, it is not entirely clear if all the funding available has been used (Pucci et al., 2015).

Moreover, after the event, the Regional Civil Protection set up an Emergency Commissariat. In 2007, €2.7 million (based on *Ordinanza* OPCM 3484/2005) was allocated for civil protection to this Commissariat. More importantly, the Emergency Commissariat presented a proposal for new structural protection works to guarantee a higher safety standard for the most endangered areas. However, in 2008, the Commissariat's €25 million risk mitigation project was rejected by the municipal council, a decision supported by many townspeople and local associations. The main reason was that the project primarily included grey measures, whereas residents had prioritized nature-based solutions and other measures with a low environmental impact. Another reason was that the cost of the project was not fully covered by regional funds. Some technical weaknesses were also identified together with different priorities for risk mitigation, including investments in non-structural measures, such as improvement of the warning system and emergency planning (e.g., clear identification of escape routes). The renovation of the hydraulic network was also considered a priority. This stalemate signaled the need for a more inclusive and transparent landslide policy and decision-making processes. In the wake of this rejection, two Emergency Commissioners were appointed in quick succession (Scolobig et al., 2011).

In 2010, following the appointment of the second Emergency Commissioner, the sum earmarked for a risk mitigation plan was €7.2 million (*Ordinanza* OPCM 3843/2010). This included the €2.7 million allocated in 2007. This time it was planned for the Emergency Commissioner to work with Arcadis, a regional agency established in the year 2004 with the aim of implementing the risk mitigation measures planned by the river basin authorities and giving technical assistance to the local authorities to carry out these measures.

At that point, the municipal authorities were keen to involve the townspeople of Nocera Inferiore in the preparation of a new plan for allocating the €7.2 million to landslide risk mitigation. Their interest in citizen participation was partly motivated by the recent public opposition to the project prepared by the Regional Civil Protection in 2008. Other local authorities such as the River Basin Authority were also interested because of the implementation of the newly issued European Union Water Framework Directive (WFD) (2000/60/EC), which called for extensive citizen participation in river basin planning issues. Curiously, despite the many calls for public participation in environmental issues over the preceding two decades, there were, at that time, no documented procedures for actually conducting this in relation to landslide risk management. The entry point to public participation was provided by the European Commission (EC) funded research project (SafeLand, [www.safeland.no](http://www.safeland.no)).

## Box 2: Landslide hazard analysis and risk estimation

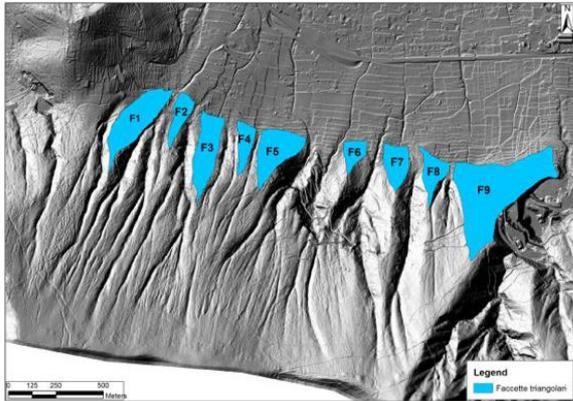


Figure 25: Open slopes (*faccette triangolari*) in Nocera Inferiore

To design risk mitigation measures, detailed hazard and risk assessment is necessary. The University of Salerno conducted several studies, including some at a very high resolution, (1:1000 scale). These studies identified 10 mountain basins and 9 open slopes (*faccette triangolari* [Italian] Fig. 25) (Ferlisi et al., 2015). The pyroclastic soil deposit at these slopes varied from 1.5–4 m and the slope grade varied between 24° and 42°. The hydrographic network was also analyzed to complement the landslide hazard analysis and risk estimation. 520 buildings were mapped in the

Monte Albino area. Notably, several anthropogenic activities were found to be contributing to increasing the landslide risk, including a quarry, deforestation, water supply, and electricity infrastructures. A detailed quantitative risk analysis is provided in Ferlisi et al., (2016).

The two-year participatory process launched by the SafeLand project (2010–2011) was structured as a series of workshops involving a group of selected residents and several parallel activities open to the public, including an online forum. After several facilitated workshops, the diverse public perspectives were reconciled, and an agreed compromise policy path was reached that included the implementation of naturalistic engineering works. It is important to highlight, even if it is a "linguistic" issue, that there is no precise Italian translation of NBS: "natural engineering works" (*opere di ingegneria naturalistica*) is possibly the closest Italian expression, but this is not really a literal translation of NBS (namely *soluzioni naturali*).

In 2011 a new (third) Emergency Commissioner was appointed. In 2012 the NBS project has been initiated. More precisely the call for the NBS bids has been opened. The process aimed at deciding which company was actually going to be selected for building the NBS lasted between 2012 and 2018, when the Regional Department for soil defense transferred the NBS funding to the municipality of Nocera Inferiore. The municipal technical office took charge of the NBS implementation, including the public procurement process and the control of the NBS construction works. After a competitive bidding process, the municipality contracted an engineering firm to prepare the project and execute the works. The latter included maintenance/remediation of the slope and naturalistic engineering works on three channels. These works included channel lining and vegetated/stone gabions aimed at reducing erosion due to frequent rainfall events.

The works started in 2018 and the NBS has been finalized in 2019 (see Fig. 26). At the time of this writing (2019) some minor works - including the construction of small

hydraulic measures to retain the debris - have still to be finalized. The costs amounted to €637,000. This is likely one of the first nature-based solutions for landslide risk reduction to have been co-generated by experts with citizen input.



Figure 26: NBS in Nocera Inferiore (©Luca Pucci)

As well as reducing landslide risk, this measure provided a number of co-benefits such as protection of a recreational area by installing several paths at the toe of Monte Albino and provision of new ecosystem services for the community. Following the Italian legislation, the municipality is in charge of the maintenance of the NBS. Finally, it is important to mention that this measure is only the first in a €7.2 million project that is expected to be further implemented in the next years. However, the timeline and the projects for the new risk mitigation measures have not been decided at the time of writing (2019).

One final aspect to understand in the NBS implementation context is the “battlefield” between grey and green/nature-based solutions for disaster risk reduction. In 2015 Arcadis (the Regional Agency for Soil Defence) again proposed a landslide risk mitigation project consisting mainly of grey measures, but with only four storage basins. This project was similar to the one proposed in the year 2008, although with a much lower budget. In 2016 the municipal council and the “Conference of the services” (literal translation of “Conferenza dei servizi”, meaning a meeting of all the services involved) rejected this project.

## 5.2 Research design

A re-analysis of the Nocera Inferiore case study was conducted to better understand how the agenda on nature-based solutions progressed up to the point of the proposed measures being implemented. The research conducted in the SafeLand project (2010–2013) was the backbone of this re-analysis, in which attention was dedicated to enabling factors and catalysts (as well as to barriers and challenges) to the NBS implementation.

Table 1 summarizes the key research phases in the SafeLand project that provided inputs for the case study reanalysis (Scolobig et al., 2011, Scolobig et al., 2014, Linnerooth-Bayer et al., 2016, Scolobig et al., 2016). The participatory process officially ended in 2011, eight years before the NBS was finalized in 2019.

Table 12: SafeLand research phases

Phase	Main aim	Methods and tools
<i>Case study analysis</i>	Describe and understand the case study	Literature review and desk study Semi-structured interviews (43) Focus groups (2) Participant observation (6 months)
<i>Questionnaire survey</i>	Collect data about residents' opinions and attitudes regarding landslide risk, risk mitigation, risk management, and emergency planning	Questionnaire piloting (20) Self-administered questionnaires (373) collected by local association volunteers (351) and online (22)
<i>Participatory process</i>	Promote useful dialogue and deliberation among participants in order to identify sustainable risk mitigation strategies	Public open meeting Meetings (5) with selected residents (16) Evaluation and feedback about the process through questionnaires Informal meetings with local authorities and community leaders (8) Parallel meetings in working groups organized autonomously by the participants (6)
<i>Communication and education activities</i>	Facilitate communication and information sharing; legitimize the process in front of a wider public	Website Online discussion group Videos to promote the participatory process (3) Press releases, contacts with local media (2 TV interviews, participation in 3 radio programs, 20+ newspaper articles of local and national relevance) Simulation exercise with students Continuous contacts with local authorities

Starting from some of the project results, we conducted a literature review, a desk study, and 21 semi-structured interviews (see Appendices G and H) with stakeholders at the national, regional, and local level to better understand the key enabling factors and benefits of the NBS, as well as the barriers to their implementation. Before presenting these results, we will briefly describe the national governance and policy framework for landslide risk reduction and disaster risk financing in Italy, with a specific focus on the role of NBS. This information will improve understanding of the context for NBS implementation in Italy.

## 5.3 National context

### 5.3.1 Landslide risk policy framework and NBS

Landslide hazard and risk in Italy are systematically assessed by the River Basin Authorities<sup>3</sup>. The Environment Ministry (*Ministero per l'Ambiente e la Tutela del Territorio e del Mare*, [MATTM]) determines trends and policies, allocates financial resources, and coordinates the action of the authorities. The authorities produce basin plans, hazard and risk maps (usually at a scale 1:25.000) and suggest landslide prevention and mitigation measures in the respective areas.

Detailed hazard and risk maps (scale 1:5.000) are produced by regional, provincial, or municipal authorities on demand. Additional elements for the assessments are also provided on an ad hoc basis by the Regional Agency for Environment Protection (*Agenzia Regionale per la Protezione dell'Ambiente*, and other technical services), the National Research Centers, the Operating Centers of the National Department of Civil Protection, or university research centers, according to specific requests.

Land-use planning criteria are provided in regulations enacted by the Presidency of the Council, under the coordination of MATTM with the agreement of i) the ministries of infrastructure, transport, agriculture and forestry policies, cultural assets and activities; ii) the Department of Civil Protection; and iii) the Department of Regional Affairs and Local Autonomies. The Environment Ministry controls the adoption of the basin plans by the River Basin Authorities and supervises their implementation, which creates binding obligations for both central and local administrations. Regions, provinces, and municipalities are responsible for the enforcement of land-use planning and for the implementation of measures foreseen in the basin plans (Scolobig 2010). There is no policy framework dealing specifically with NBS for landslide/disaster risk reduction.

We are, however, witnessing a transition at the national level toward the adoption of a resilience-oriented approach, with NBS expected to be a component of this. MATTM is a major player in this transition, together with other ministries such as the Infrastructure Ministry (Interviewees 2, 20). For example, MATTM funded the renaturalization and recalibration for hydraulic risk of one channel (Fossa Nuova) that brings water to Lake Massaciuccoli in central Italy (Tuscany region). MATTM asked to destroy the existing - and not any more effective- grey works and not to build any new grey measures in order to reduce the environmental impact as much as possible (Interviewee 2).

NBS are also increasingly included in policies supporting the green economy. Regional authorities often fund the adoption of green measures (e.g., solar panels or other individual measures for climate mitigation) and, in a not-too-distant future, NBS may also be financed by these schemes.

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<sup>3</sup> Since the year 2017 (Ministerial Decree 25.10.16 published on the G.U. n. 27 del 02.02.17) there are seven River Basin Authorities at the district level in Italy. Before that time, there were 40 River Basin Authorities (law 183/89). The number has been reduced primarily as a result of the alignment with the EC Floods Directive requirements (2007/60/EC). Indeed, the River Basin Authorities in Italy are not only responsible for landslide but also for flood risk management.

Finally, there are strong possible synergies between NBS and biodiversity, conservation, re-naturalization and agricultural policies. For example, the so-called making-room-for-the-river initiatives are generating water expansion areas that can also become wildlife habitats. Renaturalization is increasingly a priority, especially in regional and inter-regional policies and initiatives, including inter-regional EU projects (such as INTERREG). Thus, NBS can directly or indirectly contribute also to disaster risk reduction.

### 5.3.2 Disaster risk and NBS financing

As mentioned above, there is, at present, no NBS national policy framework in Italy. However, the possible synergies with other policies and sectors are strong and are expected to increase. The main reasons for NBS being a “successful business case” are the economic benefits, especially in respect of efficiency and long-term maintenance when compared to grey solutions (Interviewees 2, 20). NBS have a longer life span than grey solutions and are also relevant for ecological resilience. The NBS costs are lower for several reasons, including the fact that there is no need to anticipate the demolition of grey solutions at the end of the project. Indeed, waste removal and disposal are very expensive in Italy (about 25%, sometimes even more than 30% of the project costs – although costs can be constant or cyclical, recurring in clusters every few decades, depending on the project). NBS are thus expected to contribute to reducing costs and saving public funding. However, there are also some barriers to NBS financing, which include limited evidence about NBS effectiveness, lack of standardized technical guidelines, and insufficient funding models. Payment for ecosystem services and co-financing (e.g., by creating a diverse group of partners and financiers, from state money to foundation grants and local bonds) are definitely possible models to consider for future NBS financing. Yet, some key barriers for NBS financing in the disaster risk reduction sector are not NBS-specific but rather related to the Italian disaster risk management system.

One of the main problems of the Italian system is the divide between post-event/extraordinary financing sources versus prevention. The Italian National Civil Protection/Council of Ministry's ad hoc discretionary and post-event provisions often allow urgent risk reduction measures (e.g., reinforcement of levees, adjustments of flow sections) to be adopted much faster than routine provisions. In the last few decades, Italian state funding has been inspired by provisions aimed at covering emergency situations connected to unexpected disaster events, with the result that ad hoc provisions were enacted that varied continually over time and were characterized as discretionary. This situation has often been labeled “the emergency culture.” It has been estimated that every year the Italian Government spends on average €3.5 – 4 billion to indemnify damages caused by catastrophic events (Monti & Chiaves, 2006). Between 1944 and 2012 the overall costs for natural disasters in Italy have been estimated at approximately €242.5 billion (Monti & Chiaves, 2006).

The roots of this “emergency culture” – which is causing a vicious cycle of risk mitigation interventions undertaken only in the aftermath of a disaster – are part of the history of Italian disaster risk management system (OECD, 2009). Moreover, few private insurance schemes actually cover natural disaster damage, and very few households buy insurance policies because, thus far, indemnification by the State has always been guaranteed. Another critical problem lies at the interface between the financial and institutional systems and is related to the wide array of funding sources for risk reduction. Several interviewees (Interviewees 1,3,6,7) report that funding for risk mitigation has been allocated by different authorities acting at different levels, from the European level to the national, regional, provincial and municipal levels, and working in different sectors, such as urban planning technical offices, environmental agencies, and civil protection. There are usually no open-access databases available to provide an overview of funding allocated by the numerous authorities and agencies contributing to risk mitigation (Interviewees 3,4,9). This is the case not only for Nocera Inferiore but for many other municipalities in Italy. Existing data and datasets are not really comparable (different time series, different agencies, etc.) and this hinders the analysis of long-term trends. As maintained by an officer of a regional authority (Interviewee 3):

*The system is not transparent, and thus does not allow an overview of funding provided by the authorities acting at different levels, in different phases of the disaster risk management cycle (translated by the author).*

Another problematic aspect is institutional change, especially with respect to the allocation of responsibility for funding distribution. The national authorities in charge of the funding of risk mitigation – thus including NBS – have changed over time. Funding for risk mitigation has been provided by national authorities such as the ministries of infrastructure, environment, the Council of Ministers, and by regional authorities in charge of environmental protection, to mention a few. Building a comprehensive dataset with a specific focus on funding received at the local level (not e.g., funding allocated at the national level) would thus require huge efforts and time that local practitioners do not really have.

A problematic aspect reported by interviewees is also that the process from funding request, to allocation, actual transfer, risk mitigation project design, and realization is often far too long (Interviewees 5, 8, 9, 17). Even when funds are transferred, the implementation of approved projects takes much more time than initially planned. One example is the MOSE (Experimental Electro-mechanic module) project to protect Venice from floods and sea-level rise. The project was finalized in 1992, construction works started in 2002, and they are still ongoing at the time of writing (2019). Some 94% of the protection measures have already been built and there is still only 6% to do. So far, the costs have amounted to €5,493 million (<https://www.metropolitano.it/mose-quanto-costa/>). Unfortunately, this did not prevent a major coastal flood/sea level rise to hit in Venice, in November 2019. The MOSE example reflects a trend in many other Italian regions and towns (e.g., Camaldoli, Isola del Giglio, Caserta, Porto Empedocle, Porto Azzurro, Seveso); see Salvaggiulo (2014); Tozzi (2014).

To conclude, as reported by an interviewee working for the National Civil Protection:  
*A critical problem for risk and emergency management in Italy is funding and monetary resources. We can do any kind of risk analysis and project design but implementation is the main problem* (Interviewee 10; translated by the author)

In the year 2009–2010 the State–Region agreement identified 3,395 very urgent measures needed to reduce the impact of natural disasters: after 8 years, 78% of these measures have still not been implemented (Newspaper La Stampa 11.10.2018).

## 5.4 NBS stakeholder landscape and key actions

A multitude of stakeholders, including technical officers, politicians, academics, private consultants, NGO members, and private citizens, are typically involved in landslide risk governance in Italy. These stakeholders are working at different levels<sup>4</sup> – municipal, regional, and national. At the time of writing (2019), there is no authority with an exclusive mission to implement NBS: this is shared among different authorities. In the Nocera Inferiore case, NBS (for DRR purposes) are implemented by the same authorities that are in charge of DRR. Figure 27 provides a map of the stakeholders who play a role in NBS governance in Nocera Inferiore. The white hexagon includes the key stakeholders involved in the NBS planning, initiation, and implementation. The red includes the key interest groups/advocacy coalitions, and the blue includes all other stakeholders, more-or-less directly involved. Table 13 describes the key stakeholders acting at municipal, regional, and national levels and the actions that they undertook in relation to NBS governance.

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<sup>4</sup> The three key administrative levels in Italy are national, regional and municipal: the country is divided into 20 regions and 7,914 municipalities (updated 1 October 2019). Nocera Inferiore is a municipality in the Campania region. Until 2014 there was another administrative unit between municipality and region, namely, the province. Law 56/2014 abolished the province.

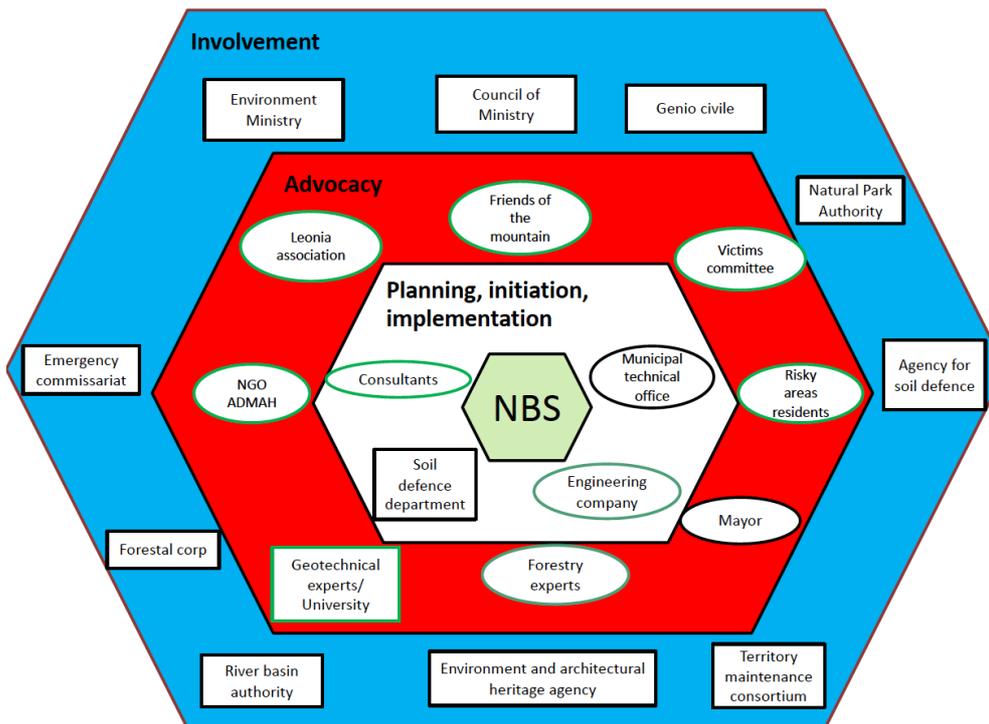


Figure 27: NBS Stakeholder landscape (circle: municipal level; square: regional or national level; black: public sector; green: private sector/NGOs)

Table 13: Key stakeholders acting at municipal, regional, and national levels, brief description and key actions

Stakeholder	Brief description	Key actions
<b>Municipal level</b>		
Municipal technical officers	Officers in charge of guaranteeing conformity with the building codes and the constraints included in the landslide risk maps prepared by the River Basin Authorities are also in charge of supervising NBS implementation	Local supervision of NBS implementation Update of risk maps through detailed studies commissioned to private companies Actions to limit unauthorized construction in the Monte Albino area
Mayor	Officially responsible for several activities related to emergency management and supervision of decisions about risk mitigation	Supervision of landslide risk governance decisions
Private consultants/geological and engineering firms	Geologists, engineers, and other private consultants undertaking different tasks such as collecting data for the risk maps, design, risk mitigation projects, etc.	Risk assessment data collection, project for the risk mitigation measures, including NBS, to be undertaken on the Monte Albino slope
Victims' committee	An NGO established after the 2005 event to help the residents impacted by the event and especially victims' relatives	Lobby the municipal authorities to expedite the reimbursement procedures Support victims' families Raise awareness regarding landslide risk NBS Advocacy

Stakeholder	Brief description	Key actions
Friends of the mountain <i>Montagna Amica</i>	NGO established after the 2005 event to safeguard and promote the Monti Lattari area; to combat unauthorized building in risky areas; to represent the interests and needs of the citizens in dialogue with local authorities	Organize meetings and conferences after the event “to better understand its causes and risk mitigation alternatives” Lobby local authorities to implement NBS Contribute to ecosystem monitoring and maintenance
Leonia <i>Legambiente Valle del Sarno</i>	NGO established in 2004, after the waste management crisis in the Campania region In 2009 it became a local branch of the national environmental NGO, <i>Legambiente</i>	Involvement in the local Agenda 21 process Raise awareness about landslide risk Organize communication campaigns and initiatives related to the 2005 landslide anniversary NBS advocacy
ADAMAH	Local NGO focused on the issues of critical consumption and activities to awareness regarding environmental and social problems	Organization of events to raise risk awareness, help the families of the victims, curtail industrial activities upslope NBS advocacy
Landslide-prone area residents	People living in the most endangered area of the town	Lobby municipal authorities to expedite decisions regarding risk mitigation measures on the Monte Albino slope
<b>Regional level</b>		
<i>Genio civile</i> /Engineering corps	Tasked with planning and/or executing structural risk mitigation measures	Supervision of the construction of the first structural protection works to guarantee higher safety standards in the areas affected by the event (OPCM 3484, 22/12/2005 and Protocol 2009.0392338 06/05/2009)
Southern Appennino River Basin Authority	The River Basin Authority has responsibility for drawing up the river basin plan, including landslide risk maps	Preparation of the river basin plan (including landslide hazard and risk maps) which is the starting point for NBS implementation
<i>Sarno River consorzio di bonifica</i>	Tasked with structural risk mitigation measures maintenance	Maintenance of risk mitigation works
Geotechnical and forestry experts	Experts in forestry and landslide risk assessment and management	In-depth studies on hazard, risk, exposure and vulnerability assessment in selected areas of the Mount Albino slope Forest management studies and research
Regional defense department	soil Decides, inter alia, how to allocate economic resources for risk mitigation provided by the Environment Ministry	Funding allocation for risk reduction in the Monte Albino slope, including NBS financing
Salerno Forestal corps	Hydro-geological risk competences in risky areas based on regional decree 3267 of 1923	Officers provide technical opinions regarding the new projects/protection measures based on projects and the risks involved
ARCADIS – Regional agency for soil defense	Established in 2004 ARCADIS is a regional agency that provides technical assistance to local authorities implementing risk	Responsibility for the implementation of structural risk mitigation measures (OPCM 3849, 19/02/2010)

Stakeholder	Brief description	Key actions
	mitigation measures; it monitors risky areas, collects data, and prepares guidelines for soil defense. Closed in 2018 "to avoid duplication of administrative functions and reduce public expenses" ( <i>art. 21 Finanziaria regionale 2015</i> ).	
Emergency commissioner	The emergency commissioner is changed subject to circumstances. In 2005 the President of the Council of Ministers appointed two emergency commissioners, the President of the Campania region and the Mayor of Naples (OPCM 3484, 22/12/2005). In 2010 he appointed a new commissioner (OPCM n. 3849, 19/02/2010)	His/her main task is to manage the recovery and reconstruction phase (i.e., authorize funding allocation)
<b>National level</b>		
Environment Ministry	The Environment Ministry decides, inter alia on allocation and distribution of resources for risk mitigation measures (l. 179/2002)	Allocation of resources for risk mitigation to the regional authorities (DEC/DDS 2007 1038, 14/11/2007)
Council of Ministry	The Council of Ministry provides post-event resources	Allocation of resources to the Emergency Commissariat (OPCM)

## 5.5 Timeline of NBS planning, initiation and implementation

Based on section 5.3, Fig. 28 summarizes the key events between the 2005 landslide and the NBS finalization in 2019. (OCPM stands for Ordinance of the Presidency of The Council of the Ministries; MATTM for Environment Ministry)



Figure 28: NBS planning, initiation and implementation timeline

## 5.6 Enablers of success

Interviewees revealed a number of NBS enablers, here defined as emerging properties that facilitated, drove, and/or catalyzed NBS initiation, planning, and implementation.

### 5.6.1 Wide-scale stakeholder opposition to grey measures

One of the main catalysts of NBS support (and later adoption) was the fierce local opposition to grey and passive measures. The reasons can be found in the history of landslide risk in the Campania region and, more precisely, in Sarno, a town located on the opposite side of the Lattari mountains surrounding Nocera.

The name of the city of Sarno has Indo-European roots, meaning “stream.” The municipality lies below the Pizzo Alvano massif, where the three main springs of the

Sarno River emerge. The toponym Alvano means “to get moving,” similar to many other place-names in the town, which both hint at liquidity (Mazza & Amendola, 1999). In 1998 a flowslide hit Sarno and four neighboring towns/villages: Quindici, Siano, Bracigliano, and San Felice a Canello.

On 5 and 6 May 1998, following two days of intense rain and a particularly wet spring season, loose pyroclastic soils mantling the slopes of the Pizzo d’Alvano carbonate massif collapsed and generated several flow-like fast-moving landslides which reached the towns causing, in total, 159 fatalities and extensive damage to property (Fig. 29). The economic losses were also enormous: more than €500 million were required for the reconstruction of public buildings alone (Cascini, 2005).



Figure 29: The 1998 Sarno landslide (source: [www.commissario2994.it](http://www.commissario2994.it))

In terms of its nature, severity, and impact, this was a unique landslide event in recent Italian history. Besides the 159 fatalities, the event also caused injuries to 115 people, made 1,210 people homeless and destroyed 180 houses (Fig. 30). Damage amounted to €24.2 million to private buildings and €8.2 million to business assets.



Figure 30: Sarno landslide: the aftermath (©Luigi Pepe)

On 9 May, four days after the mudslides, the Italian Prime Minister declared a state of emergency (D.P.C.M. 108/1998). The President of the Campania Region was later nominated Emergency Commissioner. A Technical Secretariat (TS), led by a Managing Engineer, was tasked with securing the area and safeguarding the population. Operative Unit 2.38 (U.O. 2.38) of the National Defense Group for Hydrogeological Catastrophes (GNDCI) was tasked with ensuring safety was optimized throughout the area.

The key risk mitigation measures included the new canalization and a cement tank to restrain the kinetic energy of future mudslides coming down the mountainside and to limit the mudslide (Fig. 31). These measures used consolidated engineering techniques to divert and contain future mudslides. A total of €190 million was spent in Sarno on risk reduction measures, including over 120 concrete decanting/straining structures (like check dams) and 20 storage basins (Versace, 2008).



Figure 31: Selected risk mitigation measures in Sarno (©Luigi Pepe)

Nevertheless, many residents in Nocera Inferiore have been highly critical of the measures implemented in Sarno. Critics questioned especially their esthetic and environmental impact as well as high building and maintenance costs.

Moreover, many interviewees maintained that the structural protection measures can give a false sense of full protection. As reported by a member of the victims' committee (Interviewee 14):

*Sarno gives the wrong illusion to the local population: that everything can be solved with technical solutions. Instead, the visual and environmental impact of the control works in Sarno is excessive (translated by the author)*

A member of a local environmental NGO (Interviewee 12) observed:

*Neither active nor passive control works can guarantee 100 percent safety. A long-lasting rain, for example, would jeopardize the stability of the entire slope (translated by the author)*

Moreover, the expropriation of private land to build the grey measures is also a problematic issue, as reported in a dossier -published by the environmental NGO Legambiente- dedicated to Sarno – 20 years after the event. "Twenty years have not been enough to finalize the procedures to expropriate the private land to build the complex Sarno engineering system. In the year 2018, almost 2,800 expropriation acts are still missing" (Chiavazzo et al., 2018).

Thus, many land owners are still waiting for their reimbursements. Moreover the municipality of Sarno, and the region still have to pay more than €4 million in expropriation taxes to the Italian National Tax Agency (ibidem).

Finally, the high maintenance costs of the grey measures are also a problem raised by several interviewees (Interviewees 11,12,13,14).

## 5.6.2 Environmental coalitions and experts

Several associations mediated and catalyzed the local decision-making processes for landslide risk reduction. These associations and their key members (i.e., well-known and trusted individuals) were crucial to the development of an NBS agenda on which decision-makers were confident enough to take action. These local associations acted as advocacy coalitions, that is, groups sharing a particular belief system defined as a set of basic values, causal assumptions, and problem perceptions, and/or coordinated activities over time (Sabatier & Jenkins-Smith 1993; Sabatier, 1988; Haas, 1992). They were able both to strengthen collective agency and to foster NBS transition initiatives. In the case of Nocera, the NBS-support movement was based on small group of environmental and social associations and the landslide victims' committee (e.g., *Montagna Amica*/Friends of the mountain, *Legambiente*, victims committee and

ADMAH: see Table 13 for description of association and key actions undertaken) which acted as agents of change.

Semi-structured interviews with members of these associations (Interviewees 11, 12, 14) allowed a better understanding of their views about landslide risk mitigation and NBS. For them a key environmental problem were environmentally detrimental anthropogenic practices, such as road building, industrial activities, and even the location of power lines at the edge of the slope. These practices have made Monte Albino less stable and subject to dangerous landslides. While some immediate measures will be needed to reduce the acute risks to residents of Monte Albino, the critical long-term issue is to deal with the multitude of factors that contribute to the instability of the slopes. These interviewees maintain that it is imperative, for instance, to investigate industrial activities that are adding to the problem. Not only must the residents be protected, but also the natural cycles and the evolving mountain terrain should be respected. This will mean taking a more holistic and ecological view of the mountain and its maintenance (Linnerooth-Bayer et al., 2016; Thompson, 2017). This is exemplified by the motto of *Montagna Amica*, one of these associations: “To maintain the mountains you have to love them; to love them you have to know them” (<https://montagnaamica.jimdosite.com>).

Inadequate monitoring and control of the territory, together with the lack of a forest development plan, are adding to the problem, with several detrimental consequences such as: i) vast forest areas on the slope being abandoned; ii) uncontrolled deforestation frequently occurring; and iii) large quantities of rubbish and the branches of trees being deposited along the many channels and river beds. Waste disposal is a big issue because it often obstructs the channels, and the situation becomes very dangerous especially when landslides and debris flows are triggered upslope.

The lack of a forest development plan is also considered a key problem. In reality, most of the forests are managed inadequately: trees are not cut regularly or cut indiscriminately. The undergrowth is also frequently left wild. This may trigger not only landslides but also summer fires, the consequences of which also increase landslide risk. One of the reasons for this lack of proper management is the fact that the forest is both publicly and privately owned. The private owners do not always take the necessary care of their forest. The interviewees (Interviewees 11,12) thus maintain that new forms of partnership should be identified to allow better management. The forest management plan is the starting point for moving forward.

Moreover, in the view of several members of these associations (Interviewees 11,12,14), expensive passive structural measures – like those in Sarno – will only aggravate the ecological problems and are unnecessary. These measures are challenging because of the complex mix of authorities in charge, the high costs, and the unclear allocation of responsibility for maintenance, to mention a few (see also section 5.7). Nature-based solution/naturalistic engineering works would be more suited to the job. Authorities might even consider the creation of a natural park at the toe of the slope to reduce urbanization in the area and increase recreational activities. The existing network of

walking paths should be improved so that local residents can enjoy the mountain areas and check on the terrain at the same time. In addition to the park and walking paths, small-scale organic farming on the mountain and better management of the public and private forests could be encouraged as a nature-based solution to reduce landslide risk. Finally, for these interviewees, it is very important for the residents to be involved in the design and implementation of nature-based solutions, especially as they often have a close understanding of the mountain and its risks.

Notably, some key members of these associations, for instance, the local municipal council or an environmental organization working in different domains (e.g., environment policies, waste management, disaster risk reduction) acted as mediators, translators, and networkers among different sectors (e.g., local government and civil society). Most often they represented multiple initiatives aimed at fostering environmental sustainability and were able to "speak the language" of multiple sectors (e.g., public and NGO sector) and identify and support synergies between them; see also (Kabisch et al., 2017). Being prominent members or leaders of local associations, they also contributed to the diffusion of NBS ideas, knowledge, and experience in the initiatives they were involved in. Yet, reliance on just a few actors can also make the decision-making process fragile, for example, if the individuals in question are not re-elected or decide to abandon their activities.

Finally, it is very important to emphasize that the interest/pressure groups worked and acted alongside strong expert communities of well-respected and trusted university professors and scientists who presented new and robust scientific evidence and ideas that would play an influential role in shaping the NBS policy formulation. These communities, by providing, for example, updated and reliable hazard analysis and risk estimation (Interviewee 1), highlighted the inadequacies of heavy structural risk mitigation measures in some areas of Mount Albino.

### 5.6.3 Cross-sectoral collaboration and increased environmental awareness

Several interviewees reported that the NBS agenda is part of a much broader agenda which brings together different sectors and environmental issues. For example, the issues of waste management, pollution reduction, and landscape/ecosystem preservation are nested in the case of the environmental associations and NGOs, with NBS being part of this agenda (Interviewees 1,12). The same is true for departments in the municipality, as reported by one technical officer:

*Waste management, urban development, risk reduction are all part of a broad environmental agenda. This also reflects the environmental awareness which changed over time. Thanks to a coalition of local politicians, officers and consultants, we have been able to push forward a new environmental agenda (Interviewee 1; translated by the author)*

Trust among the members of this coalition seems also to be a key element fostering the NBS implementation.

#### 5.6.4 Limited funding

It is well known that in many countries, the financial capacities for disaster risk reduction are especially scarce at the local level (UNISDR 2005). Nocera Inferiore is no exception (see section 5.3.2). The short history of landslide risk management following the 2005 event led interviewees to question whether the funds promised by the national authorities would actually materialize, and when. More specifically, over €10 million were pledged consecutively for compensation and mitigation in 2005, 2007, and 2011, but by 2012 less than €200,000 had been made available for this purpose. The €637,000 natural engineering measure implemented in 2019 bumps up the total, but this still falls fairly short of the expected millions. In Sarno a sum of €190 million was spent on risk reduction measures including over 120 concrete decanting/straining structures (like check dams) and 20 storage basins (Versace, 2008). Given the large investment in risk mitigation in the neighboring city of Sarno compared to the pledges made for Nocera Inferiore, there is clearly a sense of unfairness about how funds have been distributed, as reported especially by members of local NGOs and residents (Interviewees 12,13).

As a member of an NGO states:

*Nocera Inferiore is one of the towns which suffered more because of the unfairness in the distribution of mitigation funds in this area (Interviewee 11; translated by the author).*

Nevertheless, what usually constitutes a barrier to disaster risk reduction was actually an NBS enabler in Nocera Inferiore. As reported by the member of a local NGO (Interviewee 12):

*If large funding had been available, it would have been spent on building grey measures. (...) Another important factor is that in 2005 in Nocera, as opposed to Sarno, very few people died. Thus, the impact of the event was limited. As a result, less funding was made available and NBS became the best and most cost-effective option (translated by the author)*

A municipal technical officer (Interviewee 1) thinks the same:

*We built an NBS because of the limited funding available. Moreover, we believe that it has a low environmental impact. Yet, to mitigate the risk on the entire slope, more funding is necessary and, most likely, some structural risk mitigation measures will have to be built in the future (translated by the author)*

This points to the need for a green–grey hybrid approach to mitigate landslide risk on the slope. However, it has been difficult for the interviewees to foresee what measures will be exactly implemented in the future and when. Again, the uncertainty between

pledged and actual funding is playing a critical role in the uncertain answers about future plans.

When discussing the financial aspects with officials at the national Environment Ministry (Interviewee 15), a different perspective emerges. As mitigation funds are frequently diverted to response and emergency operations, the officials emphasize the difficulties in balancing the budget between short-term needs and medium- to long-term risk mitigation. Stakeholders at the national level also confirm that responsibilities have often been transferred to the municipal level without sufficient resources being allocated to implement the necessary programs. What happened in Sarno and in Nocera is a good description of a more widespread situation all over the country. As described in section 5.3.2, in past decades, Italian state funding was motivated by provisions covering emergency situations connected to unexpected disastrous events, with the result that ad hoc provisions were enacted that were different at different times and were characterized as discretionary. This situation has often been labeled the “emergency culture,” and Sarno without doubt benefited from this funding mechanism.

It is, however, important to point out that the adoption of the NBS in Nocera Inferiore was enabled by its relatively low costs, compared to grey measures. Also, the long-term NBS maintenance is expected to be less expensive than grey/heavy structural measure maintenance. Thus, the economic benefits are clear.

### 5.6.5 Co-design of a landslide risk mitigation plan

The two-year participatory process launched by the SafeLand project (2010–2011) was decisive in terms of unblocking the local policy stalemate for landslide risk mitigation in Nocera Inferiore. It was structured as a series of workshops involving a group of selected residents and several parallel activities open to the public, including an online forum (see section 5.6.1). After several facilitated workshops, the diverse public perspectives were reconciled and an agreed compromise policy path was reached that included the implementation of naturalistic engineering works. Box 3 presents a summary of the key steps of the process.

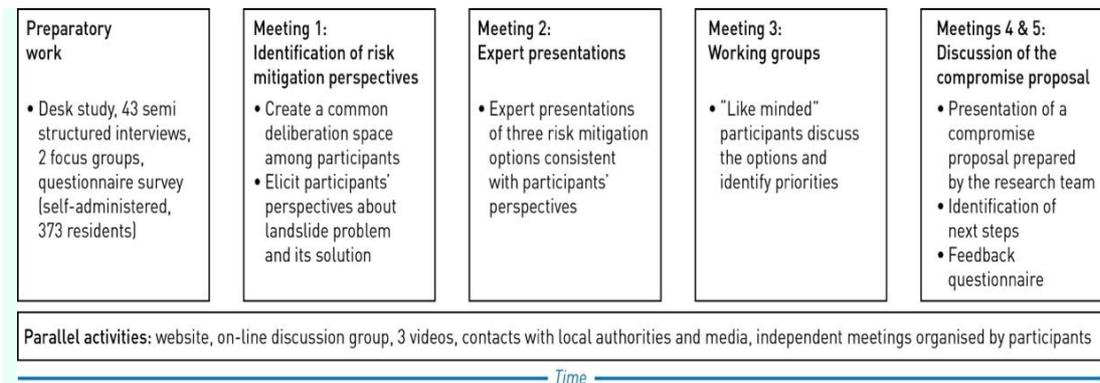
### **Box 3: A participatory process to co-design a landslide risk mitigation plan for Nocera Inferiore**



*Figure 32: Participatory process group discussion (2011)*

The key phases of the participatory process conducted in Nocera Inferiore are described below. The preparatory work included a desk study, together with 43 semi-structured interviews. These revealed a range of views on landslide risk, with markedly different “certainties” as to what both the problem and the solution are. This then provided the basis for a public questionnaire which, after being piloted, was administered (online and through a local association) to the public and resulted in 373 responses. After this preparatory work, three different views on landslide risk mitigation emerged: “Safety first,” emphasizing the importance of expert-driven safety, for example by top-down grey/passive mitigation measures; “Careful stewardship of the mountain” focusing on naturalistic engineering /active measures, mountain ecosystem services, and on the equitable sharing of risk; and “Rational choice,” centering on trade-offs and relocation of the most endangered households. Based on these three discourses, a participatory process was initiated as a second step, combining public participation and expert inputs. The process was kicked off by a public meeting with the participation of over 100 residents and officials, the purpose of which was to inform the broader public. At this point, a group of 16 residents was selected based on a questionnaire survey that identified participants holding the three main views described above. These 16 residents became the active core of the process.

Five follow-up participatory meetings were facilitated by the researchers, using different formats, such as working groups, expert presentations, and consultations (Fig. 32). In a parallel course to the process, several meetings took place, for example, to discuss the compromise proposal and collect feedback on it. A website and corresponding online group were used for outreach purposes, allowing the broader public to contribute their views to the process. Minutes of meetings were regularly shared to make the information available to the interested public, and to derive additional inputs. Further media attention was reflected, for example, by press releases, videos made by students, and an International Summer School (LAMOND) (Fig. 33).



*Figure 33: Key phases of the participatory process*

The process lasted for two years (2010-2011). Some of the topics presented and discussed at the meetings included: landslide hazard and risk assessment, warning systems, emergency planning, risk mitigation, landslide monitoring, typology of landslide events, residents' risk perception, maintenance of mountain area, co-design of risk mitigation options among experts and participants, extensive discussion of the options, and identification of priorities, presentation and discussion of a compromise proposal.

After extensive deliberations, a compromise solution was built on the areas of agreement. At the same time, efforts were made to steer an even-handed path through the areas of disagreement. These included:

- An integrated system of monitoring;
- Stabilization of the open slopes with NBS/naturalistic engineering works;
- NBS/erosion control works along the rills using material provided by the forest;
- Small storage basins at the mouth of each catchment; and
- Improvement of the warning system and institution of a territorial survey.

NBS have a central role in the compromise solution and were considered by participants as the priority measures to implement.

More information: Linnerooth-Bayer et al., 2016, Scolobig et al., 2016, Scolobig et al., 2011

As revealed during the interviews conducted for this case re-analysis, several features of the participatory process were enablers of the NBS implementation:

- The transparency surrounding the different stakeholders' views about landslide risk mitigation;
- Provision of a robust and updated knowledgebase on landslide hazard and risk assessment and on options for landslide risk mitigation;
- Promotion of discussions on nature-based solutions;
- Thee fostering of active stakeholder engagement that aimed for a compromise solution; and
- Supporting outreach activities to open the door to those not enrolled as active participants in the formal process (Interviewees 1, 12).

All these features were key enabling factors for the NBS implementation. More in general, the NBS implementation has been catalyzed by the compromise solution that had been reached by the townspeople in 2011.

From a technical standpoint, the process generated new options and packages for mitigating risk. The case was novel in that it adapted traditional analyses to a multi-stakeholder setting, bringing together townspeople and experts to co-produce landslide risk mitigation options. Compared to similar processes, this one distinguished itself by the explicit elicitation and structuring of multiple stakeholder worldviews, building on the theory of plural rationality (Thompson et al., 1990; Thompson, 2017; Thompson, 2008, Verweij & Thompson, 2006).

Finally, the process itself meant a shift away from trying to achieve a classic “best consensus solution” and toward a compromise. The process thus resulted in fair recommendations, featuring natural engineering measures combined with an early warning system. At the same time, the residents provided an active forum for the experts, encouraging them to develop novel inputs for their risk reduction options. Of keen interest to local decision-makers was the identification of the points of agreement and disagreement among the participants.

In the words of the environmental councilor at the time of the participatory process:

*I believe that the process launched by the Safeland project strongly influenced the administrative dynamics of landslide risk mitigation in Nocera Inferiore. It catalyzed the construction of natural engineering works and had very positive effects on the community. We should continue working in the same way (Interviewee 12; translated by the author).*

Several interviewees provide examples of how the results of the process were used in the following years. For example, a municipal technical officer (Interviewee 1) maintains:

*We used the results of the participatory process when we rejected—for the second time in 2016—the regional agency project consisting of grey measures to mitigate landslide risk. We used not only the robust knowledge base provided by the project but also the citizen recommendations that supported our decision (translated by the author)*

A member of Leonia, the local environmental association (Interviewee 12), explains:

*The project documents provided background for several publications/dossiers, for example, (Pucci et al., 2015) and our association's risk awareness-raising campaigns. The participants were also invited to organize parallel meetings at the end of the process. This allowed positive trust relationships to be built between the participants and it showed that*

*citizens' ideas can be taken into account in local risk decision-making processes* (translated by the author)

Finally, the participatory process helped to align the preferences of townspeople and decision-makers. Beyond reconciling different stakeholder's perspectives, the process provided much needed justification for the landslide mitigation decision and the NBS implementation that followed. As reported by a scientific advisor to the process (Interviewee 17):

*In the future any responsible decision-maker will have to take into account the results of this process. It is very important for local politicians to be aware of the agreement points* (translated by the author)

The Emergency Commissioner voiced the value of the process as shared responsibility:

*I can definitely benefit from the results of the participatory process because they help me better understand what residents think, and I can share the responsibility for the decision with the participants* (Interviewee 18; translated by the author).

Also important was the increased landslide risk awareness and knowledge and sense of agency on the part of the process participants. In a questionnaire survey administered at the end of the process, the participants said that their knowledge of landslide risk mitigation measures had improved, as had their awareness of what they can do personally in the face of landslide risk (Scolobig et al., 2011). The key benefits of the process in Nocera Inferiore can be summarized in terms of participants' empowerment, social learning, provision of improved public services, the extensive scientific knowledge of the experts, and the co-design of a risk mitigation plan by experts and stakeholders. The legacy of the process—so interviewees maintain (Interviewees 1,11,12)—has been to keep NBS and landslide risk reduction on the policy agenda.

One of the criticisms raised, however, was that the topics were too difficult and complex. Some participants felt unprepared to express their preferences and opinions about risk mitigation. Many also realized that their own lack of scientific background prevented a really meaningful debate with the experts (Interviewee 13). The evaluation of the participatory process reveals this to be a critical point for the later NBS implementation.

## 5.7 Hurdles and challenges

There were a number of challenges and hurdles to the adoption of NBS in Nocera Inferiore. For the purpose of this case study, we define barriers as “obstacles that can be overcome with concerted effort, creative management, change of thinking and related shift in resources, land uses, institutions, etc.” (Moser & Ekstrom, 2010). There is a vast literature describing barriers to climate change adaptation and disaster risk reduction as well as barriers to NBS and, especially, to ecosystem-based approaches (e.g. Adger, 2007; Biesbroek et al., 2013, Jones & Boyd, 2011; Boer, 2010, Eisenack et al., 2012). This literature set the stage for our analysis.

### 5.7.1 Diverging risk mitigation priorities

The questions of “what the key issue or problem is” and of “how it can be solved” in relation to landslide risk reduction are framed in different ways by stakeholders in Nocera Inferiore. NBS are part of the debate, and differences are evident in opposing stakeholders' views, opinions, concerns, needs, interests, and values. These opposing views caused conflicts regarding priorities for risk mitigation in Nocera Inferiore, as clearly not everybody supported the NBS agenda. In section 5.4 we described the view of the groups and individuals that were in favor of natural engineering works/NBS and prioritized a "careful stewardship of the mountains" over, for example, grey structural measures. Yet, there are also conflicting views. The key differences in terms of the priorities for risk mitigation identified by the interviewees relate to the support (or not) for relocation of the households situated in the highest risk areas and the support (or not) for grey structural measures.

There is a strong argument for relocating residents, especially as it may be more cost-effective than expensive mitigation measures. As reported by a civil protection officer (Interviewee 16):

*Rather than spending a million euros to make the entire slope area safer, we should consider the relocation option* (translated by the author)

Relocation, however, is clearly a contentious issue and was fiercely opposed by residents and members of the landslide victim committee. An interviewee living in the Monte Albino area (Interviewee 13) emphasized the importance of information:

*Many people are not aware of the existence of building restrictions and think that they can do whatever they want on their private property. For example, I realized I was living in an area of very high risk (R4) only when I went to the municipal technical office to request a permit to enlarge my house* (translated by the author)

Another interviewee expressed concern that the seriousness of landslide risk on Monte Albino is exaggerated, especially as only a small number of homes may be under threat, stating that it might be more effective to invest scarce resources in flood risk management. Several interviewees support a cost–benefit analysis to determine which risk mitigation measures to adopt and which households to relocate. They emphasize the importance of rational and informed choices on the part of individuals and the public authorities. Moreover, decisions on public investments in landslide risk mitigation should be made taking account of the returns to the public if the investment is made in flood risk mitigation or in other social needs.

Another bone of contention is related to support for grey mitigation measures. As mentioned above (see section 5.6.1), opposition to grey measures was a key enabling factor of NBS. However, there were also strong interest/pressure groups supporting a massive investment in grey/passive mitigation measures that was rejected twice by the

municipal council. These coalitions, represented primarily by officers at regional level but also by some residents and politicians, therefore blamed the municipal council and the supporting local associations for the decision process stalling. The priority for these individuals was the guarantee of high safety standards. As expressed by a farmer living on the Monte Albino slope:

*Structural control works should be built... I am a farmer and I know where the unstable areas are on my property, but the Monte Albino slope is very wide and it is difficult to identify the most endangered areas (Interviewee 19; translated by the author)*

Because of this uncertainty, the farmer supported passive measures. Another resident of Monte Albino added:

*The construction of control works upstream is necessary to stop the debris and soil from sliding down (Interviewee 13; translated by the author)*

### 5.7.2 Cross-scale conflicts

Interviewees point to the tension between authorities acting at different scales, especially municipal and regional, with two risk mitigation projects prepared by different regional authorities have been rejected by municipal authorities which clearly shows a conflict between authorities acting at different scales/levels. There was also some skepticism about the effectiveness of decisions made at local/municipal level, and more in general about bottom-up participatory processes. As a regional agency officer said:

*We all know who is going to make the decision: the regional Emergency Commissioner. We need to be more realistic about decision-making processes related to risk mitigation. Bottom-up initiatives cannot work because the residents cannot provide any new information, nor can they meaningfully contribute to the risk mitigation discussion. Instead, we need top-down participation because experts are the only ones who can provide useful advice (Interviewee 16; translated by the author)*

### 5.7.3 Trade-offs between public and private goods

One barrier to the NBS implementation related to its specific location (Interviewees 13,19), especially when risk mitigation measures were to be sited on private properties in the piedmont area. This caused dismay among those affected whose properties typically comprised a house and some surrounding land. The measures, residents felt, would lower their property values, on top of which it would mean some of their land being expropriated by the state. Thus, self-interest—so-called NIMBY (Not In My Back Yard) syndrome—represents a key barrier to NBS and many other infrastructural projects. The fact that the solution was a natural one, or—as some residents call it, “km zero,” did not actually make a big difference. It is thus important to highlight that trade-offs concerning conflicts of interest, and particularly those regarding conflicts/trade-offs

between public and private “goods,” are a common barrier to NBS and many other risk mitigation measures.

#### 5.7.4 Funding: Pledges and transfers

The short history of landslide risk and NBS management following the 2005 event has led interviewees to question whether the funds promised by the national authorities would actually materialize. As described in section X, about €11.3 million was pledged for compensation and mitigation in 2005, 2007, and 2011 (not to mention the initial €25 million project), but only €1.1 million was transferred and used for this purpose by the time of writing in 2019. The risk mitigation plan is, however, far from being fully implemented, and although funding will be probably transferred in the future, timing is definitely a problem (Interviewee 1).

Moreover, as reported particularly by members of local NGOs, there is a sense of unfairness about the distribution of funds for risk mitigation in Nocera Inferiore, given that €190 million was spent on risk reduction measures (Versace, 2008) in the neighboring city of Sarno. Equity in funding allocation in other municipalities of the region is also problematic. On the one hand, the strict application of the Sarno “structural model” at the regional level would be very difficult to carry out because of the enormous costs. On the other, several studies have been conducted to clearly identify the municipalities at highest risk (Cascini et al., 2008; Cascini, 2005; Ferlisi & De Chiara, 2016)—these identify the municipalities needing a detailed landslide risk assessment to identify the risk mitigation measures that optimize the use of the available economic resources.

### 5.8 Benefits and co-benefits

The concept of NBS has proved to be a promising strategy for reducing disaster risk, improving ecosystem-based disaster risk reduction, increasing social–ecological resilience, protecting ecosystems, and improving livelihoods through the maintenance, restoration, enhancement, and sustainable use of ecosystems and their services (de Jesús Arce-Mojica et al., 2019).

As the NBS in Nocera were finalized a few months before this case re-analysis was conducted, co-benefits could not always be easily identified by the interviewees. Besides reducing landslide risk, the NBS provide a number of co-benefits such as the installation of several paths in a recreation area at the toe of Monte Albino and provision of new ecosystem services for the community. Co-benefits also include fire risk reduction, as the NBS acts as a barrier against forest fires.

Another co-benefit is that NBS—compared to a grey solution—use less soil. An interviewee at the technical municipal offices (Interviewee 1) also mentions the reduction of soil erosion, due to frequent rainfall events, as a key benefit, together with a cross-sectoral benefit related to waste management. Thanks to the NBS construction,

waste, which often obstructed channels and small rivers, thus increasing debris flow and the risk of flash flood, has been removed from the area (Interviewees 1,12).

Another interviewee working for technical offices (Interviewee 21) emphasizes the reduced long-term maintenance costs compared to grey solutions and considers it as a key benefit

*The maintenance costs of grey measures are excessive. Natural engineering measures are cheaper also for their maintenance (translated by the author)*

As a result, ecosystem services have been generally improved. This provides several environmental benefits (Interviewee 12).

Other economic benefits include low costs (especially compared to grey measures), and a potential tourism increase at the Monte Albino sanctuary because the area has been made safer. Social benefits are also numerous: besides the recreational value mentioned above, the increased esthetic value of the area, access to the mountain, and risk/environmental awareness are also mentioned. Last, but not least, by making the residents of the slope area safer, the measure increases equity in risk distribution at the municipal level, especially between residents of the town versus those living on the mountain slope (Interviewee 12). Equity in risk distribution, even strict equality, is—in general—a very important consideration. As reported by the member of a local environmental NGO (Interviewee 11):

*There is a need to guarantee equal safety standards for all families living in Nocera and on the Mount Albino slope. We should ideally have a risk map with the same color (for risk level) everywhere, but I am not sure this is technically feasible. However, we know that there are some illegal buildings in the Monte Albino area and protecting those houses would be unfair: the priority for enhanced safety should be given to houses built legally (translated by the author)*

Yet, not all interviewees have the same opinion about illegal buildings or how to prioritize funding allocation.

Finally, it is important to mention that a precise quantification of the benefits and co-benefits is not available at the time of writing, but it may be in the medium-long term.

## 5.9 Summary and key messages

This case study reports on a landslide risk mitigation project in southern Italy that led to the implementation of nature-based solutions (NBS) for disaster risk reduction in the town of Nocera Inferiore. Several factors fostered and enabled the NBS adoption; others constrained it. We analyzed stakeholders' views on NBS enablers, benefits, and barriers based on an extensive documentary analysis, a re-analysis of data collected in the years 2010–2013, and 21 semi-structured interviews.

The following table summarizes the key results, based on a common set of categories and NBS implementation phases (from preconditions to initiation, planning, and implementation) identified for all the case studies included in Deliverable 5.1. of the PHUSICOS report.

*Table 14: The key benefits and co-benefits of NBS in Nocera Inferiore*

Category and type of NBS benefit/co-benefit	Views expressed by interviewees
<b>Risk reduction</b>	
Reduced landslide risk	Risks from landslides were reduced (seen in particular during the 2005 landslide)
Reduced fire risk	The NBS acts as a barrier against fire risk, the consequences of which also increase landslide risk
<b>Local economy</b>	
Reduced maintenance costs	The NBS maintenance costs were low, especially if compared to grey measures
Low costs	The NBS costs were low, especially if compared to grey measures
Tourism increase	The safer Monte Albino area can attract more religious tourism to the Monte Albino sanctuary
<b>Society</b>	
Increased recreational value	The NBS made a recreational area with walking paths safer
Increased equity	The NBS area is safer and more accessible to residents. This increases equity between residents living in areas exposed versus not exposed to landslide risk
Increased esthetic value	The NBS has a lower environmental impact than grey measures. It thus increased scenic and landscape quality.
Risk/Environmental awareness raising	The NBS had a catalyst function by inspiring further NBS projects in the region
Increased access to the mountain areas	The NBS area became safe to access, thus allowing better access to the mountain area
<b>Environment</b>	
Reduced soil erosion	The NBS considerably reduces soil erosion
Reduced soil use	The NBS uses less soil than grey/structural measures

*Table 15: Enablers of the NBS in Nocera Inferiore (including enablers as pre-conditions and enablers during initiation, planning/design and implementation)*

Category and type of enabler	Views expressed by interviewees	Pre-conditions/ context	Initiation, planning, implementation
<b>Socio-cultural</b>			
Opposition to grey measures	High costs, and visual and environmental impacts are root causes of opposition to grey measures	✓	
Interest groups/coalitions	Environmental, social associations, and landslide victims committee acting as agents of change	✓	✓
Environmental awareness raising	General change in social norms, more attention dedicated to environmental issues	✓	

Category and type of enabler	Views expressed by interviewees	Pre-conditions/ context	Initiation, planning, implementation
Risk awareness raised by the event	Landslide risk becomes an important topic for the residents	✓	
<b>Political/legal/institutional</b>			
Opposition to decision made at regional level	Stakeholders at municipal level opposed to decisions of regional agencies	✓	✓
Political will and support / champions	Local politicians, mayor, and environmental councilor in favor of NBS		✓
Alignment between citizens and decision-makers preferences	Wide stakeholder engagement/participatory process facilitated identification of shared priorities		✓
Existing mandate and authority	Mandate for municipal technical office to implement NBS		✓
Cross-sectoral collaboration	Waste management, urban development, and risk mitigation are all included in the same “environmental agenda”	✓	
Trust relationship	Trust relationship between coalitions at local/municipal level		✓
<b>Financial and human resources</b>			
Available funds	€7 million regional funding made available for risk mitigation	✓	
Limited funds	NBS are less expensive than grey measures		✓
Experts	Presentation of new and robust scientific evidence to support NBS	✓	✓
Co-design of risk mitigation plan	Co-design between experts and stakeholders of a compromise solution for risk mitigation		✓

Table 16: Challenges and hurdles to the NBS in Nocera Inferiore

Type of challenge / hurdle	Views expressed by interviewees	Pre-conditions/ context	Initiation, planning, implementation
<b>Socio-cultural</b>			
Interest groups/coalitions	Stakeholder coalitions, especially at regional level, supporting grey measures and/or relocation	✓	
<b>Political/legal/institutional</b>			
Private property rights	NIMBY (not in my backyard) syndrome		✓
Scepticism about effectiveness of local level decision making	Opposition to participatory process		✓
Cross-scale conflict	Tensions between authorities acting at different scales	✓	✓
<b>Financial and human resources</b>			

Type of challenge / hurdle	Views expressed by interviewees	Pre-conditions/ context	Initiation, planning, implementation
Funding transfer	Slow process of transferring risk mitigation funding	✓	
Experts	Experts supporting grey measures	✓	✓

The tables above show that political, legal and institutional enablers are more numerous than the financial/human resources and socio-cultural ones. It also shows that political/legal and institutional barriers are more numerous than the social and financial ones. Another common finding is that few of the enablers and barriers act over the entire NBS policy cycle (namely, from precondition/context to initiation, planning, and implementation). In fact, there are only two enablers—interest groups/coalitions and opposition to decisions made at the regional level—and one barrier—cross-scale conflict. Political/legal and institutional enablers are more relevant in NBS initiation, implementation, and planning while socio-cultural aspects emerge as essential preconditions. Finally, the number of societal and environmental benefits/co-benefits mentioned by the interviewees is definitely superior to the risk- or economy-related ones.

Furthermore, the role played by some key NBS enablers must be emphasized. First, wide-scale stakeholder opposition to grey measures, interest groups/coalitions, and expert communities catalyzed the local decision-making processes for NBS adoption and disaster risk reduction. The root causes of opposition to grey measures are found in the high building and maintenance costs, the esthetic and environmental impact, the false sense of full protection induced in the residents, and the potential for private land expropriation. Fueled by the criticisms of the “Sarno model,” the environmental coalitions and their key members, that is, well-known and trusted individuals, were crucial to the development of an NBS agenda which decision-makers were confident enough to use as a basis for action. The NBS implemented in Nocera Inferiore is part of a bigger plan which includes, for example, the creation of a natural park at the toe of Mount Albino slope, the improvement of walking paths, small-scale organic farming, and better management of public and private forests. Resident engagement for risk reduction and mountain maintenance was also a key concept of these groups/coalitions.

Driven especially by local environmental associations, residents were able to strengthen collective agency and foster NBS transition initiatives. This movement has been dependent on a small circle of associations (e.g., *Montagna Amica*/Friends of the mountain, Leonia, the Victims' Committee) that acted as agents of change. Some key members of these associations acted as mediators, translators, and networkers between different levels (e.g., local government and civil society, being, for example, members of the local municipal council and of environmental organizations) and different sectors/domains (e.g., environment, waste management and disaster risk reduction). They were members of single initiatives aimed at fostering environmental sustainability, but most often of multiple ones. They could speak the language of multiple sectors and therefore could identify and support the synergies among them.

Second, one of the key elements of governance innovation in the Nocera Inferiore case are the strong local networks and the wide stakeholder engagement for disaster risk reduction, especially at the municipal level. More precisely, starting in 2010, a participatory process allowed a compromise solution to be reached on a co-designed landslide risk mitigation plan that included the NBS. It made use of extensive stakeholder interviews, a public questionnaire, public meetings, an interactive web platform, and an extended citizen deliberative process (Scolobig et al., 2016). Geotechnical experts from the University of Salerno and the local municipal authorities provided three technical mitigation option packages, each within a given budget constraint and complying with Italian law. By bringing together citizens and experts to co-produce landslide risk mitigation options, the process reached a compromise solution for landslide risk mitigation. The plan included the NBS implemented in 2019. Thus, the co-design of a risk mitigation plan definitely catalyzed the NBS adoption because it provided a robust and updated knowledge base on landslide hazard and risk assessment, stimulated discussion on NBS, contributed to reconciling different perspectives, and aligned the preferences of citizens and decision-makers.

Third, and somehow paradoxically, the limited availability of funding enabled the decision to implement the NBS rather than grey solutions. After the large investment in risk mitigation in the neighboring city of Sarno compared to the money pledged for Nocera Inferiore, there has certainly been a sense of unfairness about the distribution of funds. However, the limited funding in combination with low maintenance costs was what allowed the NBS to be prioritized. Yet, the implemented NBS does not resolve the risk mitigation problem: in the future a green–grey hybrid solution will probably be adopted. However, as emphasized by several interviewees the future is uncertain: the timeline and especially funding for new risk mitigation measures have not been decided at the time of writing (2019).

Fourth, not only economic but also environmental, risk reduction, and social benefits played a critical role in the NBS implementation. The social benefits of the implemented NBS are numerous and include increased recreational value, equity, esthetic value, risk/environmental awareness, and increased access to mountain areas. This represents a critical NBS heritage, for present and future generations.

## 6 Case study highlights

### 6.1 Isar-Plan

The Isar-Plan is widely acclaimed for having successfully turned a formerly concrete and unsafe riverbank into a green/blue recreational space, now an indispensable emblem of this city of millions. The Isar-Plan is the 2000–2011 restoration project through which an 8 km stretch of the River Isar in Munich was restored using a hybrid of NBS and grey measures. The measures implemented included an increase in water flow, widening of the riverbed, addition of natural material to reduce flow speed and enhance the quality and connectivity of fish habitats, and reinforcement of existing levees to fulfil the water authorities' main goal of protecting Munich from extreme floods. The aims of the project thus evolved to be threefold: environmental restoration, recreation, and most importantly, flood protection. While flood protection is generally viewed as the principal benefit of the project and equally the rationale for financing its costs (approx. €35 million), the Isar-Plan's co-benefits (ecological restoration and recreation) are widely portrayed and perceived as the project's predominant success, as reflected in the stakeholder interviews.

Our results show the importance of strong interest/pressure groups, as well as innovation within governmental institutions, for designing and realizing the ambitious Isar-Plan. A decade before the start of the project, environmental groups succeeded in claiming increased residual water for the Isar from the *Mühlthal* hydropower plant whose concession was expiring. Having won this battle, these same stakeholders later formed an influential coalition of environmental groups (the Isar Allianz) that advocated for, and ultimately co-designed, the NBS. Indeed, the Isar-Plan was in the vanguard of the participatory approach by actively engaging environmental NGOs, residents, and other stakeholders in the planning and to some extent the co-design of the NBS.

The Isar-Plan was also innovative in another aspect of its governance model. The water authorities of the State of Bavaria and the City of Munich collaborated in advocating a far broader vision for the Isar than their customary focus on grey infrastructure for flood protection. This collaboration was initiated by ecologically committed staff members who formed for the first time a multidisciplinary working group. The multi-scale and cross-sectoral collaboration (two characteristics of polycentric governance)—breaking the silos of water and urban planning—was unprecedented for projects of this magnitude, and resulted in a relationship of trust among stakeholders who sometimes had conflicting values and interests.

The Isar-Plan process offers many lessons for enabling NBS. Not least, it reinforces the more general observation that natural measures are often viable only if they "piggy-back" on grey solutions. At the core of the Isar-Plan—and the mandate of the funding authorities—was the reinforcement of the existing flood protection. Still, it is remarkable that grey flood protection was accompanied by what is generally viewed as an extremely successful transformation of the Isar to a wild-flowing mountain river.

## 6.2 Wolong Nature Reserve

Over the past two decades China has implemented some of the world's largest NBS programs, including the Natural Forest Conservation Program (NFCP), to tackle its increasing disaster risk, environmental, and related socioeconomic challenges. The NFCP consisted of a nation-wide logging ban and large-scale afforestation and reforestation policy which involved financial incentives for community-based monitoring of illegal logging. The implementation of NFCP in Wolong, a flagship protected area located in a global hotspot region of disasters, biodiversity and cultures, was a renowned local success with innovative governance enablers.

NFCP in Wolong was effective in reverting deforestation and leading to substantial recovery of forest ecosystems and wildlife habitat. While scant quantitative evidence exists for assessing NFCP's direct effects on reducing flood and landslide risk, local communities and other stakeholders have largely acknowledged its DRR impact brought about by the improvement in soil conservation. The NFCP's impact on local economy and community well-being is also widely recognized.

NFCP was catapulted onto the government's policy agenda by an enabling event - extensive floods in summer 1998 - which opened a window of opportunity for government officials to advocate for the acceleration of a forestry sector reform and related conservation and restoration programs with unmatched political and financial resources. The renown of Wolong as the "Home of Giant Pandas" engendered strong political support for NFCP as was symbolized by the visit of Prime Minister Rongji Zhu during its initiation. The publication of an article on the Reserve's ecological issues in the prestigious Science magazine during the implementation of NFCP further focused international and national attention on Wolong.

Wolong's status as both a protected area and a special district with independent government functions and financial resources provided a unique level of flexibility in designing locally adaptive solutions. In contrast to the Isar-Plan case, in Wolong the DRR agenda was piggybacked onto the responsibilities of the administrative bodies with core interests in conservation and to some lesser extent tourism-related economic development. The Reserve's governing bodies and a wide range of administrative bodies at township and lower levels were coordinated by a cross-departmental NFCP committee in the NBS initiation, planning, design, implementation, monitoring and evaluation processes, supported by state-of-art technical expertise from research and practical partners. The resulting polycentric governance arrangements have proven to be critically important in the realization of this ambitious NBS.

Another key enabler of the success in Wolong lies in its innovative engagement of local communities with unprecedented consultation processes and incentives. Local authorities designed and implemented monetary incentives for households in consultation with villagers for community-based monitoring of illegal logging. The unique system complemented the traditional 'sticks' approach for sanctioning illegal logging with 'carrots' in the form of payments to household groups who were successful

in preventing logging in their assigned forest areas. This novel concessional system was enabled by strong pre-existing social norms and trust within the communities, which laid the ground for their mutual cooperation.

### 6.3 Nocera Inferiore

The high-risk areas of Nocera Inferiore in Southern Italy lie at the foot of the Mount Albino massif, which is prone to rainfall-induced slope instabilities. The implemented NBS (in Italian, naturalistic engineering works) included maintenance and remediation of the mountain slope, channel lining, and vegetated and stone gabions aimed at reducing erosion due to frequent rainfall events. It is also important to note that the NBS implemented in Nocera Inferiore is part of a bigger plan which includes, for example, the creation of a natural park at the toe Mount Albino, the improvement of walking paths, small-scale organic farming and better management of public and private forests.

The case study results highlight three key enablers. First, widescale stakeholder opposition to grey measures by interest or pressure groups and expert communities catalyzed the local decision-making processes for the NBS adoption and disaster risk reduction. The root causes of opposition to grey measures could be found in their high building and maintenance costs, esthetic and environmental impact, false sense of full protection, and private land expropriation. Driven especially by local environmental associations, policymakers were able to strengthen collective agency and foster NBS transition initiatives. This movement depended on a small circle of associations that acted as agents of change and were capable of speaking the language of multiple sectors and of identifying and supporting synergies among them.

Second, local networks and wide stakeholder engagement for disaster risk reduction, especially at municipal level, were key elements of governance innovation. Starting in 2010, an externally led three-year participatory process involving affected and interested residents managed to find a compromise solution on a co-designed landslide risk mitigation plan that included the NBS. The process included extensive stakeholder interviews, a public questionnaire, public meetings, an interactive web platform, and an extended citizen deliberative process. Geotechnical experts from the University of Salerno and the local municipal authorities provided three technical mitigation option packages, each within a given budget constraint and complying with Italian law. By bringing together citizens and experts to co-produce landslide risk mitigation options, the process reached a compromise solution for landslide risk mitigation. The plan included the NBS implemented in 2019.

Third, the limited funding availability paradoxically enabled the choice of the NBS option (with lower maintenance costs) over a grey solution. Yet not only economic but also environmental, risk reduction, and social benefits played a critical role in the NBS implementation. The social benefits are numerous and include increased recreational value, equity, esthetic value, risk/environmental awareness, and increased access to mountain areas.

## 7 Comparative overview

This section provides a comparison of the success factors and governance enablers of the Isar-Plan, Nocera Inferiore, and Wolong cases. The comparisons as reported in tables 4, 5 and 6 are based on opinions of the interviewees and the grey and peer-reviewed literature. The purpose is not to identify deficits or best practices across governance processes operating in different contexts, but rather to provide an overview of perceived success factors and enablers. As they are based mainly on interviews, the success factors and enablers identified are not meant to be comprehensive. Section 6.1 focuses on the cases' NBS benefits and co-benefits, section 6.2 on the preconditions up to the NBS initiation, and section 6.3 on the enablers that emerged from the NBS initiation onwards (i.e., during the NBS initiation, planning, design, and implementation).

### 7.1 Benefits and co-benefits

Table 4 summarizes the key benefits and co-benefits identified by the interviewed stakeholders (Isar-Plan and Nocera Inferiore) and the peer-reviewed and grey literature (Wolong). Although the process was initiated in each case with the official intent of reducing flood or landslide risk, this "main benefit" was often perceived as a co-benefit by stakeholders. Because of the different perspectives on the meaning of "co-" in "co-benefits," we do not distinguish between "benefits" and "co-benefits." Note that the absence of a benefit or co-benefit does not always mean that the NBS did not exhibit this attribute, but that it was not mentioned by the stakeholders or reported in the literature.

Table 17: The benefits and co-benefits of the NBS implemented in each case study as identified by stakeholders interviewed

Category and type of NBS benefit/co-benefit	Isar-Plan	Wolong <sup>5</sup>	Nocera
<b>Risk reduction</b>			
Reduced risk from floods/landslides	✓	✓	✓
<b>Technical and feasibility aspects</b>			
Cost-effectiveness	✓		✓
<b>Local economy</b>			
Job creation	✓	✓	✓
Tourism	✓	✓	✓
<b>Society</b>			
Recreation	✓	✓	✓
Esthetic value	✓	✓	✓
Inclusiveness and equity	✓	✓	✓
Nature accessibility	✓		✓
Social cohesion	✓	✓	
Cultural heritage value	✓		
Risk/environmental awareness	✓	✓	✓

<sup>5</sup> In addition to interviews, the identified Wolong case benefits and co-benefits were based on peer-reviewed literature.

Category and type of NBS benefit/co-benefit	Isar-Plan	Wolong <sup>5</sup>	Nocera
<b>Environment</b>			
Biodiversity	✓	✓	✓
Habitat connectivity	✓	✓	
Soil conservation			✓
Vegetation cover	✓	✓	
Wilderness	✓		

The results show that in all three cases stakeholders identified multiple benefits and co-benefits related to the ambits identified in Work Package 4, namely, risk reduction and cost-effectiveness in addition to economic, social, and environmental attributes (Raymond et al., 2017). Success in terms of environmental benefits was individual to each case, reflecting the unique ecological settings and NBS impacts. It should also be noted that there were potential ecosystem *disservices* originating from NBS, such as increased pressure on ecosystems from increased recreational uses, as in the Isar-Plan case (Maes et al., 2017).

Interviewees were not asked to rank the importance of the perceived (co)benefits, and for this reason our results present no prioritization. However, risk reduction was recognized as a benefit in all three cases, as well as societal benefits such as recreation and esthetics, which are predominant in the number of attributes listed in this category. This is consistent with da Rocha et al., (2017) who found that the socio-cultural benefits most often associated with NBS are esthetics and education.

Although the importance of social attributes is increasingly acknowledged (Chan et al., 2012; Daniel et al., 2012) they remain difficult to explicitly characterize and quantify, with methodologies often involving stakeholder interviews or surveys (DEFRA, 2007). Consequently, economic valuations typically overlook the nuances of non-monetary socio-cultural benefits (Derkzen et al., 2017). NBS funding is thus often mobilized for the more tangible and quantifiable benefits of NBS.

This is in line with current views on NBS co-benefit assessment. For instance, the EKLIPSE impact evaluation framework (Raymond et al., 2017) stresses the need to consider the pathways between ecological systems and socio-cultural systems. Similarly, Josephs and Humphries (2018) noted that to move beyond ecological definitions of NBS success, socioeconomic factors and particularly non-monetary benefits based on social motivations and behaviors need to be better integrated in assessments.

Our results accordingly highlight the importance of involving multiple disciplines (i.e., social sciences, economics, ecology) to comprehensively evaluate the benefits and co-benefits of NBS, and thus the importance of breaking silos for building the case for NBS. This message extends beyond formal or informal assessments of NBS. Indeed, a key insight to emerge from the case studies is the importance of merging the DRR, ecological, climate adaptation, and human welfare agendas. Cross-departmental integration for NBS—what is termed polycentric governance—can intensify rationales for financing NBS across diverse budgets and build administrative support. This was

witnessed especially in the Isar River case where the interdepartmental Isar-Plan Working Group was instrumental in the planning and implementation of the project.

## 7.2 Enablers as preconditions

Table 5 provides an overview of the preconditions that were viewed by the interviewees as helping to catapult the NBS onto political agendas. These represent factors that contributed to the NBS initiation yet were external to the NBS project. The list is not meant to be comprehensive but only to represent the pre-NBS process enablers as voiced by interviewed stakeholders.

*Table 18: Pre-existing conditions that enabled the implemented NBS in each case study in the view of the interviewed stakeholders*

	Isar	Wolong	Nocera
<b>Category and type of NBS precondition</b>			
<b>Socio-cultural</b>			
Opposition to grey measures			✓
Interests/pressure groups	✓		✓
Environmental awareness	✓	✓	✓
Risk awareness raised by event/model	✓	✓	✓
<b>Legal/institutional/political</b>			
Mandate and authority	✓	✓	✓
Local champion	✓	✓	✓
Favorable public property rights	✓	✓	✓
Existing legal basis	✓		✓
Cross-sectoral collaboration			✓
<b>Financial and human resources</b>			
Available funds	✓	✓	✓
Expert knowledge and expertise	✓	✓	✓

While NBS are also enabled by a plethora of bio-physical and environmental factors, such as available space to widen the river in the case of the Isar-Plan or extensive pre-existing biodiversity for the Wolong Nature Reserve, these were outside the scope of this analysis and therefore excluded from it. Results display the diversity of governance preconditions necessary for NBS to emerge on political agendas.

Perhaps the most essential pre-condition was the availability of funds (noting that in the Nocera Inferiore case the limited funds precluded the need for costly grey measures). In each case the financing was in place (or promised) at the initiation of the NBS policy process, meaning the three cases focused largely on administrative governance as opposed to political governance, in other words, the cases do not cover the political considerations concerning alternative uses of the funds (e.g., for schools or health care). Still, the governance system shaped the final grey or nature-based outcome. Thus, a

mandate and favorable legal conditions (such as public property ownership) played a pivotal role. Additionally, as recognized by Trinomics & IUCN (2019), NBS projects are primarily either directly financed by public authorities (especially on public land), or by authorities encouraging and incentivizing other actors (e.g. residents) to contribute to maintaining NBS in the public domain. While the Isar-Plan and Nocera cases fit the former option, the Wolong case matches the latter.

Pre-existing opposition to grey infrastructure measures and organized interest and pressure groups appeared to be critical for the NBS to emerge on political agendas in the Isar-Plan and Nocera Inferiore cases. A flood/landslide event at or near the case site, or (in the Isar-Plan case) a model which simulated a catastrophic event, opened a window of opportunity for already existing environmental groups or sympathetic state authorities —along with the expert community—that then advocated for a nature-based or hybrid solution. This is consistent with empirical investigations showing that a major event can result in policy change if groups or coalitions advocating for the policy change were already in place (Scolobig et al., 2014).

Not surprisingly, the Chinese system differs across many preconditions compared with the European systems, most notably the absence of interest and pressure groups, although the Chinese authorities recognized the importance of consulting with households that would be affected by the new monitoring and financing scheme. Moreover, many of the differences can be explained by the distinction between flood and landslide hazards. Finally, it is also not surprising that flood risk had been addressed earlier in the case of the Isar-Plan, as flood prevention has historically received greater attention and funding than landslide risk (UNDRR, 2019).

### 7.3 Enablers from project initiation to implementation

Table 6 provides an overview of the three case studies in terms of the factors that (according to interviewees) enabled the project’s initiation, design, planning, and implementation. Many of the enablers were already in place before the project landed on political agendas (table 5), and others shown in table 6 emerged or were strengthened during the course of the project’s realization.

*Table 19: The main enablers that emerged from the NBS initiation to implementation in the view of the interviewed stakeholders*

Category and type of NBS enabler during its initiation, design, planning, and implementation	Isar	Wolong	Nocera
<b>Socio-cultural</b>			
Stakeholder engagement	✓	✓	✓
Interest/pressure groups	✓		✓
Risk awareness raised by event	✓		✓
Trust relationship between stakeholders	✓	✓	✓
<b>Legal/institutional/political</b>			
Local champion	✓	✓	✓

Category and type of NBS enabler during its initiation, design, planning, and implementation	Isar	Wolong	Nocera
Trust relationship between decision-makers	✓		
Clearly defined goals	✓		
Common vision	✓	✓	
Cross-scale collaboration	✓	✓	
Cross-sectoral collaboration	✓		✓
Designed flexibility		✓	
<b>Financial and human resources</b>			
Innovative funding mechanism		✓	
Affordability			✓
Communication strategy and platforms	✓		
Expert knowledge and expertise	✓	✓	✓
Co-design of risk mitigation plan			✓

The enabling factors that emerged during the NBS policy process built on the commonalities exhibited by the preconditions (table 5). In the Nocera Inferiore and Isar-Plan cases, for example, interest and pressure groups together with expert communities existed before the project was initiated, yet continued (in a different or strengthened form) to be a main driving force for an NBS. Fueled by the criticisms of a grey structural model, the pressure groups and their champions (i.e. well-known and trusted individuals) were crucial to the development of an NBS agenda that decision-makers were sufficiently confident could be a basis for action. In the Isar-Plan case, the advocacy emerged both from within the administration (Isar-Plan Working Group) as well as from civil society (e.g., Isar Alliance), both with vocal and charismatic individual champions. Thus, in the European cases, strong pressure groups in and outside the administrative bodies, along with their individual champions, appeared to be a key enabler for realizing the NBS.

Table 6 also shows commonalities in collaboration among the authorities. The multi-scale (Isar and Wolong) and cross-sectoral (Nocera and Isar) collaboration (two characteristics of polycentric governance) broke administrative silos that are typical in public administrations. Indeed, a highlight of the cases is their illustration of polycentric arrangements in public administration that cut across administrative bodies including, for example, authorities responsible for flood/landslide risks and for water, urban planning, nature reserves, and waste management. This finding is consistent with the survey by Bernardi et al., (2019), who identify NBS drivers, including policies to support collaboration and co-design and the need to focus on the synergies of policy making at diverse scales. As reflected in her design principles, Ostrom (1999) championed the importance of the polycentric governance model (principle 7) in providing public goods. In contrast to more monocentric processes, polycentric governance provides opportunities for learning and experimentation and enables broader levels of participation (Ostrom, 1999).

In the Isar-Plan case, the water authorities of the State of Bavaria and the City of Munich collaborated in advocating a far broader vision for the Isar than their mandated and

customary focus on grey infrastructure for flood protection. This collaboration was initiated by ecologically committed staff members who formed, for the first time, a multidisciplinary working group. The collaboration was unprecedented for projects of this magnitude. A similar polycentric arrangement emerged in the Wolong case. Analogous to the Isar working group, a cross-department committee emerged, led by two governmental champions with rich local knowledge, that bridged across separate disaster protection-conservation-development agendas. In the case of Nocera Inferiore, members of the pressure groups, some of whom were also members of the local municipal council, often acted as mediators, translators, and networkers among different levels of government and different sectors/domains. Thus, in each of the NBS cases, it appears that novel administrative collaboration across sectors and scales was both unique and instrumental in enabling the realization of the NBS.

A second equally significant finding in all three cases is the importance of stakeholder engagement. This is in line with Schmalzbauer et al., (2018), who identified citizen involvement, social inclusion and public acceptance as key NBS enablers. Although there were no formal procedures (such as an environmental impact assessment) for involving civil society, businesses, and other stakeholders in the process, stakeholder engagement was a central feature of each case. However, it took different forms. In the Isar-Plan case, an ad hoc yet inclusive participatory process emerged that shaped the outcome toward an NBS; in Nocera, a unique and exemplary process was designed and carried out that coupled public stakeholders and experts in the co-design of alternative and competing landslide mitigation options, including NBS, and facilitated a compromise that influenced the broader contentious policy process. In the Wolong case, in an almost unprecedented move, public officials consulted village leaders and households on the form of the newly designed incentive system for preventing illegal logging. In ‘town hall’ meetings across the nature reserve, the authorities achieved a broad consensus for their ‘carrot and stick’ reforms and, beyond consensus, they re-shaped the scheme based on villager input.

Table 6 also shows differences in the procedural enablers. Noticeably, the trust, common vision, and clear goals so often mentioned by interviewees in the Isar-Plan case are absent (for different reasons) in the Nocera and Wolong cases. In the Isar-Plan case the differing goals of flood protection, ecological wilderness and recreation could all be accommodated to a large extent by the Isar-Plan hybrid, and the available budget could accommodate the investments. Indeed, the natural measures were "piggy-backed" on a grey solution. Thus, the interviewees spoke of a common vision and common goals. In the Nocera Inferiore case, different views on priorities for landslide risk continue to be present; thus common vision and goals have rarely been mentioned by interviewees. In the Wolong case, the government and communities shared the vision of maintaining a healthy forest ecosystem, although the common vision did not appear to be a main driver for the NBS, as there was a clear lack of trust between local communities and government before NFCP. Within communities, cooperation and trust plays an important role in the design of the group monitoring; and the successful implementation of NFCP helped stem the further attrition of trust between government and communities, if not substantially restoring it.

Finally, table 6 is interesting for what it does not show, namely, the absence of formal assessments or available guidelines (identified as an important NBS driver by Bernardi et al., (2019)). Despite the scale of the NBS projects (Isar-Plan (€35 million), Nocera Inferiore (€637,000) and Wolong (approx. €20 million to date ) there were no formal assessments at the site scale of the cost-effectiveness of the NBS in reducing flood and landslide risks, nor any assessments of the co-benefits in terms of biodiversity, climate adaptation, recreation, and other human well-being indices. Furthermore, there was little involvement of private businesses or private funds in the policy procedures and outcomes.

## 8 Summary and discussion

In this final section we summarize by recapping the main highlights of the Isar-Plan, Wolong, and Nocera Inferiore cases based on stakeholder views of their success and main enablers driving this success. We conclude with a short discussion of the main findings.

This deliverable represents a first attempt at distilling the governance factors that contributed to NBS success in complex socioeconomic and political settings. The report has provided a comparative overview of governance frameworks that have helped enable the planning, design, and implementation of NBS across the Isar-Plan, Wolong, and Nocera Inferiore cases. We have addressed two main questions:

- How do public authorities and other stakeholders view the success of the implemented NBS in terms of their main benefits and co-benefits?
- What pre-existing conditions (external to the project) and new and potentially innovative factors helped enable the NBS?

In each of the three cases the interviews and literature reviews confirmed the success of the NBS (the landslide protection in Nocera Inferiore was only recently completed) and views on their benefits with regard to reducing landslide and flood risk as well as multiple ecological and social-economic co-benefits. Importantly, the NBS implemented in each case had co-benefits reaching beyond disaster risk reduction that added significantly to their rationale, appeal, and eventual adoption. The role that multiple benefits play in the NBS policy process deserves emphasis, as it can facilitate additional sources of funding as well as widespread political and public support. Indeed, in all cases support for a natural solution to floods and landslides emerged across diverse administrative bodies and in the Nocera Inferiore and Isar-Plan cases across manifold civil society organizations. A major insight to emerge from the case studies is thus the importance of merging the DRR, ecological, climate adaptation, and human welfare agendas (Tanner et al., 2015).

This insight underlines the importance of NBS in contributing to global sustainability, as expressed in the UN Sustainable Development Goals (SDGs), the Sendai Framework on disaster risk reduction (2015), the Paris Agreement (2016) on climate change, the Global Commission on Adaptation (2019) and international agreements on biodiversity (European Commission, 2011). As shown in our case studies, the fulfillment of multiple agendas can be furthered by focusing strongly on NBS as a complement, even in some cases an alternative, to grey infrastructure for reducing disaster risk. By integrating different transformative global agendas, the transition from grey solutions to NBS is not only cost-effective and viable, but necessary and urgent. As expressed by the Global Commission on Adaptation:

*The natural environment is humanity's first line of defense against floods, droughts, heat waves, and hurricanes. A thriving natural environment is fundamental to adaptation in every human enterprise. (Global Commission on Adaptation, 2019:3)*

The merger of diverse agendas, as the NBS cases illustrate, can be facilitated with collaboration across administrative bodies and with inclusive stakeholder involvement. In fact, the case studies were innovative in both aspects of governance, as well as in novel financing instruments, which contributed significantly to their enablement. *Governance innovation* thus encompassed the following three critical enablers:

- *Polycentric governance*

The NBS success stories showcase novel governance arrangements that cut across organizational responsibilities and sectors to include NBS attributes beyond DRR, such as nature protection, urban planning, water quality, and waste management. The multi-scale and cross-sectoral collaboration (two characteristics of polycentric governance) broke administrative silos that are typical of public administrations. In the Isar-Plan case, this collaboration was initiated by ecologically committed staff of the city and of the provincial water authorities who formed an unprecedented multidisciplinary working group. In the case of Nocera Inferiore, members of the pressure groups, some of whom were also members of the local municipal council, acted as agents for change by networking between different levels of government and different sectors/domains. In Wolong an unprecedented collaboration developed across the national, provincial and local scales, each with different agendas across DRR, conservation and economic wellbeing catalyzed in large part by a cross-departmental committee led by two strong NBS advocates.

- *NBS co-design*

Despite the absence of formal procedures for involving civil society, businesses, and other stakeholders in the process, stakeholder engagement was a central and innovative feature of each case. In Nocera Inferiore, a novel participatory process was carried out that coupled residents and experts in the genuine co-design of competing grey and green landslide mitigation options, and that informed the ultimate NBS compromise. In the Isar-Plan case, an ad hoc yet inclusive participatory process emerged that shaped the outcome toward an NBS with stakeholder input into the final design by the landscape architects. In China, an almost unprecedented procedure of household consultation was carried out by the Chinese authorities.

- *Financial incentives*

In the Wolong case, the Chinese authorities in consultation with villagers designed and implemented novel and innovative incentives for households to monitor illegal logging in the nature reserve. Having experienced the lack of success of sanctions to reduce deforestation, the authorities in another exceptional move instituted incentives in the form of household livelihood supplements for households to monitor the logging behavior of other residents in their hamlet. Thus, sticks were (partly) swapped for carrots in a successful case of restoring degraded forests.

The cases provide evidence to what many consider the near inevitability of hybrid NBS solutions. Governance involves finding compromises that can resolve the interest and

value conflicts underlying the green–grey divide. In the Isar-Plan case, the compromise was a hybrid solution that included "hidden" grey flood protection; in the Nocera Inferiore case the NBS was coupled with a plan for complementary grey infrastructure; in China, the national government combined the large-scale forest conservation NBS in Wolong with grey flood protection measures in lower reaches of the Minjiang river.

While the realization of NBS is nested in complex socioeconomic settings, this report represents a first attempt at distilling the governance factors that contributed to NBS success. A limitation of the analysis is its focus on only three very disparate cases, which cannot be generalized to provide specific recommendations for enabling NBS across different political systems and cases. Moreover, the case studies report on the post-financing policy processes. Thus, they are limited to addressing administrative (not political) governance, as they do not encompass the typically politicized decisions on resource and budget allocations. Despite being a critical aspect of governance, case studies of NBS financing and financial innovation are sparse mainly because most NBS, as in our cases, are publicly funded (Ecological Institute, 2018). Further research is thus needed on both the enablers of public funding for NBS and innovative business and other financing options. Results of this analysis will inform Deliverable 5.2, which will include financing innovation in a more comprehensive analysis of the opportunities for and barriers to NBS.

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## **Appendix A: Interviewee Protocol: Exploration of the success factors that enabled the implementation of NBS through the Isar-Plan**

Interviewer Name:

Interviewee Name:

Employer, Department:

Position:

### **A. Introduction and Background**

*[Interviewer briefly explains project background: The PHUSICOS project aims to demonstrate that NBS (also sometimes referred to as green/blue infrastructure or ecosystem-based adaptation) are sustainable and effective ways to reduce natural hazard risks compared to grey infrastructure. On the basis of several case studies, we are conducting an analysis of the major success factors of NBS implementation. The Isar in Munich has been identified as a place where NBS were implemented, and interviews of experts will complement our analysis. Interviews are anonymous, which the General Data Protection Regulation form confirms.]*

*Interviewer explains that s/he will take notes on the interviewee's responses. Interviewer asks interviewee if s/he agrees that the interview will be recorded to ease the note-taking during the interview. This is where the interviewer is presented with the GDPR consent form. S/he is reminded that recording can be interrupted at any point, and that answers will be treated anonymously.*

*Interviewer explains that the interview will last maximum 1h.]*

**1.** Please briefly describe your role in your organization/work place? *[This question serves as an icebreaker]*

**2.** When and how were you involved with the Restoration of the Isar in Munich or the Isar-Plan?

### **B. Success factors of the Isar Restoration in Munich**

**3.** In your opinion, why was a Plan to restore the Isar in Munich needed when it was implemented? What was the problem? *[The interviewer specifies s/he has an answer to this, but is interested in different opinions]*

**4.** At that time, what were the other proposed solutions and their advocates? *[For the purposes of this discussion, we would welcome information on potential challenges that existed as well as conflicts that might show the different narratives. Were there any conflicts?]*

5. In your opinion, what was the one most important driver in implementing the restoration of the Isar in Munich? *[Examples of types drivers can be given to help the interviewee: political, ecological, financial, sociological, risk management, etc. Would the project have been realized without advocacy groups? Without assured funding from Munich and Bayern? Without specific legislation?]*

5. In your opinion, what was the single most important factor in the process of the restoration of the Isar in Munich? *[A different way of phrasing this question is: what was the key element in the successful process of the Project / the way it was run?]*

6. What do you think is the main achievement of the Isar restoration in Munich? *[An additional question might be asked: Do you think it was worth the money?]*

7. On the flipside, what do you think its biggest shortcoming is? In hindsight, what would you do differently?

### **C. Stakeholders of the Isar Restoration in Munich**

8. How were stakeholders involved in the decision-making process? *[Information for interviewer: What we would like to know here is if there was any co-design of NBS and if it went beyond being listened to, and whether the process was satisfactory or could have been improved]*

9. Who were the strongest advocates? Was there a champion? Who opposed the plan? *[This can also be phrased as: what were the different viewpoints on the Isar-Plan]*

10. Regarding the Isar Restoration in Munich and the Isar-Plan, where did your organization get its information from when needed? *[Information for interviewee: For the purposes of this discussion, we would welcome information on who the interviewee trusted for information and which were strong stakeholder groups. A sheet will be sent prior to the interview to the interviewee so s/he can familiarize himself/herself with it. The exercise will help produce a simple network analysis.]*

### **D. Financial and socio-ecological success**

11. Do you see the restored Isar as a wild river (“Wildfluss”)? If not, what would be further needed to make it one?

12. In your opinion, has the Isar been used as a model of good practice in Germany? *(Has it influenced green/blue infrastructure projects elsewhere? [nationally and internationally?])*

13. I understood that the costs were split between the State of Bavaria and the City of Munich. Do you think the costs of the Isar-Plan were split in a fair way?

### **E. Concluding the interview**

14. Would you be happy to be contacted by us if we needed any further information or clarification? *[Interviewer specifies that for example, we might get in touch if we were*

*unsure about writing something down correctly. This is to reassure the interviewee that we do not want to take up too much of their time].*

**15.** Is there any other person that you think would be useful for us to contact in the context of our research?

*[Interviewer thanks interviewee for his/her time and insights that were shared. Ask if s/he wants to be informed about the report once it is published—end of 2019.]*

#### **E. Additional questions (time permitting)**

**16.** Were ecosystem services a concept you came across during your work on the Isar? If you know about it, do you think it is a useful concept?

**17.** Was there funding for maintenance and monitoring of the project? Where does it come from?

#### **F. Demographics**

Age group: 18–24 years old; 25–34 years old; 35–44 years old; 45–54 years old; 55–64 years old; 65–74 years old; 75 years or older

Background: Ecology; Economics; Engineering; Environmental Sciences; Social Sciences, Political Sciences; other

Highest academic grade: A-levels; Abitur; Bachelor; Master; Diplomstudium; Doktorat; other

Gender: F / M

## Appendix B: Interviewees' key socio-demographics for the Isar-Plan case

Variable	N = 15
<b>Age group (years)</b>	
18–24	0
25–34	1
35–44	0
45–54	4
55–64	4
65–74	5
75 or more	1
<b>Gender</b>	
Female	2
Male	13
<b>Educational background</b>	
Ecology	4
Biology	0
Economics	1
Engineering	3
Landscape planning	4
Environmental Science	0
Political sciences	1
Social sciences	0
Other	2
<b>Highest degree</b>	
Elementary school	0
A-levels	1
Undergraduate university degree	2
Postgraduate university degree	6
Doctorate degree	6
<b>Interview method</b>	
Phone	8
Face-to-face	5
Written	2

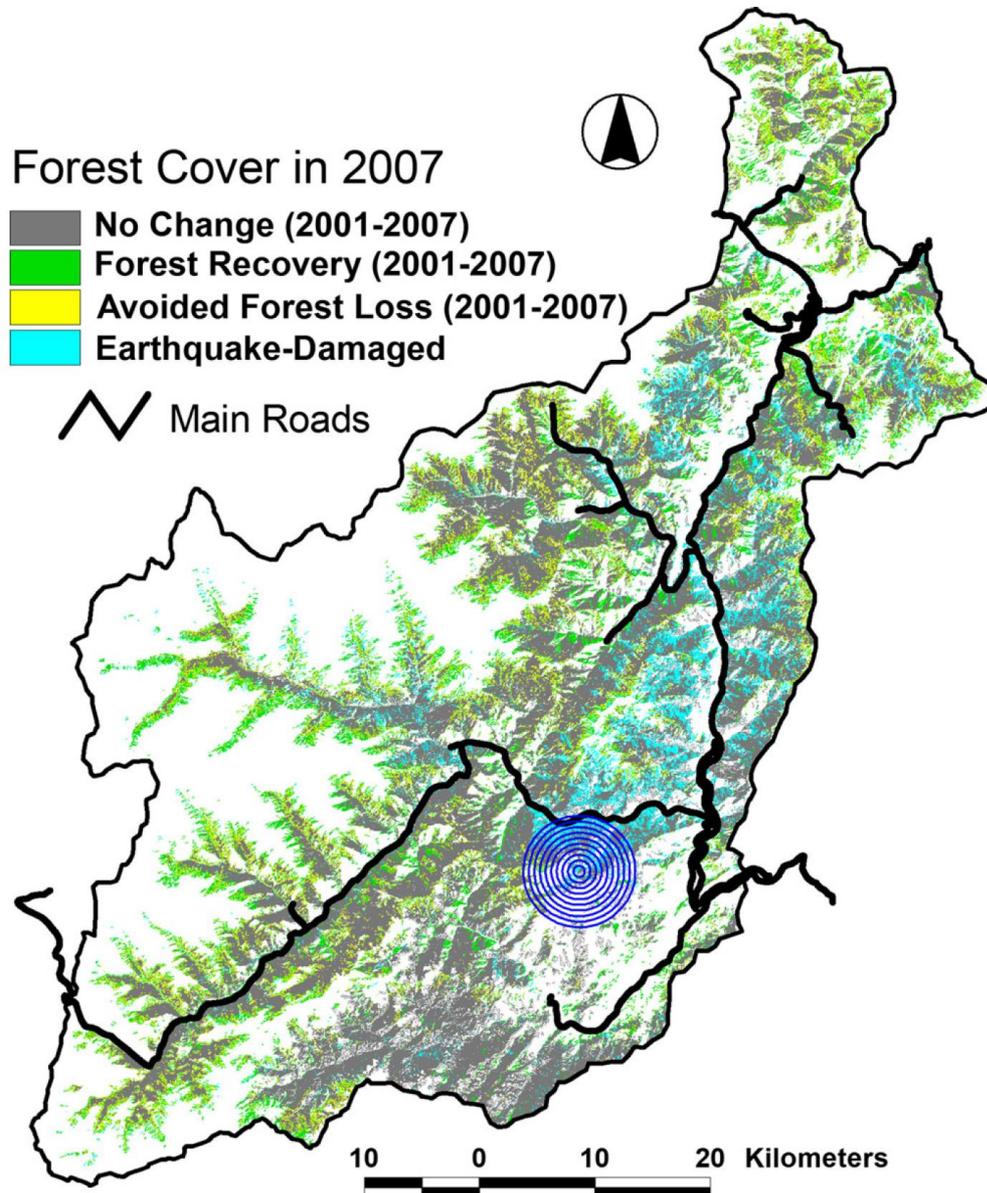
## Appendix C: Wolong interviewees during the 2019 field study

ID	Interviewee with their role in the early 2000s	Gender	Current Age
1	Wolong Nature Reserve Administrative Bureau Deputy Director	Male	60-65
2	Department of Natural Resources Management official 1	Male	55-60
3	Department of Natural Resources Management official 2	Male	45-50
4	Department of Economic Development official	Male	55-60
5	Department of Social Development official	Female	45-50
6	Administrative Office official	Male	45-50
7	Wolong township local resident 1	Female	55-60
8	Wolong township local resident 2	Male	35-40
9	Researcher 1 (WNR CCRCGP)	Male	55-60
10	Researcher 2 (Chinese university)	Female	55-60
11	Researcher 3 (International university)	Male	45-50

## Appendix D: Some major natural disasters in Wolong Nature Reserve in the past 200 years (incomplete records collated from various secondary sources)

Hazard type	Time	Impacts
Flood (torrent) / landslides/mudslide	1812	More than 60 died in Gengda township, center of Wolong township completely washed out, severe losses of houses and croplands
Debris flow	1951	2 people died, loss of cropland
Flood (torrent) /mudslide	1964/7	78 died, road blocked for 48 days, extensive cropland (>150 ha) losses and damages
Hailstorm	1973	Damage of 8 ha of cropland
Earthquake (Mw 4.9)	1976/2/15	“somewhat damaging”
Flood (torrent) / mudslide	1981/7-8	Extensive losses and damages of cropland (~10 ha), nurseries, houses, and roads (8 km)
Flood	1982	Road blocked, and cropland (>20 ha) losses and damages in Gengda township
Flood	1988/7	Road blocked for >10 days
Rockslide	1989	River blocked
Flood (torrent) / mudslide	1990/7-8	Relocation of one hamlet and deaths of 8, road blocked for 15 days
Mudslide	1990/9	Six died
Flood and mudslide	1992/7/24-28	Losses and damages of cropland (>10 ha), livestock, and road blocked.
Earthquake (Mw 8.0)	2008/5/12	Road blocked for 6 months, >150 died, 5% forest lost, devastating losses and damages to houses and croplands
Series of torrent flood, landslide and mudslide	2009-2016 summers	Extensive damages to newly re-constructed roads, cropland, houses, and other local infrastructures
Debris flow	2019/08/20	12 died, road blocked for more than a week

## Appendix E: Forest change in WNR between 2001 and 2007 and earthquake-induced damages in 2008 (from Vina et al., 2011)



## Appendix F: Selected photo of a recent disaster in Wolong



*Aftermath of a recent debris flow in Gengda township of WNR in Aug. 2019, 12 died and a number of houses were swept away (Photo Credit, Meng Ming)*

## Appendix G: Interviewee list of the Nocera Inferiore case

The majority of interviewees agreed only for their organization (and not their identity) to be cited to guarantee anonymity of the interviews. For this reason only the organization of belonging is reported here below.

- Interviewee 1: Municipal technical office
- Interviewee 2: River Basin Authority, Autorità di Bacino Distrettuale Appennino Settentrionale
- Interviewee 3: Regional Coastal Ecosystem & Water Cycle Management Authority
- Interviewee 4: International Center on Environmental Monitoring
- Interviewee 5: University of Salerno
- Interviewee 6: Municipal Civil Protection
- Interviewee 7: Municipal Urban Planning Office
- Interviewee 8: Regional Sustainable Education and Citizen Participation Office
- Interviewee 9: Regional Environmental Agency
- Interviewee 10: National Civil Protection
- Interviewee 11: Environmental NGO (Montagna Amica)
- Interviewee 12: Environmental NGO (Leonia) and municipal council
- Interviewee 13: Civil society, resident in landslide risk area/participant in the process
- Interviewee 14: Victims' committee
- Interviewee 15: Italian Environment Ministry
- Interviewee 16: Regional Agency
- Interviewee 17: Participatory process scientific advisor
- Interviewee 18: Emergency Commissioner
- Interviewee 19: Civil society, farmer living on the Mount Albino slope/ participant in the process
- Interviewee 20: Centre for GeoTechnologies, University of Siena
- Interviewee 21: Municipal technical office

## Appendix H: Interview protocol of the Nocera Inferiore case

### Interview protocol (based on Isar case protocol)

Interviewer Name:

Interviewee Name:

Employer, Department:

Position:

### Introduction and Background

*[Interviewer briefly explains project background: PHUSICOS aims to demonstrate that NBS (also sometimes referred to as green/blue infrastructure or EbA) are sustainable and effective ways to reduce natural hazard risks compared to grey infrastructure. On the basis of several case studies, we will conduct an analysis of the major success factors of NBS implementation.]*

*Interviewer explains that s/he will take notes on the interviewee's responses. Interviewer asks interviewee if s/he agrees that the interview will be recorded to ease the note taking during the interview. This is where the interviewer is presented with the GDPR consent form. S/he is reminded that recording can be interrupted at any point, and that answers will be treated anonymously.]*

*Interviewer explains that the interview will last maximum 1h.*

- 1. Please briefly describe your role in your organization/work place? [This question serves as an icebreaker]*
- 2. When and how were you involved with the Nocera Inferiore landslide risk mitigation plan?*

### B. Enablers

- 3. What is the problem concerning landslide risk in Nocera Inferiore?*
- 4. What have been the other proposed solutions and their advocates? [For the purposes of this discussion, we would welcome information on potential challenges that existed as well as conflicts which might show the different narratives. Were there any conflicts?]*
- 5. In your opinion, what was the one of the most important enablers in implementing the NBS in Nocera Inferiore? [Examples of types drivers can be given to help the interviewee: political, ecological, financial, sociological, risk management, etc.]*
- 5. In your opinion, what was the one of the most important factors in the participatory process conducted in Nocera Inferiore ?*
- 6. What do you think is the main achievement of the NBS? [An additional question might be asked: Do you think it was worth the money?]*
- 7. On the flipside, what do you think its biggest shortcoming is? In hindsight, what would you do differently?*

### C. Stakeholders

- 8. How were stakeholders involved in the decision-making process? [Information for interviewer: What we would like to know here is if there was any co-design of NBS—did it go beyond being listened to, whether the process was satisfactory or could have been improved]*
- 9. Who were the strongest advocates? Was there a champion? Who opposed the NBS?*

**10.** (if appropriate) Regarding landslide risk mitigation in Nocera, where did your organization get its information from when needed? *[Information for interviewee: For the purposes of this discussion, we would welcome information on who the interviewee trusted for information and who were strong stakeholder groups. A sheet will be sent prior to the interview to the interviewee so s/he can familiarize him/herself with it. The exercise will help produce a simple network analysis.]*

#### **D. Barriers**

**11.** What are the main barrier to NBS initiation, planning, and implementation?

**12.** In your opinion, can Nocera be used as a model of good practice in Italy?

**13.** What role did authorities at different levels (municipal, regional, national) play?

#### **E. Concluding the interview**

**14.** Would you be happy to be contacted by us if we needed any further information or clarification? *[Interviewer specifies that, for example, we might get in touch if we were unsure we wrote something down correctly. This is to reassure the interviewee that we do not want to take up too much of their time].*

**15.** Is there any other person that you think would be useful for us to contact in the context of our research?

*[Interviewer thanks interviewee for his/her time and insights that were shared. Ask if s/he wants to be informed about the report once it is published – end of 2019.]*

#### **E. Additional questions (time permitting)**

**16.** Were ecosystem services a concept you came across during your work? If you know it, do you think it is a useful concept?

**17.** Was there funding for maintenance and monitoring of the project? Where does it come from?

#### **F. Demographics**

Age group: 18-24 years old; 25-34 years old; 35-44 years old; 45-54 years old; 55-64 years old; 65-74 years old; 75 years or older

Background: Ecology; Economics; Engineering; Environmental Sciences; Social sciences, Political Sciences; other

Highest academic grade

Gender: F/M



H2020 Project PHUSICOS  
Grant Agreement No. 776681

The implemented nature-based solutions were accompanied by co-benefits reaching beyond disaster risk reduction that added significantly to their rationale, appeal, and eventual adoption. A major insight from the case studies is thus the importance of merging 'co-benefit' agendas. At the global scale, the co-benefits can contribute to major transformative agendas, including: disaster risk reduction as agreed in the 2015 Sendai Framework; climate adaptation as agreed in the 2016 Paris Agreement; biodiversity as set out in the European Biodiversity Strategy; and sustainable development as agreed in the 2015 UN Sustainable Development Goals. From this global perspective, the transition from grey solutions to nature-based solutions is in many instances not only cost-effective and viable, but also necessary and urgent.

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IIASA Policy Briefs report on research carried out at IIASA and have received only limited review. Views or opinions expressed herein do not necessarily represent those of the institute, its National Member Organizations, or other organizations supporting the work.



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**There is growing recognition that using the properties of nature can help provide viable and cost-effective solutions to a broad range of societal challenges, including disaster risk reduction.**

## Governance innovation through nature-based solutions

- New research looked at the governance factors that contribute to the success of nature-based solutions beyond their cost-effectiveness and technical viability.
- Researchers identified the key governance enablers and (co)benefits of nature-based solution success stories based on three case studies: Nocera Inferiore (Italy), Munich (Germany), and Wolong (China). The most critical enablers involve governance innovation in three areas:
  - *Polycentric governance*: Novel arrangements emerged in the public administration that involved organizations to include not only flood and landslide protection, but also nature conservation, urban planning, water quality, waste management, tourism, recreation, and many more administrative responsibilities.
  - *Participatory co-design*: Novel stakeholder participatory processes influenced the eventual shape of the nature-based solution. Despite the absence of formal procedures for involving civil society, businesses, and other stakeholders in the process, stakeholder engagement was a central and innovative feature of each case.
  - *Financial incentives*: In the Wolong case, local authorities designed and implemented novel incentives for households in consultation with villagers to monitor illegal logging in a nature reserve.
- A further enabler was strong advocacy groups both in and outside government, along with their individual champions. This was coupled with a major triggering event that opened a window to advocate for a nature-based or hybrid green-blue-grey solution.
- The cases provide evidence of the prominence and in some instances the inevitability of hybrid nature-based solutions. Governance involves finding compromises that can resolve the interest and value conflicts underlying the green-grey divide.
- A major insight from the case studies is the importance of merging co-benefit agendas, which at the global scale can contribute to critical transformative missions, such as the Sendai Framework or the Paris Agreement.

## Looking to nature for solutions

There is growing recognition that using nature's own attributes can help provide viable and cost-effective solutions to a broad range of societal and environmental challenges. The European Commission defines nature-based solutions as "actions that are inspired by, supported by, or copied from nature".

Nature-based solutions have emerged as promising strategies for reducing flood, landslide, extreme heat, and other disaster risks. They also aim to provide society with multiple co-benefits, such as ecological resilience, economic growth, and health. Nature-based solutions is an umbrella term that covers a variety of ecosystem-related approaches, such as ecosystem-based adaptation and green infrastructure, to deliver a wide range of ecosystem services. They are increasingly adopted as complements or alternatives to traditional "hard" or "grey" infrastructure solutions that exclusively involve man made structural features.

The PHUSICOS ("According to nature" in Greek) Project, funded by the European Union Horizon 2020 Program, demonstrates how nature-based solutions provide robust, sustainable, and cost-effective measures for reducing the risk of extreme weather events in, or emanating from rural mountain landscapes.

## Nature-based solution success stories

Researchers at IIASA and the University of Geneva described and compared the institutional, legal, social, and economic factors—that is, governance frameworks—for initiating, planning, designing, and implementing nature-based solutions in three successful cases as solutions to climate risks in mountain landscapes:

- i) Landslide risk in Nocera Inferiore, Italy
- ii) Flood risk on the Isar River in Munich, Germany; and
- iii) Flood and landslide risk in Wolong National Nature Reserve, China.



The three selected case studies (Sources: Pin by Yo! Baba from the Noun Project; Illustration 107207656 © Miceking—Dreamstime.com, Design by: Juliette Martin)

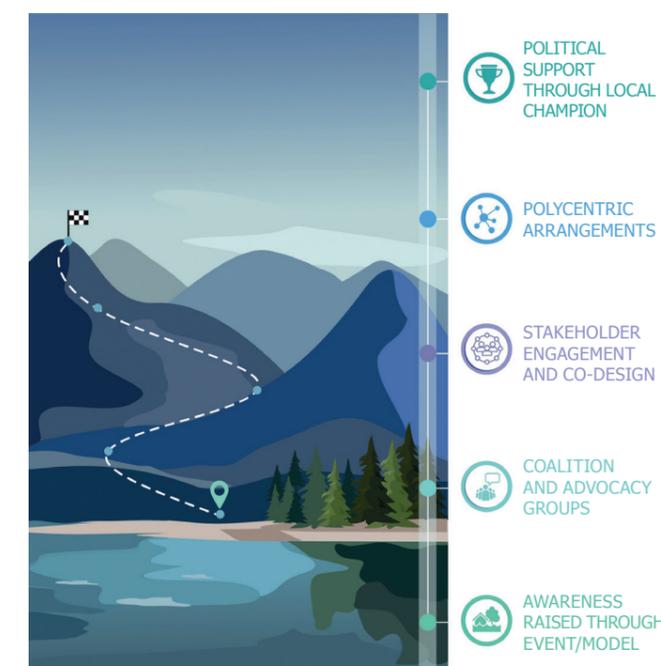
## Governance innovation for enabling nature-based solutions

Understanding the factors that characterized successful nature-based solution governance models is essential for advancing policy instruments and institutional reform that can better enable the implementation and up-scaling of these solutions. The results showed that the most critical nature-based solution enablers involved governance innovation in three areas:

- **Polycentric governance:** In all cases, novel arrangements emerged in the public administration that involved multiple institutional scales and/or sectors to include not only flood and landslide protection, but also nature conservation, urban planning, water quality, waste management, tourism, recreation, and many more administrative responsibilities. In the Isar-Plan case, as one example, the regional and municipal water authorities collaborated to advocate a far broader vision for the Isar than their customary focus on grey infrastructure for flood protection. This collaboration was initiated by ecologically committed staff members who formed a multi-scale and cross-sectoral work group, which broke down the silos of water and urban planning and was unprecedented for projects of this magnitude.
- **Participatory co-design:** All three case studies involved novel stakeholder participatory processes that co-determined the eventual shape of the nature-based solution implemented. In Italy, the process was particularly exemplary in that it coupled stakeholders and experts in an unprecedented co-design of a nature-based solution for landslide risk mitigation and fostered the consequent adoption of the solution.
- **Financial incentives:** In the Wolong case, local authorities designed and implemented novel incentives for households in consultation with villagers for community-based monitoring of illegal logging in a nature reserve. The unique system complemented the traditional 'sticks' approach for sanctioning illegal logging with 'carrots' in the form of payments to household groups who were successful in preventing logging in their assigned forest areas.

Further enablers for realizing nature-based solutions, as demonstrated in the three cases, include strong pressure (advocacy) groups, both in the administrative bodies (all cases) and outside the government (Germany and Italy), along with their individual champions. In addition, all cases included a major triggering event – a flood/landslide event (China and Italy) or a model that simulated a major event (Germany) – which opened a window for already existing environmental groups or supportive state authorities to advocate for a nature-based solution.

The cases provide evidence that nature-based solutions are often viable only if they "piggy-back" on grey solutions. For example, in the case of the Isar-Plan, the compromise was a hybrid solution that partially piggybacked the restoration of the river onto concealed grey flood protection measures.



The main governance enablers of nature-based solutions in Wolong, Munich, and Nocera Inferiore (Sources: Illustration 123136911 © Medvedeva Irina - Dreamstime.com, Participation by Vectors Market, Network by Anna Sophie, Flood by Hea Poh Lin, from the Noun Project, Design by: Juliette Martin)