OPERANDUM

OPEn-air laboRAtories for Nature baseD solUtions to Manage hydro-meteo risks

CONCEPTUAL FRAMEWORK/PROTOCOLS FOR CO-DESIGN AND CO-DEVELOPMENT

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Short Description
The Deliverable presents the conceptual and theoretical foundations of the Living Lab approach in a wider framework of transdisciplinary collaborative research. It gives guidelines and practical tools for OALs to carry out co-design and co-development as well as experiences of using these tools. It also describes the co-creation processes until now as well as the final plans for the NBS of each of the OAL.

Dissemination level		
PU	**Public**	**X**
CO	Confidential, only for Members of the Consortium, including the EU Commission Services	

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List of Acronyms and Abbreviations

CA: Consortium Agreement

CO: Confidential

DoA: Description of Action, referring to the Annex I of the Grant agreement

DRR: Disaster Risk Reduction

EC: European Commission

EO: Earth Observation

EP: Exploitation Plan

GA: Grant Agreement

IM: Innovation Manager

IP: Intellectual Property

IPR: Intellectual Property Rights

KER: Key Exploitable Result

LCA: Life Cycle Analysis

MCDA: Multi-Criteria Decision Analysis

NBS: Nature Based Solutions

OAL: Open Air Laboratory

PU: Public

SDGs: Sustainable Development Goals

TRL: Technology Readiness Level

QA: Quality Assurance

WP: Work Package

IPR: Intellectual Property Rights

Executive summary

At the core of OPERANDUM there is the concept of co-creation and co-development. Despite the concept has been widely used a tailored approach which incorporates previous findings and integrate the new ones being originally developed in OPERANDUM is needed. It is recalled that co-creation and co-development are performed using the Open Air Laboratories (OALs) as reference points. Therefore, the ten OALs in OPERANDUM provide the framework to co-create NBS and demonstrate their effectiveness in reducing hydro-meteorological risks while promoting learning and capacity building to enhance perceptions shifts towards solutions with both social and ecological co-benefits. The OALs can be considered as an extension of Living Labs typically used for urban applications and in this respect, refer broadly to a systematic user-driven co-creation approach integrating research and innovation processes. This is achieved through exploring, experiencing and assessing innovative ideas, scenarios, concepts and related technological artefacts in real life use cases. Co-creation has become a relatively common practice in solution oriented and transdisciplinary research projects including those focusing on NBS. There is a rapidly growing body of literature on co-creation in research and innovations across sectors and disciplines including the NBSs. In most cases the NBS are co-created in the urban context. Terminology is varied, so are the contexts, approaches, methods, practices and researchers' experience in participatory methods. There is no 'one size fits all' approach, but the processes need to be tailored and adjusted according to the context, aim and resources available.

This document extend the knowledge base build in previous two deliverables on *mapping and characterisation of existing NBS globally (D1.1)* and *critical evaluation of risks and their potential NBS for OPERANDUM OALs (D1.2)*, to present a conceptual framework to provide theoretical grounds and practical tools understanding for co-creating NBS primarily in rural and natural territorial context. We **review and summarize the key aspects of literature on transdisciplinary collaborative research** and describe the **diversity of the social-ecological and research contexts** of OALs to valorise the need of designing a process which suits the best for the given context. We introduce a **joint frame for the co-creation process** including four phases: co-design, co-development, co-deployment and monitoring. The joint framework is to clarify the idea of "co-working" throughout the process, rather than giving a strict procedure to follow. **A selected set of methods** are introduced for each phase to inspire and support the OALs in their work. The document describes the transdisciplinary collaborative research as a learning process not only in the OPERANDUM project and between the OALs, but also more broadly in the scientific community and society from which **collected and documented lessons learned** of these processes are illustrated.

There are several elements of novelty which define the overall methodology adopted OPERANDUM for co-design and co-development. First, it introduces and tests a co-creation framework applicable to rural and natural territory contexts by emphasizing the differences with respect to the urban counterpart. Secondly, the co-creation process is placed in a wider framework of collaborative transdisciplinary research. This is because it is argued that application of the co-creation framework requires a broader understanding of the transdisciplinary practice including the socio-cultural aspects, roles of researchers and power relations. Third, it includes a set of tools to be used in the co-creation including a monitoring of engagement to be applied in the rural and natural contexts. Finally, it also presents how these tools have been applied in different contexts to show,

how these processes occur in the real life, what the lessons learned and possible gaps are in the theory and practice of co-creation.

The work so far has revealed that the co-creation processes have been designed and evolved in OALs along different pathways, reflecting the social and ecological conditions of the respective OAL, which is important in order to come up with ecologically sound and socially acceptable solutions and enhancing the overall change from grey to green solutions. Although various novel methods and tools are available for co-creation, the OALs have found most useful the conventional methods in particular field trips, focus group discussions, Multi Criteria Decision Making analysis. Citizen science was planned for co-monitoring the environmental conditions within the OALs. This selection of methodological tool indicates that there are some barriers to adopt new tools in co-creation, which means that in the future even more attention should be focused on qualitative (social and cultural aspects) training and facilitation when co-creation is used as an approach. The OALs have faced the similar challenges typical for transdisciplinary Living Lab –type of projects, such as stakeholder fatigue, raising interest, building trust, yet there are differences in this respect between the OALs. There are some specific challenges that are reflected specifically in the rural and natural territory compared to the urban NBS: (private) landownership, the scale of the NBS, invisibility of the solution and impacts that may constrain the co-creation processes pointing out the importance of the modelling.

The results, conceptual framework and the methodological tools as well as the final plans, of this Deliverable are being exploited by WP2 *Co-design and co-development of innovative NBS* to further develop the procedures as well as by WP3 *Operationalization of NBS* including the development and implementation of NBS. The lessons learnt on co-creating NBSs in a natural and rural territory will be used by WP8 to enhance *International co-operation and capacity building* and *WP9 Maximizing outreach and impacts* to communicate them for wider non-academic audiences. The state of art and lessons learnt during the co-creation process in D1.1, D1.2 and D1.3 were converted into three scientific papers and published in top-ranked journals (Debele et al., 2019; Sahani et al., 2019; Kumar et al., 2020), which will support the wider dissemination of NBS among science, policy and practice. The final scientific paper which is under preparation by Soini et al. (2020) will present more comprehensive analysis of lessons learned throughout the WP1 life cycle (M1-M24). Furthermore, the lessons learnt will be continuously updated in the virtual story maps of the each OAL.

1 Introduction

The Open Air Laboratories (OALs) of the OPERANDUM project can be considered as a type of Living Labs, which refer broadly to a systematic user-driven co-creation approach integrating research and innovation processes through exploring, experiencing and assessing innovative ideas, scenarios, concepts and related technological artefacts in real life use cases. OPERANDUM project has eleven OALs in nine countries for co-creating NBSs dealing with hydro-meteorological risks. Co-creation has become a relatively common practice in solution oriented and transdisciplinary research projects in the field of environmental management and planning. There is a rapidly growing body of literature on co-creation in research and innovations across sectors and disciplines including the NBSs, in particular, in the urban context. Terminology is not homogeneous, so are the contexts, approaches, methods, practices and researchers' experience in participatory methods. There is no 'one size fits all' -solutions, but the processes need to be tailored and adjusted according to the aim, context and resources available. In OPERANDUM, co-creation processes deal with designing and operationalising NBSs in OALSs utilising participatory processes including researchers, public/citizen and stakeholders.

1.1 Objectives

The main goals of Task 1.3 of WP1 of OPERANDUM project were 1) to develop a conceptual framework with a set of protocols for co-designing and co-developing the NBS in each of the OALs taking into account the general challenges related to the use of transdisciplinary research practices when developing NBS and; 2) to provide the project partners with sufficient skills to conduct high-quality co-creation processes (OPERANDUM GA). This co-creation work was carried out by identifying the critical points and success factors in designing and operationalising NBS in OALs; elaborating and reflecting the results of the systematic literature review (D 1.2.); co-designing plans and protocols in joint workshops and training sessions and; finalising the co-design plans and protocols for OALS for the proposes of the WP3.

1.2 Methodology

The NBS co-creation process started at the beginning of the OPERANDUM project by mapping the state of the art of the OALs including the basic information of the OALs, the composition of the research teams and the stakeholders, the work done in the OALs before OPERANDUM, and opportunities and possible challenges for co-designing and co-creating the NBS and stakeholder collaboration (see Fig. 1, Chapter 3.1). Acknowledging the differences between the OALs, we reviewed the existing literature on procedures and methods that could be applicable for the work of individual OALs. In parallel, the general conceptual frames to carry out the work were created. We agreed to call the whole process as co-creation including phases of co-design, co-development, co-deployment and monitoring. Various methods and tools for working with the stakeholders were collected in an online document called 'Guidelines for co-creation' (for internal use). OAL leaders and social scientists planned the processes and were trained to use various methods. Common issues, experiences and problems related to stakeholder engagement and co-creation were shared and solutions were jointly discussed in workshops and bilateral meetings. In the second year of the

project, the experiences and lessons learnt were collected and the online document was completed with the "showcases" of the activities carried out in the OALs.

1.3 Connection with other Tasks

The activities of Task 1.3. were carried out and documented in close collaboration with Task 1.1.5 *Mapping of primary and secondary stakeholders* by jointly planning the procedures for stakeholder mapping (Chapter 3.1.1) and Task 1.2 *Critical evaluation of risks and opportunities for OPERANDUM OALs* (Chapter 2.1.1). Task 8.1. *Involvement of Stakeholders* explored and defined the basic values and goals for the stakeholder engagement and monitoring. This work has further been developed by Task 1. by co-designing indicators for the stakeholder engagement. WP 3.2 *Co-design of NBS in the OALs* analysed the co-creation processes conducted by the OALs and the use of different methods focusing on the barriers and success factors related to different methods (Chapter 6.1). These results served to gain a complete overview of the co-creation process. In addition to the online meetings, three workshops organised with other WP leading partners supported the work.

- *Towards common approaches in co-design/co-development, modelling and monitoring,* Helsinki, February 4-6, 2019 (together with WP8 and WP5 leading partners).
- *Tailoring OPERANDUM's stakeholders engagement strategy and related indicators (together with WP 8),* Paris, February 25-27, 2019 (together with WP8 leading partners)
- *Soft tools and monitoring* with WP2, Milan, October 17-18, 2019 (with WP2 leading partners)

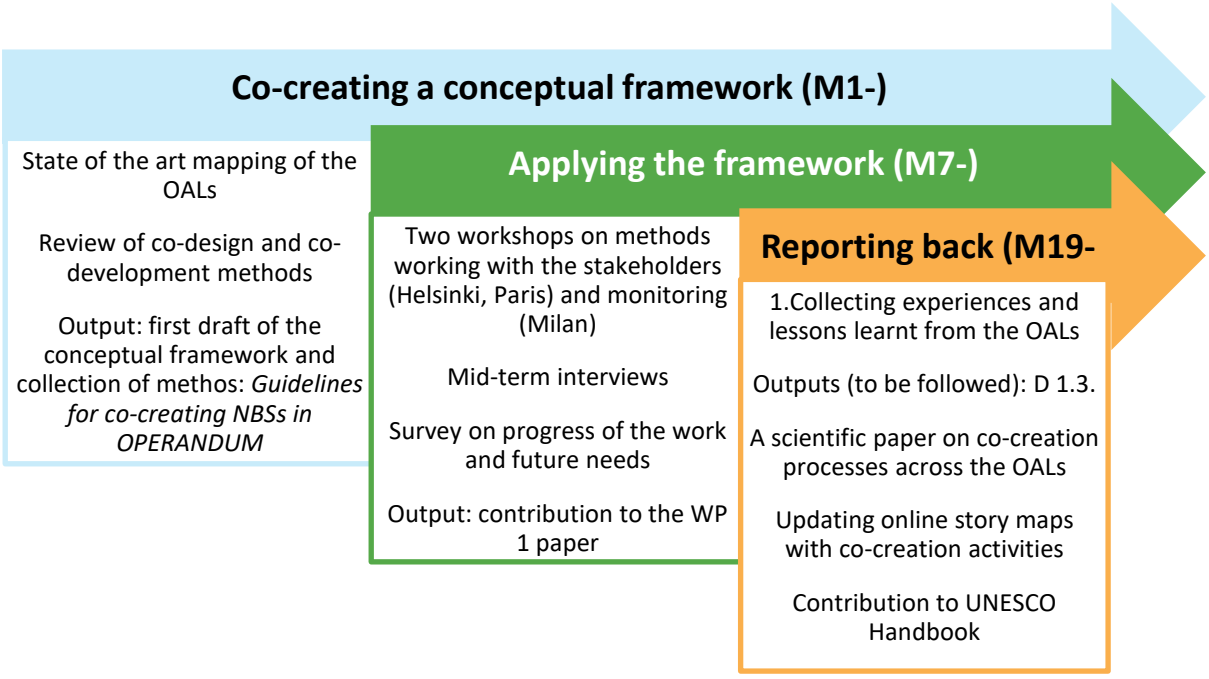


Figure 1: Activities and outputs in Task 1.3.

1.4 Content and structure of the document

On one hand this document aims to support the work of the OALs by gathering together relevant knowledge regarding transdisciplinary collaborative research and some methodological aspects. On the other hand, it presents and illustrates experiences of co-creation processes in the OALs

constituting a basis for joint learning within and beyond OPERANDUM. In this way, the work of Task 1.3 itself can be seen as a co-creation activity. The Deliverable is composed of three parts including nine Chapters. **Part I** presents the theoretical frame and contextual setting. Chapter 1 describes the overall philosophy and may characteristics of transdisciplinary research and co-creation, as well as general success factors and barriers that may be relevant in the context of NBSs. Chapter 2 introduces the contexts of the seven OALs and a joint framework for co-creation. **Part II** gives the methodological guidelines. Chapters 3-4 introduce methods and tools that can be used in each phase of the co-creation. The showcases illustrate, how these methods have been applied by the OALs as well as lessons learnt of using them. Chapter 5 describes the general framework for monitoring the stakeholder processes and presents the indicators that were developed by the OALs. Chapter 6 discusses the tools and methods that can be used to handle the challenges and conflicts in the process. **Part III** presents co-creation processes and the final plans (Chapter 8) of the each of the OAL, and then summarize the key findings so far in Conclusions (Chapter 9).

PART I

THEORETICAL FRAME AND CONTEXTUAL SETTING

2 Theoretical concepts related to transdisciplinary research and co-creation

2.1 Co-creating Nature-Based Solutions in Open-Air Laboratories

OPERANDUM is designed to address the common hydro-meteorological risks that negatively affect rural and natural territories. Seven OPERANDUM project sites located in Europe and three outside of European territories (two in China and one in Australia) are mostly affected by single, inter-related or multiple hydro-meteorological hazards depending on their geographical, topographic and climatic conditions. OPERANDUM project intends to respond to these challenges by the deployment of NBS in these ten selected OALs.

OALs are applications of the Living Labs, which are commonly used in transdisciplinary collaborative research. Living Labs as a research method or approach was originally introduced and used in the sphere of information and communication technology but can now be found in many contexts where laymen or users participate in an innovation process (Hossain et al., 2019; Zavratnik et al., 2019). Living Labs can be considered as a methodology, approach or an experimentation platform, where researchers closely interact with practitioners. The literature on Living Labs is widely covering different disciplines and contexts. In OPERANDUM, we follow the definition given by Westerlund et al. (2019) Living Lab as "a sociotechnical platform with shared resources, a collaboration framework, and real-life context, which organizes its stakeholders into an innovation ecosystem that relies on representative governance, open standards, and diverse activities and methods to gather, create, communicate, and deliver new knowledge, validated solutions, professional development and social impact" (pp. 56–57).

An important ingredient common to Living Labs is the paradigm of *co-creation,* referring broadly as any process in which different parties come together to create a mutually beneficial outcome" (Zamenopoulos and Alexiou, 2018). In research, co-creation can be traced to Latour (1983) whereby evidence results from the scientist and the investigated phenomenon co-constructing each other. The concept is also used in the business as "value co-creation" is a way of sharing, combining, and renewal of resources and capabilities among the organizations and their active customers to create value through new forms of interaction, service, and learning mechanisms (Zwass, 2014). In design research and practice, co-creation often refers to the collaboration between experts and non-experts (users) who bring their creativity together to develop a solution (Voorberg et al., 2014). The local contexts, values and economies to develop products or services are taken into consideration to make the solutions most valuable in certain social and cultural environments. In sustainability research, co-creation is getting more and more attention. In that context co-creation is often seen as a wholly collaborative process aiming for improving outcomes for groups of individuals or communities, from start to the end referring to the 'total process', positioned somewhere near the upper end of this notional spectrum, encompassing knowledge production, problem specification, needs analysis, service design and planning, service implementation and delivery, and monitoring and impact evaluation, all undertaken as a joint enterprise between end-users and professionals and others with a stake in the outcomes (Mauser et al., 2013).

2.1.1 Living Lab and co-creation methodology used in other NBS projects

Living Lab methodology including co-creation is increasingly seen as good practice for planning and implementing NBS following also the principles of International Union for Conservation of Nature (IUCN) on acknowledging the site-specific context, local knowledge and broad participation to ensure the social benefits defined (see Cohen-Shacham et al., 2019; Alves et al., 2018; Guidance on Co-creating NBS). At present there are number of research projects going on using this approach, majority of them are focusing on developing NBSs in urban areas. Below we shortly review three projects that have developed co-creation frameworks (Table 1):

CLEVER cities -project applies co-creation approach in order to highlight the full scale of co-benefits of NBS in cities. Co-creation is developed as a whole process of participation, collaboration and interaction bringing together different expertise in order to support the development of the best solution. The process is designed in five steps Co-design, Co-implementation, Co-monitoring, Co-development and feedback loops that consider stakeholders' abilities to create and provide added value. The complete co-creation process works in conjunction with innovation towards customization of nature-based solutions for the specific urban contexts of Frontrunner cities and Follower cities (see Morello et al. 2019; Mahmoud & Morello 2018; https://clevercities.eu/).

Urban Nature (UNaLab) project has defined the concept for Urban Living Lab (ULL) and used participatory action design as a basic principle for building their framework on co-creation. The model is comprised of five stages: CoExplore, CoDesign, CoExperiment, CoImplement and CoManagement creating a path that can be followed by practitioners for NBS co-creation. The project has also introduced a toolkit with a set of methods tailored for each of the stages and provided training on co-creation for all project participants (see Chronéer et al., 2018; https://unalab.eu/home).

URBiNAT -project focuses on the regeneration and integration of deprived social housing districts. Interventions focus on the public space to co-create with citizens new urban, social and nature-based relations within and between different neighborhoods. They have defined five stages for co-design: Co-diagnostics, Co-design, Co-selection, Co-implementation and Co-monitoring.

Table 1: Co-creation frameworks of three different NBS projects.

Name of aim of the project	Context	Approach for co-creation	Co-creation stages	More information
CLEVERCities Co-designing locally tailored ecological solutions for value added, socially inclusive regeneration in cities	Frontrunner and Follower cities in Europe, South-Africa and China	Business approach as a part of Urban Living Lab	Co-design, Co-implementation, Co-monitoring, Co-development	https://clevercities.eu/the-project/; Morello et al., 2019; Mahmoud and Morello, 2018
UNaLab Developing nature-based interventions in key districts of cities for urban regeneration	Frontrunner and Follower cities in Europe, South-America and China	Life Cycle Co-Creation Process (LCCCP) for NBS building on continuous improvement cycles and Design Thinking methodologies; in Urban living labs (ULL)	CoExplore, CoDesign, CoExperiment, CoImplement, CoManagement	https://unalab.eu/; De Los Ríos - White et al., 2020 Diana Chronéer et al, 2019

URBiNAT Social cohesion and urban regeneration with NBS	Nine frontrunner and follower cities in Europe and Asia;	Based on various methods and techniiques including: motivational interviewing, design thinking; cultural mapping, culture; photovoice, walkthough, collective action	Co-diagnostics, Co-design, Co-selection, Co-implementation, Co-monitoring	https://urbinat.eu/about/

Principles for designing a co-creation framework in OPERANDUM

OPERANDUM differs from these three projects in many respects having implications for co-creation:

- **Context:** Most of the OPERANDUM OALs are located in rural and natural territories
    - Environmental context: in most cases, the NBS will be established in a natural (not built environment).
    - Political and planning context: Land for operations is often owned by private landowners, which means that the landowners need to be closely engaged and they have to be willing to collaborate. The land can be under conservation.
    - Socio-cultural context: Rural and territorial contexts are often traditional and conventional and they might have less experience in participatory planning practices. In the past, there might have been controversies between nature conservation and livelihoods.
- **Scale:** OPERANDUM NBS usually deal with large scale solutions. The operational as well as impacted areas cover typically wide land areas. Following the scale, the solutions as well as the co-benefits and impacts may be indirect, invisible and appear only in the long term. The solutions can be expensive to carry out.
- **Science/research teams:** OPERANDUM is built on truly interdisciplinary approach t is also acknowledged that there is a strong component of the hard science behind the OALs; namely the modelling. OPERANDUM research team is highly multidisciplinary Only a few OAL teams have previous experience in co-creation (natural scientists, geographers, economists, and planners).

Because of the context (environmental, political and social-cultural) and scale, we highlight the importance of *understanding of the social-ecological system*; invisibility and long term effectiveness of the solutions, we highlight a *balanced integration of scientific (in particular modelling) and practical, place-based knowledge*; because of disciplinary diversity and heterogeneity of the OAL teams, we highlight *the importance of the understanding of the theoretical principles and mutual training in stakeholder engagement and co-creation activities*. To build a common orientation and understanding for co-creation, in the following, we will have a closer look on what co-creation in the wider frame of transdisciplinary collaborative research entails: What are the concepts, underlying values, principles as well as potential benefits and challenges that can be faced in a co-creation process.

2.2 Transdisciplinary collaborative research

In response to the increasingly complex social-ecological issues society is facing, there is a growing trend to conduct environmental research in large collaborative projects, such as OPERANDUM. This approach can be described broadly as transdisciplinary research as it transcends formal disciplinary boundaries and ways of conducting research. There are different ways to define and carry out transdisciplinary research (e.g., Klein, 2001; Klein, 2013; Pohl, 2010; Lang et al., 2012; Moser, 2016). In OPERANDUM project, we focus on the type of transdisciplinary research that "acknowledges that many different perspectives and types of knowledge ranging from multiple scientific disciplines to practitioners and laymen are relevant for finding solutions. In that way, it is a new form of learning and problem solving" (Klein, 2001). Transdisciplinary research starts from tangible, real-world problems, and the solutions are devised in collaboration with multiple stakeholders (Fig. 2).

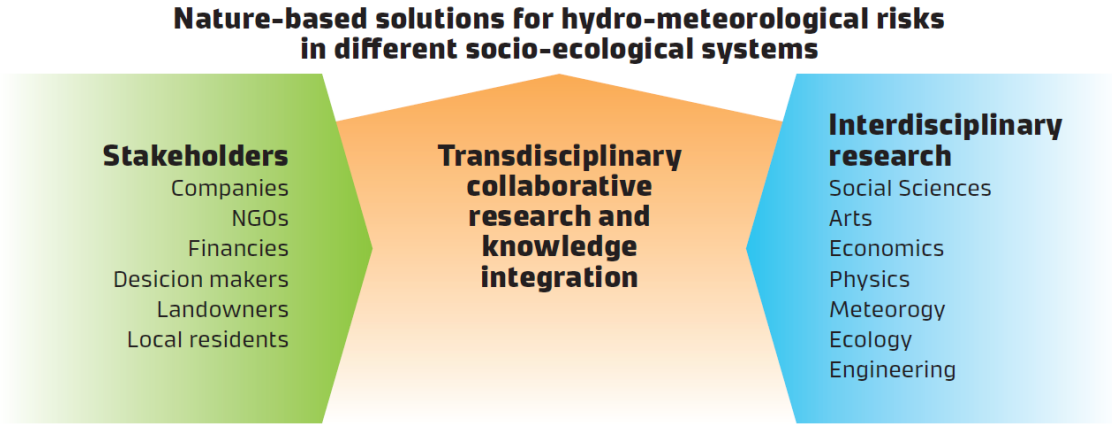


Figure 2: Transdisciplinary collaborative research for Nature-based solutions.

This kind of research may get various shapes depending on the problem, context and institutional aspects such as funding and expertise available. Given the involvement of non-academic participants in the research, it introduces special practices needed for knowledge production and governance in a collaborative manner. Various approaches and methodologies to work with different stakeholders and users of knowledge have been introduced. While participatory (action) research and planning have been practised for decades in environmental research and planning, a key characteristic of transdisciplinary research is that the domains of science, management, planning policy and practice are interactively involved throughout the process in issue framing, knowledge production and knowledge application. To achieve co-evolution of understanding, alignment of purpose and harmonized action across these domains, substantial cooperation and management effort is required (Roux et al., 2010) as well as understanding and respect of the equality of the participants (Moser, 2016). In practice, this means a strategic approach related to the collaboration requiring sufficient resources, skills, time and funds needed for carrying out the process successfully.

As a result of the transdisciplinary movement in environmental and more broadly in sustainability research, various "co-concepts" besides co-creation (Chapter 2.1) have been introduced such as co-production, co-development, co-deployment, co-research and co-management (Spinuzzi, 2005; Pohl and Hirsch Hadron, 2008; Lang et al., 2012; Moser, 2016; Hakkarainen et al., 2020). These concepts have roots in different disciplines and research traditions, and therefore they may get diverse meanings depending on the context used (Voorberg et al., 2014; Hakkarainen et al., 2020). Yet,

basically, they combine elements of generative or exploratory research with developmental design and practices and together are shifting from pretty broad and vague forms of collaboration and coordination towards more planned and conscious forms of working together. Below we briefly introduce the main concepts in this field to elaborate the conceptual framework of the OPERANDUM.

The roots of *co-design* can be traced back to different movements, community design, socio-technical design, co-creative design and social design (Zamenopoulos and Alexiou, 2018). Design is a task in which people seek to understand, interpret and ultimately address a challenge or opportunity in their present reality by conceptually developing and creating things, whether physical products, services, infrastructures, policies etc. (Moser, 2016). *Co-design* means that people come together to conceptually develop and create something that responds to certain matters of concern and create a (better) future reality. Co-design of infrastructures, products and services can be problem-driven/solution-oriented or aimed based on social innovation. Co-designing policy processes range from simulation of decisions or visions through stakeholder engagement, to uncover local priorities, to develop planning and management processes (Hakkarainen et al., 2020). In the context of transdisciplinary knowledge creation, co-design often precedes the steps of co-production and co-dissemination (Mauser et al., 2013; Moser, 2016). It's thus about setting joint research agendas, research questions and planning project implementation.

Co-production is also a widely used concept. Two main scopes of the concepts can be discerned (Jasanoff, 2010; Norström, et al. 2020; Jagannathan, 2020): One scope strives for the generation of actionable knowledge that includes the experience and perspectives of non-researchers who may, in turn, utilize this knowledge to make decisions. This approach is more practical and tangible. The other one is emerging from Science and Technology studies seeking out the transformation of norms and structures within science and society. In that way, the latter scope is broader aiming for opening up decision-making spaces in the society, reshaping the science-public-policy interface being also more ambitious. In OPERANDUM we are more interested in the first mode of the co-production, i.e. co-production of knowledge, which can further be divided into two subcategories (Hakkarainen et al. 2020): *The outcome-oriented co-production* refers to a transdisciplinary working method to integrate different types of knowledge leading to normative evaluations about validity of knowledge and what kind of knowledge is needed are still based on science as a measuring stick (Marshall et al., 2016). *The empowering and transformative co-production* aims to create a change of societal and power orders (Brattland and Mustonen, 2018). Both types acknowledge equal partners or co-researchers rather than stakeholders or end-users of knowledge (Tengö et al., 2014).

Co-development has been originally used in the context of development studies referring to find locally adapted solutions, for example, to the migration problems. It can be understood also as co-design (see above), working together for understanding, interpreting and ultimately addressing a challenge or opportunity in their present reality by conceptually developing and creating things, where physical products, services, infrastructures, policies etc. *Co-deployment* means that the process of deployment ('to put the solutions in use') could also be done jointly with the stakeholders, for example, to manage the reception and eventual acceptance of new technology in a particular environment.

Co-research emphasizes the exploratory research that is jointly conducted with the participants, co-researchers, and is often associated with the co-design (Spinuzzi, 2005). Currently, it could also be called citizen *science*; involvement of citizens to various extent to research (see also Chapter 4.1). The aims and purposes of co-research or citizen science may get many forms ranging from collaborative science where the participants contribute to the design of the research to the data collection and analysis to crowdsourcing where the participants collect data as a kind of sensor (typically environmental monitoring, accounting plant or animals etc.). In the past years, citizen science has made promising progress at the science-society-policy interface (Hecker et al., 2018). This arises from wider societal forces to improve the transparency and accessibility of science, which in the EU is referred as "Responsible Research and Innovation" a process of aligning research and innovation to the values, needs and expectations of society. On the other hand, developments like the expansion of connectedness and low-cost sensor technologies have made it relatively easy to collect volunteer observations in mass.

2.3 Key characteristics and benefits of transdisciplinary research

In order to better understand transdisciplinary collaborative research, we provide a list of its key characteristics compiled from several sources (e.g. Pohl and Hirsch Hadron, 2008; Moser, 2016; Durham et al., 2016; Norström et al., 2020; Fazey et al., 2018; NSW Council of Social Service 2017):

Place-based: It is based on understanding how a challenge emerged, how it is affected by its particular social, economic and ecological contexts and the different beliefs and needs of those affected by it.

Creative, iterative and recursive process: It is not an event, but rather a process, where ideas and solutions are initiated, developed and continually tested and evaluated by the participants. This implies that the process has to be shaped in such a way that concepts and methods can be repeatedly tested (iteration), and that underlying assumption can be modified if they are found to be inadequate (recursiveness). Changes and adaptations are a natural part of the process, trialling possibilities and insights as they emerge, taking risks and allowing for failure.

Outcomes focused: It can be used to create, redesign or evaluate services, systems and products. It aims to achieve an outcome or a series of outcomes, where the potential solutions can be rapidly tested, effectiveness measured and the spreading (or scaling) of these solutions can be co-developed with stakeholders and in the specific context.

Oriented towards change: It requires a commitment to creating change. This means changes in the mindsets and behaviour of the participants, encouraging and supporting innovative processes and solutions, which may require going beyond one's comfort zone.

Participative: The outcomes exceed by virtue of the group process, what could have been achieved by an individual member working alone. The process includes representatives from all relevant stakeholder groups, with lived or work experience, including the "critical ones", as well as the knowledge, experience and skills of experts in the field. The ideal attributes of participants, in a successful co-process, are often characterized by open-mindedness, curiosity, self-awareness, tolerance of ambiguity, willingness to suspend bias or prejudice, ability to build effective interpersonal relationships. All participants are responsible for the effectiveness of the process.

Inclusive and respectful: The process itself is open, empathetic and responsive. It uses a series of conversations and activities, dialogues and engagements to generate new, shared meanings based on expert knowledge and lived experience. Major themes can be extracted and used as the basis for co-designed solutions. All participants are seen as experts and their input is valued with equal standing. Strategies are used to remove potential or perceived inequalities. Partners manage their own and others' feelings for the interest of the process. Transdisciplinary requires everyone to negotiate personal and practical understandings at the expense of differences.

Time and resources demanding: A sound process requires reasonable resources for the engagement of stakeholders, facilitators, and experts in transdisciplinary research practices. An under-resourced process may do more harm than good.

Reflexive: Reflexivity is important for ensuring research opens up, rather than closes down, space for active critical contention over the emergence of alternative societal pathways and attention to marginalised interests]. It can also help actors or researchers of change examine how they are part of the system in which change is desired.

Benefits of this kind of research have well summarised by Durham et al., (2014 ,p. 14), see Table 2. There are benefits to research/research teams, stakeholders and wider society.

Table 2: Benefits of stakeholder engagement.

Benefits to research teams	Benefits to stakeholders	Benefits to wider society
• Higher profile and enhanced reputation • Useful contacts for future engagement • Improved dissemination of results • Enhanced impact of research • Increased support for the research • Improved chances of funding success • Opportunities for learning • Better quality data • More resources provided • Potential to improve methods • Improved research questions • Better analysis • Increase potential to leave a legacy	• Opportunities for learning • Better access to knowledge • Improved decision-making • Improved policies • Access to better technologies • Business opportunities • Sense of inclusion and involvement • Opportunities to be paid for providing data or facilities • Opportunities to influence or drive research • A sense of ownership	• Better knowledge applied in policy and practice • Reduced barriers between science and society • Improved trust and respect • Access to opportunities • Better evidence • Shared responsibilities and decision making • More relevant and more inclusive research

2.4 General principles for a successful transdisciplinary research process

There are no best-practices able to fit all approaches for co-creation, because of different context and capacities among those facilitating the process, as well as among those participating in it. The aims and needs of both project and participants may vary. Historical (e.g.previous successful/unsuccessful experiences in collaboration) or institutional factors (e.g. social relations between the participants; political context) may also affect the process.

Several principles that support successful collaboration between researchers and practitioners have been identified:

- a shared understanding of project goals and division of project responsibilities (Hegger et. al., 2012)

- a good fit between research questions and the information needs of the stakeholders (Buser et al., 2019)
- co-leadership of the project (including stakeholders participating in the analysis, democrat meeting methods, communication and implementation plans, joint analysis of data (Polk, 2014)
- iteratively (Fazey et al., 2018); and
- the good project design (Hegger & Dieperink, 2014)
- specific actors or organisation dedicated to design and facilitate co-production (Polk, 2015)

The researchers have also identified a number of challenges in this kind of research. Musch and Streit (2020) have recently concluded that those, who plan, co-design and facilitate participation in sustainability science need to be aware of possible opportunities and challenges concerning the conflicting rationales of participation, such as normative ideals for the work vs. effectiveness-oriented rationales while implementing participation. They also need to consider the possible tensions and conflicts by involving 'experts' and 'lay people' or actors with fundamentally different experiences, but at the expense of immediately deliverable outputs. This means that those who lead the processes should be ready to make compromises with the goals they have in mind with those coming up during the process. Finally, there is a need to be honest and realistic about project effects with scarce available time and human resources.

Keeping in mind these challenges, Djenontin and Meadow (2018) have reviewed environmental and climate management projects, and came up with practical methodological guidance based on lessons from how different research teams have approached the challenges of complex collaborative research processes and pointed out critical factors in each phase (see Fig. 3).

Context factors refer to *institutional* factors that influence the overall conditions for conducting transdisciplinary work, such as management agencies, funding agencies, and academic institutions. Many of the institutional factors, in turn, are affected by different *cultural norms* for example recognition and appreciation of collaborative research and determining the resources available. *Logistic factors* may refer to the geographical distances, which may have an impact on e.g. the frequency of the meetings and access to the research facilities or outputs. In some cases, logistic may be burdened by physical constraints, like internet access.

The **inputs** include aspects that shape the interaction process. Here the *proficiency and the expertise*, the skills of the researcher become important to support the successful research design and its implementation. These skills cover the social skills to work with various stakeholders as well as the skills to deal with different types of knowledge. The authors note that local knowledge is of crucial importance here. *Legitimacy*, the fairness of the process of producing knowledge as well as recognition of different values, concerns and perspectives of the actors involved, needed in the very beginning of the project as well as the result of the process. If successful, different social and cultural groups (professions, genders, cultural minorities) are involved in the balanced way and all kinds of barriers for participation (physical, economic, social, cultural) are.

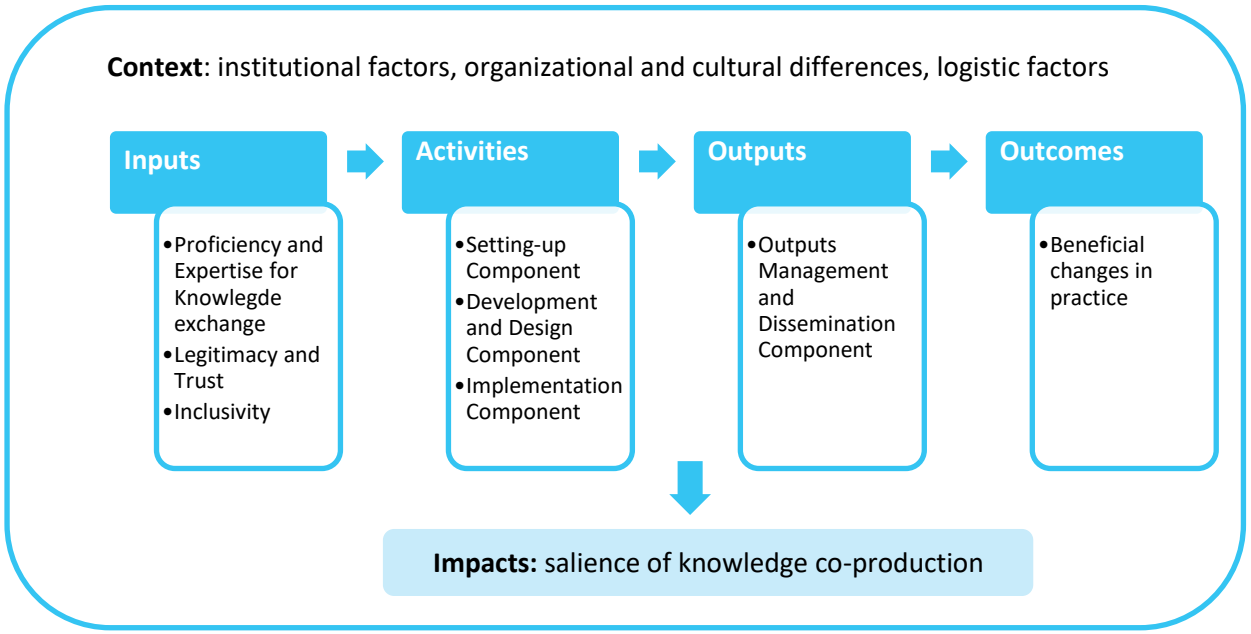


Figure 3: Elements, phases and critical factors of a transdisciplinary process. Adapted from Djenontin and Meadow (2018).

During the **activities,** important aspects are composed of setting up, development and design and implementation components. *Setting up* refers to the composition of the team with all the expertise needed. *Development and design of the project* should be organised collaboratively so that all the participants are equally involved, and in the *implementation* phase, consistent use of the engagement activities as well as appropriate communication needs to be ensured.

Regarding the **outputs,** *communication* is not just a tool for dissemination, but also a management tool and means to engage and involve. After the project activities, it is important to put sufficient efforts for dissemination among and with the stakeholders, as well as outside the project participants, and take care of their availability and accessibility (in terms of language). The whole process should lead to beneficial changes in the practice (learning) as well as salience of knowledge in co-production.

2.5 Key elements of co-creation process in OPERANDUM

In the OPERANDUM project, we have identified three main elements or conditions for a successful co-design: a social-ecological system of the given rural and natural territory context; stakeholder engagement, which is an important part of any co-creation process; and knowledge integration of governance as the modelling and hard sciences is an important aspect in OPERANDUM (Fig. 4). Furthermore, we want to emphasize the acknowledgement of the roles of the researchers in such a process, as knowledge provider, facilitator and knowledge broker among others. In the following, we briefly discuss each of these elements.

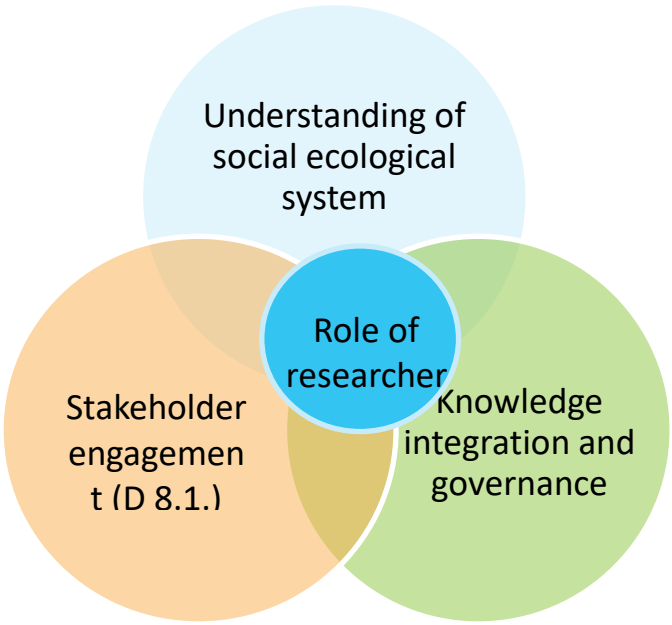


Figure 4: Elements, phases and critical factors of a transdisciplinary process.

2.5.1 Understanding of social-ecological systems

Nature-Based Solutions (NBS) have been defined as "solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience" (European Commission, 2016, p. 1). This means that we have to take into account not only the human (socio-economic) or technical system around the problem but also the ecological one (Franz et al., 2015). This is, in particular, the case in the rural and natural territory context where the values and interests can be varied and in contradiction. The socio-ecological system (SES) theory was first introduced by Berkes and Folke (1998), but since then have been applied and developed by many other authors, including Elinor Ostrom (2010). SES theory emerged from the recognition of close interaction between society, in terms of social-economic system, and natural system (Fig. 5). It acknowledges that human society represents the driving forces of ecological systems, but also a role in the management of ecosystems. So, it is relevant to understand the human sources of ecological change.

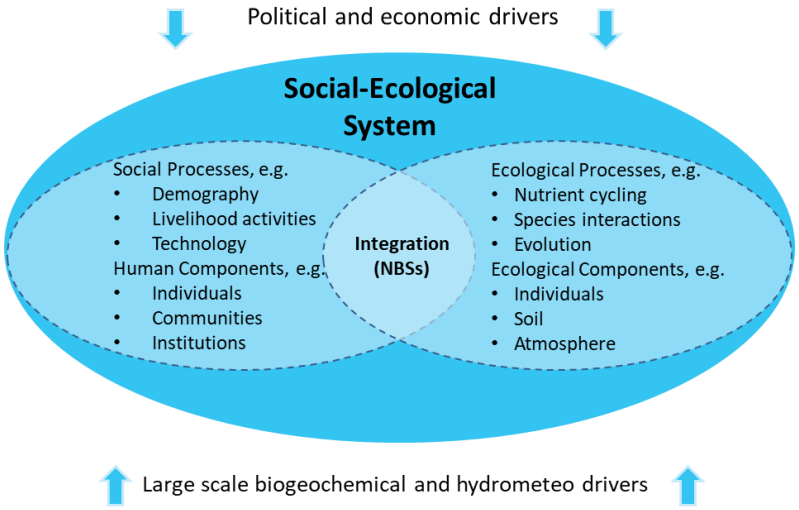


Figure 5: Elements, phases and critical factors of a transdisciplinary process. The system is shaped by political and economic drivers and large scale biogeochemical and hydrometeorological drivers. Adapted from Virapongse et al. (2016).

2.5.2 Stakeholder engagement

As the co-creation is based on the idea of working with the practitioners, stakeholder engagement is a critical phase in the co-creation process. In OPERANDUM we have designed a specific strategy for the whole procedure for stakeholder engagement including the values behind, mapping and classification, ethical consideration and tactics to deal with the challenges (see OPERANDUM D1.1, 2019; D8.1, 2019).

2.5.3 Knowledge integration, governance and power dynamics

As Tengö et al. (2017) point out to achieve a successful co-creation process, it is necessary to bring together different knowledge systems. These knowledge systems can be scientific, western knowledge systems, local or indigenous knowledge systems. To bring different knowledge systems successfully together, i.e. achieve "knowledge weaving", the co-produced knowledge needs to be legitimate, salient and credible for all involved stakeholders (Clarke et al. 2016). This forms the basis within a research project for finding innovative and constructive solutions for place-based problems, including NBS.

Bringing knowledge systems together often runs into problems related to the incommensurability of and power asymmetry between different knowledge systems, meaning among others that knowledge systems do not share a common basis or language and are unbalanced in terms of perceived authority. Tengö et al. (2017) suggest five steps to overcome these issues taking into account key aspects of the knowledge systems (actors, institutions, and processes) to work towards knowledge weaving (see Fig. 6). These five steps are: **mobilise** ("develop knowledge-based products through a process of innovation and/or engaging with past knowledge and experience"), **translate** ("adapt knowledge products or outcomes into forms appropriate to enable mutual comprehension in the face of differences between actors"), **negotiate** ("interact among different knowledge systems to develop mutually respectful and useful representations of knowledge"), **synthesise** ("shape broadly accepted common knowledge bases for a particular purpose"), and **apply** ("use common

knowledge bases to make decisions and/ or take actions and to reinforce and feedback into the knowledge systems") (Tengö et al 2017, p. 21).

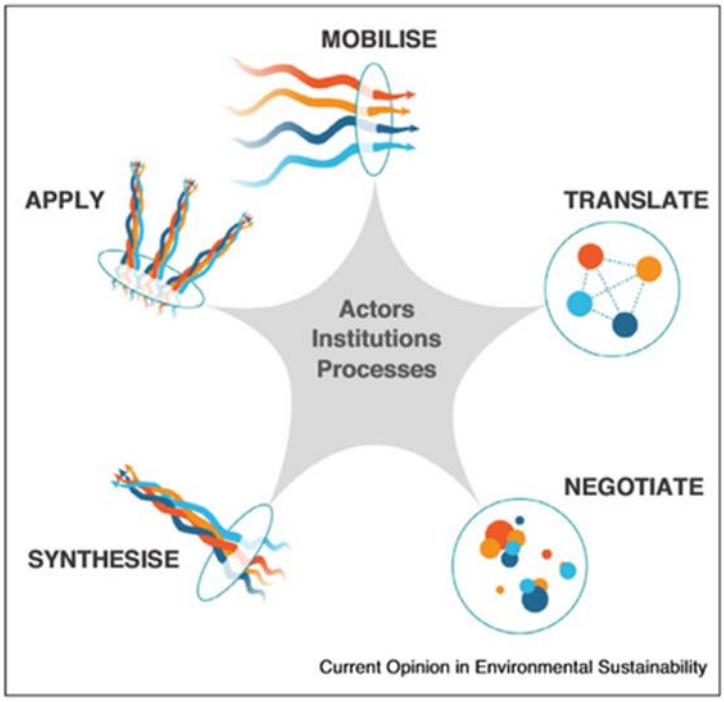


Figure 6: Knowledge weaving. Tengö et al. (2017) in Current Opinion in Environmental Sustainability.

Knowledge integration may also be understood in the context of design thinking and system thinking, which are two complementary processes. Design thinking is characterized as an open-ended, exploratory, people-centred, bottom-up, innovative, problem-solving process. System thinking, on the other hand, is a process for the successful implementation of a solution by enabling the system to adapt to changes. These two complementary processes, so-called Namahn toolkit (see: www.systemicdesigntookit.org.) are visualized in Fig. 7. Both knowledge weaving and Namahn toolkit may play an important role in the OPERANDUM project in terms of establishing a successful co-creation process and later on in a successful scaling up of NBS.

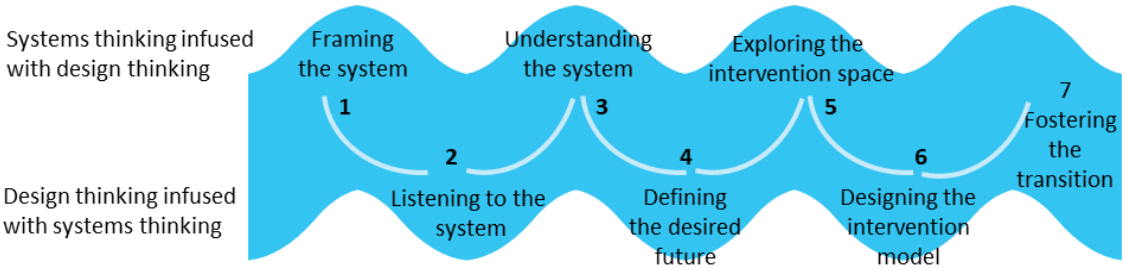


Figure 7: Integration of design and system thinking (Namahn toolkit).

Step 1: Framing the system is all about scoping the system you are going to analyse. Step 2: Listening to the system. You investigate the system through desk research and field study. Step 3: Understanding the system. In step three you explore the forces that affect your system. Step 4: Defining the desired future. You articulate what the desired future should be and what the values are you want to create. Step 5: Possibility of space. You explore possible ideas for intervening on the

leverage points. Step 6: Intervention model. You bring the best ideas together into a conceptual model. Step 7: Transition. You define how you will unfold your interventions in the current system. More information could be found via www.systemicdesigntookit.org.

Closely related to knowledge weaving and integration is the issue of knowledge governance. Without a good understanding of knowledge governance, e.g. structures and mechanisms based on informal and formal rules and conventions that together influence the creation and sharing of knowledge (Kerkhoff, 2014, Obermeister, 2017), it is impossible to achieve knowledge weaving. Currently, non-scientific knowledge systems are often not given enough weight due to knowledge governance processes that favor scientific knowledge systems, hampering a successful co-creation of knowledge. This, in turn, shapes the kind of decisions and actions taken within a transdisciplinary research project. As Clark et al. (2016) point out, knowledge production and decision making shape and reshape one another. The outcomes of a transdisciplinary project may therefore not be as inclusive as initially strived for. Reshaping knowledge governance might be necessary to achieve the objectives of OPERANDUM project.

2.5.4 Roles of the researchers

For researchers, transdisciplinary research means the adaptation of new skills and resources. Sipos et al. (2008) have offered a framework of competence needed for transdisciplinary research including a head (cognition), hands (skills) and heart (values, attitude) to identify. Horlings et al. (2019) have added feet in this list, referring to the importance of knowing a place in the research. Fam et al. (2019) have further conceptualised the head and hands dimensions with Six 'C's: Curiosity, Creativity, Commitment, Critical awareness, Communication and Connectedness that are necessary ingredients of such work.

Given the different characteristics of the research and knowledge production from conventional research, it is important to understand the different roles and positions the researchers may have in the process. There are some typologies and frameworks that aim to analyse the different roles of the researcher in transdisciplinary sustainability projects as well as studies that point out, how the roles should be reflected in particular sustainability research (e.g. Pohl, 2010; Wuesler, 2014; Schneider et al., 2019). This paper uses the frame introduced by Wittmayer and Schäpke (2014) for understanding different roles of researchers in action research in the context of sustainability transitions. These roles are determined by the level of ownership of the problem, the manner by which researchers deal with sustainability and power dynamics in the group, and by the actions the researchers take (see Fig. 8).

A reflective scientist is closest to the conventional researcher, acting as an external observer, not actively intervening in the process studied. *A process facilitator* is responsible for the design and implementation of short-term actions, and in this way engaging for example in dynamics between the participants and the learning that may take place. *A knowledge broker* mediates between different perspectives related to the issue at stake but also aims to make sustainability relevant for different stakeholders and tangible in the given context. The role of the *change agent* refers to the explicit participation of the researcher in processes of change. The researcher seeks to motivate and empower participants to trigger change. Finally, acting as *a self-reflexive scientist* is being continuously reflexive about one's normativity and positionality, while also prone to personal transformation during the research process. Overall, the activities performed in different roles

during the actual research work are complex and fluid. Consequently, instead of seeing these roles as separate, we understand them as a continuum, showing the level of engagement of the researcher during the research process. Similarly, stakeholders may have different roles in the process. We discuss them more closely in Chapter 4.

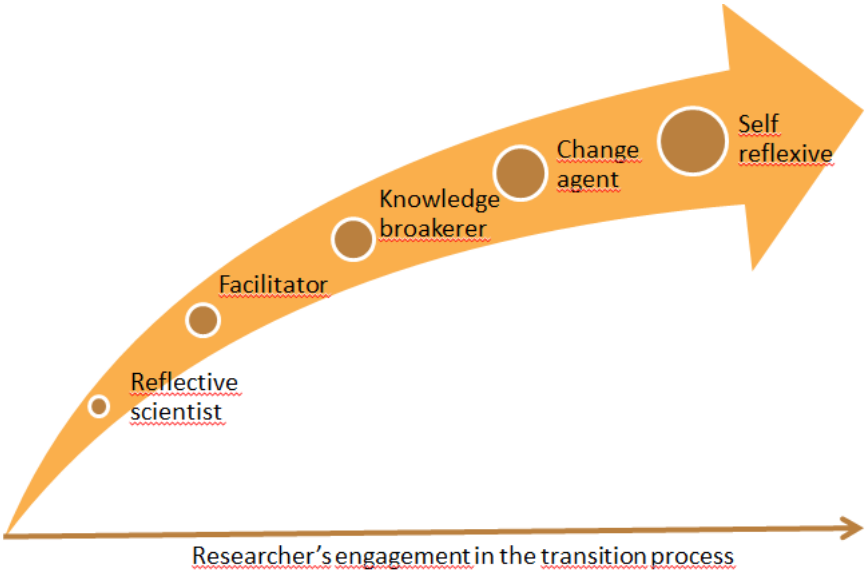


Figure 8: Different roles of the researchers. Adapted from Wittmayer and Schäpke (2014).

2.5.5 Power dynamics

Power is present in every relationship, also in research where various parties are present. Power dynamics become even more prominent in research, where multiple disciplines and stakeholders are involved in shaping the processes (Marshall et al. 2018; Pohl et al. 2010). They may arise between researchers regarding the differences in language, theories, concepts, terms and methods applied in research, as well as different understandings concerning the reality studied and how knowledge can be acquired (Eigenbrode et al. 2007). Power relations may affect the planning of the research as well as knowledge integration, which should be based on an equal and reciprocal exchange between the disciplines (Callardt and Fitzgerald 2015). In transdisciplinary research, the power issues are also present between the researchers and participants. Researchers may often take control over the process, which is not necessarily a negative thing in itself; in some cases, such leadership might be needed. The essential question is how this is done. Finally, there are often power hierarchies among the practitioners that may reflect social, educational/cultural or financial capital they have (Bordieu, 1977). As power is an essential component of all interactions and important means for innovative processes. It is good to be aware of power, and try to find means to deal with it.

3 Common framework for co-creating NBSs in OPERANDUM

3.1 State of the art for co-creating NBS in OPERANDUM OALs

3.1.1 General contexts for co-creating NBSs in OPERANDUM

Nesshöver et al. (2015) named key elements for the operationalization of the NBS concept: Dealing with uncertainty and complexity; ensuring the involvement of multiple stakeholders; ensuring the sound use of multi-and transdisciplinary knowledge; developing a common understanding of multifunctional solutions, trade-offs and natural adaptation; evaluate and monitor for mutual learning. In the OPERANDUM project's Task 1.2 various barriers for the implementation of NBSs have been identified. The most common challenges and solutions have been collected in Table 3. Some of the barriers may be linked to the economical, institutional elements, like lack of funding or lack of regulation or environmental, like climate change, which cannot directly be mitigated with the help of co-creation. However, many of them are directly or indirectly linked to social aspects, i.e. stakeholders' attitudes, knowledge, capacity or activities. Recent literature suggested that a major bottleneck that hindered the co-creation of NBS, the wider uptake and acceptance of NBS was lack of principles, standards and guidelines (Renaud et al., 2016). Kabisch et al. (2016) identified four main knowledge gaps associated with the co-creation and benefits of NBS: (1) lack of monitoring and sharing information about the NBS projects already implemented to tackle societal challenges such as climate change, food and water security or natural disasters; (2) relationship between NBS and society (drawbacks linking to the recognition of the best method of transferring successful and unsuccessful outcomes of NBS; (3) design of NBS (i.e., the optimal design of different NBS can be unknown) and (4) implementation aspects such as lack of clarity in which types of NBS are optimal, for example, to meet sustainable development goals.

Although the decision-makers still tend to implement traditional engineering-based hydro-meteorological risk mitigation and adaptation measures, instead of implementing NBS, due to lack of well-documented evidence of NBS benefits, the possible ways to overcome mentioned in Table 1 could promote and enhance participatory processes for co-design, co-creation and co-management of NBS implementation. Furthermore, the studies show that co-creation and co-implementation can help to create high levels of citizen acceptance and identification to overcome potential fears of NBS acceptance (Davies, 2015). Shanahan et al. (2015) proposed to carry out in-depth multidisciplinary research that could promote the wider acceptance of NBS. In general, the summaries documented in Table 3 suggested that participatory approaches through multidisciplinary stakeholders from different sectors, such as policy areas, social and natural sciences to co-design, co-creation and co-management of NBS can overcome the barriers and foster the uptake of NBS natural hazards than the traditional approach. This can also build and promote synergies between different parts of the community by linking together resources, skills and knowledge (see Table 3). Furthermore, in practice, NBS has not yet been proven to provide complete or an acceptable efficiency of defence against hydro-meteorological hazards, therefore there is still a long way to go. For instance, more studies are needed to develop co-creation processes and stakeholder engagement to support sustainable NBS in OPERANDUM OALs. For more recommendations to overcome the barriers and improve co-creation processes see Table 3.

Table 3: Summary of the identified gaps, potential barriers and possible ways to overcome these barriers for the implementation of NBS.

Gaps and potential barriers	Possible ways to overcome these barriers
Evidence-based knowledge of NBS	
Absence of strong evidence on NBS and their typology, e.g. lack analysis on cost-benefits of NBS implementation, lack of case studies with documented implementation phase, species restrictions, lack of key performance indicators (KPI) of NBS against hydro-meteorological hazards and Lack of clear steps for monitoring and evaluation of NBS.	More public investment, share costs and risks between the private and the public sector. Assess effectiveness of NBS at different scales, climatic and environmental conditions. Data standards - sampling, monitoring, reporting, management, formatting. Indicators of NBS efficiency should be selected at the beginning of the project and the respective measurements undertaken. Comprehensive monitoring and evaluation of NBS before and beyond the project implementation phase will help to identify benefits and potential trade-offs. Integrating NBS and the benefit they provide with social network and policy analyses will bring more favour toward the implementation of NBS.
Lack of studies that urban soil management as NBS.	Increase awareness on how to consider the application and the benefits of unsealed soils and high organic soils as NBS, which helps for carbon sequestration and storage and mitigate climate change and hydro-meteorological hazards
Uncertainties linked with the application, upscaling and replication of NBS.	Lack of clarity in which types of NBS optimal against hydro-meteorological hazards. More research is needed to evaluate at what scale and under which situations different NBS are most effective than grey approaches.
Lack of studies on the comparison of hybrid approaches and their resistance against future climate change	During the implementation of NBS, responsible stakeholders need to consider the combination of blue and green approaches with grey approaches, which have the potential to cope with future climate change.
Lack of holistic research approaches that focused on identifying social and environmental synergies and trade-offs of NBS.	Holistic research approaches are needed that consider both potential synergies and trade-offs between environmental and social developments to assess impacts of, for example, potential gentrification, social displacement or spatial segregation effects. Clear-cut research on NBS as implementation may bring negative health effects, e.g. through potentially enhanced allergies from the transmission of pollen from allergenic plants or increased vector-borne diseases through, e.g. creation of favourable habitats for vectors is needed.
Lack of evidence on social trade-offs - attitude of landowners.	Inform landowners benefits of NBS and disadvantages if NBS is not built. During the planning and implementing NBS projects, potential trade-offs among social developments need to be considered to avoid gentrification developments resulting in spatial segregation and displacement as well as conflicts.

Knowledge of and experience in collaborative research	
Lack of evidence on social trade-offs - an attitude of landowners.	Inform landowners benefits of NBS and disadvantages if NBS is not built. During the planning and implementing NBS projects, potential trade-offs among social developments need to be considered to avoid gentrification developments resulting in spatial segregation and displacement as well as conflicts.
Lack of experience to implement NBS, e.g: lack of guidelines and standards to follow-up implementation of NBS. Lack of practical experience. Complexity in the construction stage. Lack of monitoring and sharing information about the NBS projects already implemented. Relationship between NBS and society. Lack of expertise and/or qualified labour for installation and monitoring and lack of multi-disciplinary/inclusive debates of NBS.	Discuss with other experts, discuss with local people, trust your own experience, participate in training. Practical formation to the enterprises, organise short courses and training courses. Developing a new and using the existing NBS information platform/databases such as Oppla, ThinkNature, Climate-ADAPT, etc. Management programmes at local, national and international level; awareness-raising; community engagement, bringing together resources, skills and knowledge, using the existing materials, more tools, manuals, guidelines and quality criteria. practitioners need to be developed in collaboration with science and evidence and experience-based guidelines about climate change proofing NBS (e.g. species selection) should be developed to ensure that ecological functions and biodiversity gains are resilient to future changes.
Lack of integrating NBS with multidisciplinary stakeholders from the early stages of project planning, designing and implementation, e.g., highly dependent on grey approach and lack of time and consideration.	Funding of NBS related projects, training courses to improve the labour, organising more meetings, conferences, congress and workshops to disseminate executed NBS projects, the involvement of citizens and organizations throughout the life cycle of NBS projects (before and beyond the project implementation phases – planning, execution, monitoring and evaluation) to create trust, ownership and stewardship and foster participatory processes for co-design, co-development, co-deployment and co-management of NBS implementation.
Lack of local knowledge.	The experts who design and build the NBS should know their region (social-ecological system) better.
Environmental conditions	
Climate change	Uncertainty related to the future climate should be taken care of when building the NBS.
Institutional conditions	
Lack of funding	Update the system on how the financial support to build water protection structure is directed. Stakeholder engagement may help to find new funding sources and develop co-funding mechanisms. Strong commitment may also increase willingness to participate in funding.
Lack of long-term stability in the planning process of NBS.	NBS implementation based on the integration of different policy instruments such as regulation, financial incentives for public-private partnerships, investments as well as participatory community measures is recommended.

3.1.2 Similarities and differences of OPERANDUM OALs in terms of co-creation

The OALs of the OPERANDUM project are very diverse (refer to D1.2, D4.2 and others) and consequently, the co-creation processes will take different forms depending on the problem addressed, social-ecological system concerned, stakeholders engaged and research teams/expertise in the OAL. At the start of the project, Task 1.3 mapped the state of the art of the OALs. Data was collected from all European OALs and from OAL-China on the following topics:

- size and ecological character of the operational area and different environmental conditions;
- composition of research teams;
- expertise of in participatory research;
- earlier work at the OAL;
- foreseen challenges in co-creation; and
- foreseen possibilities in co-creation.

Not only do the OALs differ in dimension, ecological characteristics, and experienced hydro-meteorological risks (see D1.2; 3.1), the OAL teams also have various backgrounds, sizes, and expertise (see Fig. 9 and Fig. 10). Some OAL teams have more of a focal point in the natural sciences, while other teams are more balanced in terms of natural and social scientists. The size of the OAL teams varies from 1 person to 24 persons, which to some extent relates to the size of the OAL, the current phase of the co-creation process and the planned NBS. Most teams have worked before in the area in which the OPERANDUM OALs are located.

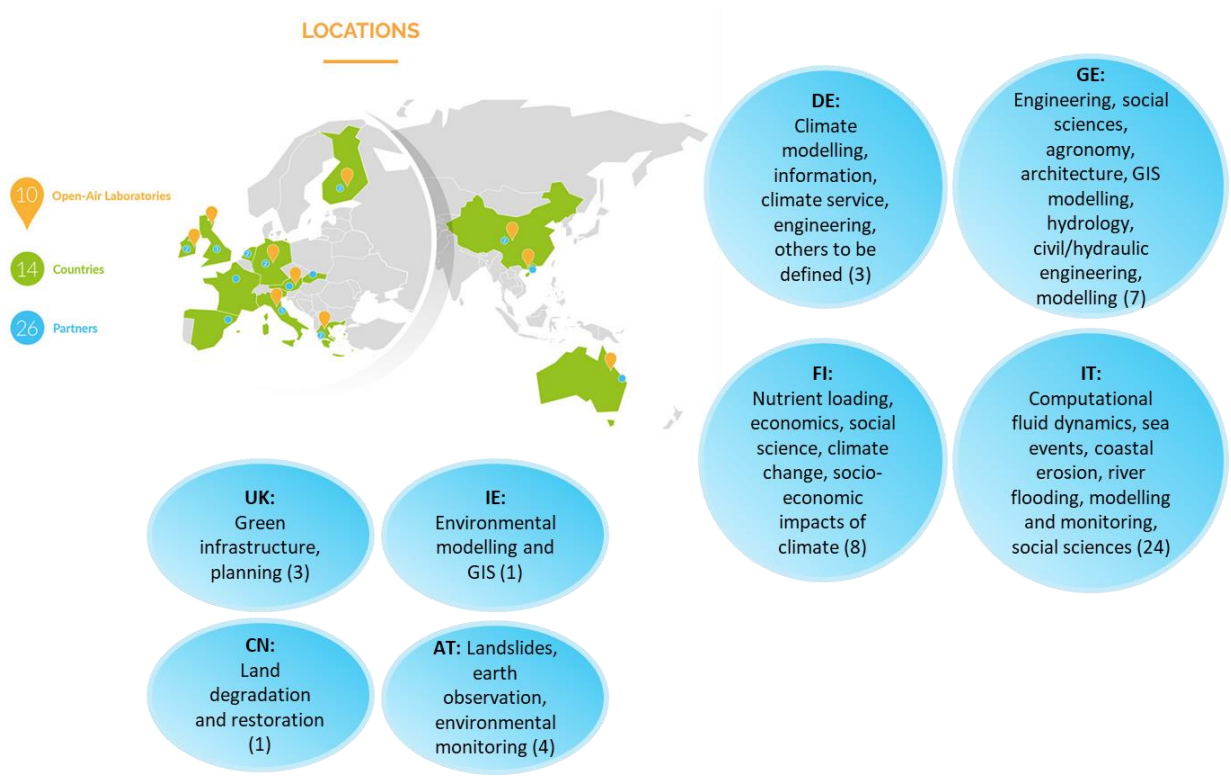


Figure 9: Expertise and size of OAL teams.

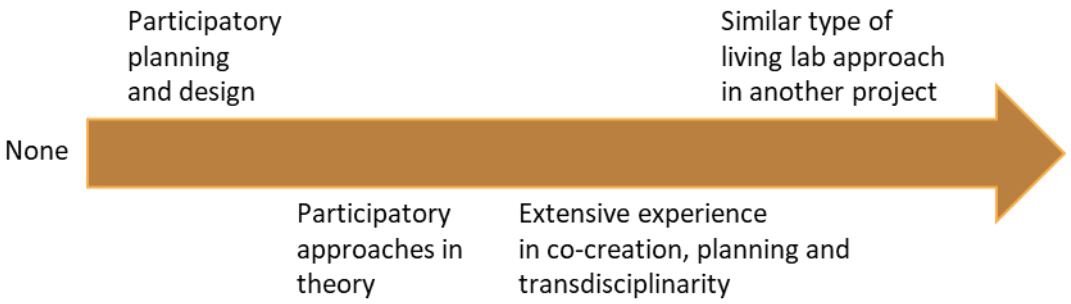


Figure 10: Type of experience in co-creation.

Most of the OALs (UK, GR, DE, FI, IE, CN) has had some research, operations or collaboration among them, while two of them (AT and IT) did not have any. Similarly, most OAL teams have experience with co-creation processes, although this ranges from limited (e.g. knowledge of participatory approaches) to extensive experience (e.g. expertise in Living Lab approaches). In Fig. 10, an overview is given of the experiences available in the OAL teams is given sorted from none to a high level of experience.

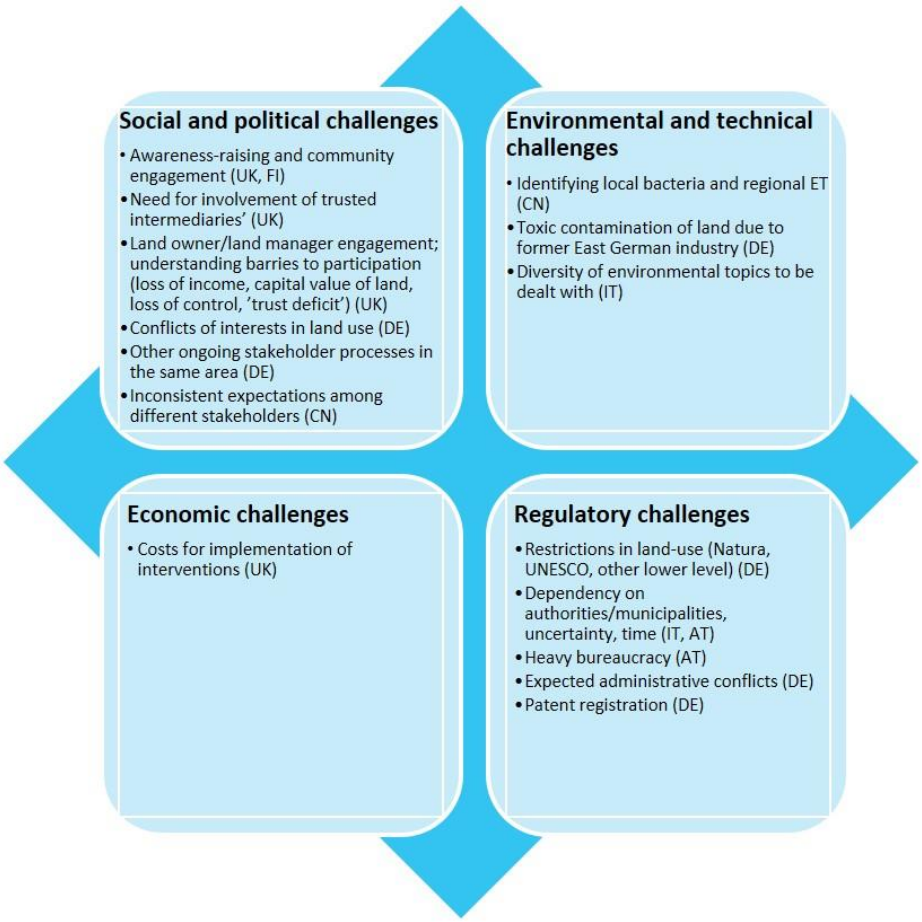


Figure 11: Foreseen challenges in the OALs.

Most of the OALs were in the planning phase meaning that the case study area is defined and the co-design process with stakeholders was about to start. Other OALs are in the exploratory phase of the NBS planning, meaning that they have established contact with relevant stakeholders and are exploring NBS options. The OALs anticipated various challenges and opportunities during the co-creation process (see Fig. 11). The challenges can be grouped into different categories and range from social and political challenges, environmental and technical challenges, economic challenges, to regulatory challenges. Following opportunities by the OAL teams are diverse and relate to the anticipated co-benefits of the implemented NBS and to the expected mitigated risks of the hydro-meteorological hazard. Some of them were related to collaboration with the stakeholders:

> "We value the opportunity for the knowledge exchange with practitioners and local authorities" (AT);
>
> "The atmosphere is positive and our collaborators have resources to implement and motor NBSs." (FI).

There were also expectations related to the added value of the co-designed solutions for the environment and the community:

> "The co-design with the local community will lead to locally attuned NBS, which will have multiple benefits to reduce flood risk and also provide service and amenity to the local community."

It was also assumed that stakeholders' engagement will also lead to solutions that are more readily adapted:

> "Adaptation of environmentally friendly approaches in water management. Approval of those strategies by regional authorities and politician" (GR);

Some of the OALs looked at the benefits more in the long term:

> "I foresee the opportunity to increase the awareness of people to the risks connected to climate change and the possibility to expand our work with schools and young people associations, and to seed this new way to see to this problem for the future" (IT).

3.2 Defining the co-creation process in OPERANDUM

Following the theoretical and conceptual exploration presented in Chapter 2 and acknowledging the different contexts, experience and situation of the OALs described above, we decided to create a common framework for the co-creation (Fig. 12) to guide the work in the OALs. The framework aims to introduce the key elements for the processes, while each of the OAL adapts this frame according to their context and needs: As explained in Chapter 2 the co-creation is a creative process allowing iteration and changing directions.

In OPERANDUM we understand the whole process broadly as **a co-creation**, in which different parties come together in order to create a mutually beneficial outcome. It implies the continuous exchange of knowledge in a recursive or iterative process. The process is cyclical rather than sequential and may require reassessing or change in the plans at any point in the process (Fig. 12). In principle, the co-creation includes four main stages.

Co-design: Co-creation starts with co-design, a process where the problem and the target area is identified as well as the stakeholders, their aspirations, shared values or common interests and aims regarding the project and the target area. This phase will result in the first plan for the collaboration.

Co-development: In this phase by using the variety of expertise and knowledge of the group potential solutions for the problem are jointly developed and with the help of some research if needed.

Co-deployment: In this phase, the solutions will be implemented and monitoring of the solutions will be established. The monitoring, as well, can be conducted with the stakeholders.

Monitoring: Monitoring is an essential part of the co-creation. It can focus on the outputs/outcomes of the processes (NBS) as well as the process itself. It shapes the way the process is structured and resourced ensuring that it is reflective and adaptive as much as it is generative. Monitoring and associated assessment is also an important element for learning.

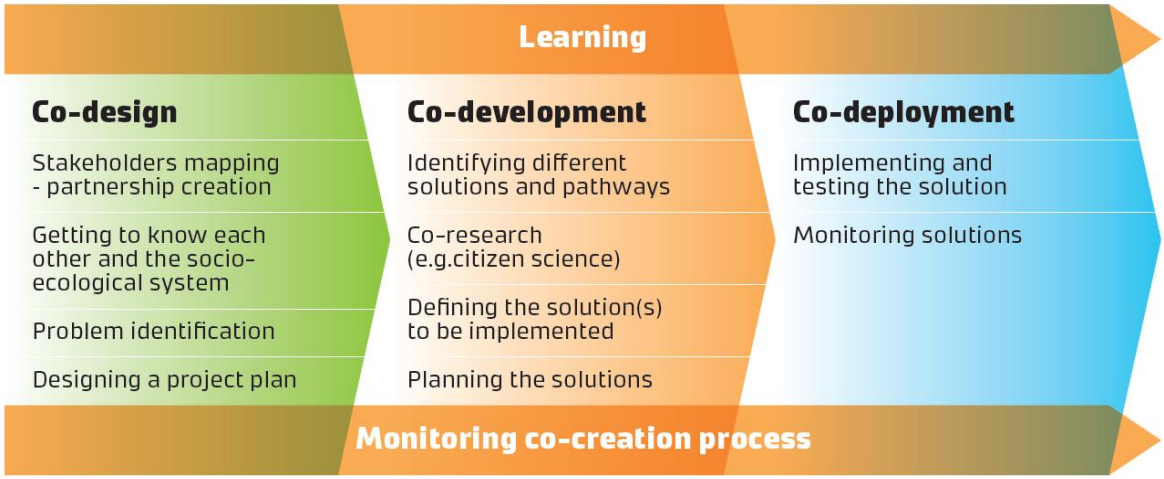


Figure 12: Co-creation in OPERANDUM.

Although we recognise all these phases in Co-creation and learning as an important topic across the process, in this Deliverable we focus on Co-design, Co-development and Monitoring co-creation process. Co-deployment, implementing, testing and monitoring of solutions is only about to start. The solution, as well as the context, determines, what the best way is to carry out the co-deployment and monitor it, and we will not propose any special methods for that.

PART II
TOOLS AND METHODS FOR CO-CREATION

4 Co-design

4.1 Stakeholder mapping and partnership creation

In the first phase, stakeholders are identified and contacted. The stakeholders are defined as group, directly or indirectly affected by a project, as well as those who may have an interest in a project and/ or the ability to influence its outcome, either positively or negatively. Both the concepts of involvement and engagement are used in relation to stakeholders who participate in the project. To *engage* means "to come together and interlock". Consequently, engagement can be understood as a mutually beneficial interaction that results in participants feeling valued for their unique contribution. To *involve* is to "enfold or envelope" meaning that someone is involving some others and it is often used to describe a variety of one-way communication processes like surveys, newsletters and "talking head" info sessions. Thus, involvement implies doing to; in contrast, engagement implies doing with suggesting that engagement refers to deeper interaction (Adapted from Thoughtexchange).

Although the stakeholders are identified at the beginning of the project their involvement in the project may vary depending on the phase. Overall, stakeholder engagement is an ongoing process (see Showcase 1.). The identification of the stakeholders regarding the problem to be solved should be achieved as early as possible in the project, to ensure full engagement. Whenever stakeholders are engaged in a project, an initial challenge lies in the question of who to engage with, where to draw the boundary between relevant and not relevant, and therefore in judging who should be listened to (Vos, 2003). Researchers must consider stakeholders belonging to a range of networks, and not only those that already know each other (Prell et al., 2009). Focusing only on those previously known and active stakeholders increases the chance of missing hidden, remote or less obvious stakeholders (Reed, 2008). It has been argued that knowledge exchange and transdisciplinary is more effective when researchers are considered as stakeholders themselves, rather than as outsiders or holders of certain powers or knowledge (Mitton et al., 2007). Mielke et al., (2016) discern the following approaches to stakeholder engagement based on the different objectives, kind of knowledge aimed for, understanding of science, and science-policy interface.

- Technocratic type: Improve scientific research by broadening the extent of available information. The role of the stakeholder is to provide issue-specific, objective and falsifiable information.
- Neoliberal-rational type: Stakeholder participation as a tool for both stakeholders the scientists to impose their perceptions and interests on each other.
- Functionalist -type: irritate the science system with other social perspectives in order to trigger the learning process that can make science more sensitive to societal problems.
- Democratic type: integrate actors in society that are touched by a complex transformation or sustainability matters into the research process. Science can create legitimacy for itself.

All these approaches lead to different types of engagement and use of methods. van der Hel (2016) has developed a similar type of typology for stakeholder engagement reflecting the rationales chosen by the researchers (see also Schneider and Buser, 2019):

- Accountability: involvement of stakeholder at the very start to jointly frame the problems, the kinds of knowledge capable of addressing them, and consequently, what research questions should be investigated.

- Impact: including stakeholders throughout the entire research process to enable trust, ownership, and implementable knowledge;
- Humility: acknowledging that science is only one legitimate knowledge form among many, and there are other relevant ways of learning and understanding in the search for solutions to complex, uncertain, and contested sustainability problems

4.1.1 Methods for stakeholder mapping

There are a number of methods that can be used for stakeholder mapping:

- Systematic mapping covers issues like previous collaboration, networks etc.; expertise (topical, local, complementary); interest and willingness; resources (time, data, financial, social); legitimacy, influence, willingness, interest and risk; (see Table 4).
- Brainstorming with other organisations that have been involved in similar activities or those working in similar locations;
- Consulting with colleagues to share knowledge about who may have an interest in the research;
- Developing a 'mind map' that can be used to identify suitable stakeholders; assessing secondary data (e.g. historical records, media articles) biodiverse stakeholder engagement handbook
- Utilising government statistics and data (e.g. census information);
- Initiating self-selection by promoting the engagement process and encouraging individuals with an interest to come forward;
- Using 'snowball sampling' techniques, whereby one stakeholder identifies further stakeholders until no additional new stakeholders are identified;
- Utilising existing lists of organisations in order to identify specific groups, networks and agencies who represent relevant elements of society;
- Consulting with forums used by the government and other organisations (e.g. local authorities, town councils, emergency services etc.).

4.1.2 Methods for stakeholder classification

Once the stakeholders have been mapped, they can be classified in different ways. A commonly used practice is to classify them into four categories (Rosendahl et al., 2015):

- Primary stakeholders: people who use the system directly
- Secondary stakeholders: people who do not use the system directly but receive output from it or provide input to it (indirect users)
- Tertiary stakeholders: people who do not interact with the system either directly or indirectly but who are affected by its success (or failure)
- Facilitating stakeholders: people who are involved with the design, development and maintenance of the system.

Furthermore, stakeholders can be classified in the following way regarding their possible engagement in the project (International Association of Public Participation):

- 'Collaborate': those with which it is likely to be most beneficial to engage. They may be able to supply relevant information, permissions and resources, or maybe markedly impacted by the eventual outcomes.
- 'Involve': they are highly influential, but have little interest in the research or low capacity/resources to engage. As a consequence, they may have significant influence over the success of the project, but it may be difficult to engage them in the research process. A

particular effort may be necessary to engage this group in the research and therefore effort should be made as early as possible in the research process.

- 'Consult': they have high interest, but low influence and, although by definition they are supportive of the research, they lack the capacity to significantly help the project and deliver impact. However, they may become influential by forming alliances with other more influential stakeholders. These are often the marginal stakeholders that may also be considered 'hard to reach', and that might warrant special attention to secure their engagement and empower them to engage as equals in the research process with more influential participants. The low level of influence held by this group is often used as a justification for excluding them from the research process.
- 'Inform': stakeholders with little interest in or influence over research outcomes. It can be argued that when there are limited project resources there is less need to consider them in much detail or to engage with them.

After selecting the key stakeholders and defining their roles, partnerships can be established.

Table 4: Questions for stakeholder engagement.

Topic	Possible question
Past experience and collaboration	• What stakeholders, or stakeholder groups, have been engaged in the past? Are there any existing networks, and, if so, how can they be utilised? • What similar projects have been undertaken previously? How successful were the projects and what were the key elements in achieving or failing the objectives? • What is the historical context to the project? What wider decision-making processes that may affect the project need to be considered? What is the relationship status with stakeholders or potential stakeholders? • Are there any relevant activities, events or communication channels that could be used to engage with stakeholders?
Expertise	• Topical expertise/relevance/stakes • Local/Regional expertise/relevance/stakes • Complementarity expertise
Resources	• Does the stakeholder have resources to engage? If not, is there something that could be done by OPERANDUM if stakeholders' involvement would be crucial? • Does the stakeholder have information, technologies or resources that could be useful/helpful to the OPERANDUM? • Is the stakeholder directly affected by the intervention? (an impact on the stakeholder's belongings)
Stake/ interest	• Does a stakeholder have well-aligned norms, opinions and goals? • Does the stakeholder have opposing norms, opinions, goals? (This is also a reason to engage) • Is him/her someone who could derail or delegitimize the process if he/she were not included in the engagement? • Is the stakeholders directly affected by the intervention? • Do stakeholders have an interest to actively contribute to the project?
Legitimation	• How legitimate is the stakeholder's claim for engagement? • How much influence does the stakeholder have?
Willingness	• How willing is the stakeholder to be engaged? What is the stake he/she has? • What is the potential level of engagement (ranging from dissemination of information to active collaboration)?
Risks	• Are there any risks that can be foreseen when engaging or not engaging a certain stakeholder?

Showcase 1: Stakeholder engagement requires continuous actions – experiences from two OALs

OAL Austria

For the OAL-AT team, the choice for a location and the first identification of potential stakeholders was made more or less simultaneously. In a pre-project phase during the elaboration of the proposal, one stakeholder, a local expert, with whom the OAL team had a previous working relationship suggested the current OAL location. They were able to engage other relevant stakeholders, most of them also local experts, in the initial discussions about setting up an OAL, coming up with a research plan, and potentially effective NBS. This first group of stakeholders was very important in establishing the OAL and making progress towards the OPERANDUM objectives. Besides the local experts who actively shaped the OAL a representative of the residents was continuously informed about the latest developments.

The group of stakeholders has expanded with new stakeholders, including landowners, during the course of the project as the NBS plans became more concrete and the monitoring activities were started. Recently, the selection of two NBS (optimized forest management and sealing of streams and channels) has also increased the number of stakeholders actively involved in the OPERANDUM project, since new expertise and supplies are needed to successfully implement these NBS. Furthermore, the sealing of streams and channel needed to be approved by environmental authorities who proposed additional monitoring experiments in the course of the permission procedure. Stakeholder identification is a continuous process that depends on the phase of the co-creation process. The constellation of primary stakeholders actively engaged in the project and secondary stakeholders who are informed about the developments within the OAL changes along with this process.

OAL Italy, River Panaro Site

In Italy, River Panaro Site OAL, several attempts have been made for engaging one of the companies involved in the installation of the NBS on the experimental site. The company was hardly available for face-to-face meetings, but at the same time complaining about a lack of assurances in the long-term activities assignments. Several phone calls and e-mail exchanges have been performed for engaging this stakeholder and for benefiting from its expertise. All the steps required from standard procedures from the administrative, research and reporting points of view have been carefully followed, providing sufficient guarantees on the action plan. Nevertheless, the stakeholder sometime seems to back out from its initial interest. This could be possibly due to the unavoidable risk related to the research activities, which does not aprioristically choose a winner and a loser, but mainly let the experiments and data interpretation decide for the better solution or the extended or variable times required for the end of activities and duties. The fundamental role of OAL members, for this reason, was to keep the communication flow constantly open throughout all the main phases of the co-design and to inform the progress and the critical aspects performed. By doing so, mutual knowledge among actors grow and consolidate, building trust and steering actions to be taken in order to reach significant improvement in the NBS experimentation.

Those stakeholders that have primarily some economic interests in activities related to the implementation of NBS and that must consider the corporate budget as a leading parameter for any action, could be hardly receptive to research improvements and environmental aspects. This may require a longer time for stakeholder engagement than standard practices and bring out limitations in their applications. Continuous communication with such companies for the whole time of research activities, sharing results and achievements, is vital to keep the stakeholder engaged.

4.2 Getting to know each other and the social-ecological system

Once the stakeholders have been identified and contacted, the next step is to move on to co-designing the project plan. This is enabled by a trustful, open and equal atmosphere. Various techniques can be used to understand, how different people are related to the place and to each other, and what kind of expertise and knowledge they have and can bring in regarding the context and the NBSs. At the beginning of the project, it is also being useful to explore the different expectations related to the project.

4.2.1 Methods for mapping the expertise and knowledge

Although the expertise and the role of the stakeholders have been identified at some level in conjunction with the stakeholder mapping, it might be good to let the participants themselves express their role and knowledge:

Venn diagram: This tool provides a structure to clarify each participant's expertise (e.g. background, interest, discipline) in relation to joint topics. The tool consists of three or more circles indicating topics that overlap. Based on their expertise and interest, participants are allocated to a circle or to an overlap area. Applied to a heterogeneous group of people, this tool serves to: 1) Show the diversity and distribution of participants' expertise; 2) Cluster participants around joint topics. See e.g. https://naturalsciences.ch/topics/co-producing_knowledge/methods/td-net_toolbox/venn_diagram

Multi-stakeholder discussion group: The multi-stakeholder discussion group brings together representatives of science, civil society, the private and the public sector to work on the development and implementation of a (research) project. The taken approach enables them to share their tacit knowledge and bridge different thought styles. It involves a specialized moderator using informal settings and story-telling. https://naturalsciences.ch/topics/co-producing_knowledge/methods/td-net_toolbox/multi_stakeholder_discussion_group

4.2.2 Methods for mapping the participants' expectations of the project/event

People may have different understandings and expectations of any activity in the project, or even of the project itself. Therefore, it is important to jointly agree and communicate the aims of the whole project as well as individual phases. A common understanding or at least acknowledging different views and expectations regarding the project activities or the entire project may prevent conflicts or help to resolve them.

Outcome spaces framework: It provides a structure to reflect on, and classify participants' preferred outcomes in a transdisciplinary project or a single event in a differentiated way. The focus may be addressed (in the form of questions): (1) an improvement within the situation or field of inquiry, (2) the generation of relevant stocks and flows of knowledge, including scholarly knowledge and other societal knowledge forms (3) mutual and transformational learning between the participants. Different views are collected and jointly discussed. See e.g. https://naturalsciences.ch/topics/co-producing_knowledge/methods/td-net_toolbox/outcome_spaces_framework

4.2.3 Methods to getting to know the social-ecological system

Besides the actual knowledge, the stakeholders may have different experiences, feelings emotions, memories about the place and community concerned. The place may afford them various things:

livelihoods, recreation or symbolic meanings. Their "sense of place" may affect the motivations and willingness to contribute to the project, having implications also their overall actions in the project. Therefore, we must understand the driving forces motivating human actions as well as the effects of these actions on the ecological and social systems in the wider context. There are various participatory ways to explore and share this knowledge and experiences.

Field trips: Nature-Based problems and their solutions are connected to a physical place. Field trips may be useful to discuss these issues in a real setting. Besides informal interaction and knowledge sharing, facilitated focus group discussions may take place (see Showcase 2), as well as other more creative methods like evoking the senses and storytelling (see 4.3.2).

Focus group discussion: In the focus group discussion setting, the researcher facilitates or moderates a group discussion between participants and not between the researcher and the participants. Unlike interviews, the researcher thereby takes a peripheral, rather than a centre-stage role. Otherwise, the focus group discussion follows the conduct of the semi-structured interview (see Fig. 14.).

Participatory mapping refers to a set of approaches and techniques that combine the tools of modern cartography with participatory methods to represent the spatial knowledge of local communities. Participatory mapping provides a visual representation of the place, and its social and ecological knowledge and values, and may help to see the connections between the problems. The discussion around the maps may add valuable information about the place or the social relations concerned. It can apply modern techniques but also more traditional (plot a spot on the maps). (see e.g.: https://www.ifad.org/documents/10180/d1383979-4976-4c8e-ba5d-53419e37cbcc;

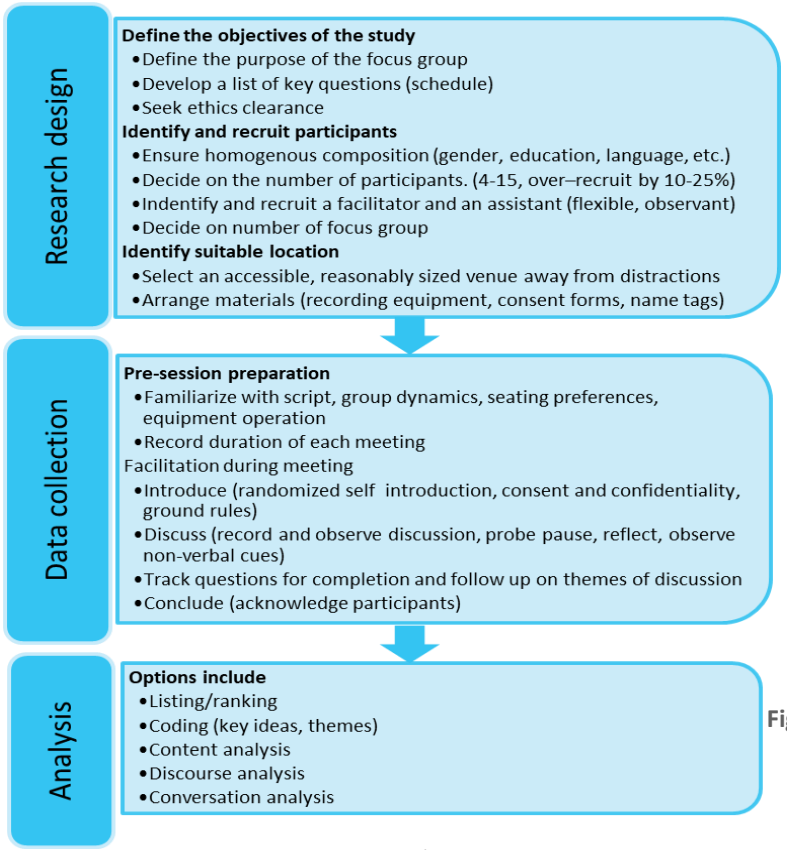


Figure 13: Organising a focus group discussion. Adapted from Nyumba et al. (2018).

Showcase 3: Field trips - OAL AUSTRIA

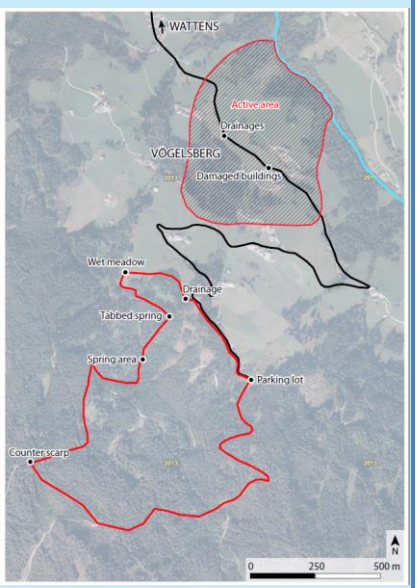
Aim:

The OAL-Austria is located south of the town of Wattens in Tyrol (Austria). It is characterized by a deep-seated gravitational slope deformation (DSGSD), which has recently shown active movement in the order of 4cm/a. The landslide continuously threatens several buildings, infrastructure, and managed forests and farmland. These elements at risk are situated on top of the active landslide, bearing the impacts of the continuous movement. The Austrian OPERANDUM team collaborates closely with expert stakeholders and public authorities with an aim to better understand the underlying processes of the slope deformation and to design and implement appropriate NBS. Most of the collaboration has taken place in the form of field trips and multi-stakeholder discussion groups, which have proved to be useful methods so far.

Application:

Several field trips were organized with different stakeholders, including with local experts, public authorities, and a representative of the local community. The OAL team mostly took the initiative to organize these fieldstrips, but one was organized at the request of a stakeholder. These field trips were used to gain a good understanding of the social-ecological system of the OAL, observe the impacts of the slow-moving landslide on buildings, infrastructures and the land, discuss monitoring strategies and potential NBS and their location, and to do field measurements. Depending on the goals of the field trip, interesting sites such as a wet meadow, spring area or potential NBS location were selected beforehand. For an example of a route planned for a field trip (see the map).

No predefined approach was used during the field trips; discussions were informal between the stakeholders and the OAL team and were later documented in field trip notes. Interestingly, in the beginning of the OPERANDUM project the OAL team learned about the OAL from the stakeholders during the fieldtrips. Lately, however, it also the OAL team that is able to provide the stakeholders with new insights about the OAL.



OAL Austria field trip. Map of the route. Photo Thomas Zieher 02/10/2018.

Lessons learnt:

The methods used so far in the Austrian OAL, have served the OPERANDUM team well. Field trips and multi-stakeholder discussion groups provide ample opportunities to exchange all type of knowledge in an informal and relaxed environment and make the best use of stakeholders' expertise.

4.3 Problem identification

Problems are defined as concrete, identified and structured questions within problem fields (i.e. an area in which the need for knowledge related to empirical and practice-oriented questions arises within society). In the case of NBSs, it might be also good to assess the stakeholders' risk perceptions. In a co-creation context, problems or risks cannot be considered as given, since researchers and different groups of stakeholders may have a different understanding about the problem. The stakeholders have a personal relationship with the place or landscape, which is the object of the project. In this case, it is necessary to let them process and express their values, emotions and feelings regarding the place or the problem. Therefore, in the first phase, it is important to determine what concrete problems are and what they consist of. Various questions, as well as different problem statements, can be used to specify these problems: What is the problem/risk? Whose problem/risk is it? What is the driver of the problem/risk? Is it an anticipated need or expressed problem? The problem statements can be divided into sub-questions that are dealt with and answered in relation to one another, after which the answers to the sub-questions go through a process of integration. (Pohl and Hirsch-Hadorn, 2008; Pearce and Ejderyan, 2019).

3.2.1 Methods for problem/risk and case study identification

Focus group discussions and field trips (see Chapter 3.1.) are also good tools for problem and case study identification. Besides or in combination with them there are other methods to be used:

Mindmapping: Mindmapping techniques may be useful when exploring different understandings, conceptualisations, values, ideas related to the problem. Here various means and tools may be used, like a virtual online board (e.g. flinga.fi), mindmapping tools (https://www.mindmeister.com); post-its, big white paper. Mindmaps have an organizational structure that radiates from the centre and use lines, symbols, words, colors and images according to simple, brain-friendly concepts. Mindmapping can be an individual or group exercise. (See Showcase 5).

Silent conservation: This is a method that combines elements of mind.mapping and concept mapping. The goal is to capture and display a collaborative understanding of a topic in a graphical format. As the title says, the main part of the work is carried out in silence, first individually and then collectively. It makes all participants voices equal whether or not they are extroverted or introverted (see Pearson et al. 2018, 50).

Soft systems methodology: This is a methodology to structure complex real-world problems and to develop and identify desirable and feasible changes in a heterogeneous group of actors. In particular, it supports dealing with different thought styles or worldviews. (see Td-net- network for transdisciplinary sciences soft system analysis)

Reflective cycle: This method is based on the cognitive psychology and work of Ulric Neisser (1976) to be used in group discussion, conflict resolution or as a tool in negotiation, or when you want to participants. Unlike interviews, the researcher thereby takes a peripheral, rather than a centre-stage role. Otherwise, the focus group discussion follows the conduct of the semi-structured interview (see Fig. 14.).

Participatory mapping refers to a set of approaches and techniques that combine the tools of modern cartography with participatory methods to represent the spatial knowledge of local

communities. Participatory mapping provides a visual representation of the place, and its social and ecological knowledge and values, and may help to see the connections between the problems. The discussion around the maps may add valuable information to the place or the social relations concerned. It can apply modern techniques but also more traditional (plot a spot on the maps). (see e.g. http://europe.foss4g.org/2014/content/community-maps-%E2%80%94-platform-participatorymapping.html)

Evoking the senses: People may have many sensuous experiences of the place. These senses may be important for their sense of place and reveal underlying perceptions and values related to the place. This method can be used when a particular case or issue is explored, especially the one that is linked to a specific place. It allows participants an opportunity to identify associations and emotions related to a specific issue or case. (see https://edepot.wur.nl/441523, p. 28).

Close observation: Typically, people move directly from posing a question to searching for an answer. Conversely, this practice supports a form of more oblique and intuitive problem-solving. Participants are asked to formulate any important question, and then take the time to closely observe their surroundings and see what insights or wisdom emerge (see https://edepot.wur.nl/441523, p. 33). This can be combined with me-we-us -method. <

Storytelling: People give the world meaning through various stories. Stories are powerful tools for achieving results (Galafassi et al., 2018). “Good stories” inspire action, establish connections, explain changes, strategies, decisions, and help to overcome established customs, practices and views. In brief stories (Lindsay, 2015)

- provide a bridge between two parts of the human brain connecting the logic and emotion in order to explain a situation based on their own experiences;
- give meaning to a situation or event: the story is; what people want to hear when they do not understand;
- analyse complex concepts and meanings in acts and attitudes: the stories give the answer when people say - "can you give us an example”;
- play connecting social role in the past, present and future;
- have the power to convey information coherently; and
- can be recorded and easily kept in the memory of people.

Stories can be told or listened to or visual**. A visual story will** can be used when describing the processes. It uses storytelling to collect individual perspectives and to create a joint understanding of the past. The starting point is a simple timeline (horizontal axis) on an empty poster. The assembled group of participants agrees on and marks major process phases or crucial events of their joint story and finds a way to exchange on what has been important, for whom and why. build common understanding and will. It starts with a description of a situation or current state of the art. After that, the participants will be asked to reflect it for example with the following questions: What did you hear? How do you feel about it? What does it mean to you? How can I apply it in my work?

How to tell a good story?

An effective **oral narrative** means exploiting a story for transmitting a message: clear information, structure, specific purpose, achieve the objective and cause positive emotions. In short, an effective story can answer the audience's basic questions: who, when, what, where, why (Vogt, Brown and Isaacs 2003).

- Engage the audience /stakeholders
- Build the scenery (like being there physically and spiritually)
- Build and release tension
- Focus on significant/important/ remarkable
- Keep the flow on a logical way
- Give a sense of recapitulation (sum up)
- Create vivid characters
- Control our voice and our facial expressions
- Talk with hands and gestures
- Practice. We learn the story.
- Always retain control of our audience
- Allow and encourage interaction with our audience.

Expanding time: When NBSs are concerned, it is important to assess the problem and the solution in the short and long term perspective. Expanding time method is used to disrupt participants' default experience of time, supporting them to look at the case study or a specific issue from multiple perspectives (see https://edepot.wur.nl/441523, p. 34).

Appreciative inquiry: Sometimes, instead of talking of problems, the attention can be directed to strengths and future. In other words, the aim is to build – or rebuild – processes around what works, rather than trying to fix what does not work. Appreciative inquiry practitioners try to convey this approach as the opposite of problem-solving. The most common model of appreciative inquiry utilizes a cycle of four processes, which focus on

1. *DISCOVER:* The identification of processes that work well.
2. *DREAM:* The envisioning of processes that would work well in the future.
3. *DESIGN:* Planning and prioritizing processes that would work well.
4. *DESTINY* (or *DEPLOY*): The implementation (execution) of the proposed design

The ultimate aim of AI is to promote change at any level within a system, from one-on-one coaching to team building, to system-wide change. Learn more: https://appreciativeinquiry.champlain.edu/learn/appreciative-inquiry-introduction/5-d-cycle-appreciative-inquiry/

Fuzzy Cognitive Maps: Fuzzy Cognitive Mapping (FCM) is a widely used participatory modelling methodology. In this method stakeholders collaboratively develop a 'cognitive map', representing the perceived causal structure of their system. This map can be directly transformed into simple mathematical models. Such simple models provide thinking tools which can be used for discussion and exploration of complex issues, as well as sense checking the implications of suggested causal links. They increase stakeholder motivation and understanding of whole systems approaches, but cannot be separated from an intersubjective participatory context (see e.g. https://www.cecan.ac.uk/sites/default/files/2018-03/FCM_summary.pdf, Santaro et al., 2019).

Showcase 4: Field trip to observe the functionality for different solutions – OAL ITALY PoRiver

Aim of the method:

Field trip represents possibly the optimal method to recognize a problem and to overcome divergences on the possible solutions to undertake. Issues at stake were, in our case, the definition of the area where NBS should be implemented.

Application:

On 09/05/2019, a field trip has been planned participating UniBo working group and one of the principal stakeholder for the OAL-Italy, Interregional Agency for the Po River (AIPo) to visit the area where the NBS could be implemented. The area was recently subjected to restoration work (hard, grey solution) and the river level was reducing just a few days after the hydrometric peak. The contemporary occurrence of these two events induced a local instability in the riverbank internal slope due to the increase in weight and the saturation of the soil, as can be seen in the figure below, producing the same kind of failure that the intervention just realized aimed at tackle and reduce.

Lessons learnt:

The direct observation of the limit of standard, grey and hard engineering solutions can directly and productively improve the attractiveness of NBS. In this sense, we find field trips are unavoidable experiences for useful and optimal stakeholders' engagement and NBS implementation.

Photo: Beatrice Pulvirenti

Showcase 5: Mindmapping used for problem identification – OAL Finland

Aim:

In the first meeting with the primary and secondary stakeholders, mostly landowners in the catchment area of the Puruvesi, the OAL team wanted to engage the participants in the discussion related to the problem definition.

Application:

After the presentation of the researchers about the OPERANDUM project and the recent results of the state of the Lake, we organized focus group discussions and used mind-mapping as a tool. The questions were: What kind of observations have you had related to the state of the Lake? What are the reasons for the situation? What could be the possible solutions? The researchers were reporters of the 5 focus groups and used a web-based whiteboard tool (flinga.fi) to collect the main items of the discussion (see Figure below). The results were visible and shortly presented and discussed at the end of the session. Afterwards, the results were organized and analysed in the more structured form using a software tool (Mindmaster.com) and included in the booklet that was delivered for the participants in the next meeting (field trip).

Lessons learnt:

The method worked very well in this case. There were some silent participants who would not perhaps participate in the public discussion and could express their opinion in a small group. The results were available quickly for all. More time for the discussion would have been good (now only half an hour and it was a bit rushed).

An extract and translated from a virtual mindmap that was produced during the small group discussions. The participants were asked to identify reasons for the current state of the Lake. Similarly, they were asked to tell about their observation about the Lake environment and the possible solutions for improving the state.

Showcase 6: Focus Group Discussion on Vulnerability and Risk Perception in OAL Greece

Aim of the method:

In the WP6, one of the tasks was to research on the vulnerability and risk perception of the community inhabiting the OAL area. We decided that the Focus Group Discussion would be an effective tool that would provide us useful information regarding the major points of discussion to identify primary ecosystem service benefits from OAL site, the identification of major hazards in the locality and ranking of these hazards. Another aim was to establish a relationship of trust with the participants in order to facilitate our future collaboration and examine the way the community perceives the existence of flood risk or if they believe, there is any other risk the community faces.

Application:

The FGD took place in the centre of OAL Gr, in Kompotades village, in the coffee shop of a gas station, on 16/4/2019. It was organized by KKT-ITC and PSTE and carried out by KKT-ITC team members and the participation of PSTE's Vice Governor. There were eight participants, representative of the local community members, mostly farmers and members of their family. After a brief presentation of OPERANDUM and the aim of the specific FGD, the team shared yellow stick-it papers and set up the whiteboard. The questions that we have shared were: How does the community interact with the natural area of the OAL (river/forest area) and to what extent does the local community appreciate/derive benefits from this area, what are the major hazards that affect the locality? How would you rank them, in terms of the potential severity of effect/ priority to OAL stakeholders, when do the hazards usually occur in the area? When did recent extreme events of each major hazard occur? How much/what areas were affected, what are the major risks related to the hazards? Which one is the most severe risk compared to others? However, when we asked the participants to write their answers and stick them to the board, there was a general discontent to this process, as they were quite unfamiliar with it. The facilitator quickly changed the process and improvised, writing the questions on the board and noting down the answers on her own. The discussion before the actual FGD process had made clear to the participants that the scientific team was not there to talk, but on the contrary, to listen and consider what the community has to say. So mostly everyone had something to say and when we noticed that someone was silent, we kindly and humorously encouraged him or her to participate. In general, we consider the FGD a success, because everyone shared an opinion, the research team managed to come up with conclusions concerning the needs and requirements linked to the risk, from the relevant stakeholders' group and we have built up a relationship of trust, as to enact further collaboration and interaction with other members of OPERANDUM and researchers.

Lessons learnt:

The overall impression we gathered from the interaction with the participants was very encouraging, as they repeatedly stated that it is the first time someone consulted them and it was obvious they needed to share the problems they face. Another important remark, from our point of view, is that they mentioned several times how important it was to them, that we have shared scientific information concerning the river, the ways hazards and risks can be identified and also the fact that in the way we did it (comprehensible speech), they did not feel underrated. The process we followed was very inclusive, no one was left without being listened to, and this fact was highly appreciated by the group. Out of the discussion, we also concluded the perception that they know perfectly well how nature works if there are no human interventions involved and that they are quite skeptical of interventions that have been implemented in the area, so far. They also mentioned that there used to be a significant culture of maintenance for the river by the community, before the grey interventions, which changed the shape of the area, took place.

4.4. Towards a project plan

After the identification of the problem and with the stakeholders, planning of the project can start. This phase may utilise methods that aim to bring together different types of knowledge (scientific, local, practical, applied) to co-design the project. There are various ways to design and agree on the process:

Roadmap: A roadmap is a strategic plan that defines a goal or desired outcome, and includes the major steps or milestones needed to reach it. It also serves as a communication tool, a high-level document that helps articulate strategic thinking — the why — behind both the goal and the plan for getting there. The important questions are: what (concrete, doable actions), who (who takes responsibility) and when (milestones). (See showcase 7.)

Co-designing a large research project: Page et al. (2015) have designed a model of iterative cycles of engagement between academic and non-academic stakeholders for co-designing a large research project. After the initial problem and case study identification, a series of surveys and workshops will be organised to identify the needs and focus of the project.

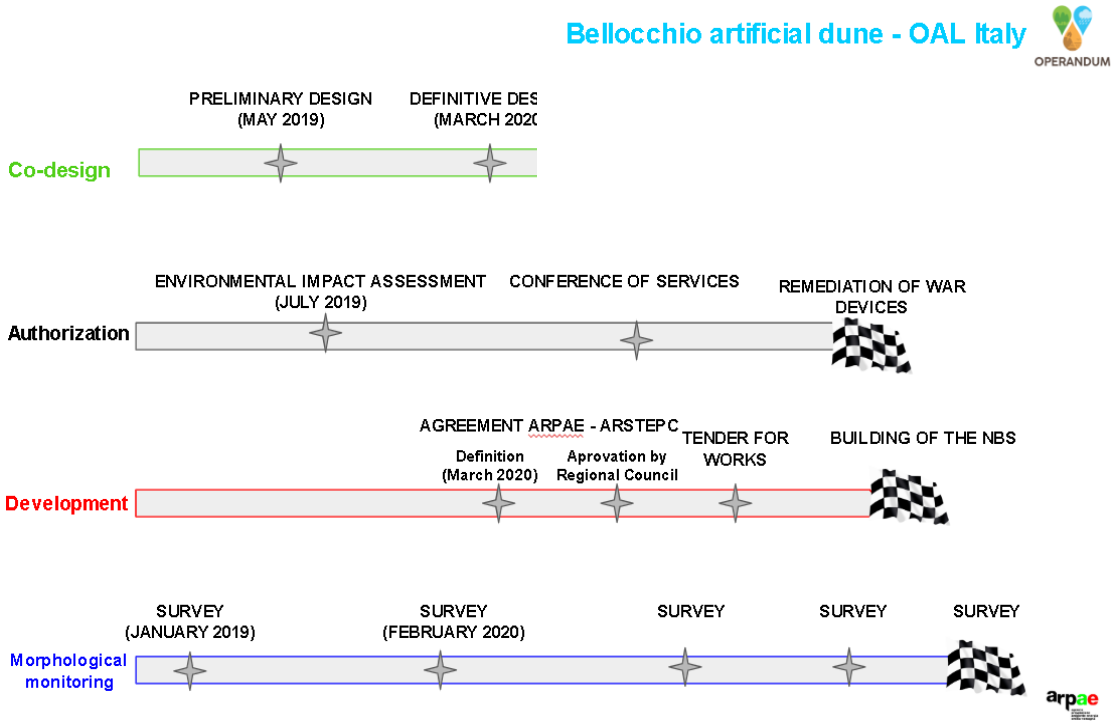


Figure 14: A roadmap designed by the OAL Italy – Bellocchio.

Showcase 7: Making roadmaps for the co-creation process – All OALs

Aim:

In the workshop organised by Task 1.3. in Helsinki 4-6 February, 2019, the OALs got to know each other and became familiar with the co-creation processes and methods. In order to practice a roadmap tool and to proceed with the planning of the work at the OAL level, each of the OAL team prepared a Roadmap for the next 6 months or similar short term objective meaningful to their OAL).

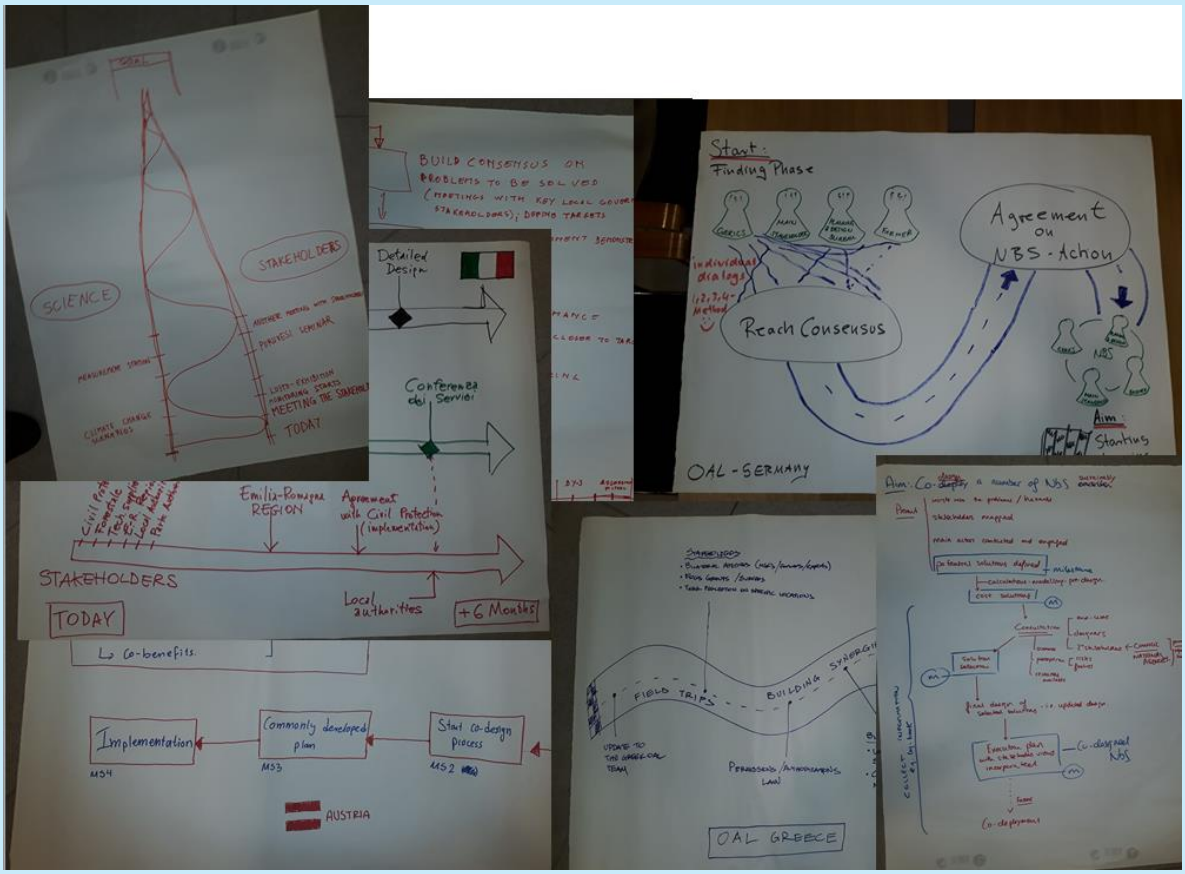
Application:

The guiding questions were the following:

- Set the aim: What is a successful goal from the point of view of co-design?
- Set the milestones and actions (approach): How to get there?
- What help do you need along the way? Make a list on A4 and name 1-3 most important

Lessons learnt:

Each of the group approached the task in slightly different ways, as can be seen from the maps below. Yet, here as in many other methods,besides the actual output (the map), the activity itself (process) is important: Drawing a map and the guiding questions serve as means to jointly discuss and reflect the issue concerned assisting in team building and interdisciplinary collaboration.



Planning the co-creation processes in a workshop in Helsinki. The roadmaps show the main steps and milestones Photo: Katriina Soini.

5 Co-development

Once we have identified the partners, the social-ecological system and the problem or risk to be addressed, various pathways can be taken to find and agree with the solution(s) to be implemented. Here, again we can take various steps and approaches.

5.1 Exploring different solutions and pathways

Solutions are often future-oriented. Various scenario-planning methods have turned out useful to depict different solutions and pathways to get there. The scenario planning methods use qualitative and quantitative to collectively draft possible developments of a societal challenge. The tools are suited to be used by heterogeneous groups of experts with diverse disciplinary backgrounds, as well as various societal actors. We may discern various types of scenario techniques (Star et al., 2016) 1) according to the owner of the process:

- **In researcher-driven approaches**, experts drive scenario development with an objective of providing rigorous descriptions of plausible futures, including details that are well supported by the available science. In climate change research, the most familiar scenarios are based on climate model projections in terms of temperature, precipitation, and other climate variables. They are often desk-research.
- **In participatory approaches with stakeholder**s, scenarios are both the framework and process to allow groups to reach agreements and make decisions. Another objective is diverse engagement, with attendant benefits of developing common understanding and community-building that fosters broader acceptance of the ultimate outcomes.

In a transdisciplinary collaboration, the latter type of scenarios should be favoured, but they could be combined with expert-driven approaches. The scenario planning techniques can also be classified 2) according to the aim:

- **Exploratory scenarios** describe a range of diverse, possible futures, with scenario teams working to assess the consequences of specific decision options. A central purpose of such scenarios is to disclose the potential consequences that different futures pose. Typically, the desired outcome is a revised strategy, policy, or perspective, and all created scenarios are deemed plausible and equally considered.
- **Normative scenarios**, in contrast, work backwards from a collectively preferred future that reflects shared values of diverse stakeholders, identifying courses of action required to create that future. They are common in regional, land-use, and community planning. The process is often termed ‘‘backcasting”—identifying what is the desirable future and what must happen for that future to become a reality. Kahane (2012) developed this thinking and labelled it as transformative scenario planning, noting that ‘‘its purpose is to enable those of us who are trying to change the future collaboratively to transform, rather than adapt to, the situation we are part of.”

Showcase 8: Co-creation Workshop - OAL –IRELAND

Aim:

Citizen science workshop was conducted as a part of OPERANDUM's OAL IRELAND citizen engagement programme with the aim to educate and create awareness on flooding and its adverse effects on human life. A design thinking-based approach was undertaken to understand the general perspective of the people on Nature-based solutions, its various types, the characteristics, the suitability of deployment that can be used for designing a flood mitigation system. The second aim of this workshop was to have a participatory role of citizen engagement where the citizens will be empowered to monitor weather data at various locations in their vicinity which will help in better understanding of the flooding process as well as will enable the upscaling of OAL concept where a vast area is monitored to regulate flooding. The event began with an interpersonal discussion where the aim was to understand the flooding process in the locality they work or live and how they are mostly affected by flooding.

How it was applied:

The workshop started with a brainstorming session where various conceptual interconnectedness of flooding with roads, buildings, women, children, and seasons was discussed. Special focus was given on what work has been done so far that has been successful to some extent and what work needs to be done to address the gaps still prevailing to control the floods. Notes and highlights were made as to *how previous flooding experiences have influenced the life of the people* in the area.

Having shared previous experiences, it was also important to understand *how it can shape the expectations they have from new flood protection schemes, and how as citizens, can they be proactive in dialogue and co-creation process of new policies for flood control; and what kind of challenges there are in this process and what are the doubts they had.* The types of user involvement, the engagement of the sensitive and vulnerable sections, the cultural differences were iterated for citizen involvement during co creation process of flood protection methodology. The participatory stakeholders, majority of them are the residents from Dublin, also discuss expectations and considerations of the element of translation and how the workshop moderator will conduct the session. Besides deciding the program of the day in detail, they also focused on how to ask questions that will help "open up'' for the workshop participants' thoughts in relation. An exercise was to vote and invest the type of nature-based solution (NBS) they feel is more relevant, why they are relevant, and kind of maintenance is necessary for those NBS to continue functioning it in the future. They did this by using post-it notes from previous sessions as input in the planning process and continuously use whiteboards for outlining and noting their plans and thoughts.

Once the preliminary inputs were obtained from the stakeholders, *a presentation on flooding* was delivered to the group. The presentation included scientific definition of floods, when we can term a scenario as floods, examples of flood events (low, medium, extreme) that were observed across the world, intensity of flood events and how climate change is impacting the flood occurrence globally, impact of floods in several countries in terms of mortality and economic loss and finally the solutions taken by several authorities to mitigate flood and the damages associated to it. This presentation was delivered by using a combination of imagery, graphs, plots and animation videos.

In the next part, the stakeholders were asked to engage themselves in co-designing different types of NBS as alternative flood mitigation systems. To successfully complete this task, several guidelines were provided to them through infographic illustrations, visualizations using films and maps. The goal of this exercise was to identify few preferable NBS from a set of potential NBS that were implemented at different parts of the world. Several factors such as aesthetic, recreation as well as economic value (urban agriculture) were considered by the stakeholders during co-design and hypothetical co-deployment stage. One core objective of this activity was to empower children and young people's creativity to reimagine the challenge of flooding from a different perspective. Their

unique and priceless ideas have sparked researchers to reimagine how they approach problems, leading to new innovations across the field. This mindset played an essential role in co-creating innovative solutions to improve flood mitigation in a city.

The workshop has incorporated the use of LEGO building blocks to understand the relationship between the build components of the area, the environmental factors contributing to floods and the impact it has on human lives through a synthesized system. The synthesized models developed with help of LEGOs help in determining the underlying complexities which may arise due to flooding process and its intensities which may impact human behavioural change in the future. In other words, the synthesized models can build up possible simulation scenarios to understand what level and extent of flooding can possibly impact, level of damages in the area, and type of behavioural pattern that may be observed from the people. This way alternate remedies that can be helped to explore to prevent flood damages in real life by adapting a resilient physical model, cognitive preparedness of the people and effective environmental policies.

Finally, an opportunity hotspot template was developed based on the inputs gathered from the ideas and experiences of the citizens. For this purpose, the flood vulnerability map (Figure 3) from http://www.floodinfo.ie/map/floodmaps/ that were prepared by Office of public Works (OPW), Ireland was used and stakeholders were asked to identify critical locations in the map.

Lessons learnt:

NBS design along with environmental awareness helped in clustering the different types of stakeholders, their level of willingness, the design of NBS in relation to the growing topographic dimensions of the area attributing to the fact that more business hubs formation, population growth, expanding pattern of urbanization of the area.

LEGO workshop. Photo: Bidroha Basu.

Showcase 9. NBS perceptions and preferences at OAL-UK

Aim: Following a meeting with the main stakeholder group, the Catterline Braes Action Group (CBAG), we wanted to gather some perceptions of Nature-Based Solutions and identify which of the presented potential NBS were preferable to the stakeholders and why.

Application: GCU were attending the Annual General Meeting of CBAG to provide them with an update on the OPERANDUM project. We prepared a Powerpoint presentation and a follow-up survey. The presentation briefly discussed the potential NBS for Catterline, where they would be located, how they would be built and what we would ask of the stakeholders in terms of input and participation. We distributed the surveys, which had a total of 10 pages, prior to the presentation to give them as long as possible to complete them.

Following a short section gathering demographic information, the survey respondents were asked the same 3 questions for 10 different NBS. The NBS were introduced individually with a short text description and photo. Respondents were then asked (On a 7-point Likert scale from "Strongly Disagree" to "Strongly Agree"): : a) To what extent they thought the NBS was appropriate for Catterline; b) What they liked about the NBS; c) What they disliked about the NBS.

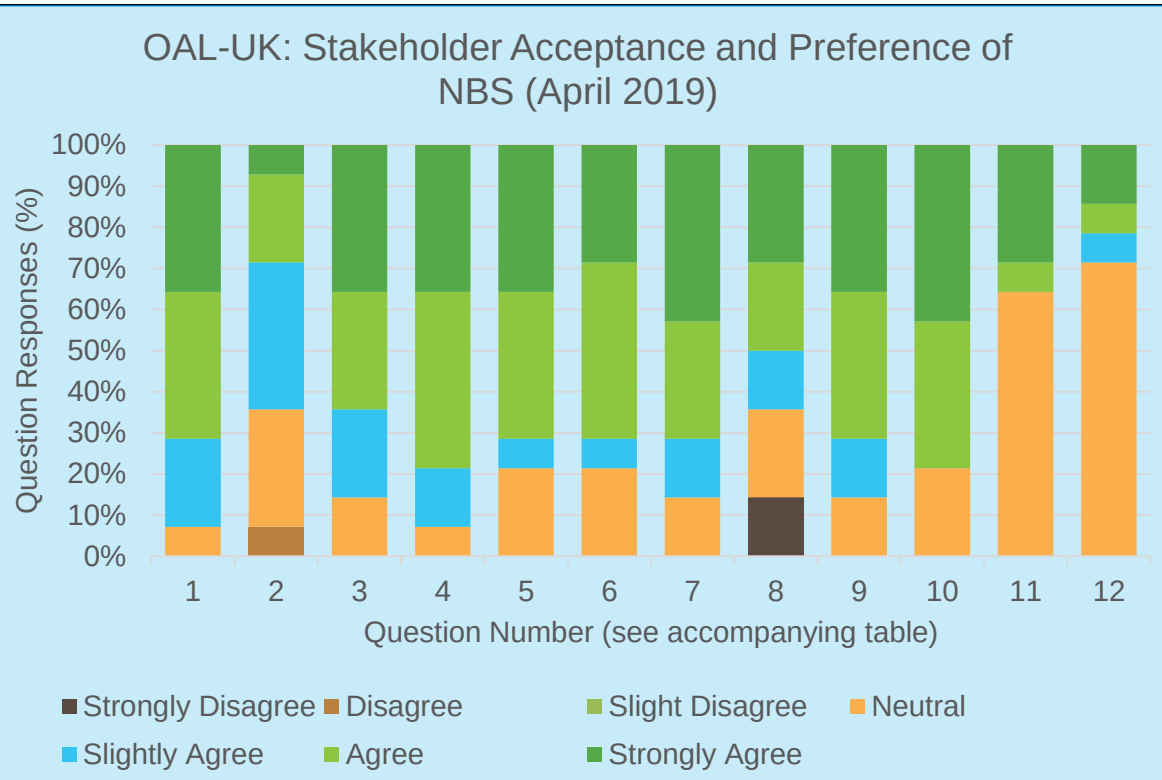
We decided to ask for feedback on NBS perception at the level of each NBS individually, rather than ask for preferences through comparing NBS. The reason for this was to gain a more thorough understanding of the acceptance and perceived suitability of all NBS; a comparative, single-selection approach would only have shed light on the preferred NBS of each respondent. The approach also allowed stakeholders to voice their priorities, concerns and expectations through the like/dislike question and gave us more understanding of the reasons behind each Likert score.

The results highlighted that overall the respondents were supportive of the use of NBS and could see the benefits for their village. A few NBS emerged as clearly having broad support, while a few others were debated more. The open-ended questions highlighted some misconceptions and confusion about how particular NBS operated, providing us with actions for future engagement, to clarify confusion. The results were analysed with Excel and two reports were prepared: one internal OPERANDUM report with full analysis and future steps for stakeholder engagement; and a second summary report for feeding back to CBAG that reported on the compiled results, and addressed the misconceptions and confusions discovered.

Lessons learnt: The intention was to distribute and collect the surveys while at the AGM; we handed them out at the start of the OPERANDUM presentation to maximize the time people had them. However, many of the 30-40 people in attendance stated that they'd like to take them away, read them properly and fill them out in their own time. We therefore arranged with the chair of CBAG that he would collect them by a date approximately 2 weeks away and return them by post to GCU. Resultantly, we only received 14 of the 30-40 distributed surveys back. For future surveys we will consider this preference to increase response rate; indeed in September 2019 Carl Anderson from the University of Glasgow visited Catterline and resided there for one week, visiting households in person with a survey that had an 80%+ response rate. We will also create an online version of future surveys to diversify the way people can complete them. Additionally, as we developed the survey around the AGM presentation, we only distributed the survey to CBAG members; there are another approximately 80 people in the village who are not CBAG members. We therefore identified that we needed to proactively engage with non-CBAG village residents and have since done so through the local primary school and recreational groups.

	Statements in Support	Statements in Opposition
Community building	*Example: "Living outside of the village property won't benefit but activities produced by construction will bring village members closer together" (M, 35-44)*	*n/a*
Environmental impacts	*Example: "would be great to increase shellfish population and absorb the destructive wave energy at the same time" (M, 45-54)*	*Example: "[is this NbS] green?" (M, 65+)*
Comparisons to "grey" solutions	*Example: "Would be better for the landscape than having "grey" infrastructure" (M, 35-44)*	*n/a*
Cost	*Example: "easy to do, cheap" (M, 35-44)*	*Example: "looks expensive and challenging to install" (M, 45-54)*
Aesthetic	*Example: "natural looking" (M, 35-44)*	*Example: "visually not the most attractive, at least in the short term" (M, 45-54)*
Impact on views	*Example: "pleasing to look at. Don't see how it would benefit the actual property" (M, 65+)*	*Example: "[…] could obstruct views across the bay" (M, 45-54)*
Ease of installation	*n/a*	*Example: "difficult to install anchors on slope" (M, 35-44)*
Ease of maintenance	*n/a*	*Example: "my worry is that these drains get blocked up in the long term and will cause water build-up" (M, 45-54)*
Immediacy of stabilising effect	Example: "proactive, immediate way of stabilisation" (M, 35-44)	Example: "[tree planting is] slow" (M, 35-44)
Perceived strength	Example: "strong support, covered with plants after a time" (M, 35-44)	Example: "[…] suspect the first big winter storm of the NE will deposit it all on the foreshore!!" (M&F, 65+)
Longevity	Example: "seems like a long term solution to part of the problem" (M, 45-54)	Example: "wonder if it will hold when the logs rot given the clay under layer" (M&F, 65+)
Relevance to Catterline	Example: "NbS can be a good solution as long as we deal with the free water as well" (M, 45-54)	Example: "don't see where this would have a use in Catterline?" (M, 45-54)
Evidence/known results	Example: "widely implemented elsewhere, proven solution" (M, 45-54)	Example: "prefer to "wait and see" before making judgement" (M&F, 65+)

Stakeholder Acceptance and Preference of different NBS in OAL UK



1=Tree planting; 2= Ground anchors with seeded bags; 3= Live lattice; 4= Live crib-wall; 5= Wattle fences and palisades; 6= Live drains; 7= Brush layers; 8= Shellfish reefs; 9= Live detlector; 10= Surface wetland

Photo: Alejandro Ollauri.

5.2 Co-research and citizen science

There might be several options for NBSs with different qualities. In order to find the most optional and socially accepted solution(s) for the given context or problem, it is good to compare the pros and cons of different solutions among a larger group of stakeholders.

5.2.1 Methods for exploring and innovating different NBS

Surveys: Surveys are classical way to explore attitudes towards and perceptions of different issues. Once the participants have sufficient knowledge of the potential solution, a survey can be conducted to explore, how the different solutions are perceived (see Showcase 9). In a survey also the marginal voices can be heard. (See Showcase 9).

Art-based co-creation workshop: Different solutions may also be explored in an art-based co-creation workshop. These workshops may aim to understand the relationship between the environmental factors (built and natural and social) contributing to floods and the impact it has on human lives through a synthesized system, as well as for creating a small preliminary model, a maquette, to represent specific physical ideas for the development of a particular place or collage. (see https://edepot.wur.nl/441523) (See Showcase 8).

Crowdsourcing: Crowdsourcing is a most common form of citizen science (see more on citizen science Bonney et al. 2009; Sauermaan et al. 2020). Here citizens voluntarily act as "sensors" collecting the data by the methods defined by the researchers. For example, citizens may monitor the prototype of the solution or environmental conditions where the solutions will be deployed to find most optimal location or installation. While citizen science is often recognized for its potential to engage the public in science and gain data, it is also uniquely positioned to support and extend participants' learning in science (see showcases 10 and 11).

5.3 Defining solutions

Scenario planning or citizen science techniques do not necessarily include any decision-making. Given the diversity of the drivers and factors affecting the problem, uncertainty, as well as interests related there might be a need to explore different options more closely in a systematic way to come up with a joint decision. There is a variety of techniques to assist decision-making.

5.3.1 Methods for defining solutions

SWOT - analysis: SWOT –analysis is an old technique, which helps to systematically analyse a phenomena or organisation by identifying strengths and weaknesses related to the present and internal factors and opportunities and threats related to the external factors in the future. SWOT can be also used in a participatory way by utilising e.g. mind-mapping techniques. (https://www.mindtools.com/pages/article/newTMC_05.htm

Plural Rationality Approaches (PRA): Here the aim is not to seek a consensus on a single best option, but rather a compromise solution reached through explicit elicitation of stakeholders' perspectives on the nature and cause of the problem and its solution. This approach draws upon the theory of plural rationality, which has demonstrated that in every policy discussion, there is a limited number of socially constructed stakeholders' perspectives that shape the discussion and decision-making process. These perspectives have been named as follows: hierarchy, individualism, egalitarianism, and fatalism. They are characterized by the stakeholders' views on what is relevant

and why for different stakeholders and help to understand and foresee different positions in the decision-making (see Scolobig and Lilliestam 2016). (Fig. 16)

Figure 15. Key phases of plural rationality approach as illustrated by Scolobig & Lilliestam 2016.

Multi-Criteria Decision Analysis (MCDA): Multi-Criteria Decision Analysis is a tool that can be applied to many complex decisions. It is most applicable to solving problems that are characterized as a choice among different alternatives. It helps focusing on e.g. what is important, logical and consistent, or easy to use. More specifically, MCDA is useful for: dividing the decision into smaller, more understandable parts; analysing the individual parts; integrating the parts to produce a meaningful solution. Generally, there are three main steps that need to be considered while using MCDA (see Fig. 17). When used for group decision making, MCDA helps groups talk about their decision opportunity (the problem to be solved) in a way that allows them to consider the values that each one views as important. It also provides a unique ability for people to consider and talk about complex trade-offs among alternatives. Indeed, it helps people to think, re-think, query, adjust, decide, rethink some more, test, adjust, and finally decide. https://projects.ncsu.edu/nrli/decision-making/MCDA.php. (See showcases 11 and 12)

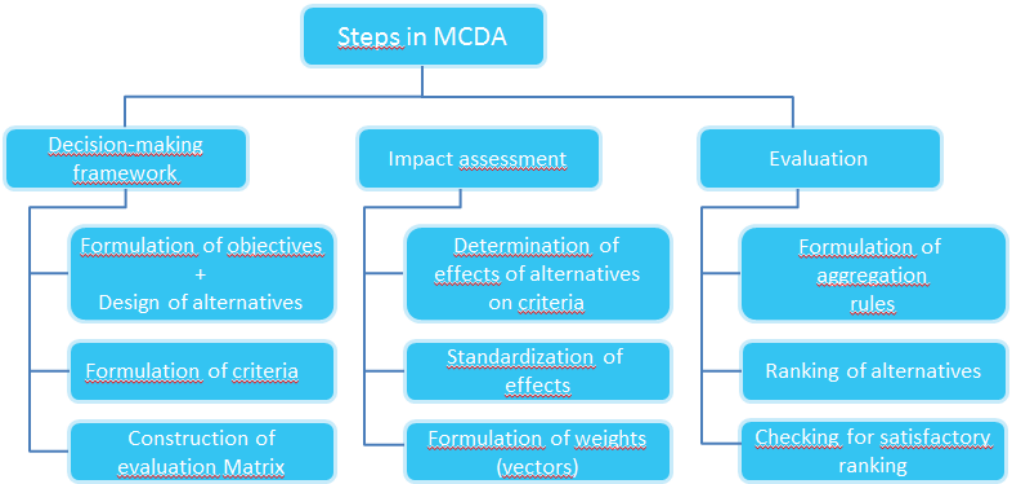


Figure 16: The main steps in MCDA. Drawing: Sisay Debele.

Showcase 10. Using citizen Science for measuring snow depth and density in OAL Finland

Aim of the method: At OAL Finland the initial motivation for applying citizen science was that it can be carried out as an interactive process with twofold aims. Firstly, volunteer citizens provide valuable data by measuring snow depth and snow density according to a monitoring plan in the catchment area of Lake Puruvesi. Measurement data obtained contribute to scientific understanding and quantification of surface runoff caused by excessive, rapid snowmelt that produces nutrient and sediment leaching especially from heavily managed forests (e.g. clear-cut, draining). To improve and calibrate models and estimate uncertainties in results snow observations by volunteers complement the regular network of snow water equivalent (SWE) measurements that are relatively sparse, e.g. no measurements are done in the catchment area of Lake Puruvesi. Regular in-situ measurements are merged with satellite-based SWE product. The additional measurements by volunteers provide high-spatial resolution at the Kuonanjoki sub-catchment area where OAL Finland research efforts are focusing. Secondly, citizen science provides opportunities for engagement of local citizens in true co-operation about issues in their interest that have technical and/or scientific components. Volunteers also provide valuable knowledge of local conditions, networks of co-operation and they can create credibility within the local community.

Application: Chairman of Pro Puruvesi (an NGO) who is also a member of the core team of local stakeholders agreed to search for local volunteer observers. At the end, a team of 6 volunteers with locations around Lake Suuri Vehkajärvi, a lake at the head of the Lake Puruvesi catchment area, gathered on 2020-01-24 to discuss the measuring task and learn how to fulfil the SWE-measurements. Senior researcher Achim Drebs from FMI with more than 20 years of experience with snowpack measurements organized for every volunteer a low-cost rebuild of the Finnish standard measuring equipment and conducted the local training. During the training session, primary measuring sites were chosen. The next day Achim Drebs inspected these sites and gave additional training. All sites fit well to monitor the snowpack conditions in the area of interest.

Lessons learnt: The first winter (2019/2020) for measurement campaign turned out to be extremely warm. There was no long-term accumulation of snow and, therefore, no snowpack to measure SWE. In order not to lose interest in volunteers a summer precipitation measurement campaign is being planned. It is considered important to have regular contacts and continue observations of rainfall during the summer period. The summer campaign will focus on extreme weather events.

Achim Drebs explains the principles of snow density measurement instruments (left). Looking for snow water equivalent (SWE) measuring places (right). Training in Kerimäki, Finland, 20.1.2020. Photos: Lasse Musakka.

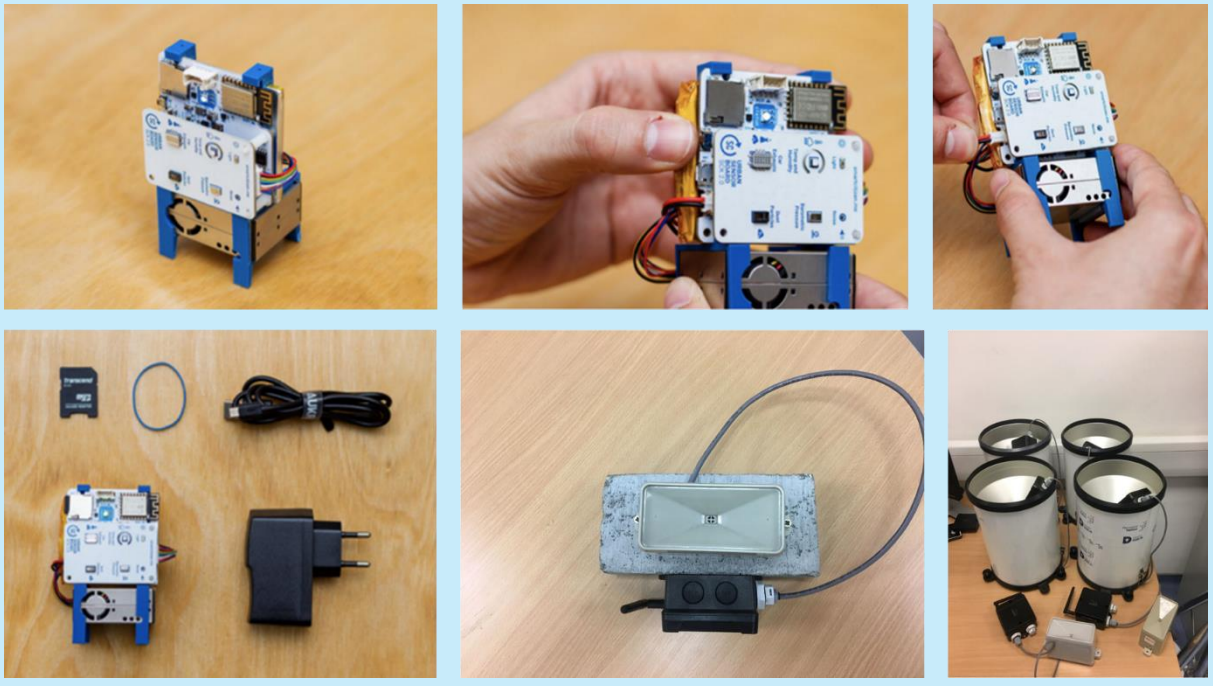
Showcase 11. Using citizen science to co-monitor the hydro-meteorological variables affecting floods

Aim:

Any scientific intervention needs to be monitored for assessment of its performance. To successfully achieve this, a citizen science toolkit was prepared for the stakeholders of the workshops. The toolkit consists of a set of low-cost sensors (Figure 4) that measures various hydro-meteorological variables affecting floods. The goal is to create an open-access database of meteorological variables that can be used by the scientific community for a detailed analysis of the flooding issue in Dublin. Also, the citizen toolkit can be an alternative approach to ensure that the stakeholders can verify the effectiveness of a deployed NBS in flood control, which is essential for their interest and willingness in supporting NBS in the future. Furthermore, any new NBS that might be deployed as part of OPERANDUM project can be maintained by a group of interested stakeholders after the project ends its term.

Application:

The goal is to freely distribute those toolkits during the next workshop once the lockdown due to COVID-19 pandemic is lifted. The advantage of the sensors is that they are small and easy to deploy at households/residential areas. The sensors can be connected to a household power cable. Also, it has an in-built battery system which lasts for a few days and is easy to recharge. The data collected can be transferred in real-time in situations where the sensor is linked up with household wifi or mobile internet network. In situations where internet is not available, the sensor can store the data inside an in-built storage card that has a capacity to collect data up to 6 months.



Low-cost sensors to monitor a set of meteorological variables. Photo: Bidroha Basu.

Showcase 11: MCDA tool in the selection of the case-study area in OAL Finland

Aim:

In the OAL Finland, we are working at Lake Puruvesi. The main focus is on nutrition loading from the forest and on co-development and implementation of NBS solutions for water conservation. The catchment area is large, altogether xxx square meter and we wanted to identify an area, which could be most critical from the point of view of loading and also interesting to implement NBS, in particular, the continuous cover forestry. Multi-Criteria Decision Analysis was considered as an interesting tool to make this selection together with the primary stakeholders of the OAL.

Application:

First we researchers designed a table with five possible areas to be considered based on the previous discussions and preliminary criteria (main categories and sub-criteria) for the selection. In the meeting where we had four external participants representing the local organisations (both NGO and governmental) first explained the aim of the process and the MCDA methodology. Then we discussed and elaborated the table (see below) with the main criteria and the subcriteria with justifications. The table inspired the participants to discuss more widely about the criteria and the advantages and disadvantages of each of the areas with respect to the proposed and new criteria. We did not manage to give any weights of the criteria and calculate the points.

Lessons learnt:

Although we did not manage to follow the methodology strictly to the end, we think that the methodology gave a good framework for the discussion and based on that we were finally able to select the area in a participatory way. A reason for not to use the methodology successfully might have been that there were only a few stakeholders, and there was already a lot of trust between the actors, and there were no major conflicts in interests. In another occasion, the facilitator could have been more strict in guiding the process.

Criteria, interest	Reasoning for selecting the site/NBS
High nutrient loading	Main attention in the project
Existing NBS	Easy to monitor and demonstrate
Applicability • Technical • Costs • Land ownership	No funds in the project to finance the NBSs, the site/solution needs to be feasible
Forestry as a form of land use	Expertise of the team, main source of nutrient loading the region, contribution to the OPERANDUM project
Existing monitoring data	To increase understanding of the efficiency of the NBS
Possibilities for measuring (install devices)	To collect data
Possibilities for modelling	Expertise and interest
Economic benefits	To use the NBS for economic purposes
Social benefits	Value for landscape, recreation possibilities, accessibility for demonstration

Summary table of the Criteria and their descriptions for the MCDA identified by the OAL. The next step would have been giving Weight and valuation for each of the criteria.

Showcase 12: MCDA on the selection of the most suitable NBS – OAL Greece

Aim of the method:

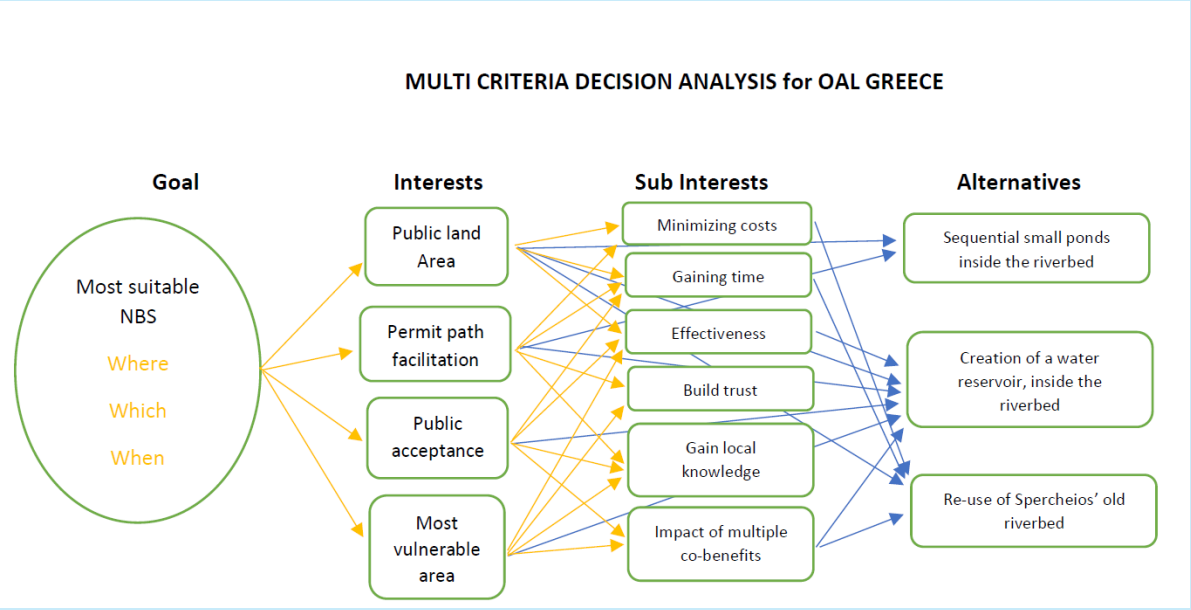
In OAL Greece, we had to take into account several parameters in order to design and deploy the NBS solution that would effectively and simultaneously mitigate the risks resulting from flood and water scarcity. A multi-criteria decision analysis tool seemed to be the most appropriate one to help us compare different combinations of measures and select the optimal NBS.

Application:

The most critical parameters we had to consider were; the ideal location (Where), the type and efficacy of the measure (Which) and also time-related issues (When), concerning both the Project as a whole and the deployment of the NBS itself. The interests and sub interests resulted from the main parameters mentioned above. Local conditions and the relative location of the measures in the catchment area as to the impact and effectiveness of the interventions, legal and statutory framework of the licensing the NBSs and Public acceptance were the main areas of the interests we had set as the OAL team. From those interests several sub interests emerged, such as cost issues, gaining of local knowledge and the accrual of (direct and indirect) impacts and benefits. Combining the data gathered through both the literature and the interaction of the group of researchers with the local community and the local policymakers, we compared three possible NBSs. Through the MCDA tool, we concluded that the most appropriate solution – in terms of completeness - would be the one implemented in the area of Komma. The team has used the tool for the other NBSs planned as well.

Lessons learned:

The application of the MCDA tool was effectuated within the group of the researchers of OAL Greece taking into account the knowledge gathered through several meetings with Stakeholders and Literature reviews. The tool assisted us to group up the information and data collected and further analyse them, taking also into account the discrete values, choices, opportunities and perceptions of the multiple factors that are significant for the final efficacy of the NBS. It helped us consider how the proposed combinations of measures could contribute to the achievement of the different policy objectives identified, as well as to the wider societal objectives.



The final result of the use of MCDA in OAL Greece. Figure: Depy Panga.

6 Monitoring the co-creation process

Monitoring should be a continuous and integral element of stakeholder engagement and communication. The idea is to keep the stakeholders informed and updated, but also to have their views and feedback throughout the process in order to improve it. Participation of stakeholders in the monitoring process may also enhance ownership and responsibility for the process, facilitating further discussions that can improve the impact of the project and enable further collaboration and learning (see D1.1, 2019; D8.1, 2019);

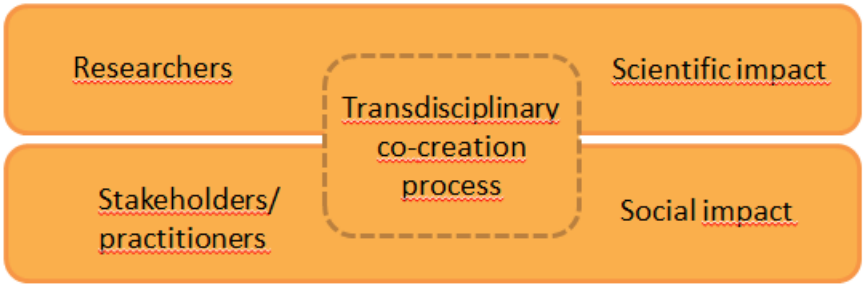


Figure 17: Transdisciplinary research brings together researchers and scientists leading to both scientific and social impact.

Several principles of 'good practice' for monitoring have been proposed (e.g. UNDP Guidebook, 2009; AccountAbility, 2015) and frameworks for assessing the participatory aspects of the project (e.g. Walter et al., 2007; Hicks et al., 2012; Schuck-Zöller et al., 2017). The main conclusion of these documents is that both qualitative, as well as quantitative methods, must be included in the evaluation, in order to fully understand different aspects of. Furthermore, evaluating participation demands that the entire process be evaluated, over a period of time. The approach needs to be dynamic as opposed to static and easily adjustable to different circumstances, changing needs, diversity among stakeholders. A conventional ex post facto evaluations performed as limited snap-shots will therefore not be adequate.

In OPERANDUM the OAL –Italy has introduced the Logbook as a tool for continuous documentation and monitoring (see Showcase 13). Documentation is the first and most crucial issue to do. Besides that, there are various mechanisms to explore the quantity and quality of engagement. For example, SWOT –analysis can be used in a participatory way to analyse the strengths and weaknesses in the engagement and also identify the actions that need to be improved. The OAL leaders and social scientists of OPERANDUM project developed in a workshop in Milan, October 2019 a set of indicators to monitor the co-creation process (see Table 4.). The participants were challenged to think of ways to measure the engagement in different stages of the project reflecting the general values of the stakeholder engagement (such as trust, inclusivity, transparency and accessibility) defined in the stakeholder engagement strategy. Following Chiaf (2013) the topic and indicators identified were classified into five clusters (see below). These clusters also follow the principles of a transdisciplinary research process proposed by Djenontin and Meadow (2018):

Indicators of Input: These are indicators useful to quantify the human resources and investments needed for the development of activities and in particular for the Stakeholder engagement. These resources include for example resources needed for participation, communication channels, common language, but also immaterial concepts like trust, reciprocity, transparency.

Indicators of Process: These are indicators that are used to measure the project processes or activities carried out for the project realization. They represent the ways in which the organization has used resources and investments to generate changes (hopefully, improvements). For example, in OPERANDUM project, examples are “the number stakeholder engaged” or “the number activities in the OAL involving stakeholders”.

Indicators of Output: These indicators are also defined as Performance indicators that measure the products and services obtained with an intervention, in other words, the immediate results (products) of the activities performed. They are useful to quantify concrete and measurable results. For example, the capacity building, leadership, responsibility and feeling of commitment.

Indicators of Outcome: These are indicators that measure changes (positive and negative) that take place as a consequence of assigned output, or in other words, the medium impacts of a project. The time horizon could be short or long, depending on the need to be satisfied or on the product (service) provided. The changes might be direct or not, expected or not initially foreseen. For example, in OPERANDUM, outcome indicators could be “the investment in NBS experimentation” or “improvement in the quality of living in the area where NBS was implemented”.

Indicators of Impact: These indicators measure the change, the long term impacts of a project. It represents the part of outcome exclusively due to the activities performed in the frame of the considered project. The impact is a measure of the outcome net of those changes that would take place anyway (without the project) and those due to other interventions. If the project is thought as an “investment”, the impact achieved on the targeted environment (i.e. the change produced) is the way to measure the profit from the investment. In the case of OPERANDUM project, it could be, “the prevalence of NBS chosen over grey infrastructures in environmental policies at local, national and international level.”

Table 5 contains a list of possible topics that can indicators suitable for OPERANDUM project, for the five categories. A full table of these categories, associated topics and examples of the indicators is provided in Annex 1. All these categories may have quantitative indicators (mostly evaluated by the OAL co-ordinators) or qualitative indicators (evaluated by the stakeholders via a survey, for example). The idea is not necessary to use all these indicators in the monitoring but to select the most appropriate given the context and the stakeholder group/situation in question. Keeping in mind that (in the case of the OALs) the context may vary, the methods for monitoring could be tailored to fit with the number and character of the stakeholders, in order also to find the best means to collect the data. The frequency of the monitoring could also be set according to the overall frame of the process. Each OAL should plan the monitoring process, create suitable formats (such as surveys with structured and open-ended questions, lists of attendance) and find the most appropriate ways to organize the data collection.

Table 5: The list of possible topics for indicators suitable for OPERANDUM project.

	Topic	Quantitative	Qualitative
Input	• Interest in the project		x
	• Trust		x
	• Time available	x	
	• Physical accessibility		x
	• Financial resources		x
	• Social accessibility (e.g. language, cultural barriers)	x	x
	• Communication channels	x	x
	• Composition of the research team	x	x
	• Composition of the stakeholder group		x
	• Agreement of goals		
Process indicators	• Number of activities	x	
	• Number of participants (different stakeholders/social/cultural groups)	x	
	• Communication (formal and informal)	x	x
	• Equity	x	x
	• Inclusiveness (vulnerable groups)	x	x
	• Tools for monitoring	x	x
Output	• Dissemination (including co-authored publications with the stakeholders)	x	
	• Interest (contacts by stakeholders and other interest groups)	x	
	• Leadership (actions led by the stakeholders)	x	
	• Commitment	x	
Outcome	• Learning		x
	• Scaling up/out	x	
	• Social cohesion		x
	• Networking of stakeholders	x	
	• Impact of the NBS on quality of life		
Impact*	• Capacity building of different parties through integrated knowledge (SO1)	x	
	• Strenghtened technology innovation (SO2) (prevalence of NBS chose over grey infrastructures)	x	
	• Improved acceptance (SO3)	x	
	• Increase market demand and competitiveness of NBS (S04)	x	
	• Adoption of new policies (SO5)	x	

Showcase 13. A logbook as a tool for monitoring stakeholder processes – OAL Italy

Aim:

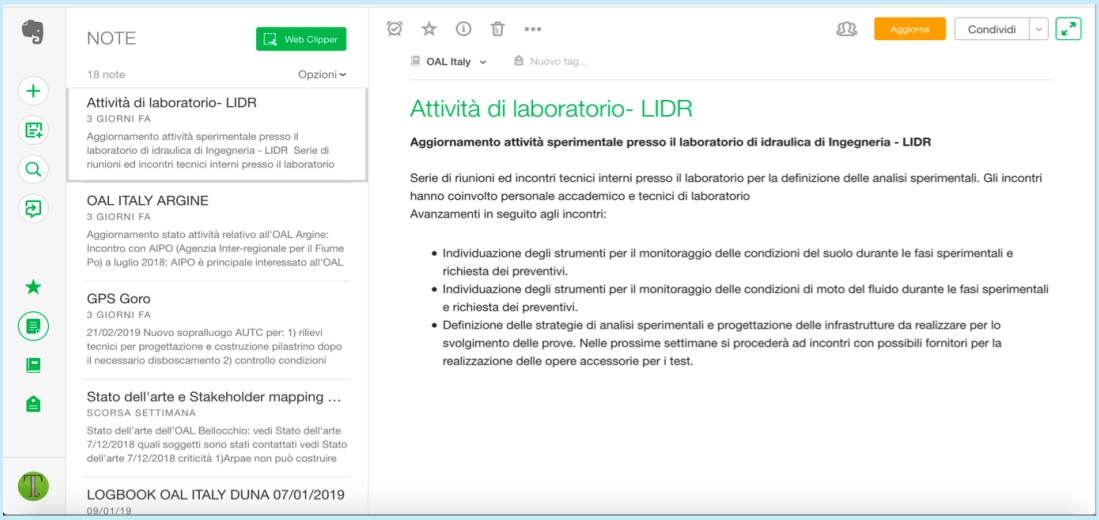
A logbook is a tool used for tracking the progress and the contact, communication, involvement of stakeholder throughout the co-design and co- deployment phase. The idea of monitoring this specific task of the OAL members is strictly linked to the need of gathering cross-phases data about how the interaction with key stakeholders develops and measuring the impact of their engagement in the process. The logbook updates the state of the art of the stakeholder engagement from a social and human point of view; verify the progress made in the technical field (learn from the errors); tune" different languages that have to proceed in parallel – introducing a tool to be managed by a hard and soft scientist in synergy.

Application:

We asked all OAL members to keep track of progress or difficulties on the engagement of stakeholder and authorization processes during co-design and co- deployment activities. Hard scientists "borrowed" a social science reporting tool belonging mostly to qualitative methods to integrate a whole set of monitoring tools used by hard scientists. Social science uses some interactive tools to report on developments that occurred in the area of interest/research such as diaries, field notes, observation notebooks in which the researchers report every single development of their activity. We also identified a coordinator for every site of the OAL and shared with them the proposal of the logbook. We also scheduled meetings with OAL members to share with them the aim of the logbook and getting suggestions from them to improve the Logbook. As a result, the whole team uses a collaborative working platform of Logbook "Evernote" to share the notes and to keep track of all the activities and interaction. Each note reports whether a specific stakeholder has been involved, consulted and activated. OAL members write a note with what has been done in terms of technical and operative steps (permission, authorizations etc.), or whether the stakeholder has already been contacted and engaged and why, if there are some weaknesses and critical situations and, finally, what could be the next steps expected.

Lessons learnt:

The information gathered in the notes helped in identifying indicators that can measure the effectiveness of the engagement in terms of improvement of the project outcome. They also provided information, how the project is factually producing transformations and changes that will impact the stakeholder area of interest at a local, national and global level.



An extract from the logbook of OAL Italy. Photo: Teresa Carlone.

7 Challenges and solutions

Although interest in transdisciplinary collaborative research is wide and there are many success stories already, many transdisciplinary projects have also reported about problems and challenges (see e.g. Lang et al., 2012; Hirschnitz-Garbers, 2018; Schäpke et al., 2018). In the problem formulation phase, there might be a lack of problem awareness and unbalance in problem ownership and solution. During the process, there might be conflicting methodological standards and discontinuous participation (stakeholder fatigue). Finally, despite efforts, the results may face a lack of legitimation, not easy to scale up, or lack of procedures for social impact assessment and peer-review. Bringing different actors with various interests together may arise some power issues and lead in the worst case to conflicts between the participants. Researchers involved in a transdisciplinary project have not necessarily been trained for participatory methods and having different roles in a project, but are increasingly learning and widening their experience.

These problems can be mitigated and avoided with careful planning of the project and stakeholder engagement strategy, including aspects regarding trust-building and the involvement of diverse groups as well as vulnerable people and training of the researchers with transdisciplinary approaches (see Chapter 2). Despite these efforts, the difficulties may lead to challenges and even conflicts between the participants. Conflicts may arise from different reasons: they may be cognitive when people have different understandings of an issue; they can be normative, related to different values, objects or interests; they may also be related to the relationships and power dynamics between the participants (Moura and Teixeira, 2010).

7.1.1 Methods for preventing the problems

Project design and co-management: Following the general principles for successful project design and management (Chapter 2) may help to mitigate different challenges emerging n a transdisciplinary collaborative project. Stakeholder engagement strategy D8.1 introduced some possible methods or tactics to deal with the challenges in the stakeholder engagement such as nudging and citizen science.

7.1.2 Methods for managing difficulties in stakeholder engagement

Dilemma cafes: Dilemma Cafe is a method that brings people together to discuss several dilemmas experienced by participants. The aim is to find alternative courses of action when it is not clear which is the right one to choose. In short, the dilemma cafes raise participants' awareness of co-creation challenges; encourage collaborative dialogue, include critical listening and questioning: stimulate learning through sharing about different ways of seeing and understanding issues; explore a variety of recommendations for action. Small groups of 5-6 persons will be established. They do not necessarily need to know the topic or the area concerned. The session starts with a brief description of the dilemma presented by the "problem owner" for example through the following questions: What have you experienced or experiencing related to the problem? Who are the participants? What is your role? What events have led, will possibly lead to the dilemma? What have you tried to solve the dilemma? The participants may ask questions, if needed, in order to get a more comprehensive idea of the dilemma. After the background and all facts related to the dilemma are clear, the participants the discussion around it may start revolving the questions: What are or what were the key stakes in this dilemma? What are the key issues to resolve the dilemma? Now

the participants are allowed to make suggestions and comments. https://www.dur.ac.uk/resources/beacon/DilemmascafebriefingforthewebSB27.11.15.pdf

7.1.3 Methods for managing conflicts:

Sometimes the difficulties may lead to conflicts. Usually, the first perception is that conflict is a negative, but it may not be the case; it may also lead to the improvement of the process or a better outcome than would otherwise be expected. The best way for solving conflicts (either individual or institutional) is transforming the conflicts into problems or preventing them to evolve from these. Nevertheless, if a conflict arises, it needs to be identified and the reasons for it carefully analysed (Durham et al. 2014). There are various techniques for solving conflict resolutions like negotiation, dialoguing, even meditating. In some cases, might be useful to turn to external assessment or facilitator in the conflict management (see more closely Moura and Teixeira, 2010).

Showcase 14. Exploring the solutions in Dilemma Cafes – All OALs

Aim:
The exercise aimed to jointly discuss and explore the challenges with the stakeholder engagement and activities and at the same time to learn about the Dilemma Café –method as a possible method to manage difficulties in co-creation.

Application:
The Dilemma Cafes were organised as a part of OPERANDUM workshop in Paris, 25-27 February 2019. The participants (OPERANDUM researchers) were divided into three groups to discuss some of the challenges that were identified by the SWOT analysis (see D 8.1.). Below the main findings of each group.

"Changing attitudes towards NBSs"

Dilemma: The Main stakeholder is a public institute responsible for monitoring, ensuring and implementing the NBS. It knows about the NBS, but do not necessarily consider it as an appropriate solution for this particular case. Fieldtrips and workshops were organized to deal with this dilemma.
Discussion: How to induce interest/willingness from this main stakeholder? Three main issues were identified:

- Awareness: The SH knows about the NBS, but do not see it as serious/main solutions
- Unrealistic expectations (maybe from the OPERANDUM side): solely NBS is not the solution
- Attitude: prioritize short/fast solutions; see NBBS only as a complementary solution and try to explain the benefits of the NBS 8why change what works)

Possible solutions:

- Try to find mixed solutions, kind of compromises
- Share data, highlight benefits, show the results
- Organize a summer school
- Bring in another public body, who have a positive experience with implementing NBS (nudging)

"Arising interests and building trust"
Dilemma: overall lack of interest in the NBS and participation in the project.
Discussion:

- Mistrust: There is a lack of trust among the key stakeholders (landowners) towards administrative (and researchers) due to Nature 2000 implementation (to-down)
- Scepticism: overall doubts about the efficiency of the NBS, the results are not visible in the short term.
- Conflicts of interests: there is an economic interest that may be in conflict with the NBS.

Possible solutions:

- Focus not only in nature protection but also in the benefits for the people and their lives
- Improve communication and show the "bigger picture"
- Exploit business: show how NBS would benefit also economically the area and the activities there
- Do not bring up the climate change topic which may be controversial among the stakeholders

"Commitment of the stakeholders"

Dilemma: How to commit the local municipality and the decision-makers?

Discussion: What is a commitment? What is the difference between commitment and enjoyment? Is it a commitment of OAL rep toward stakeholders or vice versa? How to bridge the gap between the policy-making and science?

Possible solutions:

- Gain an understanding of the decision-making process and the key actors
- Find a key person who can help us to accelerate the process or create an executive board where the administrative are part of, which can then facilitate the contact
- Show successful example of a similar type of NBS
- Show results that the authority can achieve in adopting the project solution

Lessons learnt:

The discussions and sharing experiences across the OALs were experienced as useful. Furthermore, they produced some practical solutions to be applied in the OALs. Furthermore, the researchers became familiar with a new participatory method that can be used as a means to discuss on problems.

Dilemma Café in Paris. Photo: Katriina Soini.

PART III

FINAL PLANS AND LESSONS LEARNT

8 Co-creation processes and final plans

In the following, we will describe the co-creation processes in each of the OAL from the beginning of the OPERANDUM project up to month 22. First, the basic information is given including a short description of the social-ecological system. The descriptions of the processes with the list of the methods used (by January 2019) focus on the experiences and the reflections of the OAL leaders/OAL team. The idea is to show how the conceptual framework and the common frame for co-creation process presented earlier in this report have been applied by each of the OAL. As highlighted in Chapter 3, the idea of the common framework was to clarify the concepts and phases, while the OALs were encouraged to take the freedom to apply it most appropriately in their context. Similarly, it is important to find a context-specific and sensitive model for co-creation. Therefore, the co-creation processes neither their descriptions in the following will not be consistent. It should also be noted that the work is still going on, and a more complete picture of the processes, the results and lessons learnt can be defined only in the later phase of the OPERANDUM project by Task 3.3. The co-creation processes are also being described in the virtual story maps and a scientific paper that will analyse the lessons learnt across the OALs.

OAL AUSTRIA	Lower Watten Valley
Location:	Tyrol, Austria
Hazard:	Deep-seated gravitational slope deformation
Risk:	Active landslide; the landslide accelerations are triggered by hydrometeorological events
Objective of the OAL :	To reduce the hydrological forcing and include optimizing forest management and the natural sealing of leaky streams and channels.
OAL Leader(s):	Martin Ruzinger
Link to the story map:	A link to OAL-Austria storymap.

Description of the area:
OAL-AT is located on an east-facing slope to the south of the town of Wattens and consists f mainly agricultural and semi-natural land with few residential and non-residential buildings. The slope, ranging from approximately 750 to 2000 m and covering an area of about 5.5 km², shows relict signs of landslide movement in the past. Currently, an active deep-seated landslide shows enhanced movement with annual displacements of up to 6 cm/y. Phases of acceleration correlate with moist periods of excessive, above-average rainfalls. In addition, enhanced infiltration of meltwater during snowmelt in spring leads to increasing movement rates.
The OAL is 5 km^2 and has a small number of residents. The main economic activities within the OAL are agriculture and forestry, but residents have other income-generating activities outside the OAL. The active landslide continuously threatens several buildings, infrastructure (such as roads and water supply), and managed forests and farmland. This to the extent that some houses will become uninhabitable in the near future.

Methods used: informal discussions 29; focus groups 1, field trips (3), meetings and workshops including SWOT, Plural rationality approach.

Description of the co-creation process:
The OAL-AT has been selected based on a few criteria. The first was that the OAL site needed to be affected by an active natural hazard, in particular by a landslide. The second was that the site was suitable for a NBS experiment. One of the stakeholders then suggested the lower Watten Valley to us. The OAL is very complex with many stakeholders, ranging from residents, the municipality to regional authorities and a federal research and training centre, who all have different interests and motivations. Moreover, the landslide is a real threat to the people living in the area, which makes OAL-AT more than a test case. This gives us as researchers an extra level of responsibility and makes that we need to proceed very cautiously in the OAL. We work most closely together with the expert stakeholders.

We, the ÖAW team working in OAL-AT, all have a background in geography, but with different specializations ranging from remote sensing, geoinformatics, physical geography and environmental monitoring, geology to human geography. The team has experience with interdisciplinary research, but less so with participatory research. The OAL is located 25 km away from our office in Innsbruck, which is very convenient for field trips and monitoring activities. We have no previous experience in this area and the OAL had to be built up from scratch.

It took time and effort to establish good relationships with the expert stakeholders, as we work with some of them for the first time. We see a successful co-creation process as a process that is beneficial to all involved. For example, we had to show some experts that we were capable of doing good research and that we could provide them with high-quality data

and valuable insights. It took some effort and time in the first year of the OPERANDUM project to show them that the project was interesting and could be beneficial.

The expert stakeholders are interested in NBS, but more as an experiment. It will not be possible to move beyond an NBS experiment and implement an operational NBS in the OAL, due to the serious impacts of the active landslide. Some expert stakeholders are highly interested in NBS, since it is part of their expertise. One expert stakeholder is very knowledgeable about grey solutions and less aware about NBS, but we think that if we can show them that NBS work they may see them as a cost-effective alternative as they need less maintenance. At the moment we engage less with the residents. NBS is a long-term solution that makes it less interesting to the residents, because they want understandably short-term results and minimizes the impacts of the landslide as soon as possible.

At the beginning of the OPERANDUM project, we were familiar with the concept of co-creation, but we had not worked with it previously and had no good working knowledge of the process. What we learned so far in OPERANDUM project is that the steps of the co-creation process are logical and necessary if you want to do NBS experiments with other stakeholders. At the start, we did not have a clear project plan in terms of co-creation and we have adjusted and adapted it as we went along. We have followed all steps so far of the co-design and co-development phases and are planning the co-deployment phase. It is clear to us that the co-creation process is not a neat step-by-step process; some parts take a long time or are still ongoing although they started at the beginning of the project and sometimes you have to go a step backwards when it is necessary to adapt the project plan.

Working with expert stakeholders is going well because we speak the same language. We feel that we as researchers in this OAL have limited power and influence since we rely heavily on the expert stakeholders. We are in the OAL to do an NBS experiment, which has to show the expert stakeholders that NBS are effective and efficient. If the NBS experiment works, the expert stakeholders may implement and upscale it, but at the moment their first interest is to protect houses and infrastructures.

An important milestone for us in the co-creation process was when an expert stakeholder suggested a location for the NBS experiment. This meant that they are interested in what we are doing. Another success moment was when we were invited to give a talk at an important meeting with all affected residents, representatives of the municipality, and the expert stakeholders. Overall, we consider the co-creation process very important when it comes to finding new solutions such as NBS. We try to make the process open, flexible, and reflexive. We highly value the feedback that we receive from the stakeholders and adapt the project and co-creation process accordingly.

Final plan:

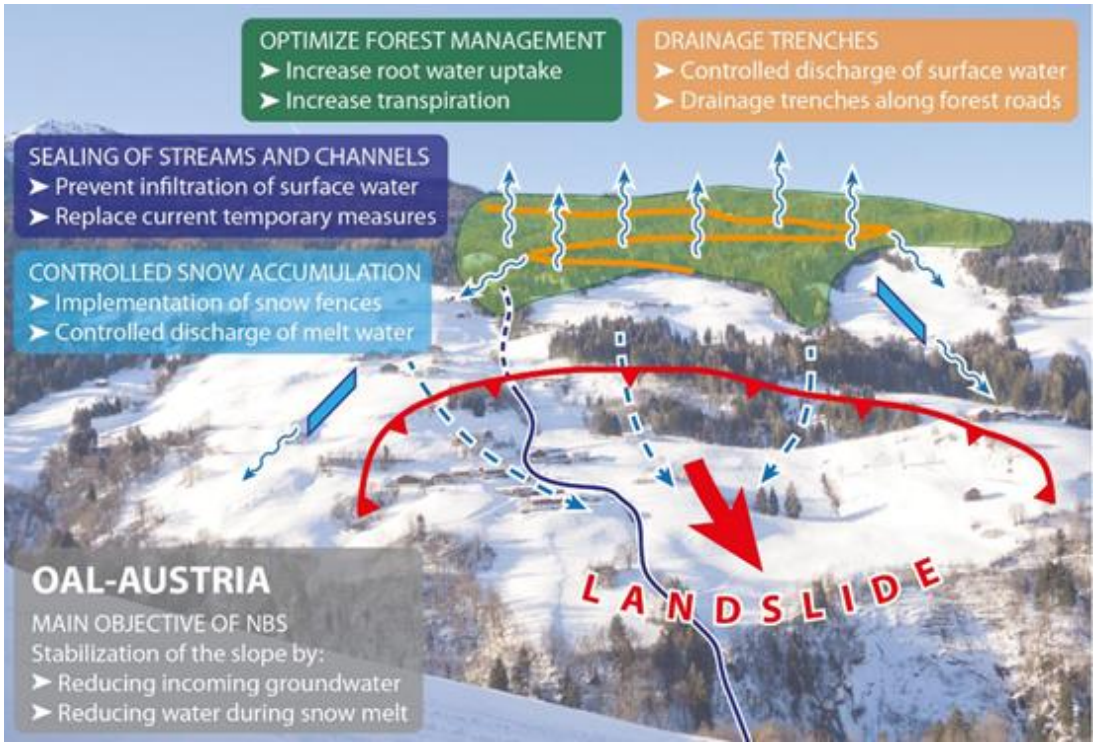
Currently, the following two NBS options have been identified in collaboration with the stakeholders as part of the co-creation processes as potentially effective for mitigating the impacts of the slope deformation (see also Figure a below):

- Optimized forest management: increasing evapotranspiration of the forest stands
- Sealing of streams and channels: preventing infiltration of surface water (see Figure b below)

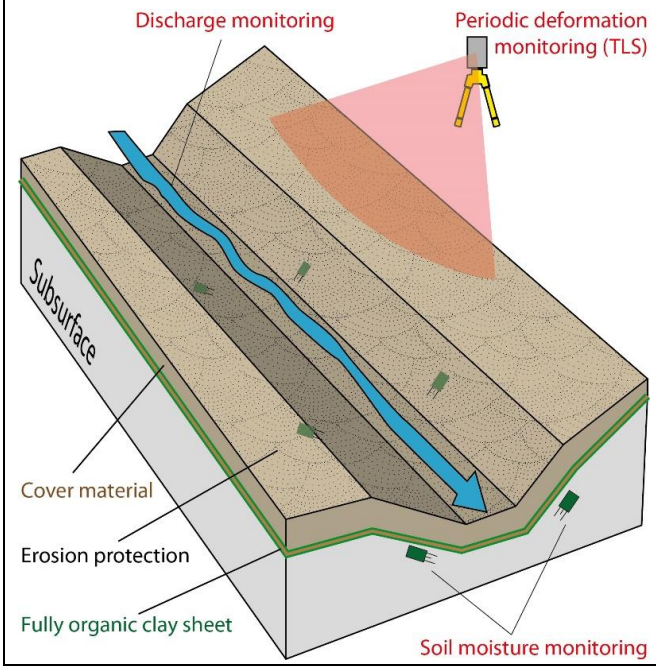
Regarding the optimized forest management, the preliminary results of the hydrological monitoring provide evidence that the incoming water governing the groundwater level originates from the forested upper part of the slope. Therefore, optimizing forest management was found to be a potentially effective NBS for OAL-AT and will be further

evaluated through modelling experiments. Specifically, the hydrological impacts of the current forest stand and structure and alternative optimal forest configurations will be assessed through numerical modelling. Implementation options will be discussed with forest owners when modelling results will be ready.

Regarding the second NBS option, potential locations for testing a permanent sealing of streams and channels were identified together with experts from the local partners who are currently proceeding with the implementation phase. Implementation start is planned for a selected sub-catchment in summer 2020.



Overview of the OAL-AT in terms of processes influencing landslides and objectives. Photo: J. Pfeiffer, 2019/02/15.



Sketch of NBS to be implemented that shows the principle of the sealing of streams and channels (modified, D2.3).

OAL GREECE	Spercheios River
Location:	Sterea Ellada, Central Greece
Hazard:	Flood and drought Deep-seated gravitational slope deformation
Risk:	Damage to agricultural yields, transportation networks as well as biodiversity and recreational uses
Objective of the OAL :	The main objective is to reduce the impacts of flood, better use of water resources, ameliorate acceptance of environmentally friendly solutions.
OAL Leader(s):	Michael Loupis
Link to the story map:	See the full story map

Description of the area:
The Greek OAL is located in the prefecture of Sterea Ellada (Central Greece) and it is the basin of Spercheios river, which springs from the mountainous parts of the catchment. The plant coverage of the research area consists of several categories of natural vegetation, which combined with the rich fauna, compose a rich and powerful ecosystem. The inhabitants of the area are mostly farmers and landowners. Several of them work in the nearby town of Lamia, which is the regional administrative centre. The main hazards in the region are flood and drought. The risks that threaten the area are degradation of agricultural yields, transport networks, biodiversity and recreational uses. Through a systematic stakeholder mapping, we identified the key stakeholder groups. Subsequently the core research group, in alliance with the OPERANDUM team, designed and implemented a participatory approach methodology to combine stakeholder's different levels of knowledge, interests, roles and agendas in order to develop the most efficient adaptation measures.

Methods: informal discussions 30, interviews 9, surveys 2, focus group discussions 1, field trips 12, meetings and workshops (2) including close observation, mind mapping, Multi-Criteria Decision Making Analysis, SWOT, Plural Rationality Approach

Description of the co-creation process:

Spercheios river basin faces the risk of flood and seasonal drought for several years. There have been several research projects, which have studied the area and have provided a significant amount of data. However, the problem remains, with the local communities being constantly burdened by the specific natural hazards. There is a strong will by the local government to set the base for further development of studies, that will minimize the problem and leave a legacy for the next generations. The regional government has a tradition of NBS implementation, even if the solutions are not designated as such and they lack foundation on a solid scientific and engineering approach. Furthermore, there was a good relationship already established with the regional administration that provided the chance for the implementation of Natural Water Retention Measures within the timeframe of the project.

The OAL Greece research group consists of researchers from various scientific disciplines such as engineers (in agriculture and forest, environment and risk, architecture etc), meteorologists, and hydrologists, geologists, social scientists and media experts. The concept was to cover the element of scientific transdisciplinarity, a prerequisite for a complex issue that affects a wide range of Stakeholders in diverse ways. There are two sub groups working in the OAL, one based in Lamia (a town near the OAL) and the other one based in Athens. The Athens team, in full cooperation with the Lamia team, overcame the

physical and social distance from the OAL, by frequent travels and meetings and most importantly by building a culture of collaboration and trust among the members of the two teams. These principles did not preexist but they were built through several discussions and the sincere personal interest from each one of the researchers, both towards the research problem itself and the other members of the group. The result was the development of a common understanding among the members of the two teams. An important parameter that influenced the above was the conciliatory attitude of the OAL leader. We did not ever argue the process we were following or the concept of OPERANDUM research and we worked in flexible ways, always taking into account the lessons learned from our previous actions. We also acknowledged the generosity of the regional government and KKT-ITC who supported the actions we needed to take, in order to move forward the research and not only financially. It is also a common observation that the colleagues from the regional government viewed their work as if they were part of the private sector and not of the cumbersome centrally managed administration. Finally, another important common observation is that all colleagues identified a broadening of thinking, training and practising science towards novel scientific aims, through the collaboration with different disciplines based on trust and mutual respect.

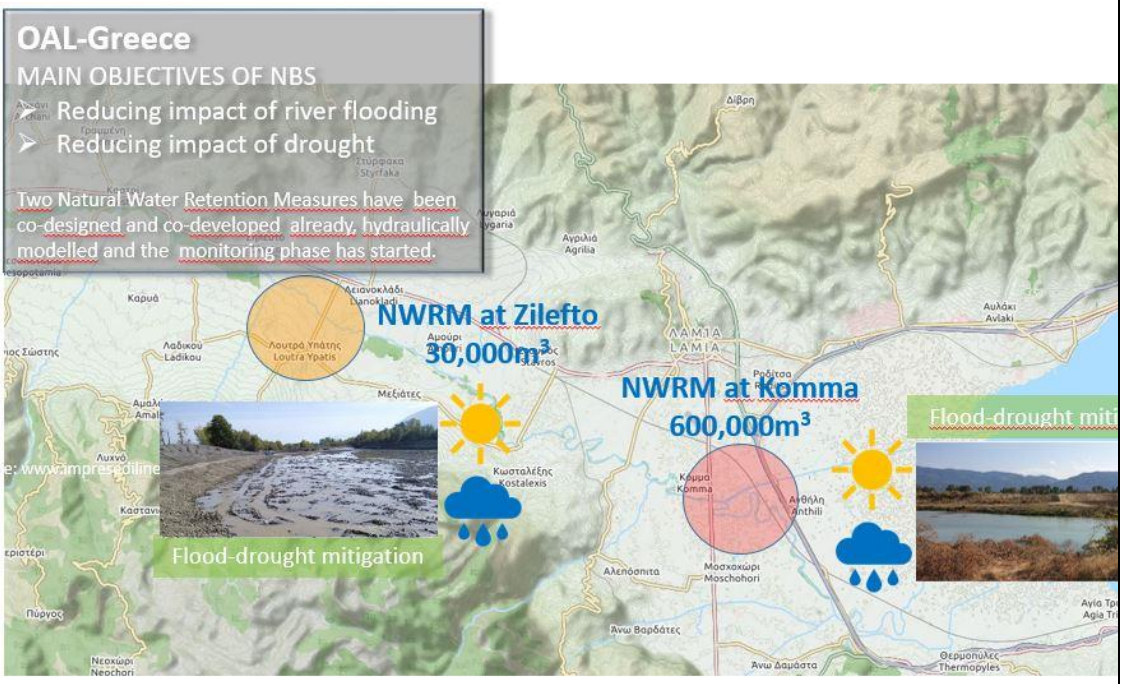
We have become to an overall agreement that this is a work in progress process and each step of the way is co-designed internally by all the OAL researchers, brought then to the individual groups of stakeholders and assessed again in order to move to the next step. We also established that it is quite hard to include in a visible manner the quality features that permeate the whole process and form a coherent consolidation. In the OAL Greece case, the stakeholders involved in the process were adequate but not enough. There is more work to be done in order to benefit the people, not only by the solution itself but from the actual involvement in the process as well. It was a common understanding that a wide involvement process requires time and resources. On the other hand, everybody agreed that the more local stakeholders are engaged, the more negative reactions seem to decline. Although we faced some controversy from the local community members, who considered our presence and research as the solution to their problem, when it was thoroughly explained that our research would be part of the solution, the negativity was reduced. A basic parameter for that is to approach people through the appropriate frame in order to avoid fatigue and mistrust.

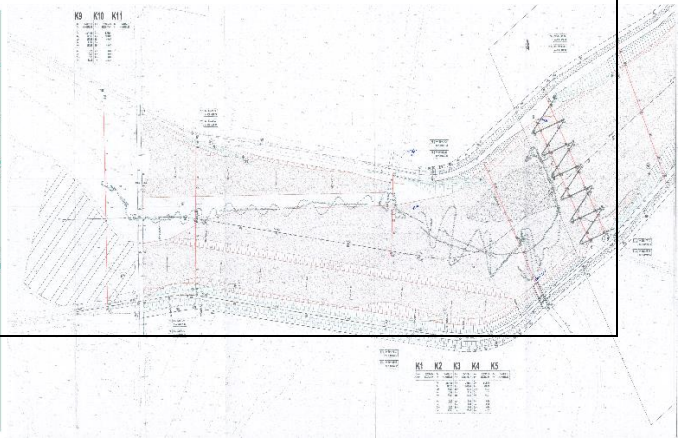
The exchange of different knowledge enriched the co-creation framework and us all and led us to think *out of the box*, with no prejudices, in order to be able to design bespoke solutions to serve the unique cases, each time and in every area. We should mention that it was acknowledged/recognised/commonly accepted that this kind of knowledge exchange is acquired through internal meetings, workshops with stakeholders and physical meetings of the whole OPERANDUM team of researchers, as the one in Delphi in June 2019 and our monthly calls in all Work Packages of the project. Overall, the group suggested that the steps towards a successful co-creation framework should include the first design of the plan on a concrete basis, among the core members of the group and at the same time, the development of a common understanding, based on respect and trust. The second, most important step should be the close contact with the local stakeholders of various categories and discussions in order to gather information and local knowledge that describe the specific socio-ecological system. A significant part of the work done in OAL Greece was the exchange of data between the different scientific disciplines. This feedback created cohesion instead of just order in the whole process.

Final plan:

In the context of previous projects, several actions have been implemented already, with an aim to mitigate flood and drought risks in the area of interest. Hence, we had to come up with a different approach that would be inclusive and holistic. The difference from the previous approaches can be summarized (a) in the way of approximating the key stakeholder groups, (b) the reconciliation of different types of knowledge into the final planning of the solution and (c) the consideration of the whole matrix of interrelated physical, engineering, socio-economic and environmental parameters for the design and implementation of a sustainable and effective NBS.

After thorough research on potential NBS for mitigating flood risks and drought impact in parallel, the co-design framework followed and the modelling experiments, we implemented the Multi Criteria Decision Analysis tool, which lead the team to the co-deployment of two natural water retention measures, one in Komma and one in Zilefto. The next steps in the deployment consist of the development of a robust plan in order to achieve the raise the awareness about NBS implementation, beyond the scale of the OAL itself, towards policymakers, market players and society in general.





OAL FINLAND	LAKE PURUVESI
Location:	Lake Puruvesi in the Eastern part of Finland
Hazard:	Forest harvesting and extreme weather events
Risk:	Increase of suspended solid and nutrient load to Lake Puruvesi leading to eutrofication and siltation
Objective of the OAL :	The main objective is to reduce the load and maintain/retain the excellent water quality.
OAL Leader(s):	Leena Finer and Liisa Ukonmaanaho
Link to the story map:	story map of Lake Puruvesi

Description of the area:
Lake Puruvesi was a natural choice for the Finnish OAL: it is an area rich in forest and lakes with high recreational value. Furthermore, water protection projects had been carried out in collaboration with the local NGO ProPuruvesi Association. Activities in ongoing Life project FRESHABIT brought some added value. Due to the previous collaboration, the primary stakeholders (core group) were already well defined. Yet, through a thorough stakeholder mapping, we tried to identify the missing ones, as well as the secondary stakeholders (like local forest owners and some local associations) which we considered important in further activities. In a first meeting with the core group, we discussed the general aims of the project and planned the first activities. A local newspaper was also presented and published an article where the aims of the project were declared.

Methods used: informal discussions, surveys (1), field trips (2), joint presentations (3) workshops and meetings (8) including mind mapping, Multi-criteria Decision-Making analysis, focus group discussions

Description of the co-creation process:
An important milestone was the first open meeting for the local people, including the secondary stakeholders. We were excited to see, how many people would show up and how they would receive the project? In Finland, water conservation and forest management issues sometimes rise strong confrontations. The researchers and local authorities presented the project and some recent facts and figures about the current state of the Lake. The participants (around 25) were invited, in turn, to share their observations and tell their stories and perceptions in small groups (mind-mapping) about the possible reasons for the problems in the water quality, which we found important for breaking the divide between the scientists and different stakeholder groups.

The catchment of Lake Puruvesi is a large area. There are numerous sources for nutrition loading and several NBSs to consider (see the story map), the stakeholders range from the residents living nearby Lake and having a livelihood, to part-time and summer house residents, and non-local institutions and entrepreneurs. In the end, private landowners are key stakeholders as the forest is for the most part privately owned and the NBSs need to be planned and deployed with them. Our challenge in the co-design process was first to identify a smaller project area, where we could monitor the loading and also plan targeted actions with the stakeholders. Following the steps of the Multi-Criteria Decision Analysis, we decided with the core group to work in the catchment area of Iso- and Pieni Vehkajärvi and Kuonanjärvi, which were responsible for a good share of the nutrient loading of the Lake. Once the target area was defined we organised an open field trip to the secondary stakeholders and also for other interested people. The aim of the field trip guided by a local expert in sustainable forestry was to become familiar with the target area and the different NBSs. Field trip constituted a good platform for a dialogue between different parties, questions and answers. After the trip, the participants' perceptions and preliminary interest in the different NBSs were mapped out. Overall the atmosphere during the field trip was open and lively.

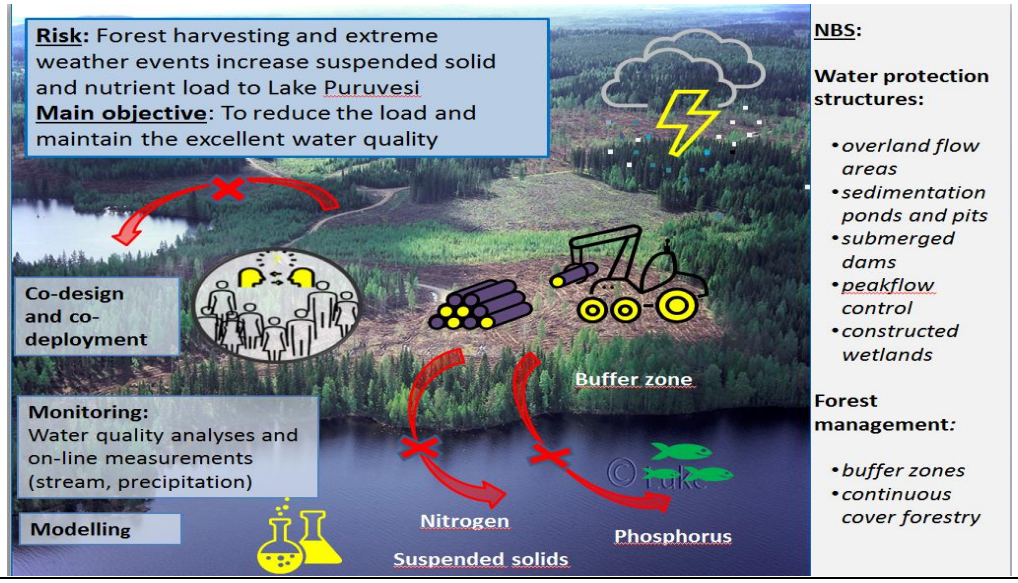
One of the challenges related to nutrient loading is that it is originating from a large area. Many of

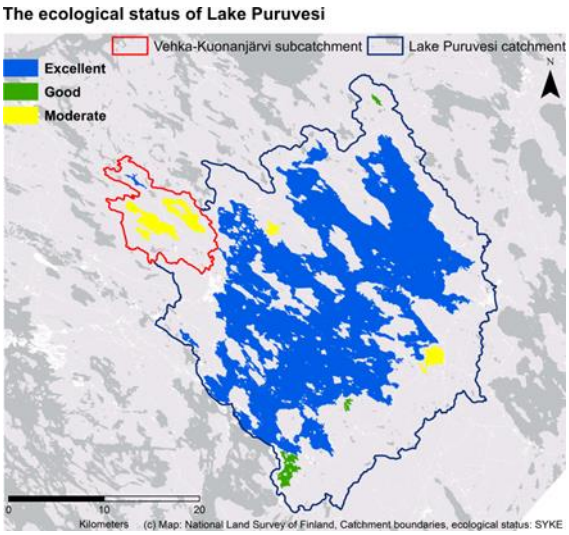
the NBSs (like sediment ponds) may be expensive if implemented for the whole area. To find cost-efficient solutions we decided with the core group to focus on the continuous cover forestry (CCF), which is increasingly seen as an option for decreasing nutrition loading and for carbon sequestration, but also for biodiversity. This kind of forests may also have a more recreational value than conventionally managed forests (with loggings, young forest and often quite homogenous forests), and in that sense, they would be ideal NBSs. Yet, there is still relatively little evidence of these benefits in different types of forests. To implement continuous cover forestry would require collaboration between the foresters and landowners, and this, in turn, may be difficult as it would require a high level of trust as well as mutual willingness to collaborate. So, the next required step was to discuss the potential advantages and disadvantages of the CCF. Again, we organised a meeting with an exchange of scientific knowledge and locals perceptions, and provided a platform for debate of the possible advantages and disadvantages of continuous cover forestry first in small groups and then in open discussion. We felt that discussion was constructive and it was good that the different views were openly presented. Currently, we have been trying to find a possible demonstration site together with the core group strengthened by the forest owners' association.

Overall, our experience so far is that it is important to have a small and functional core-group including local actors having personal contacts, at least in the case when the area is large and the secondary stakeholders are not easy to reach and the researchers are not living in the target area, as it is being a case in our OAL. Yet, a strong local leadership may also lead to a situation that some marginal voices will not be heard. On the other hand, in our case, in the end, the private landowners have the power to decide about the operations in their land. The main challenge also related to our OAL is that the water quality is a result of a number of issues and numerous sources, both natural (incl. climate change) and directly human-oriented (e.g. forest management practices), and the changes take place relatively slowly and people may adapt to them. The problem owners are few and there are economic and cultural issues that affect their behaviour. There seems to be many constraints that may hinder the required change although basic attitude is positive. We felt that it was not easy to introduce "modern" engagement techniques, as some of the stakeholders are a bit conservative and reserved. We are learning whether the modelling will help to make a change.

Final plan:

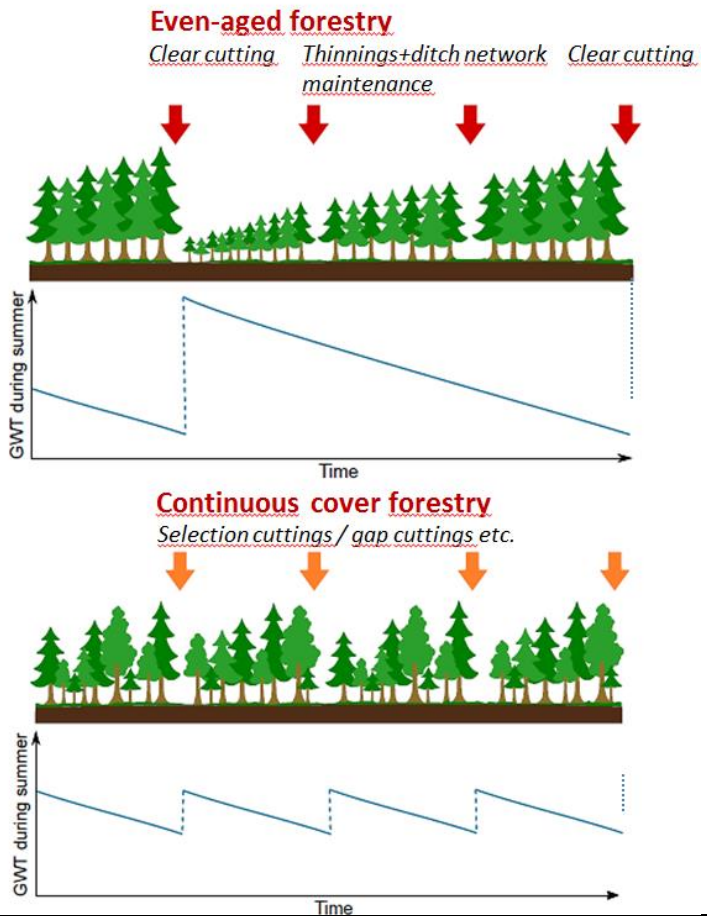
There are various water protection structures and forest management practices that can decrease nutrient load (see the figure below). Many of them have already been deployed in the Lake Puruvesi area as a part of the Freshabit Life project.





As a result of the co-creation process, the OAL Finland decided to focus on Kuonanjärvi ja Vehkajärvi subregion, where the most of the nutrient load to Lake Puruvesi is originating from and deploy continuous cover forestry in that sub-catchment area.

Continuous cover forestry management is particularly suitable for the drained peatlands, which constitute the main soil type in the target area. Continuous-cover-Forestry methods (CCF) is a forest management regime without clearfelling. Although it is currently quite common in Central Europe, However, in Nordic countries like Finland and Sweden less than 5% of forest area is managed using CCF method, clearcutting being dominant tree harvesting method there The regime involves the maintenance of a forest canopy at all times. After felling of individual large trees, the remaining trees accelerate their growth, and new trees grow from the undergrowth reserve and more emerge through natural regeneration. It is assumed that less nutrient and sediment leaching occur using CCF regime, compared “traditional” clearfellings, mainly due to that forest is covered with vegetation all the time and therefore leaching of sediment and nutrients is less. In addition, in peatland forests remaining trees keep soil enough dry and therefore ditch network maintenance, which may cause additional nutrient and sediment leaching, is not needed. The next step in the deployment is to find landowners who have a suitable forest for demonstrating the CCF and also willingness to test the method.



Even aged and continuous cover forestry. Picture: Kersti Haahti/Luke.

OAL GERMANY	Biosphere Reserve "Niedersächsische Elbtalaue (BRNE)
Location:	River Elbe
Hazard:	Floods
Risk:	Flooding of areas along the Elbe river
Objective of the OAL :	To have a well-functioning floodplain through landscape management, to improve the flood water discharge and to flatten the flood water
OAL Leader(s):	Daniela Jacob and Paul Bowyer

Description of the area:
OAL Germany (OAL-DE) is located in the Biosphere Reserve 'Niedersächsische Elbtalaue' (BRNE). The biosphere Niedersächsische Elbtalaue is a near-natural and species-rich landscape, characterized by floodplains with flood channels and oxbow lakes. A flood protection dyke separates the Elbe floodplains from the Elbe marshland with its main features, such as seepage water and fields, woods and settlements. The NBS implemented in OAL-DE is designed to aid with flood risk reduction, as one part of cooperative flood management. On the banks of the River Elbe and in the lower-lying floodplain areas, the main question is where, for flow-related reasons, areas must be kept free of woody vegetation and where, on the other hand, floodplain forest development (for nature conservation reasons) can be tolerated and, if necessary, encouraged (NLWKN 2017). The management of this OAL takes place under a complex mix of competing interests, conflicting legal frameworks, socio-economic, and socio-political change.

Methods used: Informal discussions (3), interviews (1), focus groups discussions (1), field trips (1) meetings and workshops including close observation, expanding time, mind-mapping, Multi-criteria decisionmaking, Swot, dialogue

Description of the co-creation process:

HZG/GERICS was able to win the biosphere reserve management for the cooperation in OAL-Germany. The biosphere reserve Niedersächsische Elbtalaue as OAL Germany is suitable because it is by definition part of the umbrella concept of nature-based solutions. In OAL-DE, stakeholder discussions are done differently than in other OAL's of OPERANDUM, since there is one main stakeholder - the biosphere reserve administration. Within the scope of the project "Kooperatives Auenmanagement", this stakeholder engages with around 40 different stakeholders, including planning officials, local administration, and landowners.

In the BRNE, some residents were worried by frequent flooding and had become concerned about the NATURA 2000 habitat alluvial forests. During flood events, the alluvial forests can become blocked and impede flood runoff. In order to meet flood protection requirements, forests have been cleared and need further prevention from growing. However, as this is a Natura Habitat, compensation measures have to be implemented, meaning that trees need to be replanted elsewhere in the landscape.

In order to organize this and at the same time meet the concerns of the residents, the biosphere reserve administration established an integrative approach, the cooperative floodplain management (CFM). The CFM can be classified in the NBS concept of ecosystem-based management approach. The cooperation is organized into so-called "floodplain management groups", which enable the main actors to interact regionally with the local stakeholders. CFM focuses on local solutions in each region by addressing different issues such as individual aftercare measures close to nature and the use of financial instruments. Regular information events are held, involving the residents, which help to increase the acceptance of the NBS measures and which support the further co-development of CFM.

The special legal situation for the preservation and protection of nature in the biosphere reserve is partly in contradiction to the possibilities of nature-based flood protection. In recent years, the frequent occurrence of extreme flood events has led to increased fear, which has led to conflict situations and a lack of understanding of nature conservation. The Biosphere Reserve Administration (BRA) has done a lot of communication work to calm the heated tempers in all committees and among the local residents. BRA's experience with many research projects in recent years has shown that local stakeholders are overtired by many requests, which usually do not end in visible, positive changes in the quality of life due to the short-term nature of the projects. In short, there is much discussion and questioning, but nothing comes of it. This phenomenon is known as "stakeholder fatigue" is a major concern for the BRA. To stop this process and to protect local residents, the BRA has explicitly asked to act as a gatekeeper.

This is in line with the cooperation with HZG/GERICS in OPERANDUM. The work in the biosphere reserve serves as a case study. HZG/GERICS serves as an intermediary between OPERANDUM and the BRA. We receive first-hand information for the exploration of best practices for the implementation of nature-based solutions with the BRA. The idea of cooperation is also very important for the BRA and it is important for us (HZG/GERICS) to work out the benefits of OPERANDUM for the BRA together. In the dialogue with the BRA, we have chosen cooperative flood management (CFM) as one of the many projects in the biosphere reserve, which will be of benefit to both sides. The BRA is always available to answer questions and attaches great importance to working out results for OPERANDUM together. The BRA is long-term oriented and is particularly interested in the hurdles arising from climate change. The climate information produced by WP5 will help the BRA to make decisions.

Final plan:

The NBS have already been implemented in OAL Germany. The final plan is to be able to analyse and test the NBS for their effectiveness in today's and future climates, and to try and learn more about the barriers to, and opportunities for, successful implementation and acceptance of NBS in a complex environmental and legal setting where multiple different objectives and policies need to be satisfied.

Figure (a). Main objectives of OAL Germany, (b) Map of OAL Germany and (c) . Floodplain management with grazing sheep on meadows in OAL Germany.

The NBS that has already been implemented in OAL-DE is a hybrid green-grey solution. Mechanical clearing of trees and shrubs from along the riverbank is the grey part, and, in order to try and prevent regrowth, a range of different grazing animals are used, in the hope that this can provide an effective and economical solution, and this is the green part of the solution.

OAL IRELAND	Ringsend in Dublin
Location:	City of Dublin, Ringsend region
Hazard:	pluvial, fluvial and tidal flooding
Risk:	Flooding in the area contribute to damages in buildings, increase in traffic congestion, leading to economic depletion
Objective of the OAL :	The main objective is to deploy a nature-based solution to reduce the flood risk
OAL Leader(s):	Francesco Pilla
Link to the story map:	Link to ArcGIS storymap

Description of the area:

Open Air Laboratory Ireland (OAL-IE) is located at the Ringsend region in Dublin, which is economically extremely important as around 10% of Ireland's entire GDP is generated from this area. The area is surrounded by River Dodder in the west and River Liffey in the north, while the Irish sea covers the eastern boundary. Since the area is surrounded by water bodies, it is prone to pluvial, fluvial and tidal flooding. Extreme rainfall and lower elevation in the area leads to pluvial floods, while flash floods at Dodder lead to fluvial flooding in the region, however, tidal flooding was found to be rare in the locality. The River Dodder is one of the most important rivers in the Dublin area. It originated on the Kippure (Dublin) mountain and meets River Liffey at Ringsend. The length of the Dodder River is approximately 27 km and the catchment area is around 113 square km. Due to high slopes in the catchment area, the upper and middle section of the river is highly susceptible to flooding during periods of extreme rainfall events. In the lower section of the river, ranging from Ballsbridge to Ringsend is susceptible to tidal flooding. Recent flood events indicate that the river can exhibit maximum flow up to 250 m^3/s. As the size of the river basin is small with steep slopes, it usually takes 2-3 hours to reach the water from upstream at the mountains to downstream at Ringsend, termed as lead times. Flood mitigation measures can be used to improve the estimation of lead times and reduce flood risk and damages. The flooding affects the residential can commercial buildings located in the area, as well as affect the traffic network by reducing traffic flow through waterlogging. Since the majority of multinational companies have their offices in the region, delay in traffic creates economic disruption.

Methods used: informal discussions every 2 weeks, interviews (2), surveys (1), focus group discussion (2), field trips (1), joint research projects 10-15, joint presentations 1, meetings and workshops including Multi-criteria Decision Making Analysis, SWOT, Scenario planning, Plural Rationality approach.

Description of the co-creation process:

Many nature-based solutions (NBS) such as tree pits, bioswales, green roofs etc. are being planned for implementation by Dublin City Council as their sustainable urban drainage (SUD) system initiative. Also, permeable pavements and converting concrete parking lots to green spaces are being planned in many areas in Ringsend. The local community, however, plans to have more parks and open green spaces nearby for more recreation and aesthetic value. Several stakeholders showed interest in NBS as an alternative solution for flood mitigation. However, while interviewing our stakeholders, scepticism from a few community-level stakeholders towards nature-based solutions was observed. This is mainly because engineered artificial grey infrastructure as a flood-resisting system has been dominating over decades, while changes to alternative natural solutions is a slow process. Furthermore, a lack of awareness of nature-based solutions created unwillingness to some participants during co-design activities. Some of those stakeholders who participated in the workshop requested information on the effectiveness of the NBS when compared to artificial grey infrastructure in flood control. Some details from the literature review obtained by OAL-IE research group shared this information.

The co-creation process started with a workshop with high-level stakeholders (UCD, DCC, OPW,

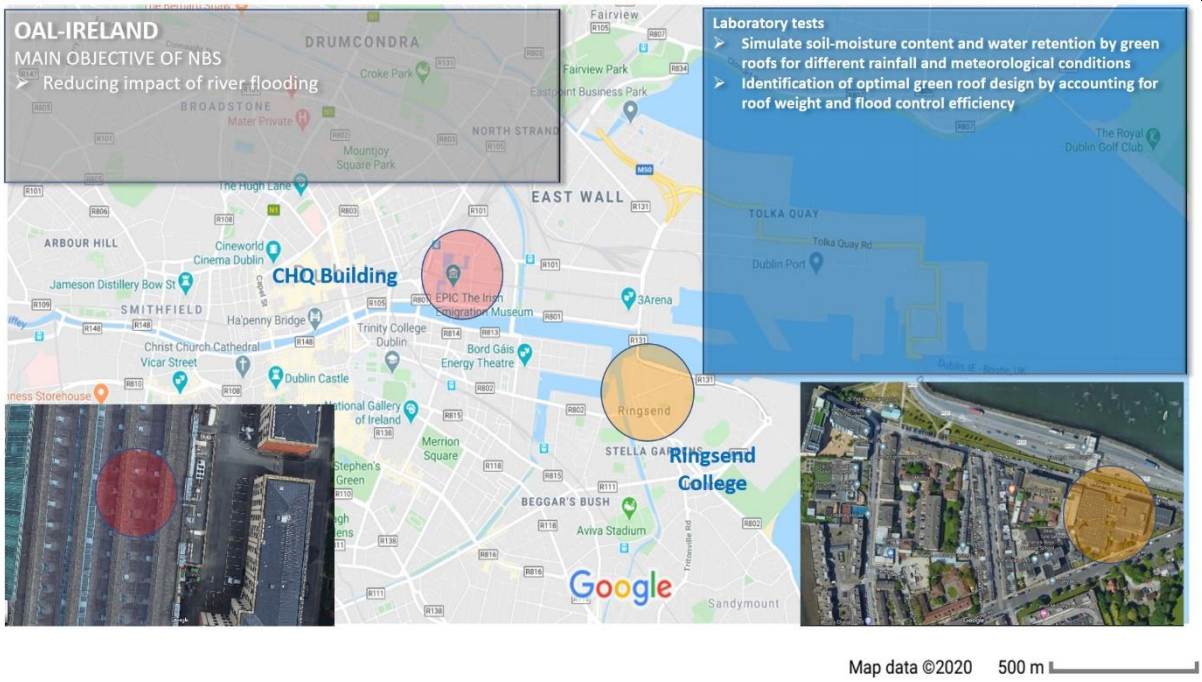
Flood risk department, Climate Action Regional Office) at the very beginning of OPERANDUM to discuss the possibility of an NBS implementation (SUDs) in the Dodder catchment as an alternative to a grey infrastructure solution to reduce fluvial and pluvial flood risk. The workshop concluded with the identification of 5 potential locations for the intervention and a broad definition of the typology of SUD to be implemented. This was followed by monthly meetings between UCD and DCC to fine-tune the selection of the location and intervention. The meetings had the following main purposes: (i) to progress with the scope of the intervention by informing DCC about the modelling activities carried out by UCD to assess the impacts of different kind of interventions at the potential locations; (ii) optimise the network of river level and rainfall monitors in DCC using a statistical approach developed by UCD, with the aim of using the network for flood risk modelling; (iii) continue the engagement of high-level stakeholders through DCC as main contact point; (iv) develop a joint strategy for local communication and engagement of local communities; (v) identify and remove potential barriers to the implementation of the NBS.

The continuous workshops with DCC allowed to identify challenges and act upon them promptly. As an example, several challenges related to the implementation of the intervention on public and private land in the city emerged early in 2019. This was due to the current housing crisis in Dublin, with a consequent disproportional increase of house prices. As such, an alternative plan was co-developed with the support of DCC and the Climate Action Regional Office which involved the deployment of a green roof as a SUD solution for the city centre. This was followed by the engagement with the Smart Dublin ecosystem which allowed to identify other interested stakeholders. In specific, an NBS enterprise called AquaRoot expressed the interest in co-developing a green roof using only recyclable materials; an IoT company called Wia expressed the interest in co-developing a pilot of a smart IoT integrated green roof; Dogpatch Lab expressed the interest in providing a space for the green roof on the CHQ shopping centre and in hosting a screen on the floor area of the building to display in real-time the data from the green roof. A series of co-design workshops were run with these companies to co-develop the concept and the implementation plan of the smart green roof. The last face-to-face workshop was run in March 2020, followed by a virtual workshop in May 2020. The implementation plan has been finalised as part of the last workshop to deploy the smart green roof in July/August 2020 depending on COVID restrictions.

Other benefits resulting from the continuous engagement with DCC and the Smart Dublin Ecosystem was the support provided by some tech companies which have their headquarters in the Dublin Docklands area. As an example, flood river sensors were provided by a tech company (the name cannot be disclosed at the moment) which will be used for the assessment in the OAL-IE.

Final plan:

A set of NBS can be used to reduce flood risk and increase flood resilience. The green roof has been chosen as one of the NBS to be deployed in OAL-IE.



The green roofs (see below) have multi-dimensional advantages such as flood control by absorbing rainwater, providing insulation and temperature control, habitat promotion and enhancement of the aesthetics of the landscape. The final goal would be to upscale the deployment of the green rooftop at a city scale for managing run-off and stormwater at greater scale. The goal of the co-deployment initiative is to inculcate a culture of ownership amongst the citizens for long-term management of green roofs by associating them to many other co-benefits derived from green roofs, such as an increase in aesthetic values, reduction in air and noise pollution etc., which can enhance the sustainable living in an urban space.

OAL ITALY	Po di Goro
Location:	Delta Po river, Po di Goro branch. Emilia Romagna region, Italy.
Hazard:	Marine flooding, drought and salt intrusion.
Risk:	Ecosystem exposure to flooding and drought, ecosystem susceptibility (biodiversity, population of protected species, etc.).
Objective of the OAL :	The main objective is the mitigation of the effects of flooding and salt intrusion on delta environment and ecosystem.
OAL ITALY	Bellocchio Beach
Location:	Bellocchio natural reserve, Emilia Romagna region, Italy.
Hazard:	Storme surges and marine flooding, coastal erosion.
Risk:	Ecosystem exposure to coastal erosion, ecosystem susceptibility (biodiversity, population of protected species, etc.).
Objective of the OAL :	The main objective is the mitigation of the effects of marine flooding and coastal erosion.
OAL ITALY	Panaro River
Location:	Panaro river near Bomporto town, Modena, Emilia Romagna region, Italy.
Hazard:	River flooding.
Risk:	Ecosystem exposure to flooding, ecosystem susceptibility (biodiversity, population of protected species, etc.). Social system exposure to flooding.
Objective of the OAL :	The main objective is the enhancement of the bank erodibility resistance to extreme flooding events of the river embankments.
OAL Leader(s)	Beatrice Pulvirenti
Storymaps	See the storymaps of the three OALs:

Description of the areas:

OAL-Italy is composed of three different sites Po di Goro, Bellocchio beach and Panaro river located in the Emilia Romagna Region. The Po di Goro departs from the right bank of the Po River, in correspondence with the settlements of Serravalle (in the province of Ferrara) and Papozze and Santa Maria in Punta (in the province of Rovigo). The stream (of about a length of 45 km) flows into the Adriatic Sea, near Gorino Ferrarese, in the municipality of Goro (FE). This area is subject to flooding, drought and salt intrusion. In this area there is a great interest for NBS that mitigate salt intrusion and save the many activities related to agriculture along the Po River. Bellocchio beach is one of the remaining natural littoral of the Emilia Romagna region. It consists of a low sandy beach with a lagoon where only a few residual natural dunes are still present. This area is subject to coastal erosion. The NBS will consist of an artificial dune consolidated with naturalistic engineering work that should protect a naturally vegetated dune from erosion and marine floods. Panaro river is the last right tributary of the Po river. For total length it is the third right tributary of the Po River; its basin is 2,292 km² at the Po confluence and the downstream part of the river has high earth banks on both sides since this area has always been subject to flooding. The NBS will be the installation of herbaceous perennial deep rooting plants as coverage of earth embankments, for preventing river bank failures induced by erosion.

Methods used: informal discussions, surveys (7), focus group discussions (7), field trips (8), joint research projects (2), joint presentations (2), meetings and workshops including close observation, problem tree analysis, SWOT, Appreciative Inquiry

Description of the co-creation process:

Each site is experimenting different NBS and the combination of the heterogeneity of competences, knowledge and skills open up to a huge challenge that has been (and still being) well carried by all the OAL members. The team is composed of a variety of researchers and professionals in the field of engineering, physics and geophysics coming from different institutions (University, ARPAE- public environmental institution). The co-design approach is not immediate to those who actually work and operate in the field and the contribution of the social scientist was mainly in guide and training

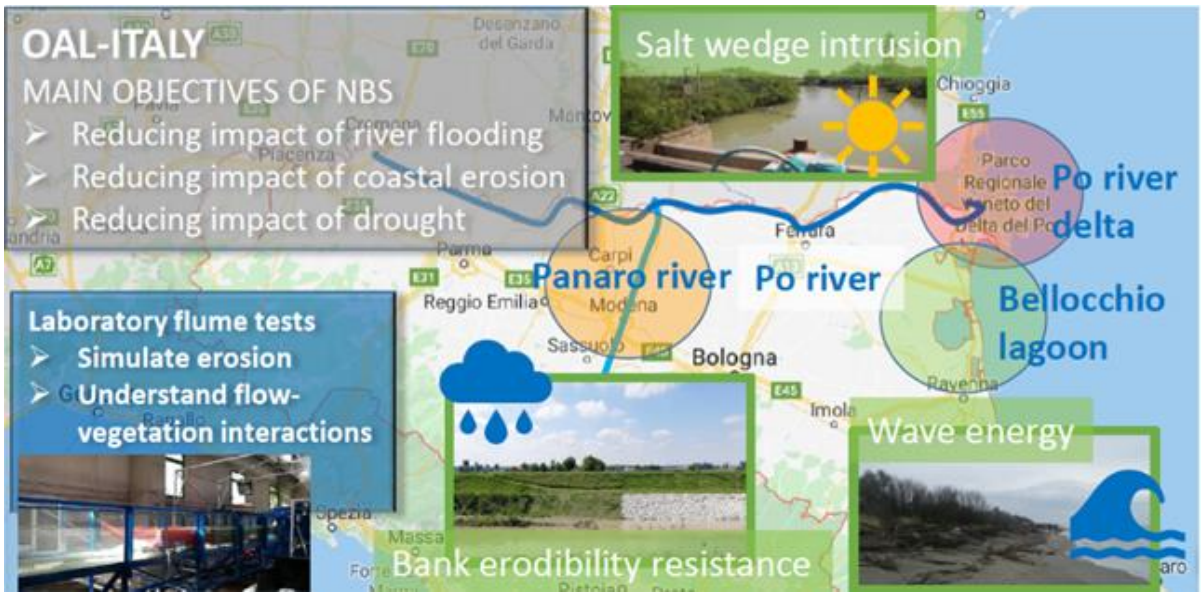
the members in interacting with the most crucial stakeholder. The choice was made because the primary stakeholders were (and still are) public institutions and local authorities: Municipality, Management Boards, Operative Centre and the whole team agreed to let the OAL members manage and structure the interaction with them. The social scientist's contribution was to support the OAL member with formative activities and training workshops to develop skills and tools to better activate and engage stakeholder in the co-design process. In some specific complex cases the team (hard and soft science researcher) led the co-design meeting together using a collaborative and open approach to build a positive relationship with a crucial group of stakeholder (i.e. Civil Protection volunteers in the site of Panaro River – Modena).

OAL members regularly meet and have contact with stakeholders in order to proceed with actions and activities in the three sites. The OAL teams organized several field trips and focus group involving local authorities, engineering private service provider in order to define technical aspects, the authorization and implementation procedures and also the willingness of all to participate to the whole OPERANDUM processes: co-design, so-implementation, co-deployment and so on. They report every update in a logbook within a common folder shared in a collaborative platform: the logbook, presented in the showcase in chapter 6 of the present deliverable.

Since the experimentation of the logbook was conducted in the OAL Italy, we notice that the activity of monitoring addresses the need to manage a complex communication flow within and among sites of the OAL (that proceed at different velocity and progresses), thanks to the continuous update of the state of the art in terms of stakeholder involvement and consulting and the main success or failure gained in every step of the process. In particular, the implementation of this tool has shown how OAL members got more and more used and familiar with data gathering and for reporting to OAL leaders and social scientists any helpful information to use for practical activities and to improve, as it goes, the current strategy and tactics in SH engagement. Moreover, it's notable the improvement of SH involvement activities among hard scientists and the consolidation of a renewed way of working in the OAL site, considering stakeholder a legitimate partner in the project.

There were some critical issues that arose from the interaction with the stakeholder. In terms of logistics and organization the communication was easy with stakeholders that usually collaborated with the OAL members, while other public bodies were not reached despite several attempts. All local authorities expressed difficulties in finding time and resources because they are busy with many urgent works. Regarding the definition of technical aspect of the co-design, the process was quite easy and smooth, despite the innovative nature of the work. Instead, it was very difficult to deal with administrative problems (permissions and authorizations) due to the complicated bureaucracy. OAL members experimented that cooperation starting from earlier phases of the design, during implementation until the last monitoring phase, is indispensable to reach the goal. Process and procedures are very complex: technical and administrative aspects intertwine with each other and several skills are needed to face every phase of the project.

There are some challenges still open, such as the engagement of secondary and informal stakeholders (citizens, tourists, associations) that should be taken more into consideration and involve a more structured way. The possible actions to be implemented in order to reach this goal could be: program some events to inform the stakeholders of the OPERANDUM project and report the event with photos and videos to be uploaded in periodically in website Increase the participation of stakeholders to the OPERANDUM website and social media or experiment new methodology of collaborative processes and activities such as citizen science, guided tours or open field trip for non-specialists in the site, conferences or meeting organized in collaboration with the Municipalities involved in the project.



A summary map of the solutions to be deployed in the three OALs in Italy.

OAL UK	Catterline Bay
Location:	North-East Coast of Scotland, UK
Hazard:	Landslide, Surface and coastal erosion, Storm surge
Risk:	Coastal erosion super-imposed on a bay subject to shallow landslides and surface erosion leading to infrastructure damage, loss of scenic beauty, impacting tourism, recreation and livelihoods
Objective of the OAL :	The aim is to mitigate the hazards while maintaining the area's natural beauty as well as demonstrate the utility of ground stabilisation techniques and live vegetation approaches in this challenging site
OAL Leader(s):	Rohinton Emmanuel
Link to the story map:	See the storymap of the OAL –UK:

Description of the area:

OAL-UK consists of the village of Catterline, on the North-east coast of Scotland, UK. Catterline has approximately 160 residents, in around 60 residences, one primary school, and one restaurant/pub. The residences sit atop a cliff above Catterline Bay and the North Sea; the slopes are locally referred to as "Catterline Braes". The Bay is known for its scenic beauty, including potential sightings of sea-life, and was made famous through landscape paintings by the artist Joan Eardley, who lived in Catterline. The main hazard facing OAL-UK is landslides. The slopes down to Catterline Bay have experienced many minor and major landslides in living memory. In 2012 a significant landslide blocked and damaged the vehicular road to the Bay, raising concerns about the integrity of the slope and road; the impact a future landslide could have on the recreational activities occurring in the Bay; and the safety of properties atop the cliff. This concern resulted in the creation of the Catterline Braes Action Group (CBAG), a group of around 40 residents who aim to proactively preserve the slopes.

Methods used: informal discussions, surveys (2), focus group discussions (1), field trips (15), joint research projects (1), joint presentations (2), meetings and workshops with mind mapping, reflective cycle, SWOT, Plural Rational Approach, Expert judgement, quantified risk assessment

Description of the co-creation process:

The co-creation relationship between GCU and CBAG predates OPERANDUM, dating from 2012 when CBAG reached out to Prof. Mickovski at GCU. He had previously played a significant role in a green infrastructure project to protect a slope, road and houses near Catterline. CBAG are stakeholders who are unique in being self-organised and motivated prior to GCU's involvement; there was an awareness of hazards and risk developed in the community's collective mindset; and as a community, they had actively researched solutions. Early GCU collaboration with CBAG included: co-writing of funding applications for small interventions; field visits with summer students; and co-designed and -deployed initiatives including extensive tree planting.

Following OPERANDUM's launch, Dr Ollauri attended a CBAG meeting to explain the project and its potential input into ongoing work in Catterline. GCU and OPERANDUM partners Naturalea then developed potential NBS for Catterline, based on CBAG and Dr Ollauri's knowledge of the hazard; technical characteristics of the soil, climate and topography; and financial and workforce constraints. At a second CBAG meeting, Dr Ollauri presented community members with potential NBS based on the aforementioned criteria. CBAG members were able to give verbal feedback, noting their preferences, concerns, and providing further local knowledge. GCU also distributed a questionnaire to gather information on the level of acceptance for NBS generally, and comparative preferences between the specific NBS proposed. The results were analysed and fed back to CBAG. GCU personnel continued to make field visits to Catterline with summer students, both supporting CBAG in pre-arranged community-led installations and gathering data to support the OPERANDUM

installations.

GCU and Naturalea began preparations for an NBS workshop to be held in Catterline in March 2020. The workshop would bring together local stakeholders, industry professionals, local authority, and academics to learn the theory and practice behind NBS. Due to the size restrictions of OAL-UK, there would be a maximum of 40 attendees. The workshop would form the cornerstone of the co-deployment stage, with four NBS being constructed in its three-day duration. It would build skills and capacity for both local stakeholders and professionals alike to discuss, design and implement NBS in other settings. Summer 2019 was also a period of concentrated stakeholder engagement, the objective being to diversify and expand the stakeholder pool. The relationship between GCU and CBAG had been formed and developed organically; however, future stakeholder engagement required a more deliberate process to bring Catterline's many other stakeholder groups into involvement with OPERANDUM.

A stakeholder engagement strategy was developed and utilised, identifying stakeholders through online searches, conversations with known stakeholders, and visits to the OAL. The strategy followed OPERANDUM processes to identify categories of stakeholders; their needs, expectations or requirements; and their Interest and Power (I-P) in the OPERANDUM project. Two I-P matrices were created; one for the stakeholders as they currently stood, and another for the target I-P by the co-deployment and monitoring stages. This process allowed the identification of the stakeholders to be prioritised for increased engagement; these were rowing, paddle boarding and diving groups actively using Catterline Bay for organised recreation; the local primary school who would be a key stakeholder in the Monitoring stage; and local authorities who could support the co-deployment stage either through publicity, resources, or workforce.

GCU successfully built relationships with the local primary school, rowing club and Aberdeenshire Council. Council representatives also connected GCU with Kincardineshire Development Partnership (KDP) who support community-led projects. The Council and KDP assisted GCU with publicising March NBS workshop; a programme of parallel activities was in development with the school; and members of the rowing club signed up for the workshop. One week prior, 37 people from a mix of local stakeholders, industry, and academia had signed up to the workshop. Yet, it was cancelled due to the outbreak of COVID-19.

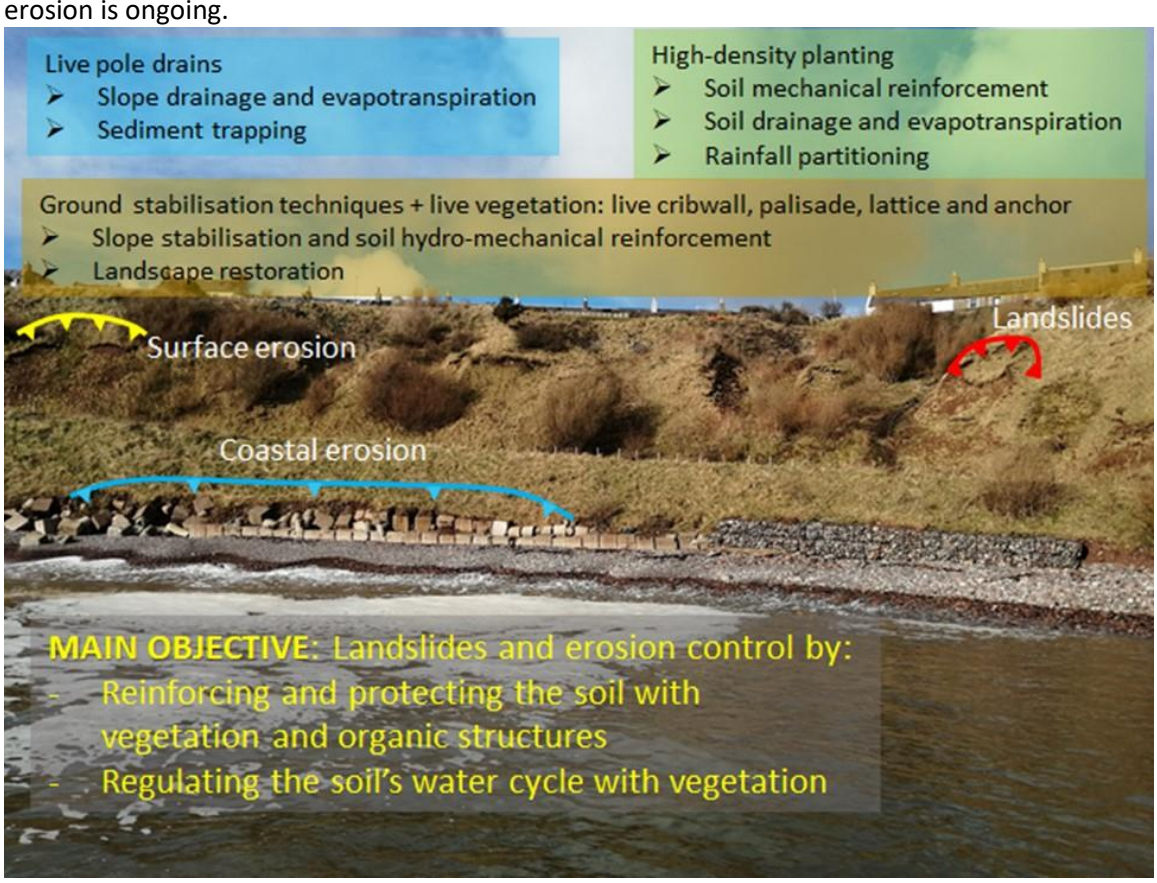
GCU's stakeholder engagement process has experienced numerous successes and challenges. The use of a stakeholder engagement strategy allowed the successful identification and engagement of new stakeholder groups, who offer more depth of understanding of the socio-cultural life of the OAL. The strategy also allowed the realisation of the priorities of each stakeholder, which in turn informs the method used to engage with them and the level and type of detailed information of interest to them. A significant challenge, however, is stakeholder fatigue: after 8 years the members of CBAG have become less active and interested in contributing to ongoing landslide protection work; in theory, they continue to support the work and the use of NBS but many are no longer personally committed to taking part in works. The largest challenge is the uncertainties COVID-19 brings. However, with the crisis also comes opportunity; Catterline Bay is likely to become increasingly significant in the daily lives of residents forced to stay close to home, and it will be interesting to see the eventual result of this on socio-cultural aspects in OAL-UK.

Final plan:

Based on co-design and co-deployment, eight (08) NbS (live pole drains, ground stabilisation and high-density planting) techniques to mitigate the hazards while enhancing biodiversity AND maintaining natural beauty, are currently being deployed to demonstrate the utility and act as exemplars of NBS.

Sealevel monitoring and modelling work in collaboration with UNIBO for coastal flooding and

erosion is ongoing.



9 Conclusions

The OPERANDUM project has applied a Living Lab and co-creation approach for developing NBS for hydro-meteorological risks. This approach was chosen to take into account the different social and ecological contexts and to better integrate different actors and knowledge , and in that way, to boost the advancement of and learning about NBS in rural and natural territory contexts. In order to support the work of the OALs in the transdisciplinary collaboration, we provided a review on the current literature (Chapter 2). A joint conceptual framework and an "ideal process" for co-designing and co-developing NBS were designed to support a common understanding of the main phases of the process and create a common language (Chapter 3). Furthermore, suitable methods and techniques to be used in the OALs were collected and introduced. In addition, the experiences of co-creation in the OALs, as well as the emerging problems, were shared in joint workshops (Chapters 4-5). A monitoring framework was created (Chapter 6) and tools for solving problems were given in Chapter 7. Although the co-creation work in the OALs will continue we can already summarize some key findings and lessons learnt.

In many cases, the primary stakeholders were identified and contacted at the beginning of the project. These stakeholders have had a key role in the planning the activities planning the activities and developing the NBSs in close collaboration with the researchers. They often have a strong interest in co-developing the NBS and they often speak a similar language with the scientists, which ensure easiness of the communications, actions and enhance mutual learning. The secondary stakeholders, usually local residents, associated companies, administrative and media usually find the issue interesting, but the issue might not be their first priority. In the rural area, these stakeholders may be physically widely spread (including also part-time residents) and they do not necessarily form a natural "community" with which to collaborate. Yet, the commitment and engagement of such secondary stakeholders are necessary, in particular, if they are private landowners or key companies having the resources (land), expertise or technology needed for the NBS. We have learnt that among the secondary stakeholders there may be individual people or organisations that are committed to promoting the NBS if the issue is somehow connected to their immediate lifeworld or business. Identifying these persons or organisations is crucial for successful project implementation.

The transdisciplinary collaboration is composed of the work with the external stakeholders across the sectors and highly multi-or interdisciplinary research teams. This resulted in different social worlds in all OALs. As for the collaboration with the stakeholders, preliminary experiences from the OALs tell that it is crucial to gain an understanding of the whole social-ecological system, not only about the current state but also about its history, previous actions, and social relations. It is also important to be present, to listen to the different stakeholders, and to understand the perceptions of the problems and possible solutions. This takes time, which is often a limiting factor in a project. In many cases, researchers visit the area only seldom, which does not necessarily allow informal encountering or meetings with the local stakeholders. On the other hand, field visits may, in turn, ensure a full commitment and attention once the researchers are at a place and help to keep a certain distance and objectivity to the local issues, particularly in the cases where the social relations are complex and tensions exist. In any case, getting to know the place and the people is a critical foundation for the co-creation, the role of which cannot be underestimated. In many OAL, the

researchers were already familiar with the area, which made it easier to get the project started and build the work on existing knowledge and networks.
There are a variety of methods that can be used for the co-production of knowledge with the stakeholders ranging from more creative ones (e.g. evoking senses or appreciative inquiry) to more conventional ones (field trips, focus group discussions). The researchers in the OPERANDUM project have realized that it is important to understand the context where the methods are used and ensure that the participants feel safe to maintain trust. This calls for good social and facilitation skills and understanding of right framing of the activities: finding means and tools that are somehow familiar to the participants but may help them to look at the issue from a new perspective or position. If there are no resources for using an external facilitator, the researcher may have to adopt different skills and roles and step out from the conventional roles (observer).

Continuous reflection of the collaboration and regular monitoring activities are important parts of the work with the stakeholders. Besides instrumental value (getting feedback and redirecting activities if needed) monitoring is an expression of respect for the work of the stakeholders. We developed a common framework for monitoring quantitative and qualitative indicators. Yet, we wish to underline that besides this formal side of the monitoring and quantitative measures, the monitoring framework provides a platform for an open discussion and feedback about the process.

Our experience also reveals that although it is easy to agree on many of the ideals, principles and values of such work, the real-life/practice is different. Researchers have their aims and resources, time schedules, and the stakeholders have a lot of other issues on their plate, which may result in a kind of imbalance between the goals of different parties. Stakeholders also had high expectations of the results of the project and the NBS, which are hard to meet within the time frame of the project, given the slowness of the ecological and/or administrative processes. This may cause some frustration on both sides. Modelling and other virtual tools are here for a great support. Understanding of the research nature of such projects may also assist stakeholders to reflect with acceptability and enhance a stronger base for further collaboration.

In a transdisciplinary project, it is also important that the collaboration within the research group is running smoothly, as this may have an impact also on stakeholder work. We find that this internal collaboration is not sufficiently recognized in the existing literature. Within the OAL research teams different disciplines, backgrounds, experiences and goals are present. This kind of broad expertise is needed, as the NBSs cover many different aspects ranging from physical, ecological and technical to social, cultural and economic. Planning and leading the co-creation processes is also a special field of expertise. The researchers do not necessarily have previous experience working together, and it may take time to get to know each other and to find a common language. There may be some hidden power-structures in the research team, which are not necessarily easy to open. Finding compromises might be good for internal balance, but not necessarily best for the project. Time will also help here. Some of the key principles for a successful collaboration with stakeholders also apply to the collaboration within a research team, including clear and effective communication, realistic expectations, and coordinating activities.

Six out of seven OALs of OPERANDUM are located in the semi-urban or rural area and we have already had an excellent opportunity to reflect on the differences between the rural and urban processes. As already mentioned, in some of the OALs in the rural areas we face the issues of bigger

geographical scales and physical distances and land ownership with related cultural issues. For many researchers, the OAL in rural context means also stepping out from the everyday work routines, into a different social and cultural environment and taking on different roles. This was mostly experienced as positive, but also to some extent challenging.

In the OPERANDUM project, we have common objectives to achieve and a joint Living Lab -approach to use. In this task, we have developed a joint conceptual framework, which we are implementing. All the OALs have shaped and tailored this framework to be applied in their OALs and picked up the working methods that suit best for their context and competence. In this way, each of the OALs have developed a different pathway and at the end of the project, we have a better understanding of how these pathways are like, how they differ and why. Yet, as a mid-term conclusion, we can confirm that co-creating NBS is not a technical process that can be followed step by step. It is about continuous learning and being sensitive for the environmental, social and cultural contexts we are working, and a continuous dialogue between different social worlds, the ones of both the stakeholders and the researchers. As we are working across Europe and beyond we can also see cultural differences and that the evolution of the democratization of the science is developing in different phases and possibly, also getting different forms. This diversity is a necessary condition for environmentally sustainable and socially acceptable NBS.

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ANNEX 1

THEME OF THE INDICATOR	Topic to evaluated?	Quantitative (listed/evaluated by the project co-cordination)	Qualitative (evaluated by the SH with the help of survey)	Possible questions in the questionnaire	
INPUT INDICATORS: What resources are needed for successful stakeholder engagement?	Interest	list/number of previous activities in the field	level of interest, reason for interest	How would you rate your interest in co-creating NBS? NBS as a topic ingeneral?	rate 1-5
			reason of interest	awareness or experience of the hazard/risk	open ended
			object of interest	what kind of activities you are interested in?	multiple choices
	trust		feeling of confidence on the project co-ordination and other stakeholders	How do you find the collaboration with a) project organisation and b) other participants of the project?	rate 1-5 and open ended question
	time	list/number of hours to be used for the project	subjective evaluation of time availlable		open ended question
	capabilities, physical access			Are there any other issues which may enable or disable your participation?	rate 1-5
	communication channels	list/number of communication channels	diversity/inclusivity of communication methods (i.e. mix of mail and internet based depending on SH)	How feasible do you assess the following communication channels for you/for the collaboration?	rate 1 -5
	composition of research team and stakeholders	list/number of different disciplines/fields of list/expertise involved; number of different interest groups presented			
	understanding/agreement of goals		understanding of the goals and roles while reflecting and acknowledging different SH priorities	Do you think that you have a clear understanding of co-creation processwhat is planned to be done in the OAL, what are the roles and responsibilities of the each parties etc. ?	rate 1-5 and further explanations
ACTIVITY/ PROCESS INDICATORS: What doest the stakeholder engagement process do? What are the activities?	activities	list/number of joint activities (co-authored publications; joint events, field trips etc.)			
	participants	list/number of participants in different activities		Do you feel everyone who has a stake has been involved?	rate 1-5, open ended question
	communication	frequency of use of various communication channels (e.g. posts and shares of social media)			
		informal communication (number of mails, discussions)			
	integration	list/number of use or visits to NBS/OAL			
	equity		respect	Do you feel all SHs have been treated equally and with respect?	rate 1-5
	inclusiveness		involvement	Do you feel everyone who has a stake has been involved? Do you feel you have been heard/you have had voice?	rate 1-5

	accessibility		access to the events, access to the materials	Do you feel that you have had an access to the project materials? Were the project materials and language understandable?	rate 1-5
OUTPUT INDICATORS: What does the stakeholder engagement it produce during the process and right after?	commitment	Responsiveness (replies to emails in time etc.)			
	responsibility	Number of Stakeholders engaged voluntarily in implementation and operation and maintenance of the NBS			
	leadership	Number of events organised and led by the SH			
	dissemination	Number of publications led by the SH			
	interest	Number of information requests and contacts by the stakeholders			
OUTCOME INDICATORS: What does the stakeholder engagement achieve or lead to?	learning		new knowledge of e.g. NBS, climate chage	Do you feel you have gained new knowledge about NBS or climate change?	rate 1 -5 + open ended; what kind of knowledge
	upscaling	number of new projects as spin off			
	social cohesion			Do you feel being more part of the community because of the project?	rate 1 -5
	impact of the NBS on quality of life		happiness, feeling of satisfaction, improved environememt		rate 1-5
	networking	number of new contacts and collaboration		Do you feel you have get to know new people/organisations?	rate 1-5,
IMPACT INDICATORS: How does the Stakeholder engagement contributes to Higher level strategic goals (in our case promotion of NBSs for HMR)?	Capacity building of different parties through integrated knowledge	Number of Universities that have changed/enriched their curriculum with NBS concept and practices			
		Number of new professionals with competence of NBS			
		Individual student projects (Bachelor, MSc, PhD)			
	Strengthening technological innovations	Number of new patents related to NBS solutions			
	Improved acceptance	Number of NBS solutions in use compared to grey solutions			
	Market demand and competitiveness	Investments in NBS resources, cost-efficiency of NBS			
	Policy	New policies related to NBS			

OPERANDUM

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