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Research Note

Innovation in NBS co-design and implementation

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Abstract: Impact in the form of innovation and commercialisation is an essential component of publicly funded research projects. PHUSICOS, an H2020 Innovation Action project, aims at demonstrating the use of nature-based solutions for mitigating hydrometeorological hazards in rural and mountainous areas. The work program is built around key innovation actions, and each WP leader specifically responsible for nurturing innovation processes, maintaining market focus and ensuring relevance for the intended recipients of the project results. Key success criteria for PHUSICOS include up-scaling and mainstreaming of NBS to reach broader market access. An innovation strategy and supporting tools for implementing this within PHUSICS has been developed and key concepts forming the basis for this strategy are presented in this research note.

Keywords: Innovation, Up-scaling, NBS Nature-based solutions (NBS); Hydrometeorological hazards; PHUSICOS project; Flooding; Landslides; Avalanches; Rockfall; Europe

1. Introduction

1.1 PHUSICOS

PHUSICOS is an H2020 demonstration project (grant agreement no. 776681) focused on the application of nature-based solutions (NBS) to mitigate hydro-meteorological hazards such as flooding or landslides in rural and mountainous areas. PHUSICOS aims to integrate existing state-of-the-art methods and technologies in practical settings, and over time develop an evidence base regarding the performance of these solutions. Key outcomes of PHUSICOS will be innovations as well as enabling up-scaling of these innovations for real-world applications.

In PHUSICOS, we employ the concepts of co-design (stakeholder involvement) in the implementation of test cases, effectively anchoring the research results as practical and applied solutions relevant for the intended users, e.g. the production of innovations as PHUSICOS results. This technical note explores the approach to innovation implemented within the PHUSICOS consortium.

1.2. What is an innovation?

Many definitions exist for innovation, where the definitions often reflect the context or paradigms of the field where the definition is applied [1]. As a demonstration project to reduce geohazards with NBS, PHUSICOS represents applied research in the context of value creation for stakeholders, and one broad definition of innovation seems appropriate for this context: "Innovation

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is the process of creating value by applying novel solutions to meaningful problems" [2]. In PHUSICOS, we further refine this definition as the successful exploitation of NBS research results to produce tangible benefits, for example satisfying needs and wants of relevant users. These benefits may be in terms of societal benefits, promoting sustainability and resiliency, improved life quality as well as direct economic activity. Technology innovations may take the forms of techniques, methods, data or other products and services (Figure 1), or service and social innovations closely linked to the technological innovations through the explicit objectives of producing co-benefits of social impact [3].

Figure 1. Defining technical innovation *(Illustration by author)*

Potential innovations come in all sizes and forms. Most often 'showcase innovations' are the culmination of a series of 'incremental improvements' [4], e.g. the 'showcase' project results are often built on the stepping stones of smaller ones (Figure 2). A potential pitfall is that these may not even be recognized as incremental innovations by the researcher producing them, as from their perspective these innovations may seem minor or inconsequential. However, for others less engaged in the topic they may have great importance. Innovation opportunities may be lost simply because the potential of the results is not recognized, or the significance is underrated.

Innovations may be technological, social or related to service; they may also include scaling (up-sizing) of existing solutions, sharing of tools and knowledge across national borders, and converting experiences and know-how into shareable knowledge.

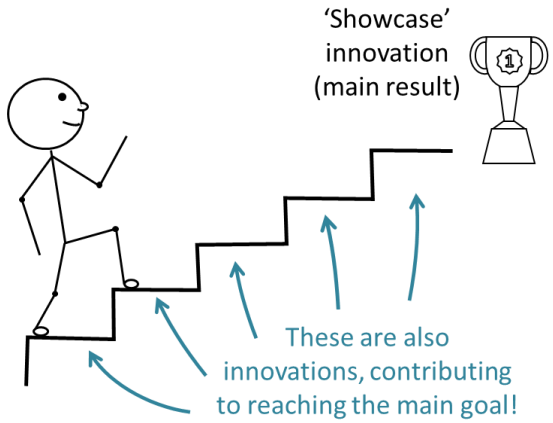

Figure 2. Small innovations are stepping stones to larger ones *(Illustration by author)*

Preserving these opportunities and promoting the innovation of project results is precisely a specific goal within demonstration projects like PHUSICOS. Demonstration projects are a form for

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practical verification of earlier research, and inherently the results from these are quite close to market ready solutions needing only market access and the enablement of up-scaling and distribution. Innovation of these as commercial products or as open access solutions leverages earlier research investments and helps to realize the full potential of these.

1.3. Stakeholder expectations

The innovation process is a value chain [5,6], where research results represent the starting point and the culmination of the process is the strategic implementation of these as improved products, services, methods or knowledge able to create value for the user of the results [7]. Specifically, in PHUSICOS results from NBS research become innovations when they provide value for a diverse set of stakeholders (adapted from the PHUSICOS Description of Action):

- National, European and International administrators and policy-makers
- Local, Regional and National practitioners and entrepreneurs
- Private sector to include insurance, green banks, and other businesses
- Environmental groups and other NGOs
- Academic networks working with disaster relief reduction, climate adaptation, water management and the implementation of NBS.
- Site-specific stakeholders from our demonstration case sites, including local citizens
- Stakeholders from other rural mountain communities which may benefit from the PHUSICOS demonstration site experiences.

This represents a broad swath of potential stakeholders. For simplicity, these can be grouped and identify their common characteristics and interests (Table 1).

Table 1. Stakeholder groups

Groups [8]	Characteristics	General interests
Commercial sector	Private companies and consultants providing services, such as construction, supply of materials, service etc.	Providing services and solutions creating value for the customer and the company. This group needs efficiency, quality, risk reduction.
Media (Information sources and lobbyists)	Media, Public interest groups consisting of groups of citizens or organizations, dedicated to pushing forward specific interests, needs or wants (interest groups/ advocacy groups/ coalition groups)	Promoting information dissemination. Promoting the interests of a segment of society. This group needs information and evidence.
Political representatives (Authorities)	Government bodies, public agencies or regulatory agencies serving citizens and companies.	Implementing policy and actions to manage, protect and improve society.
Transnational and international organizations	Public organizations operating across national boundaries and often as a collaboration between nations or multi-national private interests	Promoting social justice and economic equality, enabling development and growth.
Academia (Experts)	The scientific community	Research and development to improve knowledge and provide knowledge-based services to other stakeholders.
Civil society (citizen)s	Individual citizens or persons who have their own personal interests and needs, not belonging within other groups	Motivation and interest varies

The demonstrator sites are the core of PHUSICOS, and the organization of the project consists of work packages (WPs) building thematically around the cases (demonstrator sites). Stakeholder interests and needs are captured using the Living Labs (LL) methodology, where the application of LL to rural NBS implementations for hazard mitigation may be intended itself as an innovation.

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Relevance for PHUSICOS in society is promoted by identifying opportunities to grow NBS technologies for hazard mitigation in Policy Business Forums.

Additional stakeholder needs and expectations are met through various forms of innovation:

- technical (science and engineering of NBS solutions)
- service (stakeholder involvement through LLs)
- governance (policy and promotion of NBS/sustainable solutions)
- learning arena (training and education tools)
- specific products, software or knowledge bases

Finally, the researchers and research organizations have expectations regarding their research results (intellectual property, IP). In the broadest sense, a researcher can choose between publication and dissemination, or alternately commercial exploitation. In practice we may include elements of both.

Publication of research creates provenance (e.g. who created the results), formal IP protection through copyrights, and helps to ensure that the results reach a broader audience and are taken into use, while providing appropriate credit to the researchers and research organizations who have produced the results. This is by far the common choice of most researchers.

Legal protection of the IP may be established, for example patents, copyrights, and trademarks, all of which create legally defined rights for the disposition and exploitation of IP. Exploitation of IP may include economic instruments like licensing or royalties for access to the IP. The results have the potential to reach a broader audience in the form of commercial products and services.

2. Innovation in PHUSICOS

2.1 Project level innovation process

The PHUSICOS project includes a central technical role to enable and promote innovation and commercialization processes. The purpose of this role is to assist the Partners in the process of identifying innovations and bringing these to the appropriate market, where the pathway to the market may be through traditional commercialization, traditional dissemination or an open innovation (Figure 3 and Figure 4).

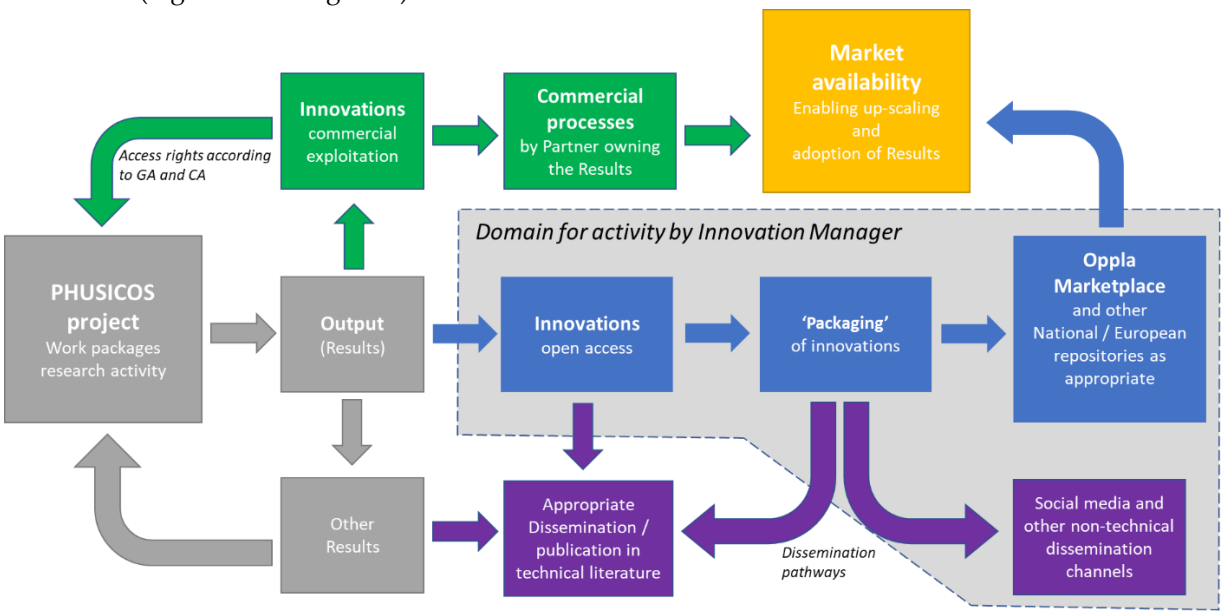

Figure 3. The innovation process in PHUSICOS *(Illustration by author)*

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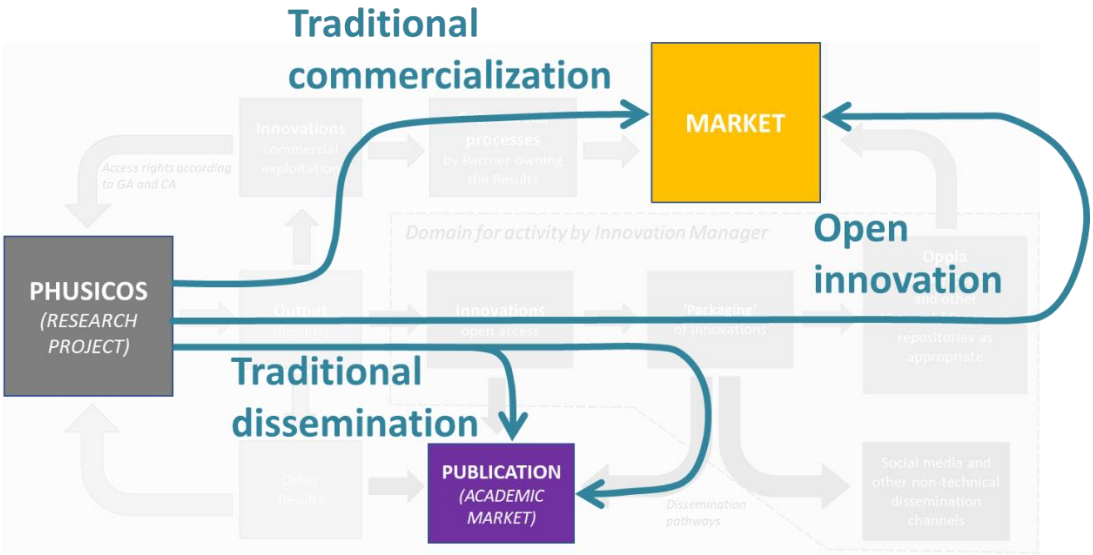

Figure 4. Pathways for innovation *(Illustration by author)*

2.2 A practical example: The PHUSICOS Assessment Framework Tool

An example of an early PHUSICOS result is the Assessment Framework (AF) tool for evaluating NBSs, developed within WP4 and described in deliverable D4.1 [9]. The tool is based on selecting performance indicators relevant for a specific NBS and performing a multi-criteria decision analysis to score the NBS. The tool contains several novel results, including a comprehensive generalized set of performance indicators grouped by Criteria and Ambits, and a multi-level weighting methodology for scoring indicators, criteria and ambits according to a bottom-up approach (Figure 5).

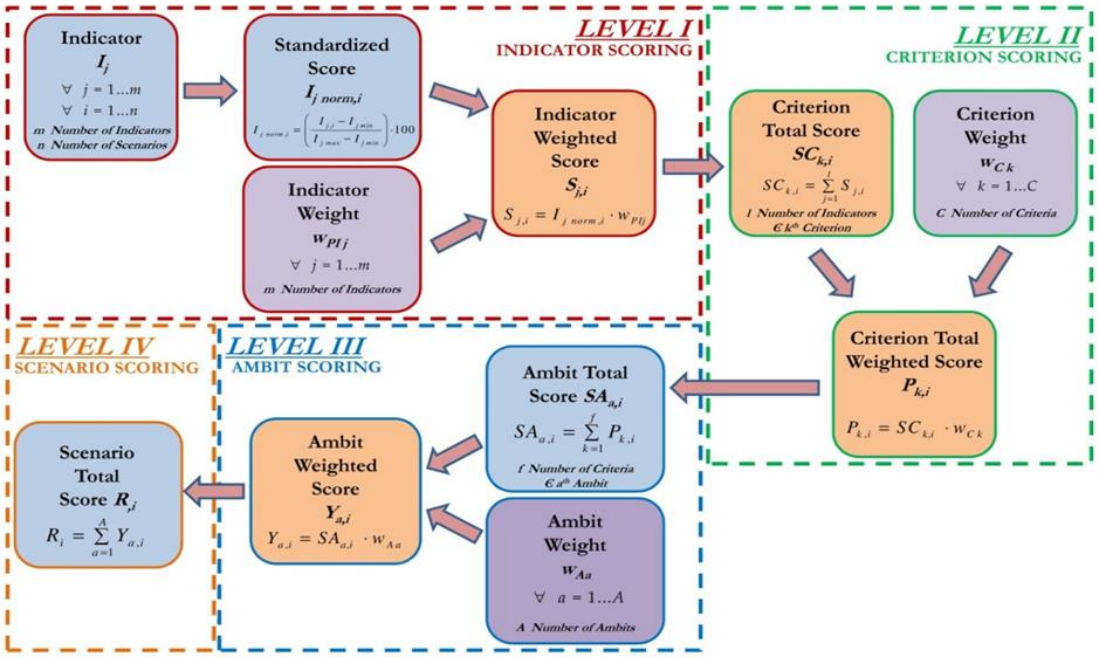

Figure 5. Assessment Framework tool - scoring flow chart (illustration by author [9])

Innovative aspects of the the AF tool consist of scalability and adaptability to different territorial contexts and to sector-specific analyses and its ability to be applied for either *ex ante* or *ex post* assessment. The former provides for the selection of the most suitable design scenario among a set of

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available ones, whereas the latter allows monitoring of the effectiveness of the implemented scenario, against the pre-intervention one (baseline scenario).

Moreover, a greater attention is given to social and economic impacts compared to existing frameworks. The AF tool is a technical innovation, and will be tested, customized and refined through its application to both the demonstrator sites and the concept cases. The Living Labs methodology [10] will be used to identify relevant performance indicators.

2.3 Making research results accessible for innovation

The PHUSICOS project consortium has established that the primary focus for innovation within the project will be open access / open innovation, although this does not preclude potential commercial processes if the Partner owning the IP sees this as relevant. The initial channel to the market for open innovation will be via information repositories / public databases, for example the Oppla Marketplace [11], European Open Science Cloud [12], and the OpenAIRE initiative [13]. Results that have been identified as innovations and intended for dissemination through these public databases need to be prepared for further utilization, dissemination and up-scaling, e.g. making the results accessible for a larger group of stakeholders.

In PHUSICOS, this essentially consists of 'packaging' the research results together with other essential information and structuring this in a way that a target user will have the information needed to successfully use the results. For example, consider the AF tool. The information needed to make this tool accessible for others may include:

- The PHUSICOS deliverable describing the method (a document)
- The table indicating the full matrix of ambits, criteria and indicator parameters (a spreadsheet)
- An example using one of the PHUSICOS demonstrator sites (a spreadsheet showing the reduced matrix specific for the site, with weightings and calculations as a practical example)
- A list of key parameters suitable for identifying the content and purpose of this result, for example language, license terms (e.g. open source), contact details, etc. These metadata will be used to help identify the result when it is made available on various databases, for example Oppla Marketplace. (Oppla is the EU repository of Nature-Based Solutions, accessible via the Oppla internet portal [11])

These items would define a complete 'product package' for the AF tool which can be posted in the public databases.

2.4 Up-scaling of innovations

Up-scaling takes a niche innovation, known only to a few and with little specific tangible value, to something that is accessible, available, familiar and can be broadly applied, creating value for the parties involved in its implementation and use (Figure 6).

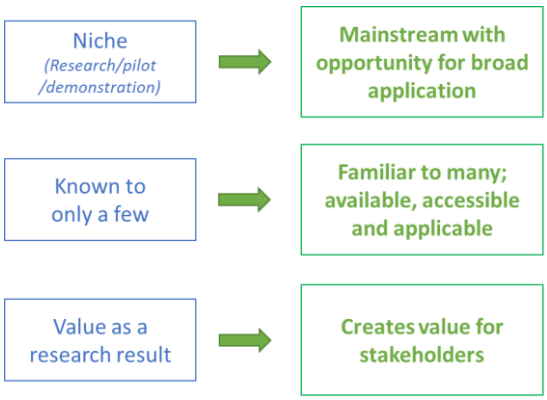

Figure 6. Up-scaling *(Illustration by author)*

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An up-scaling strategy should be anchored in a viable business model, addressing several key aspects of this including the value creation potential (value proposition), who the stakeholders are, what their interests/needs are, and how the innovation can be made broadly available.

We can define the reach of our innovations using a nested scale: local, regional, national, and European, and define the approach for up-scaling as:

- Literal: Expanding the reach of a product, service, or knowledge to increasingly wider extents. E.g. up-scaling from a niche solution at one location, to something that is well known and can be easily implemented at any location across Europe.
- Figurative: Generalizing the nature of a product, service or knowledge, such that it becomes relevant and valuable for larger contexts. E.g. from being a local skill, to becoming a European standard or recommended practice.

In some cases, up-scaling may be straightforward and quick, but unfortunately it will more often be a complicated and time-consuming process relying on factors, elements or actors outside of the project's control. For example, incorporating a design method into a national or international standard may require years of committee work. Therefore, it is important to define appropriate sub-goals (milestones) achievable within the project timeline that positively contribute to the overall vision for up-scaling of the innovation after the research project is completed.

2.5 Performance indicators for up-scaling

Tangible results and innovations will be made available for public use or provided as commercial services to the market at the different scales. Ideally, the success in meeting this goal would be directly measured via selected indicator parameters measuring the uptake of PHUSICOS innovations in other projects, activities and contexts, e.g. up-scaling. Indicator parameters could be defined as measurable entities, for example the number of NBS designed and constructed; number of countries implementing policy documents etc. However, this uptake will take time, and it will most likely be difficult or infeasible to measure this effect quantifiably within the timeframe of the PHUSICOS project. The alternative is to identify indicators relevant for the *enabling* of up-scaling, dissemination and uptake of the PHUSICOS results. The key assumption of course is that if these indicators are positive, they signal that the process of up-scaling is started and can continue after PHUSICOS is completed.

An analogy may be drawn from journal publications: key performance indicators for researchers are the number of journal articles published and the relative standing (rating) of the journals. However, there may be a significant delay from when the article is initially submitted to when it finally appears in 'print', as this depends on peer review, revisions etc. As alternative indicators researchers may use '*Accepted for publication*', '*Abstract submitted*', '*under peer review*' or other nomenclature to specify the intention to publish and the overall progress of the publication process.

Essentially up-scaling in PHUSICOS will be enabled by identifying innovations, making these accessible (see Section 3.6), and by 'marketing' the innovations via social media/non-scientific fora, and encouraging the Partners owning the Results to publish these in traditional technical / scientific fora (journals, conferences).

As an indicator for *enabling* up-scaling, the project will count the number of individual innovations made openly accessible and subsequent promotion on social media. Specifically, the number of:

- Innovations published on Oppla Marketplace or similar (minimum 1 per work package)
- Postings on social media (minimum 3 mentions per published innovation)

Result owners will be encouraged to produce additional publications describing their innovations or presenting applications of their innovations as a means of increased technical dissemination.

2.6 Structuring and tracking innovation up-scaling within the PHUSICOS project

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EU research projects often involve multiple participants collaborating on a complex set of tasks and activities. In PHUSICOS, added complexity is added by the core focus on co-creation with stakeholders for the implementation of the NBS demonstrator projects. In this mix of stakeholders, tasks and ambitions maintaining focus on the overreaching goals of innovation through implementation and up-scaling is challenging. A clear need for developing a method or tool for identifying, structuring and tracking innovation processes arose.

A tracking schema addressing relevant topics was developed in PHUSICOS. The schema is populated with specific detailed information for each WP. The information is specified both as overarching information for the WP, but also specified for each level of scale for up-scaling activities. An example is given in Figure 7. Individual topics in the figure include:

- Innovation expectations. Products, services and knowledge expected from the WP
- Stakeholder interests. Which stakeholders are relevant and what are their specific interests
- Up-scaling needs: Specify for each of Local, Regional, National, and European
- Potentials for value creation: Describe how the products will create value for various stakeholders. Consider both economic value and non-economic benefits
- Up-scaling needs. What specific actions or measures are required to achieve effective up-scaling at each of the four scales
- Challenges: Potential pitfalls, difficulties or obstacles that may prevent up-scaling
- Time scale: Reasonable estimates for time required to achieve up-scaling.
- Actions and sub-goals for up-scaling: Specific targets or goals to be achieved within the project time frame that will help ensure that up-scaling continues after the contractual end of the project.

3. Conclusions

This technical note outlines some of the key concepts and principles employed within PHUSICOS for managing and promoting innovation processes within the project. A key aspect of this is recognizing the value of incremental innovation as stepping stones to showcase (major) innovations, opening for the identification of individual innovations within essentially all the work packages. The consortium prioritizes open innovation/open access; project results and innovations will be disseminated through public repositories and databases to encourage broad implementation and up-scaling.

The coordination and management of innovation activities uses a simple schematic approach to structure and organize specific innovation process considerations at various scales (local, regional, national and European):

- Stakeholder interests and needs,
- Potential for value creation
- Up-scaling needs
- Specific challenges
- Time scale needed for up-scaling
- Specific actions needed to implement the up-scaling

Up-scaling of the innovations will likely require more time than the overall PHUSICOS project duration. To address this, the PHUSICOS consortium will use indirect performance indicators to measure innovations. These include dissemination of results, tools and supporting documentation into the public repositories and databases (ensure availability) and promoting awareness of these materials via promotion on social media channels and through traditional scientific dissemination.

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Innovation expectations	Innovations developed in WP4 may include: • A comprehensive Framework for NBS assessment • Database/platform for monitoring and early warning • Methods for developing hazard and risk maps to illustrate flood patterns and landslides for different climate scenarios • Methods for Evaluating ecosystems and ecosystem services for alternative landscape scenarios with plan designs			
Stakeholder interests	The most relevant stakeholder groups for these innovations are Experts and Authorities: Experts as users of these tools, and Authorities as beneficiaries of the knowledge/information created.			
Scale:	**Local**	**Regional**	**National**	**European**
Potentials for value creation	Tools supporting development and monitoring of NBS and Hybrid solutions, improving ecosystems	Tools for managing risk and protecting environment at regional and national scales. While flood and landslides are in focus, other hazards can be added over time to reach a broader application base.		Input at policy level for embracing NBS in risk reduction/ecosystem management across Europe
Up-scaling needs	Dissemination/information regarding the technical innovations, and development of evidence base for implementation. Toolboxes, frameworks and methods need to be clearly described in recommended practice documents to be properly tailored as a function of the audience. Business opportunities may exist for developing of tools/apps, for example GIS toolboxes for producing hazard and risk maps; or an excel-based toolbox for calculating the index parameters in the assessment framework. (literal up-scaling). Most applicable for local, regional and national scales.			Products and results from applying the tools used to develop a compelling case for Lobbyists to promote NBS solutions in DRR across Europe.
Challenges	Uncertain if this tool is accessible on a local scale, as broad technical and scientific competency is needed that may not be available in small communities	These tools and methods can clearly be distributed via Oppla Marketplace and other fora to Up-scale availability and application across larger scales. It is less clear if there can be developed a competitive business case for creating commercial products (like a GIS toolbox). This may require public investment for viability. Need to develop evidence base over time, need to find appropriate special interest groups. Pan-european applications may face difficulties with varying laws and requirements.		
Time scale	Up-scaling via Oppla Marketplace: short term, can be implemented immediately. Developing commercial products at regional/national scale will require a longer period to develop a business case and secure investors.			Very long term to expand across Europe
PHUSICOS actions and sub-goals for up-scaling	• Create concise summary of the following and publish on Oppla Marketplace: • the assessment framework tool (AFT), including supporting worksheets/aids • monitoring/early warning database • methodology for risk map production and progressive updating. • methodology for ecosystem/services assessment • Create Information packages/news releases for the above at appropriate technical levels and release into social media			

Figure 7. Innovation tracking schema; PHUSICOS WP4 *(Schema/content by author)*

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