LEarning and action alliances for NexuS EnvironmentS in an uncertain future

LENSES

WP3

D3.3.1 Guidelines for Transformative Nexus Policy Scenarios

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Project coordinator

Project partners

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Executive summary

This deliverable is meant to define and share the framework for developing policy scenarios referring to both the results of the T3.1 analysis concerning the main barriers hampering the effective and sustainable management of the Nexus, and the work carried out in WP4 regarding the complex web of connections affecting the dynamic evolutions of the Nexus system. This document describes the different methodological steps to be implemented in the different LENSES case studies for: i) detecting the leverage points for enabling transformative changes; ii) defining policy interventions scenarios; and iii) identifying potential policy resistance mechanisms to facilitate the actual implementation of the policy interventions.

This document describes the first draft of the methodological framework, and it is meant to be used internally for supporting the activities in the different LENSES case studies. The critical analysis of the results obtained in the LENSES case studies will allow us to revise and improve the methodological framework. The final version of this document will be delivered in month 34.

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1. Introduction and key conceptual definitions

The LENSES project entered in the second part of its implementation in the different case studies. The main goal of this phase is to move from the Nexus understanding toward the Nexus doing. Therefore, the results of the analysis carried out in the first part of the project implementation, whose main aim was to enhance the understanding of the complex and non-linear relationships – i.e. feedback loops – among the different elements of the Socio-Ecological-Technological system (SET system), will be used to in the second part of the project implementation to support the co-definition of the most suitable combinations of policies for the Water-Ecosystem-Food (WEF) Nexus resilience.

This document describes the first draft of the framework for the Policy Intervention Scenarios development and analysis. The framework will be, then, tested in some of the LENSES case studies. The obtained feedback and the critical analysis of the results will be used to revise and adapt the framework. The final version of this deliverable will be delivered in month 34. This deliverable is organized as follows. Section 2 describes the different methodological steps. Section 3 describes the criteria for evaluating the effectiveness of the defined framework, to be used for revising and adapting it prior the finalization of the deliverable. Concluding remarks close this document.

Prior to describe the different methodological steps to be adopted for achieving above-mentioned goals, key definitions are provided in this section. Firstly, it is worth citing that, in LENSES WP3, the policy scenarios development and analysis is designed to support decision-makers in defining the most suitable combinations of actions. To this aim, WP3 activities support the exploration of the impacts of planned interventions, the identification of unexpected events and impacts, embracing uncertainty and risks. In other words, WP3 uses the LENSES models, specifically the PSDM (WP4), as a "what-if" tool to simulate the impacts of different policy options, accounting for the causal relationships between variables – i.e. feedback loops, delays and non-linearity.

In this work, the combination of Participatory System Dynamic Model (PSDM) and Agent-Based Model (ABM) will be used as Exploratory Model (EM). In this type of modelling, which contrasts with traditional consolidative forecasting modelling, modelers conduct computational experiments to explore the consequences of alternative sets of assumptions pertaining to various uncertain factors, without privileging one set of assumptions over another (Agusdinata 2008; Bankes et al. 2013). EM allows to perform as many computational experiments as the hypothesized futures; based on potential futures, it is possible to ascertain which policies work well on more futures (Babovic et al. 2018). When EM is used with an appropriate experimental design, i.e. appropriate questions and a well-chosen set of cases to address them, the full range of model results can prove really useful toward informing policy choices and support inductive reasoning (Marchau et al. 2019).

Several new model-based scenario techniques to perform EM, and consequently assist decision-makers with making long-term plans and informed policy decisions under deep uncertainty, have been developed (Weaver et al. 2013). Describing the available modelling approaches is out of the scope of this document. It is, however, worth mentioning that the existing modelling methods not only allow to identify robust strategies to shape the future or to reduce vulnerability to uncertain developments, but also to understand

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when to change political practices based on new experiences and insights (adaptive management) (Walker et al. 2001).

In this work, a combination of PSDM and Agent-Based Model (ABM) was adopted as exploratory modelling approach for supporting the development and simulation of the policy intervention scenarios. Specifically, the qualitative PSDM (Causal Loop Diagram) was used to identify the main WEF Nexus and to detect the leverage points – i.e. elements in the system where a policy intervention could have a large impact on the dynamic evolution of the system – and the external drivers affecting the interventions' effectiveness. The quantitative PSDM (Stock-and-Flow) and the ABM were adopted for simulating the different interventions and assess their effectiveness accounting also for the potential actions/reaction of the different actors.

For the aims of his report, we define policy scenario as a representation of possible future of one of more components of a system, including alternative policies or management options (IPBES, 2016). Policy scenario analysis is an exercise aiming at informing decision-makers about the outcomes and effectiveness of different policy intervention options, allowing them to decide whether implement a proposed policy. Specifically, policy scenario analysis aims at (UN, 2021):

- Contributing to set the agenda of the policy interventions through the identification of the main issues to be addressed;
- Identifying and assessing the most suitable policy intervention(s) by defining policy performance indicators and comparing the performance against a reference scenario;
- Supporting the estimation of the outcomes of the policy interventions, accounting also for the undesirable ones (negative side effects);
- Shedding a light on uncertainty, by accounting for the system configuration under different possible futures;
- Facilitating the combination of different policy interventions to reduce the emergence of trade-offs.

Before moving to the description of the framework to be implemented for the policy scenario analysis in the LENSES case studies, it is worth mentioning that in this work we consider two main types of scenarios: i) ***Business-As-Usual (BAU) scenario*** – i.e. a scenario considering the likely future path without the implementation of the any measure. The impacts overtime of existing drivers – e.g. the climate change impacts – will be accounted for; ii) ***policy intervention scenario*** – i.e. a scenario generated to determine how the performance of a system is affected by a proposed policy intervention.

Finally, key elements that need to be accounted for in this document concern the transformative change and the leverage points. Transformative change means transforming the system stability, to create a fundamentally new system when ecological, economic, or social structures make the existing system untenable. In literature, transformative change is often considered as opposed to incremental changes, whose main goal is to secure continuation of desired systems into the future in the face of changing contexts and uncertainty (figure 1).

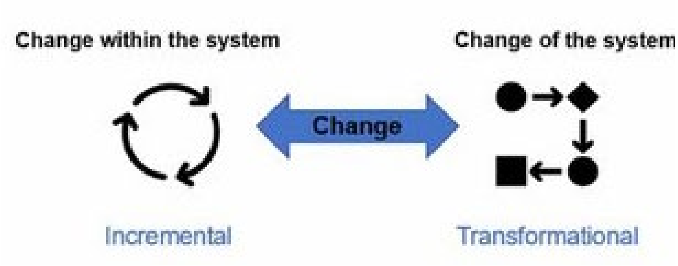

Figure 1 Incremental and Transformational change (Deubelli-Hwang & Mechler, 2021)

However, rather innovative studies start considering the incremental and transformative change as different parts of the same process, in some cases connected in a continuous circle (figure 2) (Park et al., 2012).

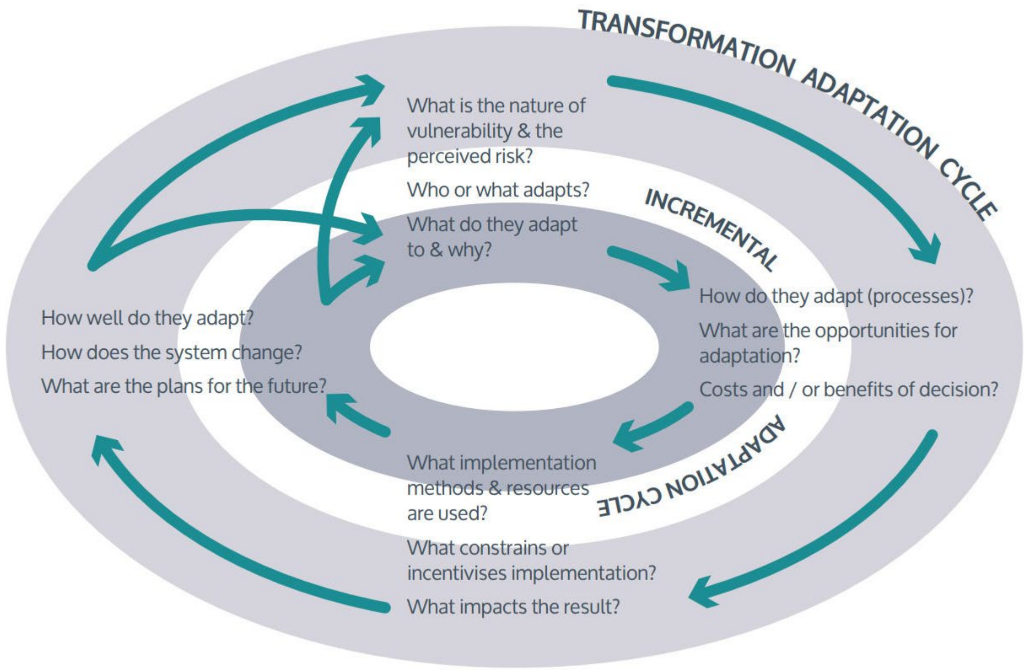

Figure 2 Incremental and transformative adaptation are connected in a continuous circle (Park et al., 2012)

Transformative change requires the implementation of policy intervention capable to generate impacts on the whole system. Therefore, transformative change claims for a deep understanding of the dynamics of the current system, allowing the identification of the leverage points. Leverage points are "places within a complex system…" – be it a company, an economy, a living body, a city, an ecosystem, or even a galaxy for that matter – "…where a small shift in one thing can produce big changes in everything." (Meadows, 1999). In other words, leverage point can be a physical element in the system, a resource available for specific processes in the system, information flow, causal connections among elements in the system, rules of behaviour of different actors, institutional settings, etc.

Different kinds of leverage points can be activated in a system, as shown in figure 3.

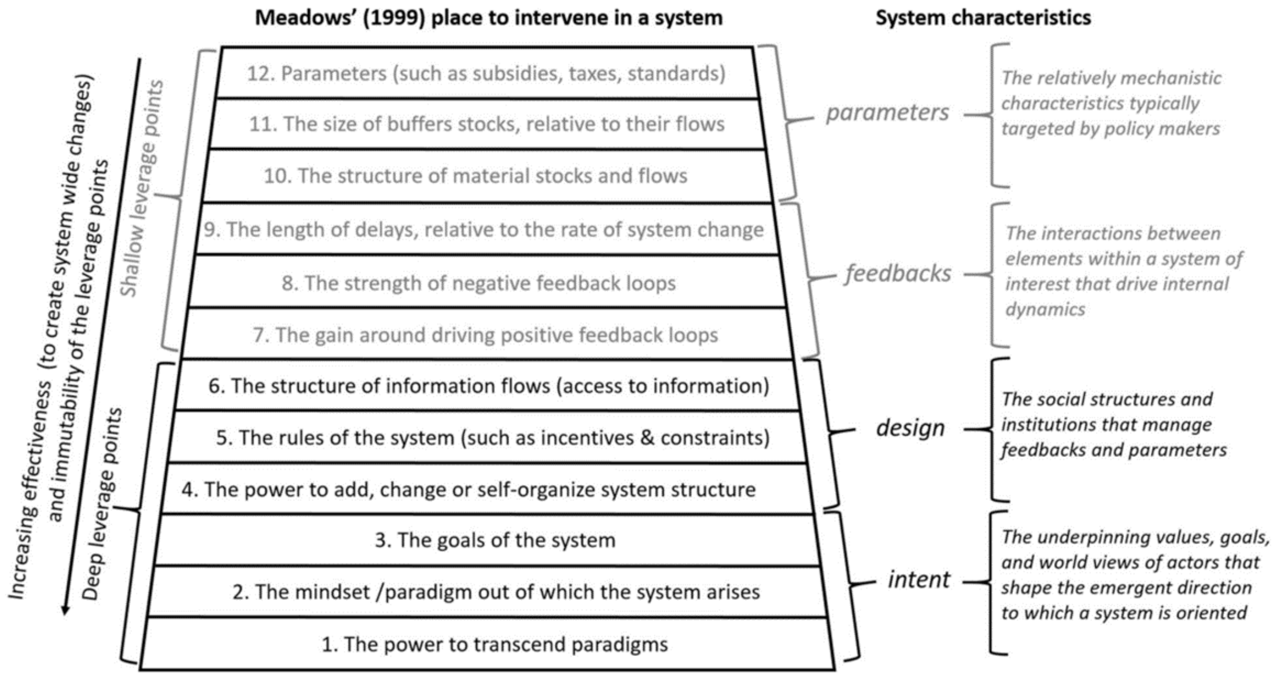

Figure 3 Different kinds of leverage points (Meadows, 1999).

Roughly speaking, two classes of leverage points can be identified: i) shallow leverage points, i.e. places where interventions are relatively easy to implement yet bring about little change to the overall functioning of the system; ii) deep leverage points, i.e. place where it might be more difficult to obtain an alteration due to a policy intervention, but potentially result in transformational change. Examples of both the shallow and the deep leverage points are shown in figure 4.

They are, therefore, of immense interest to anyone seeking to affect change within our interconnected ecological, social and economic systems.

2. LENSES methodological framework for policy scenarios analysis

Figure 4 shows the different steps of the developed methodological approach.

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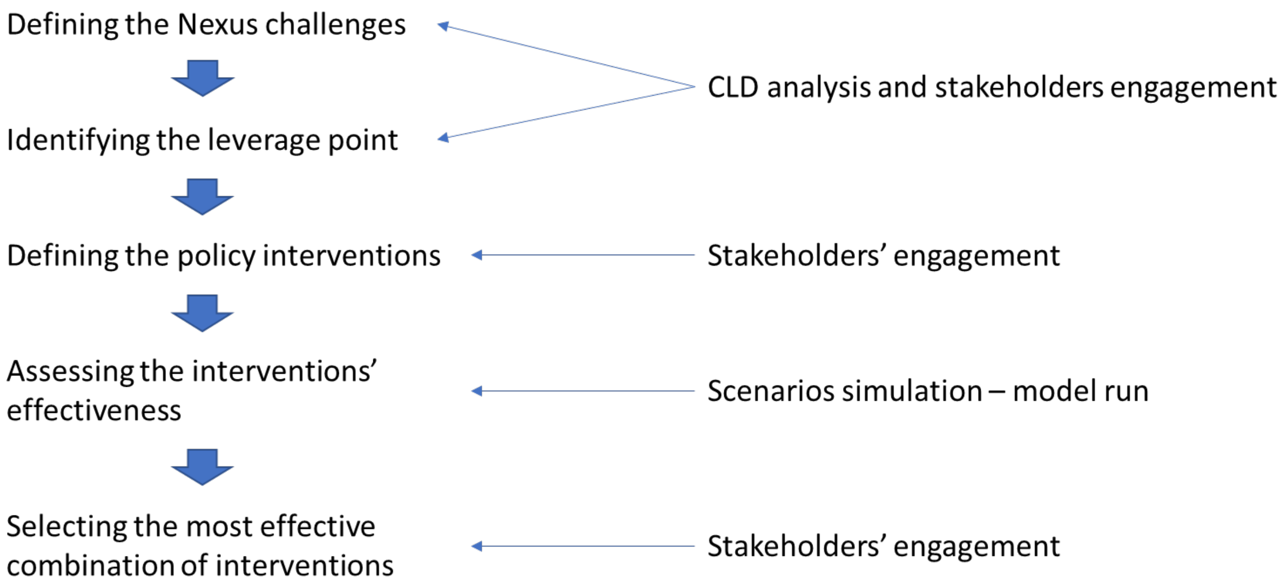

Figure 4 Overview of the different steps of the methodological approach for the policy scenario analysis

The following sections describe the different steps of the methodological framework.

2.1. Defining the Nexus challenges

This step is meant to identify the main reasons for defining and implementing policy interventions – i.e. to identify the main issues to be addressed, the problem to be faced and the opportunities to be seized. In LENSES, the definition of the agenda for policy scenarios is guided by the Nexus challenges, i.e. the elements in the system that are having a negative impact on the Nexus sustainable management.

In this framework, CLD analysis is proposed to identify the Nexus challenges. Specifically, the different methodological to this aim are described as following:

- Define cluster of elements in the CLD, accounting for the different sectors – i.e. Water, Energy, Food and Environment;
- Identify the central elements for each sector by implementing the centrality degree analysis (Santoro et al. 2021): the centrality degree allows to identify the variables in the CLD that relate to a high number of other variables.
- Assess the level of intersectoral connections: among the most central elements in each cluster, we define as Nexus challenges those having connections with the other sectors as well. To this aim, the Impacts-tree analysis of Vensim can be useful. Figure 5 shows an example of Impacts-tree analysis.

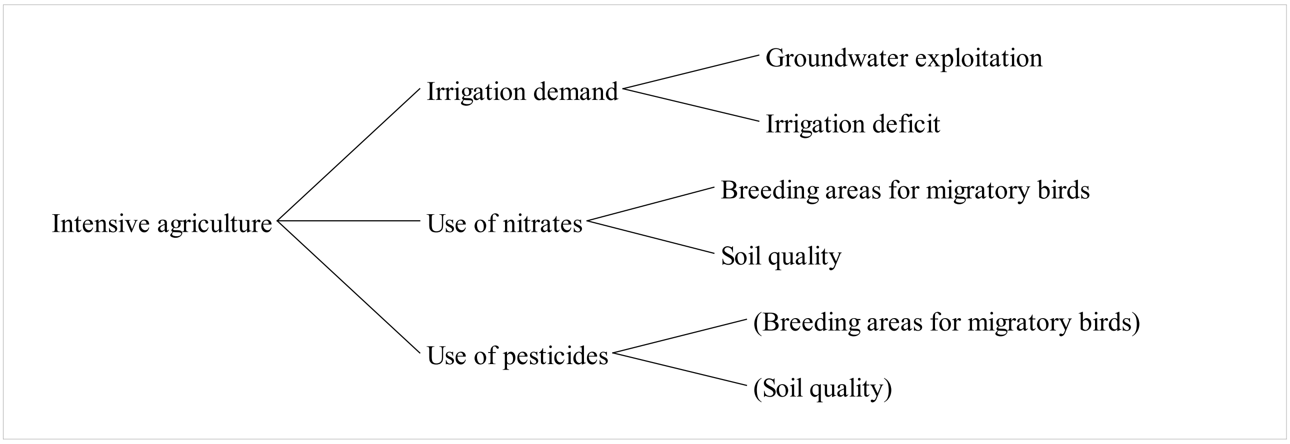

Figure 5 Impact-tree analysis with Vensim©.

At the end of this phase, we could identify the Nexus challenges and explain their impacts on the different sectors. As an example, the following table shows the identification of the Nexus challenges for the Tarquinia case study.

Table 1 Nexus challenges in Tarquinia

Challenges	**Causes and impacts (Sectoral)**			
	Water	***Energy***	***Food***	***Environment***
Quality of surface resources (Marta river)	-Wastewater treatment efficiency -Limited water availability for productive uses	-n.a.	-Run-off from agricultural areas -Negative impact on the quality of water for agriculture; Potential limitation of water quantity	- Potential quality improvement through natural processes -Negative impact on the e-flow and water for ecosystems
Quality of groundwater resources	-Wastewater treatment efficiency ***** (-Limited water availability for productive uses)	-n.a.	-Infiltration from agricultural areas ***** -Negative impact on the quality of water for agriculture	- Potential quality improvement through natural processes ***** -Negative impact on the e-flow and water for ecosystems
Agricultural productivity and sustainability	-Depends on water quantity, availability and quality - Negative impact in terms of demand increase for some productions	- n.a. -A low productivity may cause a transition towards renewable energy sources.	-Conditioned by market, demand and subsidies -Quantity and quality of products -Direct impact on farmers' income	-Good environmental conditions may improve productivity -Intensive activities and wrong practices may heavily affect

				environmental conditions - Potential reduction of natural areas
Reduction of water quantity and conflicting uses	-Climate change - Conflicting uses (in some periods) -Limited water availability for productive uses	n.a.	-overexploitation of available resources -Limited productivity and reduced income	Improving natural storage could have a positive effect -Negative impact on the e-flow and water for ecosystems
Quality of the environment	-Water (with good quality) for the environment can increase its quality -(Limited water availability for productive uses)	n.a.	- Negative effect due to irrational agricultural practices, and increase in intensive agriculture Good environmental conditions may improve productivity	

2.2. Identifying the leverage points

This step aims at identifying the leverage points in the system. As already stated in the previous section, the leverage points are the elements in the system that, due to their position within the causal network, could amplify the effects of the policy interventions.

The identification of the leverage points accounts for the betweenness centrality and for the number of loops. The betweenness centrality is a way of detecting the amount of influence a node has over the flow of information in a graph. It is often used to find nodes that serve as a bridge from one part of a graph to another. The algorithm calculates shortest paths between all pairs of nodes in a graph. Considering that, in this work, we calculate the betweenness centrality in a causal graph, this measure allows us to detect the capability of a specific node to influence the propagation of the effects of an action. Among the variables with a high degree of betweenness centrality, we assume as potential leverage points those belonging to several loops in the CLD. This is because, being part of a loop, an element could amplify its effects. To this aim, the loop analysis in Vensim can be carried out.

The results concerning the CLD analysis are, then, used to inform the stakeholders' debate aiming at the identifying the leverage points. Figure 6 shows how CLD can be used to identify points of intervention in the system structure.

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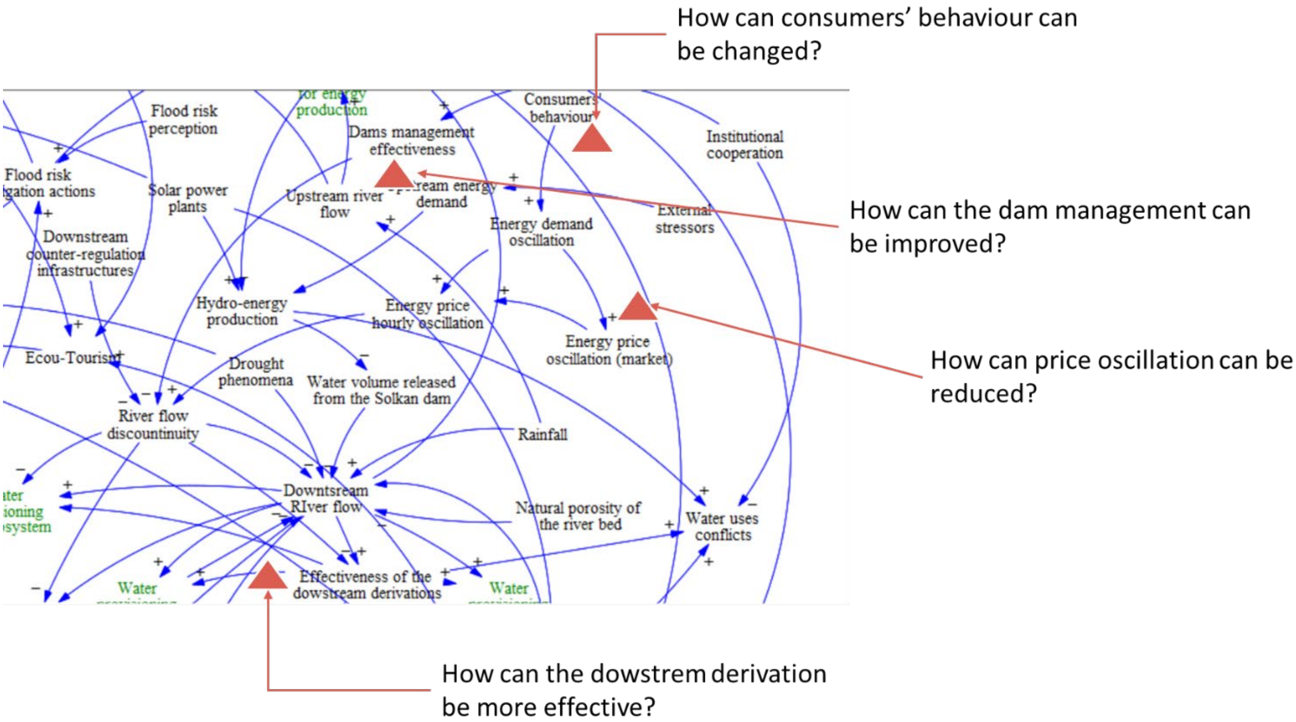

Figure 6 Using the CLD for identifying the leverage points

2.3. Defining the policy interventions

Once the key challenges and the leverage points have been identified, the next step for developing the policy scenarios concerns the definition of the policy interventions. In this work, we refer to two main categories of interventions, i.e. those dealing with the nexus challenges and the networking interventions. Networking interventions are based on the diffusion of innovations theory, which explains how new ideas and practices spread within and between communities (Valente, 2012). Networking interventions are purposeful efforts using social network characteristics to generate social influence, accelerate behavioural changes, and enhance organisational performances through punctual interventions in specific network nodes that could act as leverage points in the system (Giordano et al., 2021).

Stakeholders' workshops are organized for defining the policy interventions. To guarantee the success of the workshop, sharing information in advance with the participants is key. Specifically, this framework assumes that stakeholders participating in the workshop should be aware beforehand of the main Nexus challenges, their causes and the main effects, and the leverage points. The latter are presented to the stakeholders as the points in the system where the interventions should be implemented. To this aim, the results of the CLD analysis should be shared prior to the policy scenarios' interventions. Moreover, informative materials concerning the Nature-based Solutions (NBS) must be distributed among the participants. This is mainly due to the limited familiarity of the stakeholders with NBS. Specific information concerning the potential effects of NBS, the co-benefits that can be produced and the expected costs – non only the monetary costs – should be shared.

The workshops should be organized in two main phases. Firstly, starting from the main Nexus challenges, stakeholders could be asked to describe the system configuration in the future, in case of no-interventions.

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To this aim, coherently with the System Thinking approach, we suggest adopting the Behaviour-Over-Time (BOT) approach. Figure 6 shows an example of the BOT graph developed in a stakeholders' workshop.

Figure 7 Behaviour-Over-Time (BOT) graph of specific variables in the CLD

BOT graphs show the perceived dynamic evolution of the most important variables in the CLD, i.e. those related to the Nexus challenges. As shown in figure 6, stakeholders can be asked to describe the elements' evolution under different conditions. In LENSES, we start from the BAU scenario ("most likely behaviour" in the example in figure 7). In case of abrupt change, stakeholders are required to describe the events in time that could provoke such change – e.g. change in the CAP policy, etc. Similarly, stakeholders are required to draw the BOT for the main CLD variables in the desired scenario. At this point, stakeholders are required to describe the measures that ought to be implemented to move from the BOT in the BAU to the BOT in the desired future. The guiding questions here are: "What are the policy interventions that need to be implemented to obtain the desired BOT"? "When these measures should be implemented?". The latter question refers to either a specific time step – i.e. a possible answer is "the policy A should be implemented after 10 years" – or a triggering event – i.e. "action A should be implemented after the flood episode".

At the end of this step, a list of suitable policy interventions is defined. The effectiveness of these interventions will be assessed in the next step, using the LENSES modelling tools. However, this step requires to define the networking interventions as well. Starting from the results of the SNA analysis (see deliverable D3.1), stakeholders are required to describe policy interventions to overcome the main barriers hampering the effective collaboration in the Nexus, and to enhance the network of interactions.

2.4. Assessing the interventions' effectiveness

This step aims at supporting the assessment of the defined policy interventions and the selection of the most suitable combination of interventions, in terms of efficiency, social acceptance, technical feasibility and social acceptance. To this aim, three main activities must be implemented: i) defining and prioritizing the main objectives to be achieved; ii) simulating the impacts of the different policy interventions; iii) comparing the different impacts and define the ranking among the interventions.

Concerning the first point, we need to collect stakeholders' perception about the objectives to be achieved. That is, starting from the variables associated with the main Nexus challenges, stakeholders will be required to define the values that these variables should assume in the desirable future. To facilitate this task, linguistic

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assessment will be used. Fuzzy linguistic functions can be used to connect numeric values and linguistic assessments (Giordano et al., 2010).

In LENSES we are aware that a single policy cannot be sufficient to achieve the Nexus sustainable management. Stakeholders are, then, required to combine different policy interventions to formulate policy strategies. Three "baskets" of policy interventions are created by the stakeholders accounting for their perception of the efficiency, technical feasibility and acceptance of the interventions. To assess the effectiveness of each basket of interventions, the LENSES modelling tools are used to simulate intervention scenarios. Specifically, the PSDM and the ABM are adopted to simulate the effects of each basket of policies on the dynamic evolution of the system. PSDM (WP4) are used to simulate the impacts of each policy strategy on the physical components of the system. ABM allows to simulate the reactions of the different actors to the implementation of the policy strategies. The networking interventions are simulated suing the ABM, because it is capable to simulate different processes due to the agent/agent interactions – e.g. adoption of innovative irrigation system in a community of farmers, emerging of conflicts over the use of resources, etc.

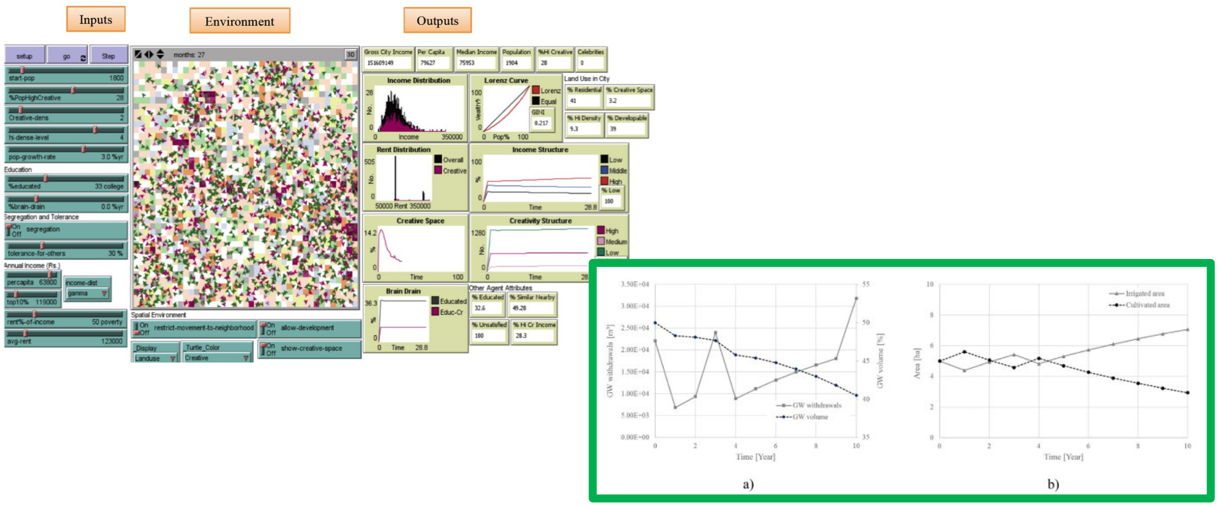

Figure 8: Examples of ABM and PSDM simulation

The results of the models' simulation have a twofold role. On the one hand, they can support the evaluation of the policy strategies and the selection of the most suitable ones, in terms of efficiency, acceptance and feasibility. On the other hand, LENSES models can support the detection of potential policy resistance mechanisms, i.e. the tendency for interventions to be defeated by the response of the system to the intervention itself (Sterman 2000). The detection of a policy resistance mechanisms claims for further discussion with the stakeholders to identify further actions to overcome these mechanisms.

Multi-Criteria Decision Analysis (MCDA) approaches are adopted to identify the most suitable policy strategies accounting for the impacts on the different objectives. The following table shows an example of MCDA for selecting the most suitable policy strategy.

Table 2 Example of Multi-criteria Decision Analysis table

	Criterion 1	**Criterion 2**	**…**	**Criterion n**
Policy strategy 1				
Policy strategy 2				
Policy strategy 3				

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It is worth highlighting that the MCDA approaches allow to account for potential trade-offs among different objectives, and to introduce weights for each objective according to their importance.

At the end of this phase, the most suitable policy strategy can be identified accounting for the results of the models' simulation. The final LENSES stakeholders' workshop will be dedicated to discussing the results of this analysis and to further refine the policy strategy for the Nexus sustainable management.

3. CONCLUSIONS

This deliverable describes the first version of the framework for developing and analysing policy scenarios for the Nexus sustainable management. Different methodological phases are defined. Some of them require a strong interaction with WP4 concerning the use of LENSES modelling tools for analysing the Nexus system and for simulating the policy interventions' impacts. Stakeholders' engagement is key throughout the whole process.

This deliverable is meant to be used internally as guidelines for organizing the next activities for the policy scenarios analysis in the LENSES case studies. This framework will be primarily applied in the three WP3 frontrunner case studies, i.e. Tarquinia, Donana and Koliaris. The results of the first implementation will be used to deliver a revised version of the framework, to be delivered and applied in the other LENSES case studies.

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