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"NAture Insurance value: Assessment and Demonstration"

NAIAD

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EXECUTIVE SUMMARY

In the present document, the first version of the open-web insurance value platform is presented. The platform is based on complex System Dynamic (SD) models that integrates physical, social and economic data as well as high resolution regional climatic data. The methodology used to create the SD models is explained in this document. The first stage of the models that are being developed for Copenhagen, Glinscica, and Lower Danube DEMOS are presented.

The deliverable also compares the open-web platform with other available platforms and highlights its innovative aspects. The document also describes how the platform will be used by the stakeholders.

This deliverable contributes to task 5.1 Data management interface and to task 5.2. Integrative participatory modelling approach. The information presented in this document set the basis the correct functioning of the platform that will be available in month 24$^{th.}$ It also set the basis for Deliverable 5.3. and Deliverable 5.4.

1. General context – NAIAD objectives

NAIAD (Nature Insurance Value: Assessment and Demonstration) is a new H2020 European project (started in December 2016) dedicated, to assess Nature Insurance Value. The *H2020* **NAIAD** project aims to operationalize the contribution of ecosystems to society's resilience concerning extreme-water-related disasters in Europe and beyond. The goal is to gather existing knowledge and methods (operational objective), but also to characterize information quality and uncertainty in assessment and decision processes. In relation with other partners, the proposed holistic approach will integrate social, economic, environmental issues in a spatial distribution model that will allow an effective evaluation of the ES, their vulnerability and its role in natural hazard protection.

NAIAD focuses on the insurance value of ecosystems, i.e. "the value of the sustained capacity of ecosystems to maintain their functioning and production of benefits despite any disturbance"[1], specifically of benefits regarding water-related disaster mitigation. Ecosystems protect but are also vulnerable and exposed to threats such as storms, wildfires, diseases, climate change, etc. Specific management operations might increase their resilience, although possibly involving management costs. NAIAD aims to **bring evidences of ecosystem protection roles, provides integrated hazard assessment methods and tailors innovative business model for insurances.**

NAIAD is organized in 10 work package (WP). The present document is the first deliverable of WP5 called "Integration of methods and tools".

1 Definition retained by the European Commission in the document: "Towards an EU Research and Innovation policy agenda for Nature-Based Solutions & Re-Naturing Cities", 2015

2. Why this open web-based Insurance Value platform linking to participatory DSS?

An interactive web platform will be created to allow the user to make informed decisions by analysing and simulating different scenarios with different adaptation measures.

In this WP, the integrative participatory modelling approach allows interactive exchange of information between physical and social scientists and local stakeholders for the insurance and nature protection sectors, including also regional planners. In the transition of assessing impacts and risk in management decisions, the open web-based platform is the main communication tool that allows to connect the integrated framework to end-users.

The open web-based platform contributes to the three main WP5 objectives; first, WP5 is the integrator of the methods and tools developed in WPs 2, 3 and 4 and the context of the DEMOs (WP6) (www.naiad-nbs.eu). Second, it provides a versatile and tailored portfolio of tools and methods to create an integration chain that facilitates decision making in adaptation planning for the various DEMOs. Third, it creates a strong link between the planning process and implementation by establishing the link with business models and financial arrangements (WP7) and policy (WP8).

The open-web platform is needed to allow larger-scale engagement with stakeholders and end-users of Nature Based Solutions (NBS) as well as open the door for the creation of a longer-term feedback channel through which the suitability and sustainability of NBS solutions can be discussed. The platform will be designed to act as a hub for biophysical inputs to Insurance value assessment, by allowing users across the EU to populate it with fine data as assessments are carried out, thereby creating an open and constantly improving platform for insurance relevant ES assessment.

It will link the outputs of the tools developed in WP2, 3 and 4 into an analysis platform of insurance- relevant ecosystem services, physical hazards potential and socio-economic factors such as social risk perception or natural capital accounting. The platform also includes high resolution climate data.

This platform will be designed to support WP6, 8 and 9 in an enhanced diffusion of the project results and allow end-users to explore assessment at the scale of DEMOS as well as national and EU scale based on publicly available data. The platform will be built in collaboration with WP9 and after an active consultation process with relevant stakeholders to ensure user-friendliness and relevance of the information provided.

3. Already available NBS open-web platforms

NAIAD open-web platform should complement other tools and platforms already available. For this reason, a preliminary study has been conducted to identify the principal functions of these platforms. Gaps in knowledge will be identified in order to improve the platform.

Table 2. Available NBS platforms.

NBS Platform	Objective	What they offer?	Scope	Link
ThinkNature	Understand and promote NBS	• Information about Stakeholders and projects involved in NBS. An interactive map showing where the projects and different stakeholders are located. • Dialogue between experts in a range of different topics: NBS, ecosystem services assessment, ecosystem disservices… • Interactive map showing NBS case studies. • Reports and information about conferences and webinars.	Global Rural and Urban areas	https://platform.think-nature.eu/home
Oppla	Promote collaboration between academia, policy and practice on natural capital, NBS and ecosystem services.	• Crowd-sourced enquiry service with Oppla members. • System for networking • Resources such as guidance, software, data.	Global Urban and Rural areas	https://oppla.eu/
TURAS	Provide examples of solutions for	• Provides documentation and guidelines for the implementation of NBS.	Urban areas.	http://www.turas-cities.org

NBS Platform	Objective	What they offer?	Scope	Link
	building urban resilience.			/solutions
OPERAs	Integrate cutting edge ecosystem services science into policy and practice	• Webinars, resources and guidelines to put ecosystem services practices into practice. • OPERAs work with OpenNESS to develop an open platform to allow community participation.	Global Rural and Urban areas	http://www.operas-project.eu/about
Nature-based Solutions Policy Platform	Provides information about climate change adaptation planning	• Database of scientific evidence for the effectiveness of NBS • Country by country information about including NBS in adaptation plans	Global	https://www.iied.org/nature-based-solutions-policy-platform
Naturel Water Retention Measures (NWRM)	It gathers information on NWRM (Measures that aim to protect water resources and address water-related challenges)	• NWRM related concepts • Practical guide to implement NWRM • Synthesis documents • Catalogue of measures • Catalogue of case studies.	EU level Urban and rural areas	http://nwrm.eu/
Nature4Cities platform	Raise awareness about NBS and foster new collaborative models for NBS uptake	• Knowledge repositories • Tools for the assessment of benefits, co-benefits and cost of NBS projects. • Tools to manage stakeholder's participation processes.	EU level Urban	https://www.nature4cities.eu/platform
Green Growth Knowledge platform	Promote the collaboration between organisations and experts in areas related to green growth	• Global network of international organizations and experts • Database with national documents, good practice, etc. • List of projects	Local, regional, national and international level	http://www.greengrowthknowledge.org/

NBS Platform	Objective	What they offer?	Scope	Link
Oasis Platform for Catastrophe and Climate Risk Assessment and Adaptation	Provide the information, tools and capacity building to understand risk and to scale up in insurance coverage and adaptation planning for regions vulnerable to climate change	• Loss Modelling Framework: Open source modelling software to calculate potential economic damages and financial risk associated with catastrophic events. • An e-Market: Web-based marketplace that links demand for analytics with suppliers of hazard, exposure a vulnerability data. • Capacity building: Online training modules for catastrophe risk models.	Global but case studies (Labs) are in Asia	https://www.climatefinancelab.org/project/climate-risk-assessment/

Platforms such as Oppla and ThinkNature have developed an interactive user-friendly platform. Both of these platforms provide information about case studies and NBS projects across Europe. They are also networking platforms.

Other EU projects provide guidelines and other types of resources for the implementation of NBS to increase the resilience of cities under different scenarios (e.g. CONNECTING, GROW GREEN, UNLAB and URBAN GreenUP), to integrate green infrastructures into the urban planning (e.g. OpenNESS) or to develop new business and financial models for NBS (e.g. Nature4Cities or NATURVATION).

NAIAD open-web platform will fill the gap of the platforms mentioned above by developing an interactive tool to support decision-makers in the selection of suitable adaptation measures, based on the integrated assessment of their effectiveness and impacts. NAIAD's platform will provide links to OPPLA and ThinkingNature to provide additional information to the end-users about other case studies or other related projects.

3.1 INNOVATION OF THE INSURANCE VALUE PLATFORM

The platforms mentioned in section 3 are designed to promote and spread the use of NBS in science, policy and planning. They provide a wide range of information and resources (webinar, guidelines, articles, reports, software information, news etc.) to reinforce well practice in the field of NBS. Some of the platforms such as ThinkingNature or Oppla also support the dialogue and interaction between different stakeholders from academia, policy and business. The open-

web insurance value platform complements these platforms as it is an interactive tool that allows the user to 'test' the effect of different adaptation measures in different contexts and scales. The platform includes three innovative aspects that differ from the platforms mentioned in section 3:

1. The platform is based in complex **System Dynamics models** describing different systems with different characteristics and challenges. These models integrate economic, social, physical and regional climatic data. The user will be able to interact with the models though a user-friendly dynamic interface. The dynamism of the platform will allow the user to set up different scenarios and explore:

- The potential of different NBS to reduce the risk associated with water-related hazards. This means, the insurance value of NBS.
- The economic and social cost of applying or not applying NBS.
- The effectiveness of NBS in different contexts and scales.
- Long-term resilience of NBS under different climate change scenarios.

2. the platform is **being co-created** along **with the key stakeholders** of the system. This allows the development of the platform according to stakeholders needs. This co-creation is being done in two ways:

- Using the Participatory modelling approach to create the basis of the user interface: The platform is based on complex System Dynamics models. The user interface that is being created to allow the user to interact with the models depends on how the models are designed. For the creation of the models, we are using stakeholder's perception captured trough participatory methods (See section 4.2).

- Stakeholder's consultation: Once the platform is finished, it is planned to present the platform to the key stakeholders that have been involved in the design process. The opinions of them will allow a further improvement of the platform. The date and place of the workshop has not been decided yet.

3. **High resolution Regional climate data** is integrated in the model. To effectively assess the long-term resilience of NBS or other adaptation measure is necessary to evaluate them in a climate change context. For this reason, we are including high-resolution regional climate information coming from cutting-edge regional climate models (e.g. REMO model).

4. System dynamic models and knowledge integration

The platform will be mainly based on the use of System Dynamics (SD). SD will connect physical, socioeconomic and climatic data (provided by WP 2, 3 and 4) to understand and model the main dynamics emerged in the analysis of DEMOs. As it will be described in further details in the following, also based on a detailed state of the art, SD will be used due to the following reasons:

- SD can support the connection of different models providing the basis for quantitative and qualitative system analysis.
- Data from different sources and spatial-temporal scales can be integrated into a SD model.
- The behavioural model built is able to represent the dynamic problem of concern. Thus, it is possible to understand (by setting up scenarios) how different policies and measures will affect the system.
- It is easy to engage stakeholders using participatory techniques. Allowing the development of the model according to stakeholders' needs.

4.1 STATE OF THE ART

The system dynamic approach was described for the first time in 1950 by Forrester and Cole. Since then, it has attracted the attention of a number of management scientists.

System dynamics (SD) is a mathematical modelling technique used to understand the non-linear behaviour of complex systems. SD incorporates concepts such as stocks, flows, feedback and delays to describe and represent the dynamic aspect of the system over time.

The structure of SD models has four hierarchical levels:

1. The closed boundary: Different behaviours are created by the interactions between the different components of the system within the boundary. This means, that the behaviours are not necessarily influenced by factors from outside the boundary. For this reason, all the elements considered to have an influence in the systems behaviour should be included in the model.
2. The basic component of SD is the feedback loop: An important premise in SD is that the dynamic behaviour is a consequence of the system structure. SD considers that feedback structures are responsible for the changes in the system over time.
3. Levels (or stocks) and rates (flows): Stocks representing accumulations within the system, e.g. the amount of ground water in an aquifer. They represent the (observed)

state of the system that can be changed by flows. For example, the state of the water of the aquifer change depending on the rain (inflow) or the water extraction (outflow).
4. Goals, observed conditions, discrepancy between goals and observed conditions and desired actions: Systems are composed by a number of interactions linked by feedback loops. The combination of feedback loops with delays and non-linear relationships produce a wide variety of behavioural characteristics.

Modelling the systems behaviour over time can help to prevent undesirable consequences arising from different policies. It can provide information about the relationships of different factors within the system and expose the source of different system behaviours (Neuwirth *et al.,* 2015) . For this reason, this tool has been used worldwide to understand, for example, a variety of socio-economic problems and to study the effect of various policy interventions. SD is a valuable tool for understanding different adaptation measures because:

- It is possible to observe if a structural change in one part of a system affect or not the behaviour of the system as a whole.
- It is possible to set different scenarios to study how system behaves under particular input conditions.
- It is possible to engage stakeholders in the co-design of the model.

New hybrid modelling and simulation approaches as well as approaches to include real-world (big) data in the SD model allow the study of feedback loops, accumulation effects as well as the integration of agent-based characteristics, geo-spatial characteristics, uncertainty, etc. All these characteristics have made SD models to be integrated in real decision –support systems.

As it has been mentioned above, SD models allow the integration of knowledge of end- users and stakeholders within the model. The participatory modelling or group model building approach has been used to build models more relevant to stakeholder needs. This approach is conducted to integrate key stakeholders in the co-design and co-production of conceptual models of the system. It is a way of engaging non-scientists with scientist and introduces a new perspective for both the modeller and the stakeholder.

Using this approach, it is intended to identify the key factors and issues that are relevant for the modelling of the system. Moreover, this approach enables the stakeholders to have a better understanding of the model, which increases the confidence on it and, thus, are more willing to use it.

For each individual interview, an individual qualitative model is built. A group model is built using the individual models. This group model is validated and completed using group model building

techniques. This enables the integration of different stakeholder's perspectives and allows them to interact directly with each other.

The qualitative model obtained through the above-mentioned steps represents the relationships between different factors and variables within the system. In addition, the model allows the identification of causal feedback loops. Such causal feedback loops allow to easily visualize and forming explanations and simulating the causes-effects of the processes occurring in a complex system.

4.2. SYSTEM DYNAMICS AND THE PARTICIPATORY MODELLING APPROACH IN THE CONTEXT OF THE DEMOS.

Knowledge integration will be achieved through a system dynamic model that will act as a metamodel allowing the integration of physical, social, economic and climatic models. The integration will be based on a conceptual model created along with the stakeholders. Due to the complexity of the integration, this technique will only be applied in 4 of the DEMOS: Medina del Campo, Copenhagen, Glinscica catchment (Slovenia) and Lower Danube basin (Romania). These Demos have been chosen with the objective of having a representation of different scales and contexts.

For the four above mentioned DEMOs the knowledge integration approach will be applied. This approach has basically three phases, which are totally similar, although some differences are due to the specificities of the case study and on the objectives to be achieved:

1**) Conceptual qualitative modelling building**. This is divided in three steps:

1.1. Individual interviews with key stakeholders. Individual conceptual models are created in each interview. Particularly for the Glinscica and the Lower Danube case study, coherently with the objectives of the Task 3.3, the individual interviews were carried out aiming at collecting and structuring stakeholders' risk perception.

1.2. Group model building- A group model is created using the variables more repeated within the individual models. All the differences identified in the previous step were discussed and consensus among stakeholders was reached.

1.3. Group exercise- model validation. The group model generated is validated in a group exercise where all the stakeholders are able to interact and exchange ideas.

2) **Quantitative modelling step**. Outputs from WP2, 3 and 4 are integrated in the validated qualitative model. In order to proceed to the quantification, it is necessary to simplify the model

by divide it in submodels. The submodels are then structured following the system dynamic principles.

3**) Scenario building**. To assess the Impact of NBS and other adaptation measures into the system. As climate information is also integrated in the model, the effect of climate change on NBS will be also tested.

Step 1 has already been implemented in Copenhagen DEMO. In Medina del Campo only steps 1.1 and 1.2 have been conducted. A workshop is being organized for the end of January to validate the group model and thus, complete step 1. Concerning Glinscica and Lower Danube case study, the whole phase 1 was completed: a set of individual interviews was carried out, in order to get all the key information to build the SDM and to identify and rank the main variables, measures (NBS, 'grey' and 'soft'), impacts, benefits and co-benefits according to stakeholders' perception of the problem.

To conduct the individual interviews (s.1.1) in all the cited case studies, key stakeholders of the system were selected (See table 3, 4, 5 and 6). The selection of the stakeholders was made, through the support of local partners, to ensure that the most representative and influential were included in the whole process. The 'snowballing' technique was used to update the list, thus involving all the potentially relevant stakeholders that were cited or mentioned during the process.

Table 3. Stakeholders involved on the individual interviews in medina del Campo Demo.

Stakeholders	Rational for selection
Provincial Council of Ávila	Regional government of the area of study
Regional government of Castile and Leon (JCyL)	Regional government of the area of study
Municipal Council Valladolid	Local government of the area of study
Municipal Council Medina del Campo	Local government of the area of study
Municipal Council Horcajo de las Torres	Local government of the area of study
Municipal Council Rágama	Local government of the area of study
Irrigation Community Río Adaja	Farmers association in charge of the distribution of water in the irrigable area of the Adaja river.
UCCL: Association of Young Farmers (Jóvenes Agricultores)	Farmers association.
ACUAES (Aguas de las cuencas de España):	Public Company in hydraulic infrastructures.
University of de Salamanca. (Centro de Investigación y Desarrollo Tecnológico del Agua).	Academic/Research institution. They can provide information about the system from a scientific point of view.
L' ALHONDIGA de Arévalo	Cultural association with information about the socio-economic aspects of the area.
WWF Spain	NGO that can provide ecological information about the area, as well as different adaptation and conservation measures that have been implemented in the area.
SEOBirdlife	NGO with ecological information about the area.

Table 4. Stakeholders involved on the individual interviews in Copenhagen Demo.

Stakeholder	Rationale for selection
HOFOR	Greater Copenhagen Utility supplying 1.1 million customers in the Copenhagen metropolitan area with: Drinking water, District heating, District cooling, Town gas, Disposal of wastewater. Also, climate proofing the metropolitan area against torrential downpours.
Lundgrens Attorneys	Public services and project development, PP business models, urban and area development, public sale of real estate, public procurement, PPI projects and innovation partnerships.
Region Hovedstaden (Capital Region of Denmark)	Danish Regions have an interest in protecting people health and the groundwater resources for drinking water purposes, as well as protecting surface water and nature.
City of Copenhagen (KK)	The Technical and Environmental management section is responsible for urban development with respect to urban use (e.g. compliance with environmental regulations), daily maintenance (cleaning etc.), urban development (e.g. infrastructure, built environment, climate proofing, and resource management).
Smith Innovation	Company working with public authorities and private stakeholders. The company has a solid academic background in economics and social sciences, and a broad, cross- disciplinary approach, working with public authorities and private stakeholders towards rethinking the industry, fostering dialogue across established divisions and creating economic growth to the benefit of both companies and society.
INNOBA	It is an innovation based company with a cross- and multidisciplinary approach for solving innovation projects. Employees have a background in anthropology, sociology, design, law, IT etc. Focus is on practical innovative solutions for e.g. strategical business development.
KLIKOVAND	It is a cooperation between municipalities, utility services and the Capital Region of Denmark and supports efficient and sustainable climate adaptation solutions in the region.

De Danske Regioner	Danish Regions have an interest in protecting people health and the groundwater resources for drinking water purposes, as well as protecting surface water and nature.
Miljøpunkt Nørrebro	The Environment Point is a foundation to promote a better environment in urban neighbourhood Nørrebro by executing practical environment and climate projects. Opportunities are challenged with regard to administrative rules and regulations in close collaboration with the local council who also provides economic support.

Table 5. Stakeholders involved in the individual interviews in the Glinscica Demo.

Stakeholders	Rationale for selection
CIPV Civil initiative for flood protection of SW part of Ljublajna	They rescue the population in case of emergency and provide an information and prevention activities about flood risk in coordination with governmental organizations.
DRSV Slovenian water Agency Sector for development and planning	They participate in the establishment of emergency urban plans as the National Water Management Plan, some parts of the Flood Risk Reduction Plan and some parts of the Water Rehabilitation Plan.
MKGP Ministry for agriculture forestry and flood of the Republic of Slovenia	They provide a contribution to build all national plans and strategies in which agricultural areas are included and establish wet retention reservoirs, especially in relation to irrigation of farm land.
MOL nat Municipality of Ljubljana, Department for nature conservation	Participating in approving of any plans that affect good state of ecosystems.

Stakeholders	Rationale for selection
MOL Civ Municipality of Ljubljana - Department for civil protection and disaster relief	They coordinate and connects the other departments within the Municipality of Ljubljana.

MOL Urb Municipality of Ljubljana - Department for Spatial Planning	They prepare strategic plans at urban level and are involved in the preparation of the National spatial plan.
MOP Od The ministry of environment and spatial planning – Water and investments directorate – Sector for natural disaster rehabilitation	They prepare a program to reduce the impacts of natural disaster.
MOP Var Slovenian Ministry for environment and spatial planning, Sector for nature protection	They are directly responsible for the preparation of the National Water Management Plan and of the National Plan for Reducing Flood Risk as per the Floods Directive and the national Plan for Management of the Marine Environment.
RD Fishing Club Dolomiti	They are directly responsible for the Fish Management Plans, prepared in coordination with the Fishing Club and The Fisheries Research Institute (FRIS).
URSZR Administration for civil protection and disaster relief	They operate at the regional level to regulate and implement protection against natural disasters on the area of 32 municipalities
ZRSV Institute of the Republic of Slovenia for Nature Conservation	They are integrated in Water Management System and for the Flood Risks Reduction Plan at National level.
ZZRS Fisheries Research Institute of Slovenia	At the national level, they are responsible and included in the process of acquiring permits for interventions in streams for all Slovenia; at Strategic level, they are involved in the preparation of Flood Risks Reduction Plan.

Table 6. Stakeholders involved in the individual interviews in the Lower Danube Demo.

Stakeholder	Rationale for Selection
Municipality of Bistret - Environmental Department	They control the environment wellbeing, in particular the protected areas.
Municipality of Calafat - European Projects Department	They implement improvement of policies, strategies, procedures and action plans of the local administration and monitoring of public services and utilities.
Municipality of Corabia City (vice Major)	The vice-mayor attributions are to support and to coordinate the following departments within the local municipality: the urbanism department, the market administration, the public servant's personnel, the public service for water supply and waste water management, the sanitation department and the district heating department.
Municipality of Dabuleni - urbanism department	They operate to the development of the local infrastructure (roads, sewage and potable water).
Ministry of Agriculture and Rural Development (MARD)	They are the central public authority responsible to implement the government policies and strategies in the agriculture, food industry, rural development, fishing and aquaculture, land improvement, phytosanitary protection, sustainable soil management and connected research activities. MARD is also the management authority for implementation of the national rural development program and the EU policies in the agricultural sector. The ministry has also a major role in the implementation of the national strategy for adaptation to climate change.
Municipality of Turnu Măgurele (Local Development Dpt. Environment Protection Dpt., City Hall)	The local development department is monitoring the social and the business environment, evaluate and propose the actions and the activities to be implemented with the aim of local development; the environmental protection department is monitoring and evaluating the environmental conditions within the city and propose the actions and the activities that lead to better environmental conditions
WWF Romania	Environmental protection activities and its educational programs for environment and green economy.
Municipality of Zimnicea - International Projects department	They provide support for the implementation of the measures to reduce the flood risks and to protect the local community against floods. As local municipality, they have also to implement the plan for emergency situations interventions and development strategy of the town, a guidance document for investment projects: infrastructure, education, economy tourism, social, etc.

Individual interviews were conducted for each of the stakeholders. Conceptual individual models representing the causal relationships between environmental, social and economic factors and other key variables were built. In both the Glinscica and the Lower Danube case studies the individual conceptual models were used to identify the central elements in the stakeholders' risk perception, that is, the issues that need to be addressed in order to deal with water-related risks. Moreover, the models allowed us to make a preliminary assessment of the NBS acceptability, according to the stakeholders' risk perception. The results are described in D3.1.

A conceptual group model has been built for Medina del Campo and Copenhagen. The group models include the factors and variables more frequently repeated in the individual interviews as well as important information that could only be provided by specific key stakeholders. The same procedure was used in both Glinscica and Lower Danube case studies, aggregating the information provided by different groups of stakeholders and trying to overcome discrepancies in the causal connections between variables.

The Copenhagen group model has been validated in a workshop. This validated model will be complemented with information from literature and the expertise of the analysist. In order to improve the physical, institutional and economic/ecosystem services sub-models, specific consultation with experts in the areas mentioned above will be conducted. A second step of model validation will be conducted in December. Individual interviews will be held via skype or web seminars. A workshop will be held in Medina del Campo Demo at the end of January to validate the group model. The Medina del Campo group model is not shown in this deliverable because it needs to be validated before publication.

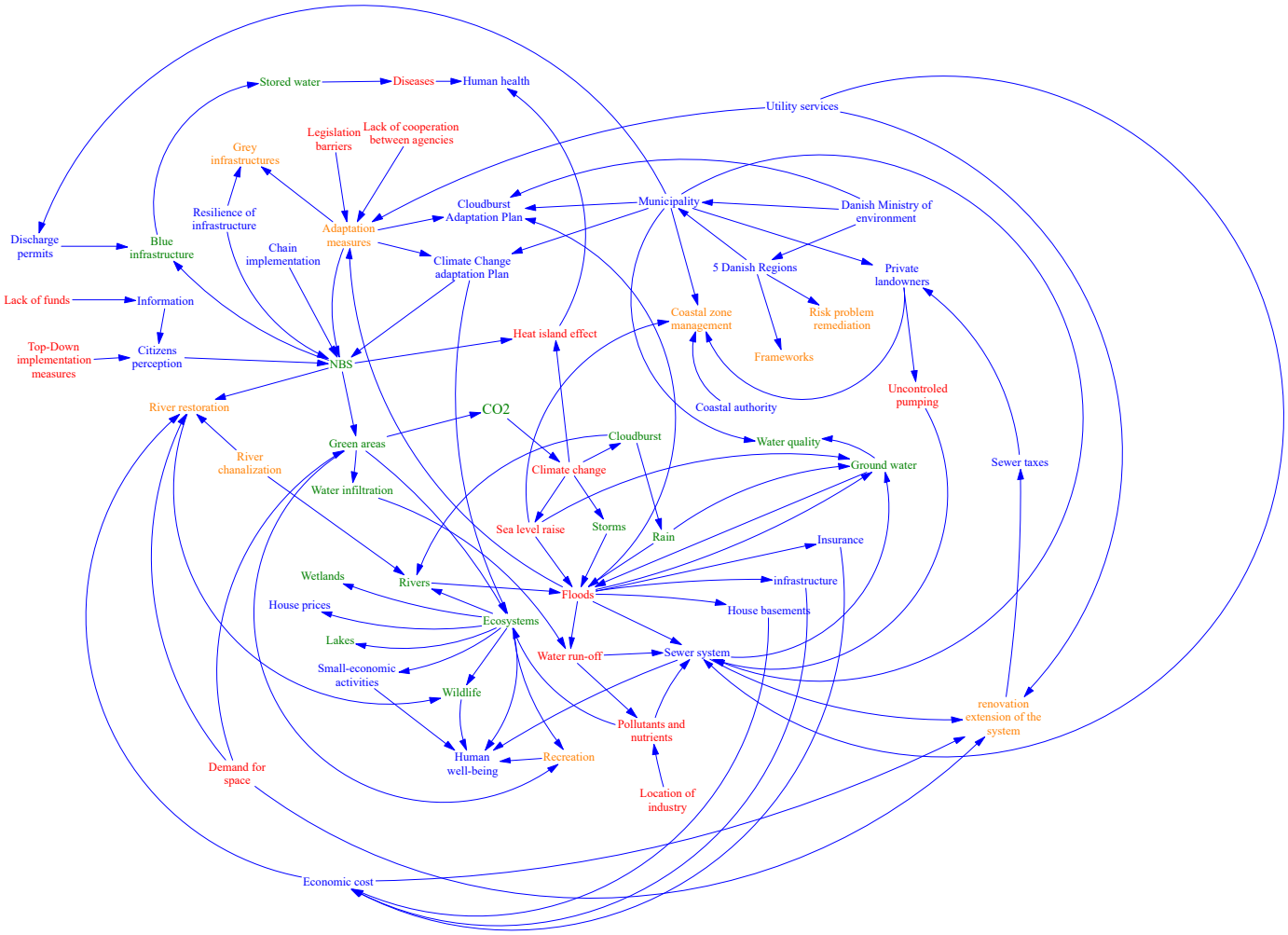

Figure 1. Copenhagen group model.

Figure 1 shows the Copenhagen group model validated. Different variables and factors have been highlighted in different colours to ease the understanding of the model. All the variables appearing in green are environmental factors, in blue, socio-economic factors, in orange are marked all the activities or actions of the system. Finally, all the barriers, risks or challenges are marked in red.

The model shows that the floods are the most important risk perceived by stakeholders. Floods are affected by sea level raise, storms and heavy rain. All this weather events are aggravated by climate change. In the model, Sea level raise and rain have a strong relationship with the ground water level, that at the same time has an influence in urban floods. When a flood event occurs, the major part of the water goes to the sewer system, and from there, it goes to the ground water. This has an effect in the water quality.

The increase of the ground water level affects private house basements as well as other types of infrastructure. This means an important economic cost for private landowners and for the city of Copenhagen in general.

Floods events have been worsened by the channelization of urban rivers. The restoration of these revers could potentially reduce the costs of flood events. However, due to the lack of space and the cost of the restoration it is difficult to implement. In the model, the main measures identify to reduce the damage caused by floods are grey or engineering solutions and NBS. The implementation of NBS could potentially promote other benefits such as carbon sequestration or wildlife enhancement. However, lack of space, economic cost and lack of coordination between agencies have been found to be an important barrier for the implementation of this approach.

In the model, it is possible to see the relationships between different governmental and private institutions. Lack of coordination between these agencies has been identified as a barrier for NBS implementation.

After validation, these models will be quantified using economic and physical data from WP2, 3 and 4. Before quantification, the model will be divided in submodels, each submodel will be complemented with literature and expert consultation. All the variables that cannot be quantified will be eliminated, and the structure of the submodel will be adapted into a system dynamic structure of stocks, flows and feedback loops.

Similarly, both the Glinscica and the Lower Danube group models have been validated during the first workshop. The models were built by the analysts in a draft form according to the results of interviews but have been also gradually adapted (and are still being updated) according to the new available knowledge (both scientific and expert). Particularly, the participatory activities arranged during the workshop(s) were focused on the identification and ranking of the key variables of the model (drivers, impacts, measures), on the assessment of the main impacts to be reduced and objectives to be achieved and on the identification of the potential associated to the introduction of NBS. Once the model was built, a second round of interviews was also performed, to support a better ranking/rating of the key variables and a thorough analysis of the causal connections between specific measures and the potential effect connected to their

implementation. This activity is highly useful to write the equations behind the quantitative SDM. The following Figure 2 includes the Causal Loop Diagram (CLD) developed by the Glinscica case stakeholders. In the Figure, using the conventional notation of CLDs, the polarity of the arrows identifies the relation between the connected variables, i.e. a positive polarity denotes variables changing in the same direction, whereas a negative polarity denotes variables changing with a negative relation. The thickness of the arrows defines the strength of the connection, which was defined according to the stakeholders' knowledge.

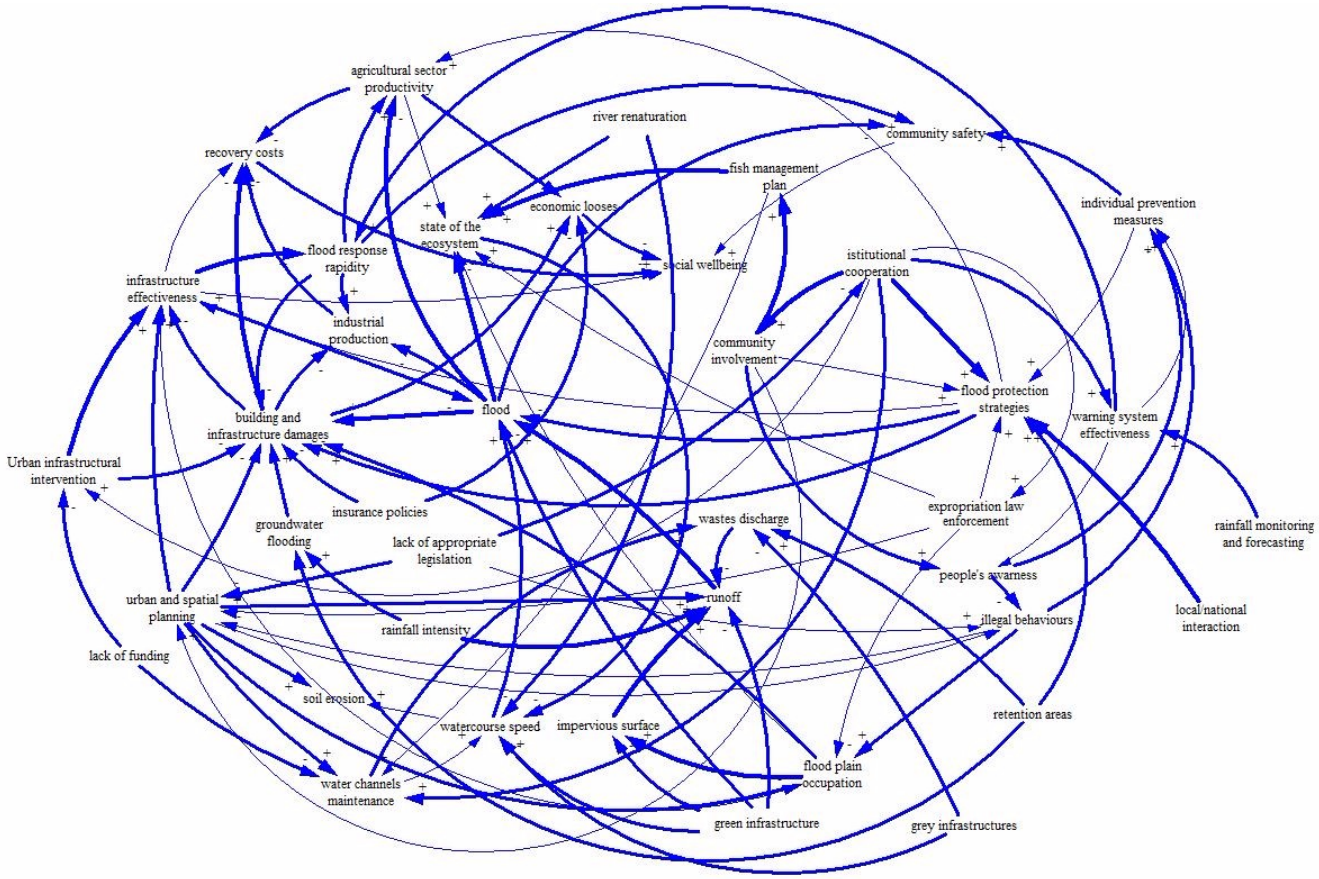

Figure 2. Glinscica group model.

The second workshop has been already scheduled for the Glinscica case (10th of October 2018), and will be based on the analysis and participatory discussion of the main results provided by the preliminary version of the quantitative model, which has been built starting from the model in Fig.2 The second workshop, with the same purpose, will be held in Romania in the first week of December 2018.

As far as the Glinscica case study is concerned, the quantitative version of the model, based on the CLD of Figure 3 has been already developed using a 'stock and flow' approach. The following Fig. 3 proposes the preliminary version of the model, while Figs. 4-5 are referred to the specific sub-models focused respectively on: physical risk assessment (Fig. 4), impact assessment (Fig. 5) and co-benefits assessment (Fig. 6). Relying both on the results of the WP2-4 and on the results of the 2nd workshop, the model will be improved and completed, in order to be fully operative by the end of the project.

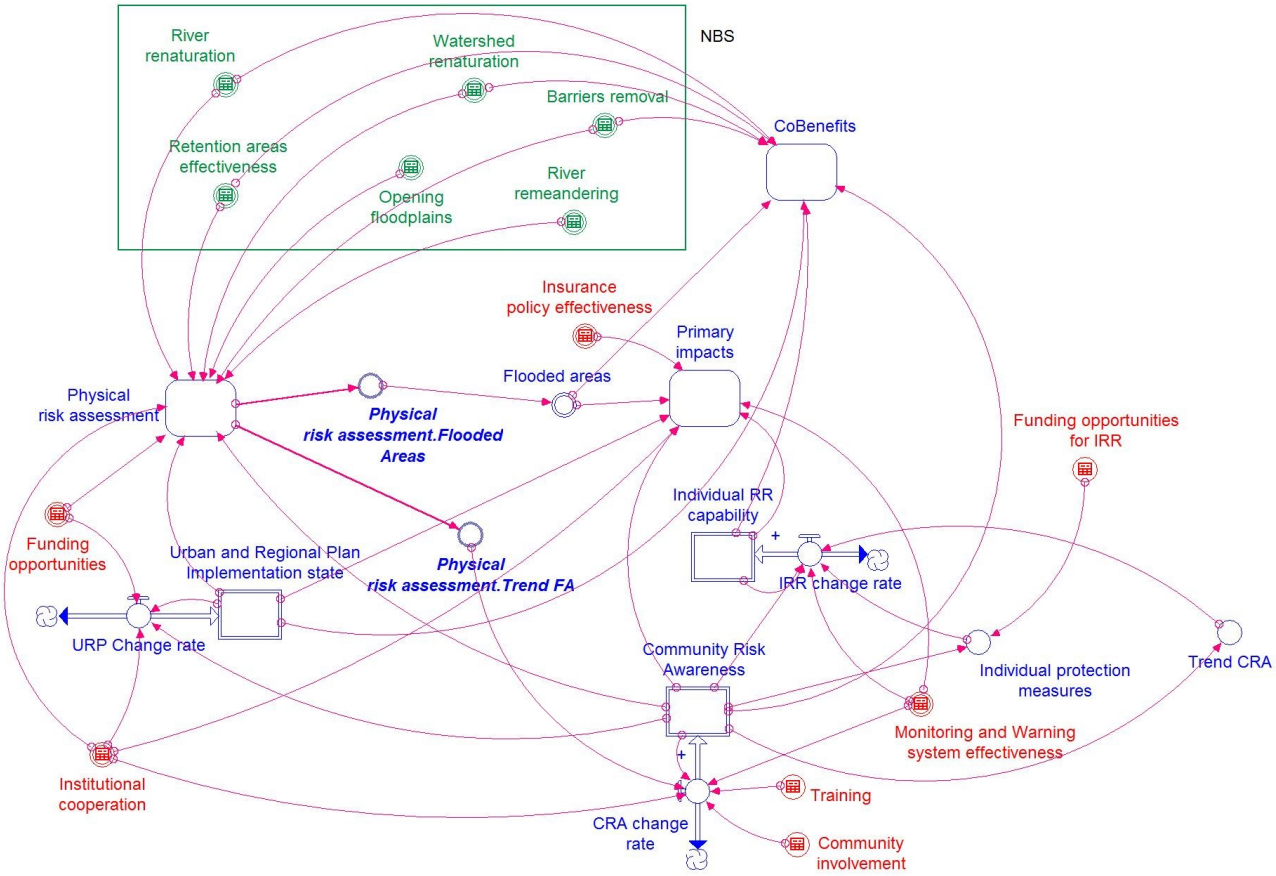

Figure 3. General SDM model: Glinscica case study.

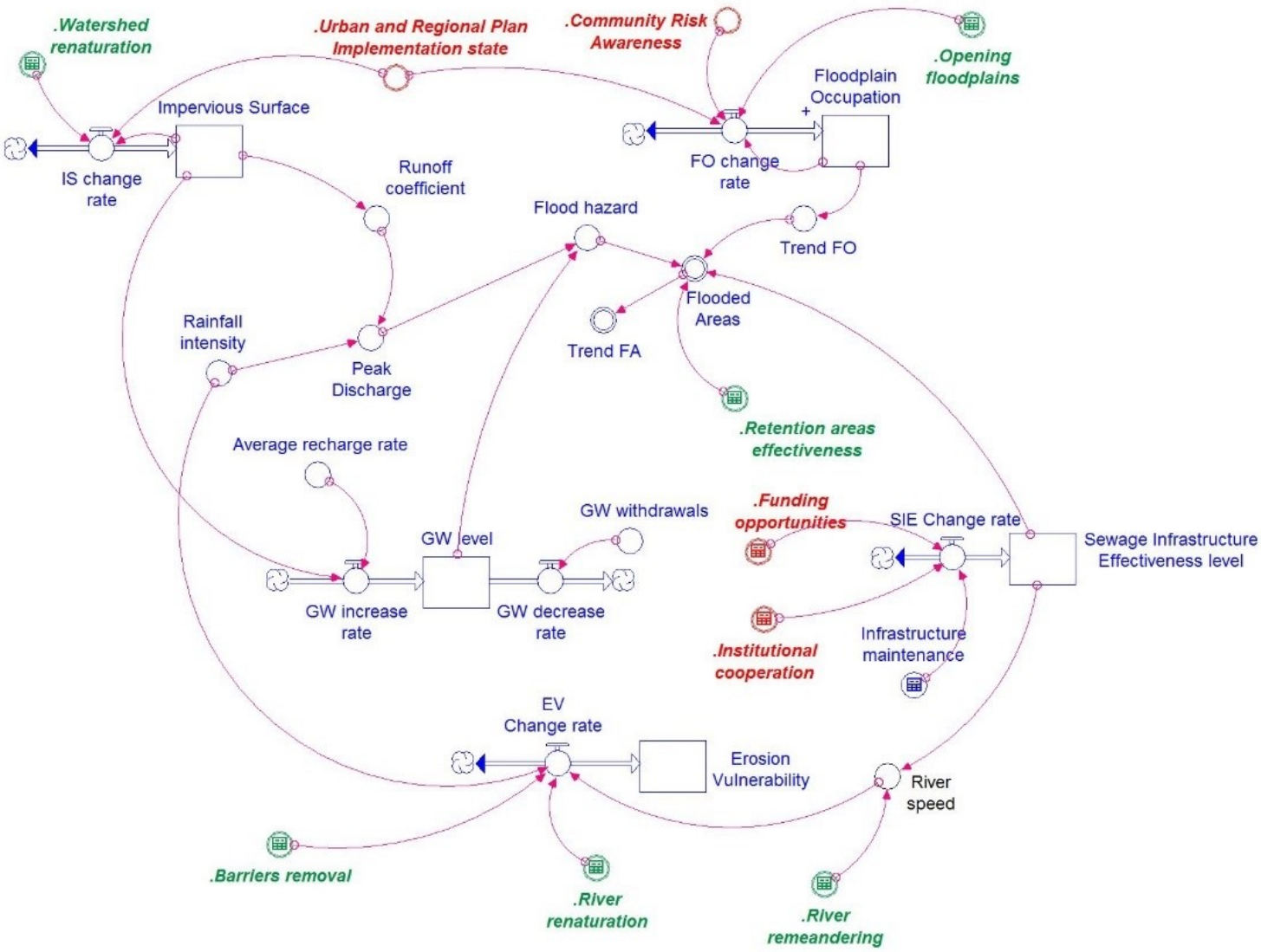

Figure 4. Physical risk assessment sub-model: Glinscica case study.

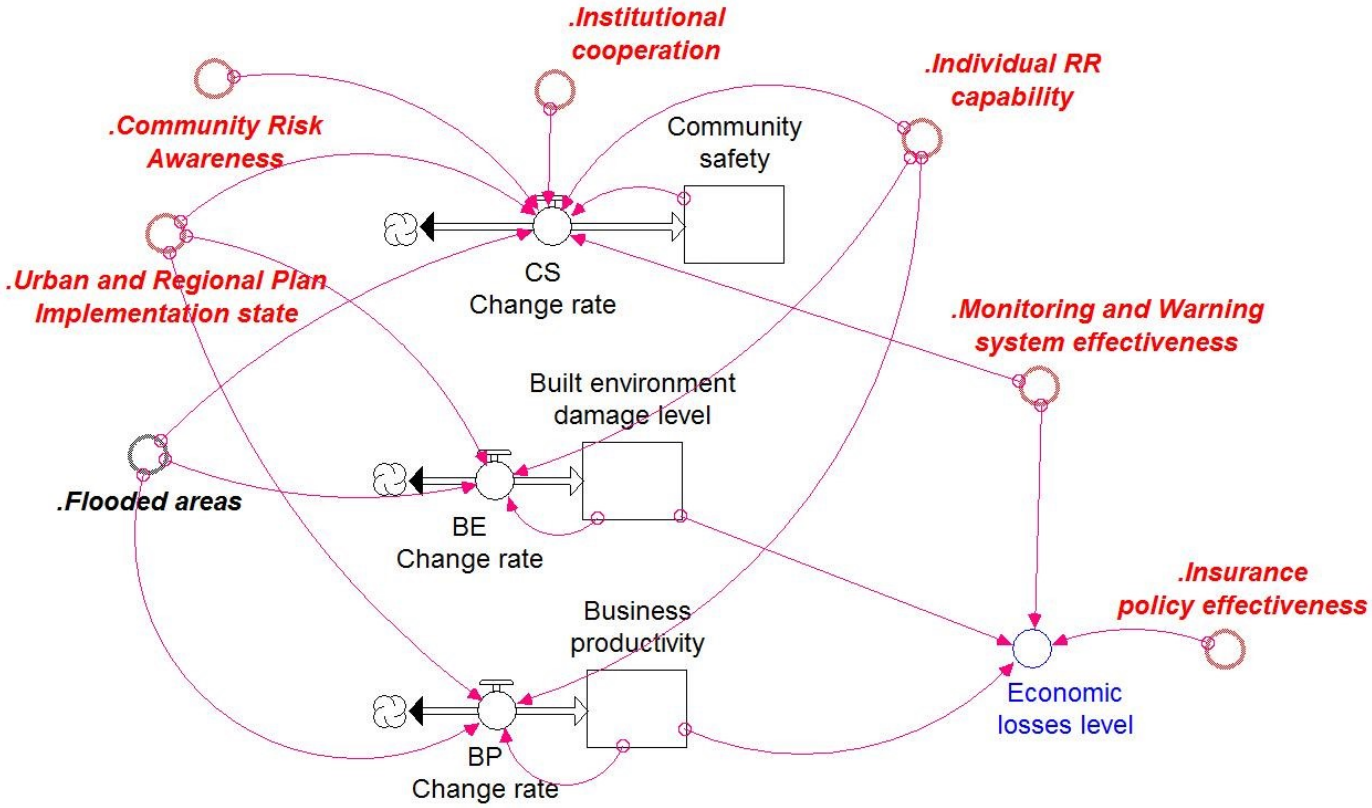

Figure 5. Impacts assessment sub-model: Glinscica case study.

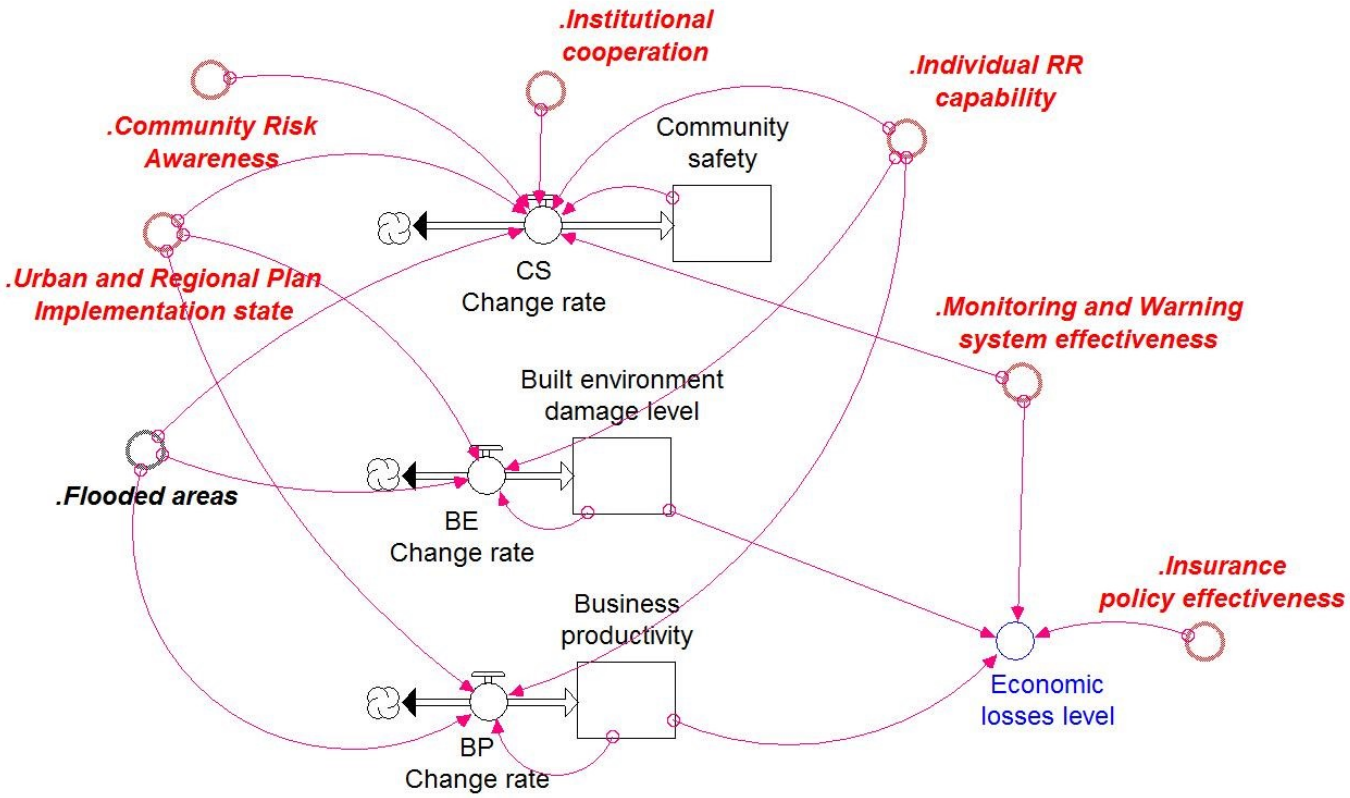

Figure 6. Co-benefits assessment sub-model: Glinscica case study.

Just to provide an example of the potential results of the model, the following Figure 7 provides an overview of the dynamic evolution of the key variables of the model over a time span of 50 years, referring to the current situation. It is worth mentioning that, according to the stakeholders' perception, the conditions of the whole system are expected to significantly worsen over time. The introduction of specific measures (NBS, soft measures, combination of measures) should help improving the state of the key variables, thus supporting in the achievement of the main objective (i.e. flood risk reduction and limitation of the associated impacts) and of the associated co-benefits. Such scenario analysis will be discussed and performed during the 2nd workshop.

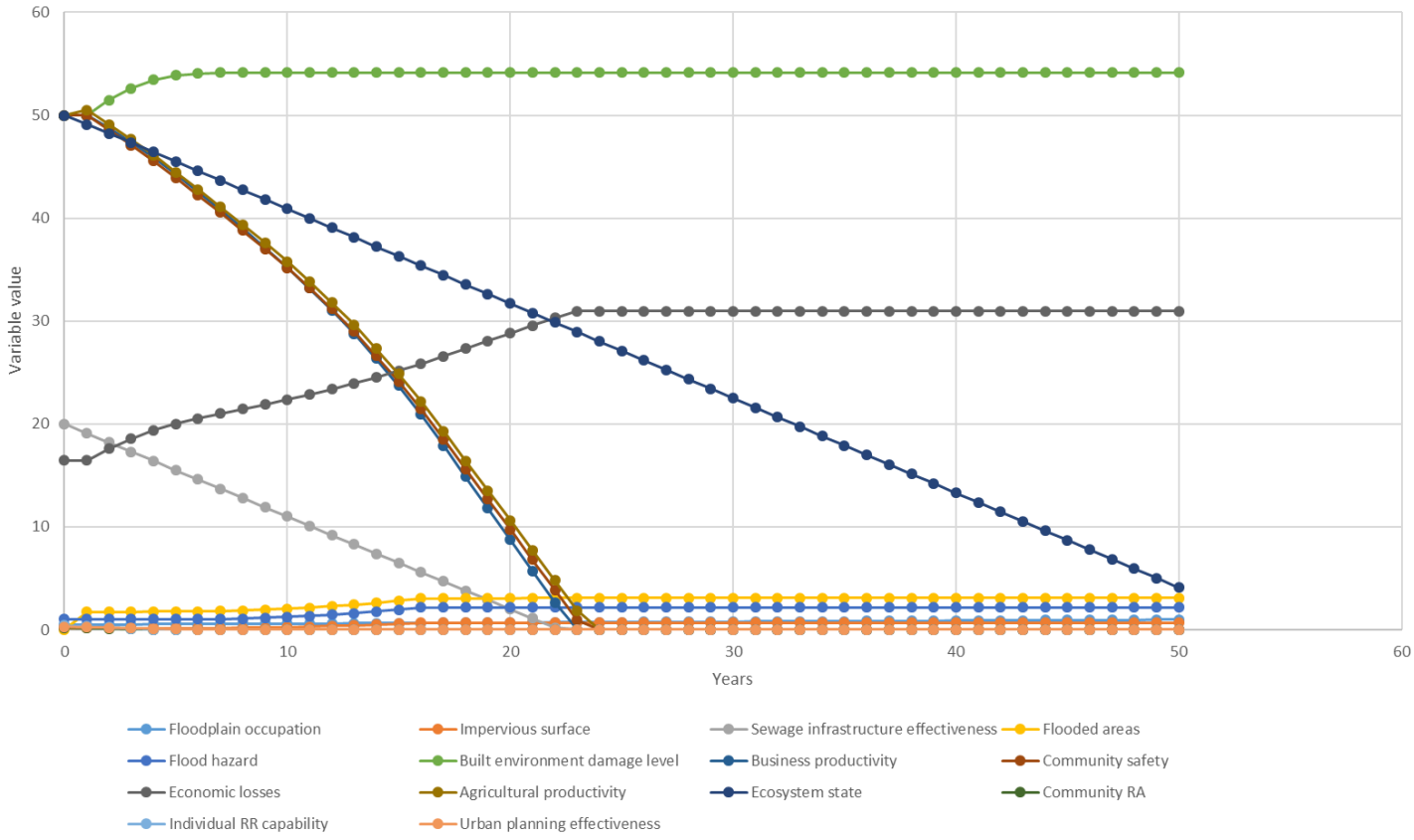

Figure 7. Evolution of the key variables for the Glinscica case study in the current scenario.

5. Creating a user-friendly interface for the quantitative model

In order to create an easy-to-use interface, Forio epicentre platform will be used to host the quantitative SD models created in Stella Architect® and Vensim. Forio Epicenter is a computational free platform for hosting server-side models. The interface will be built using HTML code to create an interactive web that will allow the user to choose between different discriminatory parameters. Stella Architect® and Vensim are modelling tools to create simulations and presentations, with significant capabilities to build user-friendly interfaces, useful to explain model concepts, explore different assumptions and see the outcomes over time.

Adaptation measures must be site-specific and dependent on the characteristics of the area. For this reason, the discriminatory parameters settled will depend on the final SD models. The parameters will differ from one demo to another as those will depend on the factors and variables described by the stakeholders along with the information provided by the experts in the model valuation phase.

The platform will allow the users to simulate the effects of different measures on the system. Information about co-benefits, disservices, infrastructure resilience or trade-offs and synergies will be provided to the user. The user will be supported in the simulation of how the system could react to climate change scenarios as a high-resolution regional climatic data will be integrated in the final model. As the SD model will also integrate economic data, cost-effectiveness analysis will also be possible, allowing the user to compare different strategies, legislations or measures.

5.1. OPEN-WEB PLATFORM V.1

The activities carried out in DEMOs were mainly oriented to the definition of a conceptual model. The final quantitative models are currently under development. A very simplified model has been created, and it is included in the present deliverable (See figure 8). This simplified model has been used to develop a basic HTML code.

The functioning and the design of the interface is dependent on the quantified dynamic model that goes underneath. The HTML code created is based on the dynamics and interactions of the model. For this reason, the user interface will only be available when the quantified model is finalised. The quantified models are dependent on the models created by WP2, 3 and 4.

Due to the complexity of the models, the Open-web platform will only host four quantitative SDM. The DEMOS chosen to be hosted in the platform are Medina del Campo, Copenhagen, Lower Danube and Glinscica. These four DEMOS have been selected because they represent different systems with different scales and contexts. It would be possible to explore the potential of NBS in reducing the negative effect of water-related hazards.

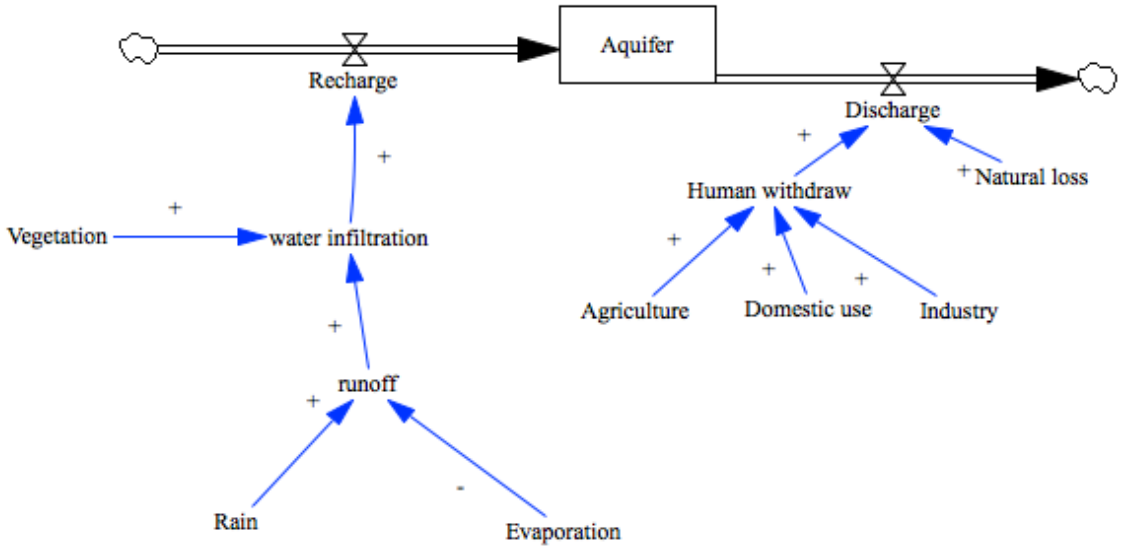

Figure 8. Simplified model for start creating the basis of the user interface.

In this model, the value of the variables has been settled randomly. In the final models, physical and economic data provided by WP 2 and 4 will be used.

This model represents a simple system of stock (Aquifer) and flows (Recharge and Discharge) being influenced by variables (water infiltration, human withdraw and natural loss) that are at the same time, influenced by other variables (vegetation, run off, agriculture, domestic use, industry).

The equations and the values of the different components of this model can be seen in table 7.

Table 7. Variables and equations of the model V.1.

Name	Type	Equation/Value	Units
Aquifer	Stock	Recharge-Discharge	m^3
Recharge	Inflow	water infiltration	m^3/month
Discharge	Outflow	Human withdraw+ Natural loss	m^3/month
Water infiltration	Variable	runoff*Vegetation	m^3/month
Runoff	Variable	Rain-Evaporation	m^3/month
Human withdraw	Variable	Agriculture + Domestic use+ Industry	m^3/month
Rain	Variable	600	m^3/month

Evaporation	Variable	500	m^3/month
Natural loss	Variable	5	m^3/month
Agriculture	Variable	10	m^3/month
Domestic use	Variable	10	m^3/month
Industry	Variable	50	m^3/month
Vegetation	Variable	0.45	Dmnl

Considering this simplified model, the platform will allow the user to run different scenarios comparing, for example, which impact would have an increase of the agricultural production in the system. The final version of the platform, will allow the users to take informed decisions about risk adaptation measures. The interface is dependent on the quantitative SD models that are currently under development. Improvements in the user interface will be made once the quantitative models are finished. The design of the platform as well as its functioning will depend on the completed system dynamic models created. For this reason, it is not possible to provide a full detail of the platform functioning and design at this stage of the project.

The platform is being created dynamically. This means that the user will be able to interact with the models and 'test' which is the effect of different adaptation measures in the system. It will be also possible to explore the effectiveness of these measures in the long term. The effectiveness will be explored under different economic, social and climate change scenarios.

The interaction between the user and the model will be trough an interactive interface that will include different bars and buttons where the user will be able to choose between different discriminatory parameters (See deliverable 5.1). The results of the runs will be displayed in tables, graphs and risk maps. See first version of the platform clicking in the below link. In this version is not possible to visualize geographic information as it has not yet been integrated in the SD model.

The platform will include:

- Web-based dynamic model for different case studies in which the results of NBS implementation can be visualized, focusing on changes of hazard and on a different set of scenarios (climate change) and alternatives (different types of NBS/grey infrastructures or other type of adaptation measures).
- Catalogue of NBS linked to case studies (OPPLA). NBS will combine the classification made by IUCN (Cohen-Shacham *et al.,* 2016) and BioDiversa (Eggermont *et al.,* 2015) and will be updated and completed with literature.
- Cost-effectiveness analysis of adaptation measures.
- Description of the 4 DEMOS.
- Integration framework description.

- Glossary

The first version of the open-web based insurance value platform v1.0 can be found here: forio.com/app/eulalia_gomez/naiad-open-web-platform

6. References

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