Chapter 15
Glinščica for All: Exploring the Potential of NBS in Slovenia: Barriers and Opportunities

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Highlights

- An overarching and comprehensive participative process can result in a risk-management NBS scheme accepted by the stakeholders
- Citizen science can support risk management
- Spatial planning in Slovenia is not yet aligned with the European NBS agenda
- Decision makers rather than the general public fail to accept NBS as an alternative to grey solutions
- Methods for assessing economic value of NBS co-benefits need further development in the field of ecological and cultural benefits

15.1 The Glinščica Catchment Characterization

Glinščica catchment is situated within the borders of the City Municipality of Ljubljana (MOL) that spans roughly 275 km^2 and has a population of about 284,000 inhabitants (Fig. 15.1). The case study site covers 7% of Ljubljana's surface area, it

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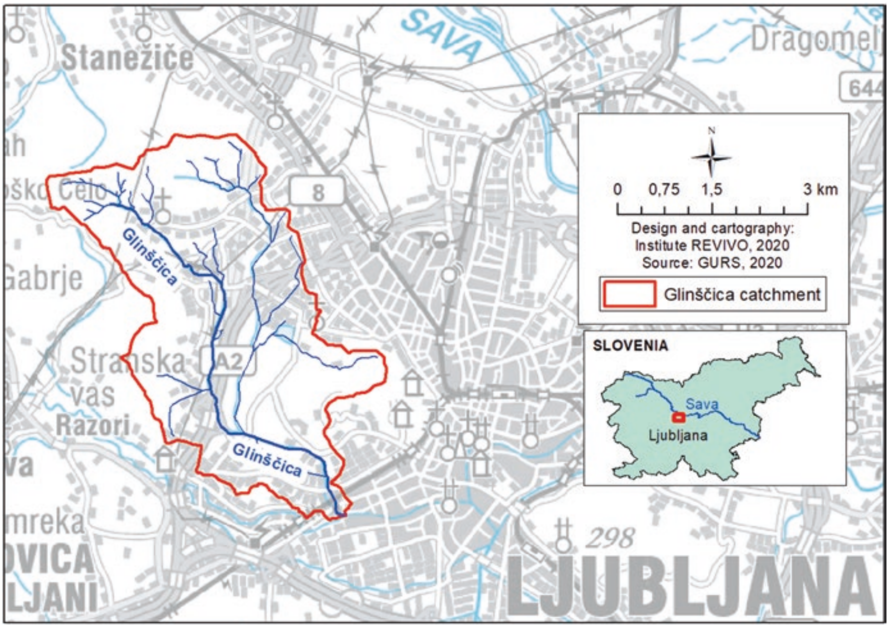

Fig. 15.1 Glinščica catchment location and extent

includes five of its districts (Dravlje, Šiška, Rožnik, Vič, Šentvid) and accounts for 8.17% (23,200) of its population. Ljubljana has spread extensively over the flood-plains of rivers like Glinščica, Gradaščica and Ljubljanica during the past decades (Komac et al. 2008). Furthermore, the spatial planning process allowed properties to be built right on the banks of the watercourses, leaving no space for flood waters. Consequently, both hazard and vulnerability increased significantly, multiplying the flood risk in the catchment. Nevertheless, natural areas still cover approximately 50% of the catchment, agricultural land about 20% and urban areas about 30%, which allows for the planning and implementation of NBS. Over the last decade, the City Municipality of Ljubljana has implemented numerous urban green measures and was designated the European Green Capital in 2016.

Urban watercourses in Ljubljana are an important component of the urban green system, primarily as a network of natural areas which stretch into the urban fabric and introduce natural landscape elements in the urban area. However, the lower reaches of Glinščica have been lined with concrete for several decades and other forms of regulations extend upstream to the mountainous headwaters. Inappropriate regulations coupled with urbanization of flood plains are reflected mainly in the high frequency of flood events and low species diversity. Fast drainage through the straightened stream channel conveys flood waves directly into the city center. The most recent devastating floods of 2010 cost an estimated 14.74 million € in damages, mainly to watercourses, houses and buildings (Benedičič 2011).

Straightened channels and the continuous removal of riparian vegetation have also reduced the aesthetic and educational value, as well as the status of the water environment and thus the experiential value of the stream. Therefore, Glinščica ceased to provide many of its functions as an urban green corridor: hydrological, ecological, spatio-structural, aesthetic, sports and recreational and social.

Several local initiatives have been put forward during the last 10 years to restore parts of the Glinščica stream to a more natural status. Together with the EU requirements arising from the Water Framework Directive (WFD) and Floods Directive (FD), these resulted mostly in changes on strategic level. Sustainable development is one of the main targets of the 2014–2020 Strategy of the City Municipality of Ljubljana (Trajnostna urbana strategija … 2015). Furthermore, restoration of natural features has been integrated as one of the priorities in water management in the strategic part of the Municipal Spatial Plan (Odlok o občinskem … – strateški del 2018) and in the implementation part of the Plan, through the conservation of the ecological status of water bodies (Odlok o občinskem… – izvedbeni del 2018). Glinščica River is also one of the priority streams for river restoration in the Program of Fish Management in Freshwaters of Slovenia for the period until 2021 (Program upravljanja… 2015). However, based on monitoring data and actual conditions in the field these changes have thus far had little or no effect on the practical planning and implementation.

Glinščica was selected as the target catchment by the NAIAD project in Slovenia due to several reasons. First of all, it is a small catchment, located entirely within the borders of one municipality, which is exceptional in Slovenia, having 212 municipalities on a land surface area of 20,3 km^2. Second, the series of floods since 2010 illustrates the insufficient capacity of the current risk management measures. Third, the Glinščica catchment is defined as the green wedge of the city of Ljubljana, both locals and tourists using it for recreation and relaxation, but the stream itself is completely channelized and void of riparian vegetation. Last, but not least, the number of previous local initiatives and the extent of agricultural land (Fig. 15.2) indicate the desire and potential for restoration.

The NAIAD process was therefore applied to offer an alternative strategy, based in the concepts of NBS and catchment management approach, to Glinščica stakeholders, identify the potential of NBS for risk management in the Glinščica catchment and to demonstrate participative planning process. However, the long-term willingness to implement the NBS strategy developed by the stakeholders, remains to be achieved.

15.2 Risk Assessment and Perception

Floods are quite frequent and severe in the Glinščica catchment, with increasing damages to communities and the built environment, as a consequence of historical regulations. Continuously, grey measures are being implemented to reduce flood risk with limited effectiveness and a detrimental impact to the environment (Griessler

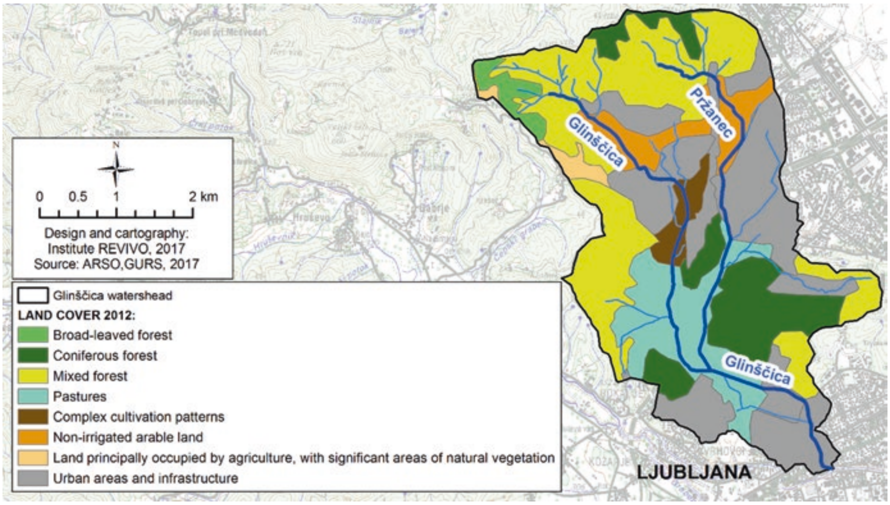

Fig. 15.2 Land use in the Glinščica catchment shows great potential for using NBS for flood risk management

Bulc et al. 2017; Žaberl et al. 2011). Meanwhile, NBS and hybrid solutions that could simultaneously contribute to flood risk reduction and achieve good environmental status have not been considered in the current risk management planning.

Moreover, local knowledge and initiatives are not considered in flood protection planning and public participation in flood risk management in Slovenia is limited to submission of suggestions after the course of action and/or design has already been decided. However, experience shows that flood management measures need to be considered as a collective decision-making process characterized by multiple-actors with different, and often conflicting, risk perceptions (Santoro et al. 2019).

In an institutional decision environment, where the presence of ambiguity is unavoidable, the different roles played by the decision-actors affect the lens through which these actors give a meaning to a certain situation. Evidence demonstrates that making the decision actors aware of the existence of ambiguous problem framing is the key to enable creative and collaborative decision-making processes (e.g. Giordano et al. 2017). Addressing the existence of different and equally valid problem framings (unilateral decision-making process) in the initial stage of the participatory process increases the time required for making the decision. However, the diversity in frames also offers opportunities for innovation and the development of creative solutions (Brugnach and Ingram 2012), thus facilitating the implementation phase and the measure's effectiveness. The process and the underlying scientific methods are explained in detail in Chap. 5 (Giordano et al., this volume), while this chapter focuses on the implementation of these methods in the Glinščica case study. This chapter is therefore intended mainly for the decision makers and managers wishing to transition to a modern water management approach, but scientists will also find information on how theoretical knowledge fairs in practice and hopefully work on further developing the methods accordingly.

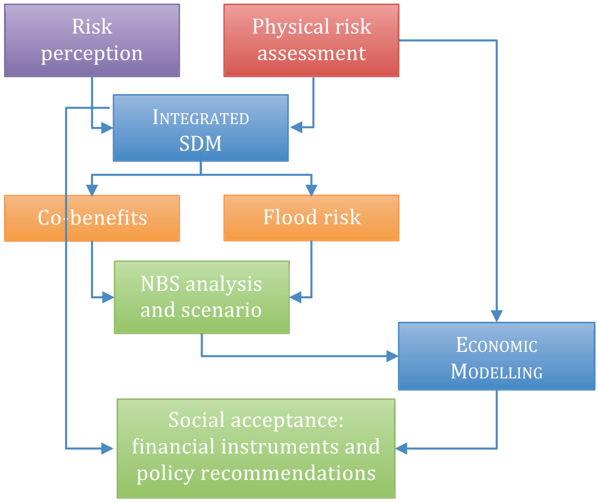

Fig. 15.3 The full participative process as implemented in the Glinščica catchment. (please refer to Chap. 5 (Giordano et al., this volume) for methodological explanation)

As already stated in other parts of this book (Chap. 5, Giordano et al., this volume), stakeholder engagement in defining risks and designing NBS was a key step in the process. The main aim of the Glinščica case study was to enhance the future NBS implementation by investigating the potential impacts from NBS measures, facilitating a dialogue between stakeholders, aligning divergences and promoting the social acceptance of NBS measures for risk reduction and co-benefit generation (i.e. a natural assurance scheme) at different levels (local, regional, national) and sectors (e.g., municipality, civil protection). To this end, the process was implemented as a fully participative (Fig. 15.3; please consult Chap. 5 (Giordano et al., this volume) for methodological details of the process). This also allowed for the most important impact of the activities, a raised awareness about NBS and demonstration of how participative planning can ensure the most acceptable solution is developed and accepted by all.

15.2.1 Physical Flood Risk Assessment

First of all, a physical flood risk assessment was performed to determine the hazard and vulnerability levels. It was based on a full hydrological study (see Chap. 4 (Mullingan et al., this volume) for the overall approach), which considered a statistical regional analysis of rainfall and discharge data of a river station, with the identification of peak flood values for different return periods. The model was calibrated to the official flood maps available for the larger Gradaščica catchment (Fig. 15.4).

Expectedly, flood risk is most extensive in the lower reaches, but several areas at risk were identified far upstream. These are generally areas where historical

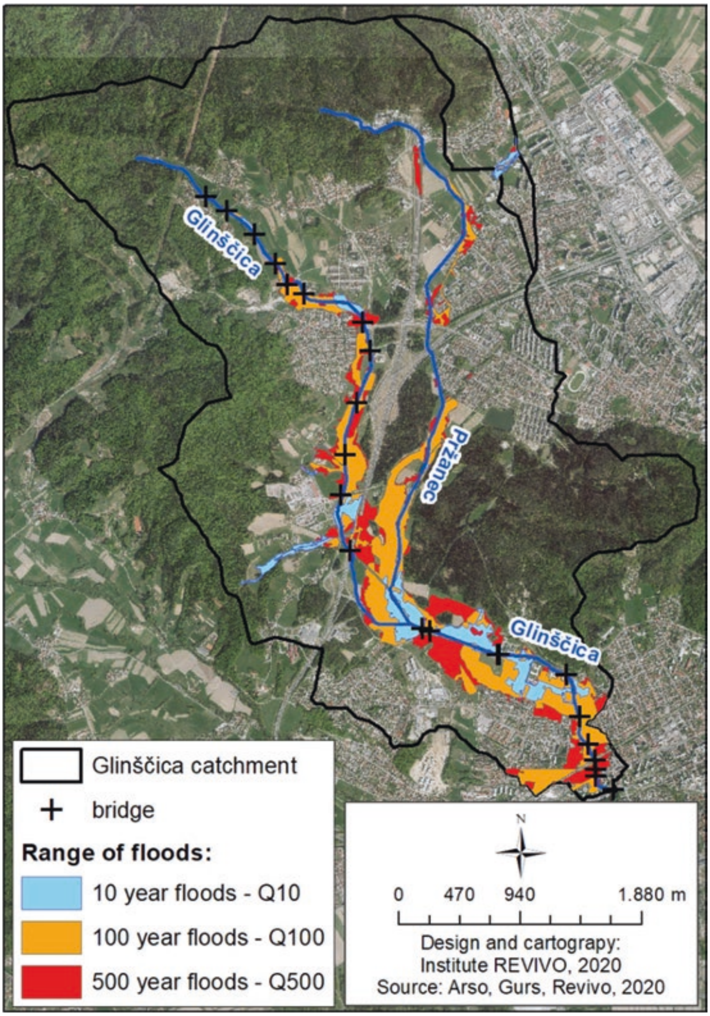

Fig. 15.4 Flood extent in the Glinščica catchment, for 10-, 100- and 500-year return periods. Bridges play an important role in flood waters distribution

regulations have impacted the river channel the most and where buildings and infrastructure have spread to its banks. Comparison with the land use distribution was performed to reveal the highest vulnerability areas and areas with highest NBS potential.

Additionally, it was found that the bridges on the Glinščica stream and the relevant roads play an important role in distributing flood waters during high discharge. They act as bottlenecks, stopping and redirecting flood waters to the flood plains and thus controlling the downstream discharge.

15.2.2 Risk Perception

Watercourses are considered public goods in Slovenia and the Ministry for Environment and Spatial Planning (MOP) is directly responsible for their management and maintenance. Therefore, MOP was identified as the most important stakeholder in NBS solution planning in the Glinščica catchment. MOP is also responsible for the transfer of WFD, FD, Birds, Habitats and all other water related Directives into Slovenian legislation, as well as their implementation throughout Slovenia. To understand and map the many number of different functions and/or roles of MOP in the NBS solution planning in Glinščica, 12 different departments were identified within the Ministry, one regional department and three of its agencies and institutes directly involved in water management. However, it was difficult to map and determine the exact responsibilities of each of these actors within the water management system. In addition, at least 16 other stakeholder groups were identified and targeted following the snowball approach (see Chap. 5, Giordano et al., this volume, for details on the process), including governmental institutions, research institutes, chambers, recreational associations, city quarters, civil initiatives.

The initial stakeholder participation was performed through a series of individual interviews, through which different risk perceptions, existing cooperation, responsibilities and level of NBS awareness were collected and used as part of the overall catchment characterization. A large number of individual stakeholders (over 50) were initially contacted and invited for an interview, of which only a handful accepted participation. Of those that agreed to participate, only a couple of stakeholders understood the principles and were able to indicate examples of NBS, but all of them considered flooding as the main risk for the Glinščica catchment, which was in agreement with the physical risk assessment performed simultaneously.

15.3 The Participative Search for Solution

Research shows that solutions developed through public participation are more likely to be trusted and accepted by individuals within the network, prompting individual and collective action. The initial interactions described above revealed a considerable lack of awareness of modern water management concepts such as NBS, adaptive management, catchment approach among the participating stakeholders. The first workshop was consequently structured to provide an extensive explanation of these concepts, including best practice examples from abroad. Furthermore, the interviews resulted in a list of issues that need to be addressed in order to support the flood risk management in the Glinščica catchment. The workshop thus included a ranking of these issues and defining the main goals for flood risk management in the Glinščica catchment (Table 15.1).

These results defined and directed the following work and development of the solutions in the Glinščica catchment case study.

Table 15.1 The five most important issues and their transition to management goals for the Glinščica catchment as defined by the stakeholders through participative process

Issue	Goal
Flood plain occupation	Maintain flood plain occupation (do not increase)
State of the ecosystem	Improve the state of ecosystem
Lack of public funding	Increase public funding
Community safety	Increase community safety
Watercourse speed	Decrease watercourse speed

15.3.1 Identifying Potential Solutions

The process started with experts developing a comprehensive list of available measures, including grey, hybrid and green (Chap. 5, Giordano et al., this volume). These were presented during the first workshop, when the stakeholders were encouraged to propose, discuss and finally rank the different potential solutions (NBS, hybrid and grey) in relation to their contribution to achieving the five set goals for the Glinščica catchment. The stakeholders mostly selected hybrid solutions with a general notice that the correct design and location of these measures is of utmost importance for achieving their effectiveness. Moreover, they felt that the measures should be designed in harmony with each other and help to achieve multiple goals simultaneously (co-benefits). The following five measures were selected as the most promising:

1. Dry retention areas
2. Re-meandering of the stream (including revegetation)
3. Opening of the flood plains
4. Widening of the stream channel
5. Small multi-functional wet retention areas

It was suggested by the stakeholders that the dry retention areas and opening of the floodplains should be implemented in the spaces upstream of the built-up areas. The stakeholders explained that flood risk management measures have been planned for the Glinščica catchment since the 2010 floods and that one of the dry retention areas had already been built. Re-meandering has somewhat contradictory expected impacts on the five main goals according to the stakeholders. Re-meandering will greatly improve the state of ecosystem and slow the water flow, but should be implemented within the opened-up flood plain or within a dry retention area, because it might increase the risk of flooding by slowing the flow and hence will not attribute to community safety. Widening of the stream channel was suggested for the stretch of the Glinščica within the urbanized areas, where buildings and other infrastructure prevent other restoration measures. The concrete lining should be removed and the more natural two-level channel restored to maintain the ecological flow in the lower, smaller channel during low flows, but to allow the larger volumes during flood events to be discharged efficiently. As the last suggested measure, wet retention areas were seen as the least effective in flood risk management, but as an important factor for improving the state of ecosystem and an important addition to the green areas of the city.

15.3.2 Identifying and Modelling Co-benefits

Following the first workshop, the stakeholders were again approached individually to identify and rank the different co-benefits and to identify and rank the soft measures[1], intended to enable the implementation and enhance the efficiency of physical measures (Chap. 4, Mullingan et al., this volume, for a description of method to assess NBS effects). The objective of this step was not only to understand which of the selected measures provide the most benefits, but also to be later used in the valuation of the different solutions, both in monetary as well as non-monetary terms (see Chap. 6, Le Coent et al., this volume, for a description of the valuation methods and Chap. 5, Giordano et al., this volume, for a description of the stakeholder engagement methods).

During the second round of semi-structured interviews, individual stakeholders were first requested to rank the level of individual co-benefit production for each of the five measures, selected during the first WS. This step was highly controversial for the stakeholders in that they felt the co-benefit production depends heavily on the exact location and design of the selected measure, an issue already raised during the first workshop. Moreover, the stakeholders also identified overlap or counteracting impacts of the measures or they were not aware of the functioning and hence, they couldn't predict the co-benefits. In some cases, they refused to perform the ranking and so the scores were not taken into account. Finally, although the stakeholders were encouraged to expand the list of co-benefits, no new suggestions of co-benefits were given. The results were later grouped and averaged to obtain the common score of five highest-ranking co-benefits, which would be included in the next steps of the process. The five most important co-benefits identified by the stakeholders were reduction of flood extent and damages to the built environment, enhancement of biodiversity and the state of ecosystems, improvement of community safety and increase of the social value of ecosystems, which were well aligned with the main goals for the Glinščica catchment management. A similar, but simplified process was applied to define the five most important soft measures, which were intended to support and enhance the effectiveness of the physical measures. These were: enforce land protection planning strategies, enforce urban planning strategies, territory control (illegal activities), implementing projects that target the

[1] A socio-institutional measure to support or enhance the functioning or impact of its opposite, a hard measure, either NBS, hybrid, grey. Examples include policy and legislation, enforcement and financing, but also behavioural change, capacity building, education.

involvement of local communities, defining innovative protocol of interaction among different institutions.

All the information collected was eventually integrated by experts into the System Dynamic Model (SDM) for the Glinščica catchment, developed in order to allow a comparative analysis of the different strategies. The SDM is based on the integration of different stakeholders' risk understandings and problem perception and the physical assessment of the water-related risk (see Chap. 5, Giordano et al., this volume, and Pagano et al. 2019 for a description of the SDM approach). On the one hand, the model was used to support the development of an integrated community-based evaluation method, drawing both on scientific evidence (e.g. deriving from physical risk assessment activities and economic analyses) and on the local/expert knowledge. On the other hand, the SDM enabled a participative (semi-) quantitative simulation of the impacts of specific strategies to deal with water-related risks, supporting a comprehensive analysis of trade-offs among different stakeholders and analysing costs and benefits (including co-benefits) at different scales and on different issues.

15.3.3 Identifying and Selecting Indicators

The identification of the most useful set of indicators for evaluating NBS effectiveness (Table 15.2) was not required for the continuation of the process as such. However, the task implemented at the start of the 2nd workshop encouraged the stakeholders to discuss again the desired (co-)benefits and agree on the future evaluation and monitoring after the implementation of the NBS measures. This served to further consolidate their acceptance and ownership of the developing solutions as well as to re-confirm the most important benefits sought.

Additionally, during the discussion on indicators and monitoring, the lack of water level monitoring station was identified as a barrier for improved flood risk management on the Glinščica stream. Although a discharge gauge existed on the Glinščica stream in the past, it was dismissed in the 1990s and so no current reference discharge data are available for either up to date hydrological/hydraulic modelling, as an early-warning support system or for tracking the impact of climate change now and in the future.

The Department for civil protection of the City Municipality of Ljubljana is, among others, responsible to monitor, report and issue early warnings in cooperation with the national civil protection agency (URSZR) in case of natural disasters. Since there had been no gauging station on the Glinščica stream (neither on other streams in the municipality) before this project, the department officers were required to regularly monitor the water levels during high rainfall events in-situ, or by deploying officers of other available civil protection departments or services (e.g. local volunteer firefighter community personnel). In either case, the personal field observation in time of emergency is a waste of valuable and limited time that

Table 15.2 The three most important indicators according to the stakeholders' opinion were determined for each of the five most important (co-)benefits

Reduced flood extent	Runoff coefficient in relation to precipitation quantities (mm/%)
	Flood peak reduction (e.g. Qmax,0/Qmax,1) and increase in time to peak [s]
	Volume of increased storm water retention
Reduced damages to built environment	Reduction in human casualties n° or ratio
	Value of damages on public infrastructure
	Value of damages to buildings
Enhanced biodiversity and ecosystems state	Species richness and composition
	Biodiversity index
	Water flow speed (in relation to natural)
Improved community safety	Flood peak reduction (e.g. Qmax,0/Qmax,1) and increase in time to peak
	Extent of urbanized floodplain areas
	Number and extent (number of people affected) of intervention events
Increased social value of ecosystems	Distribution of public green space – total surface or per capita
	Improved human health and wellbeing
	Urban green: index of biodiversity, provision and demand of ecosystem services

the personnel could be using to organize and implement mitigation and/or rescue activities.

Therefore, the utilization of the FreeStation approach in the Glinščica catchment was initially suggested to collect the reference data for improving the hydrological/hydraulic models used in assessment of the NBS solutions. However, the stakeholder participation process revealed that it can also be used to monitor the impact in case of implementation of the selected NBS and to establish a remote sensing location to support civil protection service of the City Municipality of Ljubljana in monitoring water levels and issuing flood warnings.

15.3.4 Freestation as a Multi-functional Monitoring Tool

The FreeStation open-source initiative enables different stakeholders and communities to build and deploy reliable environmental data loggers with the lowest cost and easiest DIY build possible (please consult Chap. 4, Mullingan et al., this volume, for a full description of the Freestation initiative). Its modular design allows the user to select and install the assortment of sensors most suitable for their specific purpose.

Fig. 15.5 The Freestation was installed on the driftwood barrier at the lower end of the newly built Brdnikova reservoir

The first FreeStation monitoring station was installed on a suitable bridge over the Glinščica stream upstream from the vulnerable urban area to test its efficiency and usefulness for the above-mentioned purposes (Fig. 15.5). The data collected from the Glinščica monitoring station will be incorporated into the existing flood monitoring system of the MOL, available online to the general public and used in various analyses and forecasts. Besides water level, the station is also collecting data on air temperature, humidity and pressure, and it can be upgraded with modules for rainfall and wind speed monitoring if requested by the stakeholders. The solar panel powered FreeStation is completely independent and requires minimal maintenance. It is thus not surprising that the City Municipality of Ljubljana has deployed 7 additional FreeStations to the different observation locations throughout the municipality as of 2022.

15.4 Developing, Testing and Selecting the Most Suitable Strategy

Eventually, the 2nd workshop aimed to co-design the most effective combination of NBS, hybrid and soft measures for achieving the selected benefits (strategies). The participants were required to create three different boxes, each representing a strategy and each of which should contain five different actions selected among the potential NBS, hybrid and soft measures identified in previous steps (Table 15.3).

Table 15.3 The measures included in the three developed strategies

Renaturation	Bureaucratic	Bottom-up
Retention areas effectiveness River renaturation with re-meandering Wetlands restoration Physical risk management infrastructure maintenance Funding opportunities for infrastructure	Opening floodplains Territory control Community involvement Monitoring and warning system effectiveness Insurance policy effectiveness	Retention areas effectiveness Community involvement Institutional cooperation Training Funding opportunities for infrastructure

Once the measures had been selected, they named the three strategies the "Renaturation", the "Bureaucratic" and the "Bottom-up", their names indicating the main measures considered.

The results were integrated in the SDM model described above to support interactive comparison of these strategies with a real-time visualization of their impacts on the selected parameters of co-benefit production (Fig. 15.6). In other words, the simulation of strategies in the SDM model over a 50-year period provided relative information about the impacts of applying the different strategies on the flood risk as the primary goal and on the environmental, social and economic co-benefits, selected by the stakeholders. The key result of this exercise was that the stakeholders recognized the relevant importance of combining the physical and soft measures. In the specific case of Glinščica catchment, stakeholders understood the important role that institutional measures play in either preventing or increasing the implementation and effectiveness of urban and regional management plans and measures.

The results were discussed among the stakeholders, who were asked to rank the strategies and choose the best one according to their opinion. An agreement emerged that, while the "Renaturation strategy" was the most promising one, none of the strategies adequately addressed the challenges of the Glinščica catchment management. The stakeholders felt restrained by the number of measures allowed per strategy, so an additional strategy was proposed by them with no constraints on the number of measures. To develop this strategy, the "Renaturation strategy" was complemented with seven additional soft measures, since the simulation results indicated that their simultaneous implementation with the proposed NBS and hybrid solutions could help achieve the target benefits in the long term. This strategy was named "Glinščica for all" and was approved by all the participating stakeholders (Table 15.4, Fig. 15.6).

As the last step of the 2nd workshop the stakeholders were provided with a map of the Glinščica catchment and required to indicate the locations where the selected three physical measures should be implemented. This map was used to develop the final Glinščica catchment management plan (Fig. 15.7).

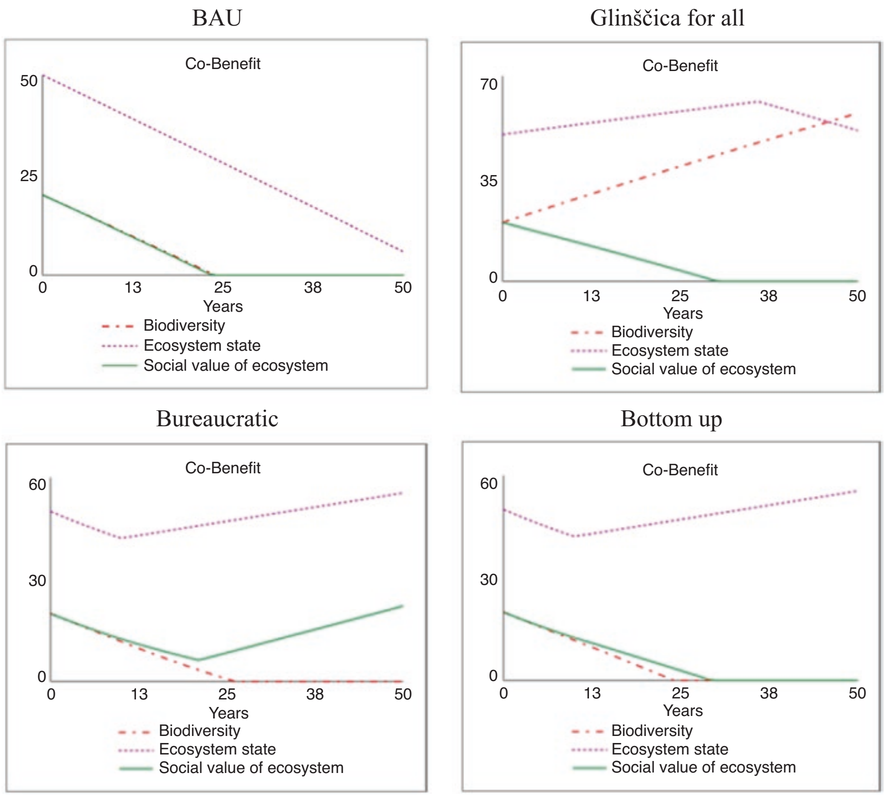

Fig. 15.6 The output of the SDM model predicting the changes in the 3 ecological co-benefits production, depending on the Glinščica catchment management strategy applied

Table 15.4 The list of NBS/hybrid and soft measures defining the Glinščica for all strategy developed by the stakeholders

NBS measure	Soft measure
Regular maintenance of retention areas	Territory control
Wetlands restoration	Funding opportunities for IRR
River renaturation with re-meandering	Launch of an effective monitoring and warning system
	Community involvement
	Insurance policy effectiveness
	Training
	Institutional cooperation

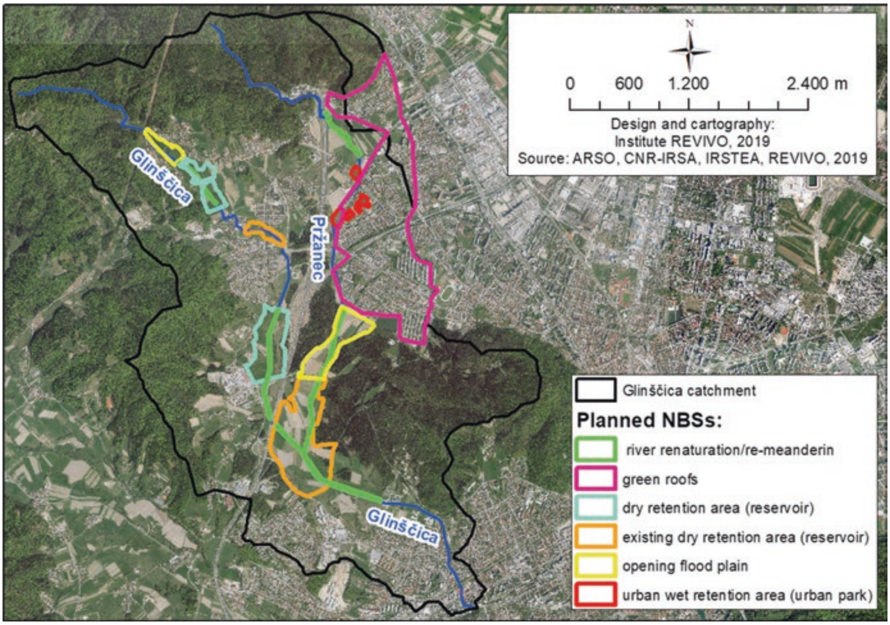

Fig. 15.7 Locations of proposed NBS and hybrid measures as predicted in the Glinščica for all strategy developed by the stakeholders

15.5 The Road to Implementation (E/Valuation)

The physical solutions of the Glinščica for all strategy selected during the 2nd stakeholder workshop were detailed by experts and integrated into the hydrological/hydraulic model built in HEC-HMS and HEC-RAS and combined with the results of the Flood Excess Volume (FEV) methodology (Fig. 15.8).

More specifically, the hydrological/hydraulic models (HEC-HMS and HEC-RAS) were used to assess the impact of individual NBS and to produce maps of the flood extent, whereas the FEV methodology was applied to provide a simplified assessment of the synergistic effects of all the measures. The results of the integrated modelling (HEC-HMS, HEC-RAS, FEV) were used to analyse and evaluate the impacts of strategies co-designed with the stakeholders on flood risk. The most important aspect and advantage was the possibility of modelling a complex (and variable) set of measures keeping on the one hand the flexibility and modularity given by FEV, while relying on the other hand on a solid rainfall/runoff model to build maps of the flooded areas. In the end, this was highly relevant to support a strong and reliable analysis of economic benefits of NBS in terms of flood risk reduction.

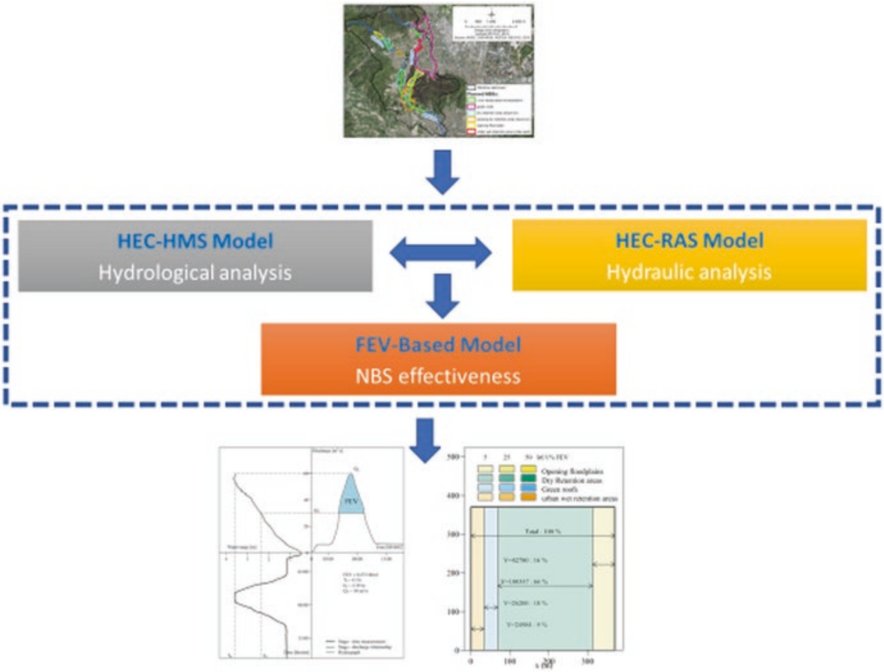

Fig. 15.8 The impact of the "Glinščica for all" strategy on flooding was evaluated using HEC-HMS, HEC-RAS and FEV-based model. Please consult Chap. 4 (Mullingan et al. this volume) and Bokhove et al. (2019, 2020) for description of the FEV and hydrological modelling applied to the Glinščica case study

15.5.1 Economics of Glinščica for All Strategy

Relying on the previous research, it was expected that the added value of NBS in terms of providing co-benefits would outweigh the known limitations of the BAU strategy. The BAU strategy was defined as a continuation of current management practices and urbanization trends, with no or only grey measures applied. On the other hand, future conditions, under which the stakeholder defined NBS strategy was developed, is one of increasing flood risks, combined with the pressures of further urbanisation and population expansion in the area. Therefore, the selected strategy, named by the stakeholders "Glinščica for all", was recognised as the most suitable, especially in the light of future pressures of green taxation or even penalties, deriving from EU policy.

The economic valuation of the chosen strategy was performed as an ex-ante analysis with the goal to compare the chosen NBS and BAU strategies as alternative strategies for the development and management of the Glinščica catchment over a 30-year time scale.

Main objective of performing the economic analysis was to show that in the long term, proposed NBS strategy will be a more rational choice for the following reasons:

1. The future area development, under BAU, foresees continuation of housing construction and grey measures as flood protection measures, with maximum profit in mind. This in long term is not favourable for a capital city, aiming for green and sustainable development practices.
2. The preservation of fully functional ecosystems, supported by NBS measures and alternative development of the case study site will result in preservation of the area's potential for a combination of quality living area, recreational area as well as support local green economy in terms of urban farming.

Calculations were performed following the:

1. Proposed methodology and guidelines, on LCA and CBA assessment (please consult Chap. 6 – Le Coent et al., this volume). Given the drawbacks of both LCA and CBA approaches, a combination of top-down and bottom-up approaches was used, where all proposed elements of calculation were tested with the stakeholders. This especially refers to the co-benefits identification and assessing the viability of their development potential in terms of there being a realistic chance of being accepted as credible alternative to BAU. This also reflects in the nature and cost assessment of soft measures supporting or at least promoting the implementation of selected NBS strategy.
2. National legislation and recommendation under the Decree on the uniform methodology for the preparation and treatment of investment documentation in the field of public finance (Official Gazette No:. 60/06, 54/10 in 27/16), proposing a discount rate of 3%.

Under this methodology the investment costs, taken into calculations include:

1. Costs of land works for implementation of proposed measures

   This includes: (a) costs of investment documentation and studies, (b) preparatory work, (c) building of the infrastructure and (d) maintenance of the built infrastructure
2. Costs of soft measures in support of NBS strategy implementation

   These costs were estimated as costs of (a) awareness raising and competence building for public sector stakeholders to increase their understanding of NBS as fully credible alternative to BAU in flood protection. This would be implemented in series of workshops (five foreseen in calculations); (b) cost of developing suitable sustainable plans for spatial planning and land use, possible due to the restored ecosystem potential following implementation of selected NBS; (c) costs of preparation of individual projects (three annually, using Local Action Group funding opportunity, financing scheme being part of National Cohesion Funds) with relevant stakeholder for future development of an area.

15.5.2 Co-benefits

In order to fully exploit and present the alternative NBS scenario as opposed to BAU, a special attention was given to the identification and (e)valuation of co-benefits. A supporting template was used, allowing to systematically elaborate every co-benefit for its individual impact on the ecosystem status, integrated further on into economic impact as well.

The co-benefits identified by the stakeholders were then translated into ecosystem services and used as the foundation for monetary valuation (Table 15.5). Combining the two approaches and wide literature review on monetary value of use or non-use value of the ES that provide these co-benefits, led to the calculation of net present value (NPV) of ecosystem services production potential in the 30-year period, which amounts to cca. 0,5 MIO EUR annually.

In addition, results of the SDM semi-quantitative model, aligned to the Glinščica case study, showed the following correlation (Table 15.6), which is based upon stakeholder responses and aggregated input from literature and was used as an input for economic valuation of co-benefits.

15.5.3 Costs of Strategies

It is important to highlight that assessed values of co-benefits (Table 15.7) are calculated as the developed potential of ecosystems in good status, which would be enabled by the implementation of all measures in the selected strategy of Glinščica

Table 15.5 A generalized list of services (translated from benefits) adjusted from Wright (2007) and used for economic valuation in the Glinščica catchment

Physical benefits	Ecological benefits	Societal benefits
Store and convey floodwaters thus, reducing flood velocities and food peaks Control water temperature Manage sediment flows Filter nutrients and pollutants thereby enhancing the quality of surface waters Enhance infiltration that ensures groundwater and aquifer recharge, thus mitigating low surface flows	Enable biological productivity Enable biodiversity Sustain critical habitats for aquatic organisms (from birds and fish to dragonflies and frogs), including rare, threatened, and endangered species	Sources of wild and cultivated plants Fertilize agricultural lands for higher productivity Provide sites for aquaculture Provide forest lands Provide recreational opportunities Provide aesthetic resources Provide areas for scientific study and outdoor education Contain cultural resources (historic and archaeological sites)

Table 15.6 Expected change in co-benefits production for Glinščica for all and BAU strategies. All variables related to co-benefits production are expressed in dimensionless form (ranging from 0 to 100, where 0 stands for 'extremely poor' and 100 for 'extremely high'). The 'expected change' compares the NBS scenario with the BAU condition both in absolute and % form. (Short – 10 years; Medium – 20 years; Long – 30 years)

	BAU			NBS			*Expected change*			*Expected change*		
Co-benefits	Short	Medium	Long	Short	Medium	Long	Short	Medium	Long	Short (%)	Medium (%)	Long (%)
Infrastructural damages	45	72	72	45	28	10	0	−44	−62	0.0	−61.11	−86.11
Biodiversity	12	10	8	29	38	67	17	28	59	141.67	280.00	737.50
Ecosystem state	41	32	14	54	60	76	13	28	62	31.71	87.50	442.86
Community safety	35	10	10	49	51	52	14	41	42	40.00	410.00	420.00
Social value of ecosystems	12	8	8	23	30	53	11	22	45	91.67	275.00	562.50

Table 15.7 Discounted costs of strategies over 30 years lifetime (in MIO EUR)

Strategy	BAU	Glinščica for all
Investment	3,9	2,6
Maintenance	0,6	0,2
Total	4,5	2,8
Comment:	Estimation on proposed solution, prepared by Municipality of Ljubljana in 2013/2014 Includes the cost of buying land and properties needed for construction Does not include any soft measures Does not include any economic activities to be developed as support for maintenance of the solution or area as such No co-benefits included	Co-benefits in estimated value of 0,5 MIO EUR / annually in ecosystem services potential preserved

for all. This means that the implemented measures will preserve the ecosystems' potential, while the BAU strategy would continue their degradation at a current rate. This difference allows for the development of activities that lead to an economic benefit for the area and the stakeholders, like the increase in the attractiveness of the area which is translated into higher market prices of exiting real estate (non-use value) or the area developed into sustainable farming land, using suitable crops, which represent further revenue flows.

The economic comparison of the BAU and the Glinščica for all strategy revealed that the NBS approach to flood risk management in Glinščica catchment is:

I. The more rational policy choice in light of predicted climate change by taking into account and responding to future environmental challenges, calling for adaptive planning and ensuring climate resilience[2]. By this we imply that the implementation of NBS now, will result in positive effects in opportunity costs in comparison to the BAU or other alternatives that do not build on ecosystem approach and climate change trends in the next 30 years.
II. The more rational investment choice in terms of financial investment and financial burden for the municipality and the state, since it preserves the use value of the area for implementation of different development strategies/land use practices. Investing in proposed NBS measures and land use practices opens the potential for utilisation of co-benefits, either as avoided costs (or damages) or added value in terms of land use.
III. The more holistic approach to flood risk management by engaging the relevant stakeholders to jointly set the goals, develop and assess the impacts of proposed

[2] See NAIAD Deliverable 6.2., Chap. 1 on EU policies and regulation that foresee principles of climate change adaptive planning. Alongside that, Ljubljana has committed to development vision, building on green, sustainable and preserved natural and cultural heritage, which call for ecosystem preservation and policies that take into account the need for climate resilient, adaptive planning principles.

solutions, allowing them to adjust and accept the reality of the changing climatic and social conditions and embrace the adaptive water and land management principles. Financial means already exist that can complement the implementation of NBS at the stakeholder level, thus reducing the operating cost of the proposed NBS.

IV. Encouraging the long-term holistic spatial planning approach, which would support preservation of the natural capital, added value and attractiveness of an area to live and work in.

15.6 Conclusions and Lessons Learnt

The Slovenian case study is specific in the size and the governing structure of the country. Slovenia's socio-cultural background that shapes its political and governing processes developed a rigid and overt (as opposed to public) governing structure, ill-suited to solve the inter-connected and often contradictory challenges of the twenty-first century which require a high level of adaptive capacity and cooperation across all sectors and actors. In addition, it was found that the fear of flooding is used in political risk discourses to downplay other challenges, such as biodiversity loss and/or ecological degradation, and to eventually support urbanization of the floodplains. Therefore, it was not surprising that the last workshop, designated to fine tuning the economic assessment and identifying potential barriers to implementation, revealed several previously raised issues about the national water management system in Slovenia. This chapter thus provides a short overview of the main issues raised by the stakeholders that are believed to be effectively preventing the implementation of the chosen Glinščica for all strategy.

15.6.1 Barriers to Implementation

All freshwaters are centrally managed by the Ministry of environment and spatial planning (MOP), but the risk management, watercourse maintenance, water quality monitoring and disaster recovery are managed independently by three different ministerial agencies and twelve different departments within the ministry. The lack of communication among these bodies has been recognized as the main barrier to implementing nature-based risk management in Glinščica by the stakeholders participating in the NAIAD process. Moreover, the institutional knowledge gap has been put forward both as the reason and the consequence of the lack of institutional cooperation. At the onset of this process of development of a natural assurance scheme, only individual stakeholders had heard about the nature-based solutions, natural water retention or adaptive water management, with only two experts having a thorough understanding of these concepts and were able to give us examples.

Therefore, despite focusing on NBS solutions to flood risk in the Glinščica catchment, our research revealed a broader issue of failed transition to an adaptive integrated water management in Slovenia. As other researchers have found before, the technologies (including NBS) already exist, but the barriers to their implementation are socio-institutional rather than technical and include uncoordinated institutional frameworks, ineffective regulatory frameworks, limited community engagement, empowerment and participation, unclear, fragmented roles and responsibilities, technocratic path dependencies and little or no monitoring and evaluation (Godden et al. 2011). Unfortunately, the Glinščica catchment is a perfect example of all these barriers. However, the applied process was successful in demonstrating the potential effectiveness for flood reduction and other co-benefits as well as several aspects and/or principles that derive from an integrated adaptive planning approach (see Chap. 6 Basco et al., this volume for more details).

Since scientific research and knowledge is undervalued in Slovenia, participation by decision makers and/or public institutions in large collaborative EU research projects is very limited. Our experience shows that at the decision-maker level, these stakeholders perceive research projects as a theoretical exercise that does not produce any viable and/or applicable solutions and fail to see the benefits from their participation. These stakeholders participated in the first individual interview, but later never joined any other part of the participative process. In addition, it was highly surprising that the Civil initiative for the flood safety of Ljubljana (CIPVLJ) did not wish to participate in the process. On the other hand, the public officers and experts working in risk management, nature conservation, spatial planning and other disciplines, as well as individual residents and their representatives (including farmers) were more willing to participate, contribute and learn throughout the process. Overall, the stakeholder participative process revealed that stakeholders of all levels lack the awareness and understanding of a fully participative process. They have never experienced this kind of participation themselves nor were they ever involved in capacity building in participative planning and/or management. Moreover, when they did participate in a typical public participation process led by Slovenian governmental institutions, they most often had the feeling that their participation was not appreciated, nor their suggestions taken into account. The stakeholders that did experience the whole participative process in the Glinščica case study found it very engaging and connective, they were happy with the results and have committed themselves to spread this knowledge further and use the principles in their future work.

The third most important barrier to efficient flood risk management in Slovenia that was revealed through the participative process was the lack of enforcement. The stakeholders note that the policy/legislation already in force has advanced much in recent years, but the implementation is far from meeting the standards. This only confirms the common knowledge, evident from the several pilots and infringement processes being held by the EU against Slovenia due to failed implementation of EU Water Framework, nature conservation and other directives. During the discussion about the reasons for this situation, the stakeholders were reluctant to discuss the failure of the relevant institutional frameworks, especially with the representatives of those institutions present. However, several examples of lack of knowledge from the Slovenian enforcement authorities were shared among the group, explaining the necessity for reaching out to the EU.

Finally, once the stakeholders developed and agreed on the best future strategy for the Glinščica catchment, we detected a mismatch between the perceptions of the different stakeholders regarding land ownership. While this is a broader issue, also connected to the struggles of the EU Common Agricultural Policy, the implementing institutions expressed the opposition from land owners (mostly farmers) as the main barrier, specifically preventing the implementation of NBS measures that usually require more space than grey solutions. Although the Ministry for agriculture, forestry and food was invited to participate in the process, they only took part in the first interview and expressed their opposition to using agricultural land for water risk management. On the other hand, while farmers require a specific participation approach, their opposition was more declarative than real and reflected their past bad experience with governmental institutions that usually fail to understand and accommodate their requirements. Surprisingly, one of the farmers expressed his anger with the governmental institutions that prohibited him from building small retention reservoirs on several of his fields, a practice that he learned from German colleagues was supported by the German government. We believe that this misunderstanding results from an inefficient institutional harmonization on the national level as well as the poorly executed public participation processes in Slovenia.

Unfortunately, the three main barriers identified, first, the failure of decision makers to participate and consequently learn from research results, second, the institutional knowledge gap and lack of cooperation and third, the inadequate public participation process, form a broader water management approach loop that is practically impossible to influence and/or adapt by a bottom-up approach. Therefore, as was also expressed by several of the participating stakeholders, the top-down guidance and pressure from the EU through the changes in its own policy, regulations and enforcement are a key leverage opportunity to support the required transition to integrated adaptive water management in circumstances such as the one in Slovenia.

Box 15.1 Key Lessons Learnt

- Awareness of NBS/green infrastructure, adaptive management and participative planning concepts as well as appreciation of co-benefits improved through the process.
- Fear of flooding is used in political risk discourse to downplay other challenges, such as biodiversity loss and/or ecological degradation.
- Including ecosystem state as the main benefit parallel to flooding helped keep the focus on NBS.
- Lack of participation opportunities for local people to engage in city planning/ management/development.
- Cooperation among governmental institutions hampered by political discourse.
- No R & I within the insurance sector in Slovenia.
- Decision makers not involved/interested.
- Freestation replacing work intensive personal observation for civil protection department of the municipality.

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Supplementary Material (Tables 15.8, 15.9 and Fig. 15.9)

A promotional video was produced to present the results and impact of the NAIAD project in the Glinščica case study, which can be accessed at https://www.youtube.com/watch?v=dT_zMHge-eM. In addition, the specific details of the NAIAD process for the Glinščica case study can be referenced according to the table below (Table 15.9).

Table 15.8 Process flow of participatory approach employed in the Glinščica catchment

STEP	Method	Information collected
STEP 1 Case study characterization (problem framing)	1st round of interviews	Study stakeholder risk perception.
	Literature review	Describe the climatic, meteorological, ecological, societal, political and cultural characteristics.
	Data analysis	Hydrological, agricultural, spatial characteristics.
	1st SH workshop	Identify main goals in Glinščica catchment management.
STEP 2 Develop alternatives		Identify potential solutions.
	2nd round of interviews	Identify the co-benefits.
	2nd SH workshop	Identify and select the most suitable indicators for measuring the efficiency of the solutions.
		Develop, test and select the most suitable strategy.
		Identify the most suitable locations for implementation of physical measures.
STEP 3 Value the chosen strategy(s)	3rd SH workshop	Economic assessment and comparison of different strategies.

Table 15.9 Additional publications where specific detailed information about the Glinščica case study can be found

Title	Form	Main topic	Access
Chapter 4.5 of the Catchment Characterization Report	NAIAD deliverable 6.1	A full description of the catchment.	http://naiad2020.eu/media-center/project-public-deliverables/
PART 5 of the From hazards to risk: models for the DEMOs	NAIAD deliverable 6.2	A full description of the hydrological modelling applied.	

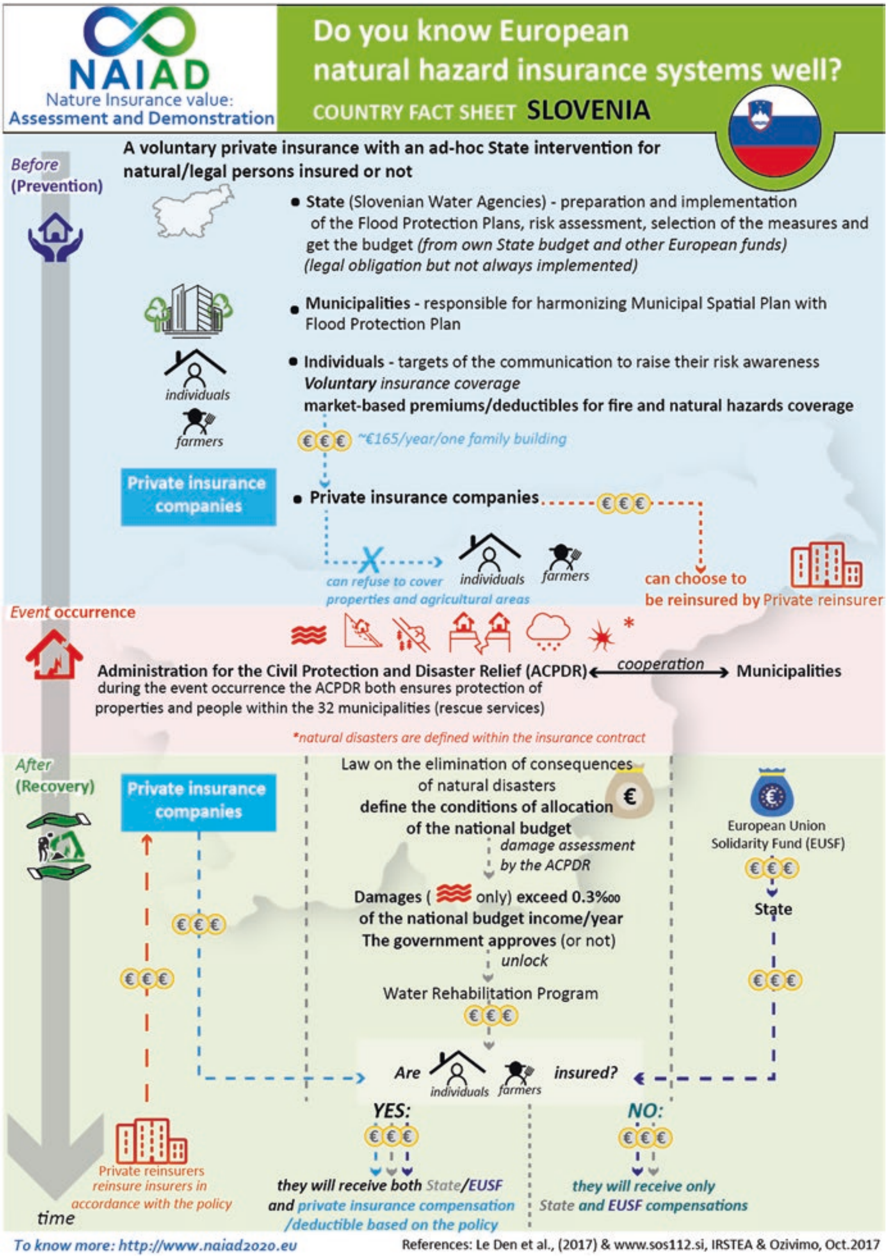

Fig. 15.9 A fact sheet on natural hazard insurance system in Slovenia as a result of public participation process and insurance analysis

References

Benedičič U (2011) Poplavna varnost Ljubljane in poplave septembra leta 2010. Dipl. nal. – UNI. Ljubljana, UL, FGG, Študij vodarstva in komunalnega inženirstva, p 68

Bokhove O, Kelmanson MA, Kent T, Piton G, Tacnet JM (2019) Communicating (nature-based) flood-mitigation schemes using flood-excess volume. River Res Appl 35:1402–1414

Bokhove O, Kelmanson MA, Kent T, Piton G, Tacnet JM (2020) A cost-effectiveness protocol for flood-mitigation plans based on Leeds' boxing day 2015 floods. Water 12:1–30. https://doi.org/10.3390/w12030652

Brugnach M, Ingram H (2012) Ambiguity: the challenge of knowing and deciding together. Environ Sci Pol 15(1):60–71

Giordano R, Brugnach M, Pluchinotta I (2017) Ambiguity in problem framing as a barrier to collective actions: some hints from groundwater protection policy in the Apulia Region. Group Decis Negot 26(5). https://doi.org/10.1007/s10726-016-9519-1

Godden L, Ison RL, Wallis PJ (2011) Water governance in a climate change world: appraising systemic and adaptive effectiveness. Water Resour Manag 25(15):3971–3976. https://doi.org/10.1007/s11269-011-9902-2

Griessler Bulc T, Uršič M, Vahtar M, Krivograd Klemenčič A (2017) Ekosistemske tehnologije za trajnostno upravljanje z vodami. In: Globevnik L, Širca A (eds) Zbornik. Drugi slovenski kongres o vodah 2017. SLOCOLD – Slovenski nacionalni komite za velike pregrade/DVS – Društvo vodarjev Slovenije, Ljubljana, pp 391–396

Komac B, Natek K, Zorn M (2008) Geografski vidik poplav v Sloveniji. (Geographical view on floods in Slovenia). Geografski inštitut Antona Melika ZRC SAZU, Ljubljana, p 180

Odlok o občinskem prostorskem načrtu Mestne občine Ljubljana – izvedbeni del (2018) (Uradni list RS, št. 78/10, 10/11 – DPN, 22/11 – popr., 43/11 – ZKZ-C, 53/12 – obv. razl., 9/13, 23/13 – popr., 72/13 – DPN, 71/14 – popr., 92/14 – DPN, 17/15 – DPN, 50/15 – DPN, 88/15 – DPN, 95/15, 38/16 – avtentična razlaga, 63/16, 12/17 – popr., 12/18 – DPN, 42/18 in 78/19 – DPN). Municipality of Ljubljana, Ljubljana, 2018

Odlok o občinskem prostorskem načrtu Mestne občine Ljubljana – strateški del (2018) (Uradni list RS, št. 78/10, 10/11 – DPN, 72/13 – DPN, 92/14 – DPN, 17/15 – DPN, 50/15 – DPN, 88/15 – DPN, 12/18 – DPN in 42/18). Municipality of Ljubljana, Ljubljana, 2018

Pagano A, Pluchinotta I, Pengal P, Cokan B, Giordano R (2019) Engaging stakeholders in the assessment of NBS effectiveness in flood risk reduction: a participatory system dynamics model for benefits and co-benefits evaluation. STOTEN. https://doi.org/10.1016/j.scitotenv.2019.07.059

Program upravljanja rib v celinskih vodah Republike Slovenije za obdobje do leta 2021 (2015) Government of the Republic of Slovenia, 2015

Santoro S, Pluchinotta I, Pagano A, Pengal P, Cokan B, Giordano R (2019) Assessing stakeholders' risk perception to promote nature based solutions as flood protection strategies: the case of the Glinščica river (Slovenia). Sci Total Environ 655:188–201

Trajnostna urbana strategija Mestne občine Ljubljana 2014-2020 (SUS MOL) (2015) Municipality of Ljubljana, Ljubljana, 2015

Žaberl M, Pavšič Mikuž P, Perc A, Hodalič J et al. (2011) Okoljsko poročilo za Občinski podrobni prostorski načrt za območje zadrževalnika Brdnikova. EIA Report. E-NET OKOLJE d.o.o., p141