4.5 Glinščica demo (Slovenia)

4.5.1 General description

Glinščica catchment is situated within the borders of the Municipality of Ljubljana (MOL) that spans roughly 275 km^2 and has a population of 284,000 inhabitants. The demo site covers 7.01% of Ljubljana's surface area, includes 5 of its districts (Dravlje, Šiška, Rožnik, Vič, Šentvid) and accounts for 8.17% (23,200) of its population, which should all be considered stakeholders in flood management. Originating at 409 m.a.s.l., the headwaters in the steep hill slopes of Toško Čelo give the Glinščica stream a torrential character which, together with climate change (less frequent, but higher intensity rainfall) and hard regulations, results in regular flooding of the Vič and Rožna dolina districts of Ljubljana.

A number of initiatives have been put forward during the last 10 years to restore Glinščica to a more natural state and to secure the vulnerable districts from flooding. Together with the EU requirements from the WFD and 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…, 2015). Furthermore, restoration of natural features has been integrated in the Municipality Spatial Plan as one of the priorities in water management in the strategic part of the Plan (Odlok o občinskem prostorskem načrtu Mestne občine Ljubljana - strateški del) and as conservation of ecological status of water bodies in the implementation part (Odlok o občinskem prostorskem načrtu Mestne občine Ljubljana – izvedbeni del). Glinščica 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).

Unfortunately, these changes have thus far had little or no effect on the practical planning and implementation, which is clearly evident from monitoring data and actual conditions in the field. The main challenges in the Glinščica catchment demo together with the main objectives, impacts and timeframe are presented in 8. Table 18 and Table 19 offer a list and timeline of activities planned in the Glinščica demo according to the work flow of methodological work packages.

Table 17: Overview table of Glinščica demo task force work plan.

demo site	Glinščica catchment (SLOVENIA)
Lead partner	REVIVO
Other partners	Iskriva
Main Objective	Our main objective is to prepare an Integrated catchment management plan for the Glinščica catchment which will serve as a case study for the relevant stakeholders to start a process of

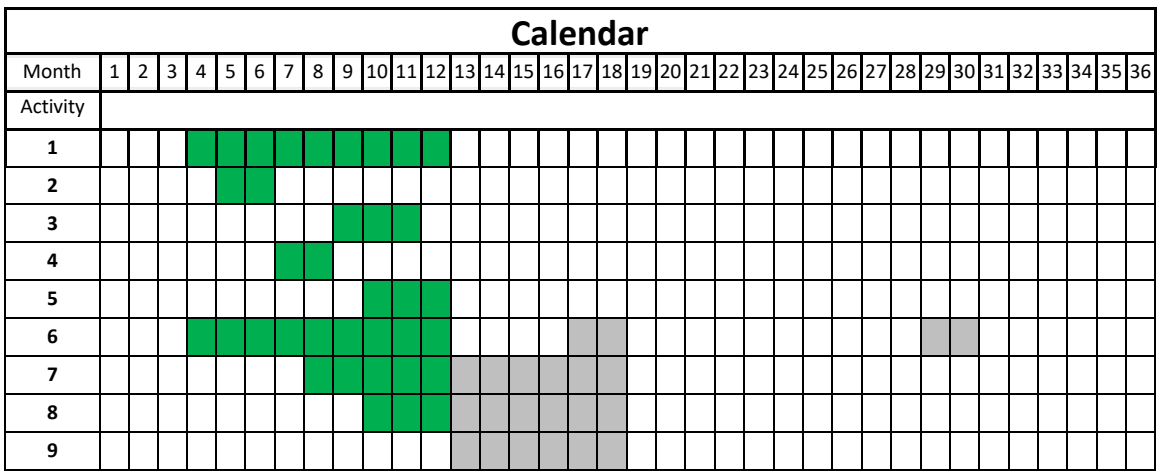
	modernization of the outdated and inadequate current management practices.
Brief description of the Demonstration	Sustainable natural water management measures such as natural bank stabilization, infiltration structures, buffer strips, re-meandering and wetland restoration can effectively provide multiple benefits/ecosystem services. Based on the highest pre-identified risk of flooding in the catchment we will consider and valuate the insurance value of flood attenuation together with other ecosystem services provided simultaneously by the applied NWRMs: biodiversity, habitat creation, groundwater recharge and purification, raw materials (wood), sediment retention, ecotourism, advertising, outdoor sports, and recreation.
Impact on the demo Site	The state-of-the-art approaches and concepts to integrated spatial management as well as an example of the most advanced methods available up to date will be presented to the relevant stakeholders to start a process of modernization of the outdated and inadequate management practices.
Impact from the demo Site	The specific challenges of the small size and natural features of the catchment as well as historically characterized social and economic circumstances will require locally adapted solutions to be developed within the wider framework of methods development. Hence, the demo will ensure a wider applicability of the methods used and provide adaptation examples for easier transfer and uptake by interested users.
Time span	Different tasks will be performed throughout the project duration, but our final objective lies outside the scope of this project and we envisage the systemic change that we wish to promote through NAIAD to be slowly integrated within 20-30 years after the completion of this project.

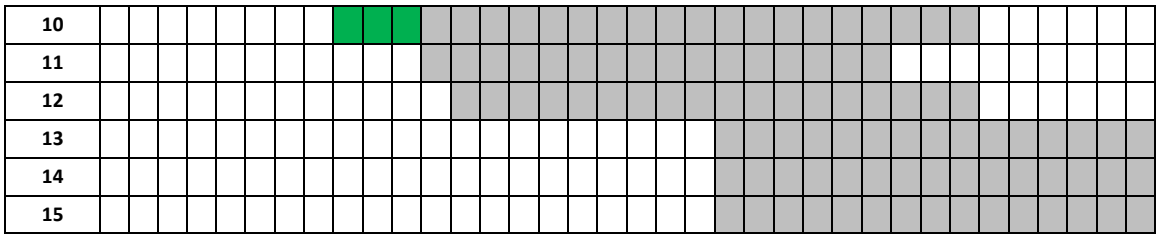
Table 18: Activities planned for SLO demo for M1-M36.

Activity no.	Description	Support needed from	Potential challenges
1	Data collection	WP2, WP3, WP4	data availability
2	Mapping physical hazard potential (T2.1-T6.1)	WP2	data availability; internal communication

3	NBS selection (T6.1)	WP2	lack of knowledge/support from WP2
4	Mapping socioeconomic risk (T2.2-T6.1)	WP3, WP2	unsure about stakeholder cooperation
5	Mapping insurance-relevant natural capital (T2.3-T6.1)	WP2	sensitive data availability; gaining stakeholder cooperation
6	Social Network Analysis (T3.1-T6.1)	WP3	unsure about stakeholder cooperation
7	Estimation of Life Cycle Costs for different scenarios (T4.2-T6.3)	WP4	lack of timely and sufficient input from previous tasks
8	Mapping insurance-relevant ecosystem services (T2.4-T6.1)	WP2	lack of timely and sufficient input from previous tasks
9	Damage valuation (4.3-T6.1)	WP4	lack of timely and sufficient input from previous tasks
10	Participatory modelling exercise (T3.3-T6.2)	WP3	lack of stakeholder cooperation
11	Acceptance of policies (T3.5-T6.4)	WP3	lack of stakeholder cooperation
12	Ecosystem services and natural capital accounting (T4.4-T6.3)	WP4	lack of timely and sufficient input from previous tasks
13	Insurance value analysis (T4.5-T6.3)	WP4	lack of timely and sufficient input from previous tasks
14	Climate, land and ecosystem scenarios (T2.6-T6.2)	WP2	lack of timely and sufficient input from previous tasks
15	Strategies for natural capital interventions (T2.7-T6.4)	WP2	lack of timely and sufficient input from previous tasks

Table 19: Timeplan for SLO demo. green – implemented; grey – planned.





4.5.2 Demo biophysical modelling (WP2)

Eco:actuary model cannot be applied to Glinščica catchment due to the spatial scale limitations of this tool. Therefore, other means of hazard and risk mapping will have to be applied to our demo. Since support in WP2 (Physical hazard and ecosystem services assessment) is provided to our demo from IRSTEA, the methods applied will follow the same process as described in the Brague demo.

Urban watercourses in Ljubljana are seen as an important component of urban green systems primarily as a network of natural areas which stretch into the urban structure and introduce natural landscape elements in the urban area (Mušič 1970). However, the lower reaches of Glinščica have been trapped in a concrete channel for several decades and other forms of regulations extend upstream to the mountainous headwaters (Balant, 2006). Inappropriate regulations are reflected mainly in the high frequency of flood events and low species diversity. Straightened channel and lack of riparian vegetation have also reduced the aesthetic and educational value of the stream as well as the status of the water environment and thus the experiential value of the stream. Therefore, Glinščica ceased to constitute a basis for many of its functions as an urban green corridor; hydrological, ecological, spatio-structural, aesthetic, sports and recreational and social (Balant, 2006).

4.5.2.1 Climate

Glinščica catchment mostly experiences moderate continental climate typical for central Slovenia, which is categorized in the Köppen's climatic classification as Cfb - temperate humid climates with warm summers. However, the proximity of bordering submediterranean (Cfa) region less than 20 kilometres away influences the climate and precipitation regimes in the catchment. The average temperatures of the coldest month (January) range from -3 to 0°C, and the warmest (July/August) between 15 and 20°C (Figure 32). The continental precipitation regime in the catchment is characterized by the precipitation maximum in summer and minimum in winter with the secondary maximum in autumn due to the influence of the submediterranean climate which also promotes persistence of higher temperatures into autumn months. The average annual rainfall is around 1300mm. (Ogrin, 1996)

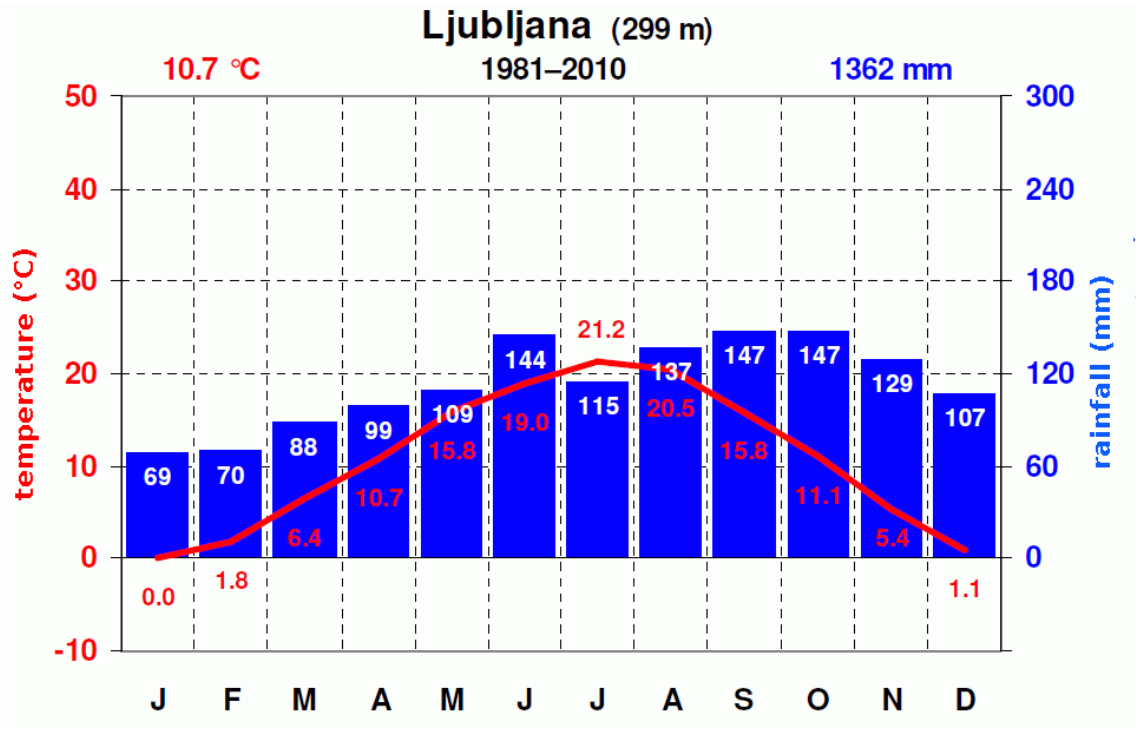


Figure 32: Climatogram for Ljubljana municipality for the period from 1971 to 2000. Source : ARSO (http://meteo.arso.gov.si/met/sl/climate/diagrams/ljubljana/).

Precipitation data (Figure 33) is in line with climate change predictions and show a trend of less frequent but more intense precipitation as well as more frequent and more intense extreme events such as droughts, floods and thunderstorms (Ogrin, 2004).

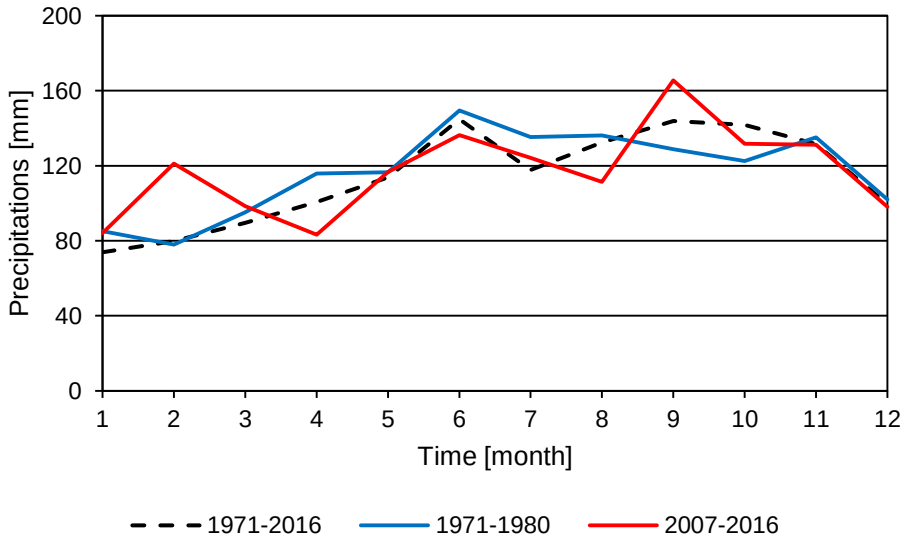


Figure 33: Precipitation data from weather station near Glinščica catchment for three different periods of time.

4.5.2.2 Hydrology

Glinščica River has a Mediterranean pluvio-nival river regime characterized by two maxima, in spring and autumn and two minima, in summer and winter (Figure 34). The primary discharge maximum is in April due to the high amount of precipitation coupled with the snow melt occurring during this period. The primary maximum may also appear in March or May. The secondary maximum occurs in November as a result of high precipitation rates, but without the addition of snowmelt (Kolbezen, 1998).

Despite the concurrent precipitation maximum, the primary discharge minimum occurs in summer due to high temperatures and consequent loss of water through evapotranspiration. The secondary minimum in winter is greater than the primary, but it is in line with low amounts of rainfall and it does not last long. In a typical Mediterranean river regime the high autumn rainfall rates continue throughout winter and hence the autumn and spring precipitation maxima are merged which is also reflected in the discharge rates (Kolbezen, 1998). However, Slovenia lies on the border between the continental and Mediterranean regions and so both the precipitation and discharge regimes do not follow the typical regimes described, but rather vary in between the two extremes.

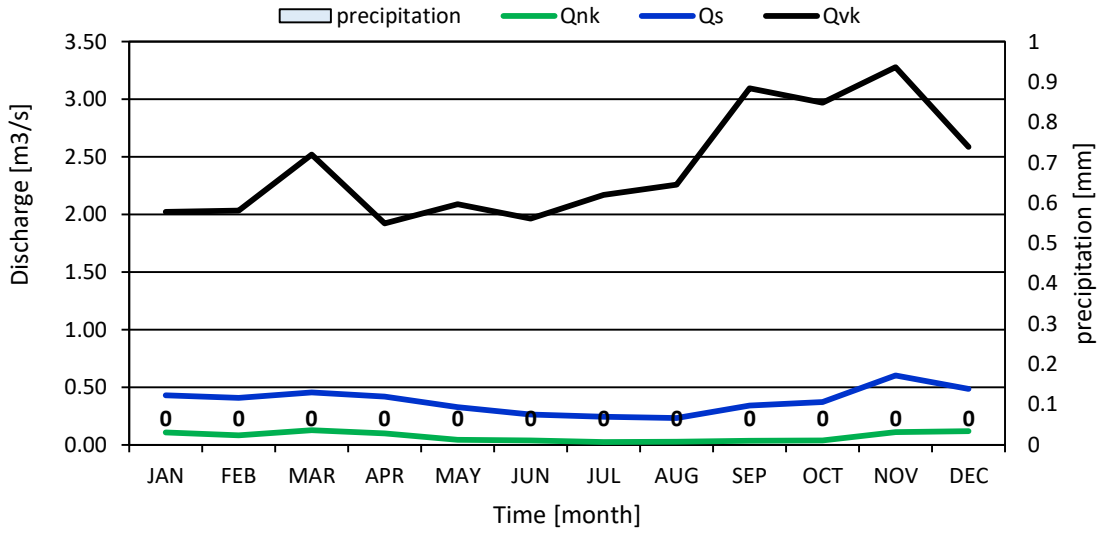


Figure 34: Rainfall and discharge regimes for Glinščica catchment in the period 1971-2016. Qnk: average daily minimum discharge, Qs: average daily discharge, Qvk: average daily maximum discharge.

4.5.2.3 Geology

As expected, the Glinščica floodplain is covered by gravel brought here by the river from its source in the hills of Polhograjsko Gorovje (Figure 35). The North-Western, hilly part of the catchment is made up of limestone and dolomite, soluble sedimentary rocks typical for majority of Slovenia that rose above the surrounding land and formed the Polhograjsko Gorovje during the last uplift period approximately 3 million years ago. Smaller silt and sandstone areas occur

in regions where the larger Ljubljanica and Sava Rivers deposited material during extreme floods.

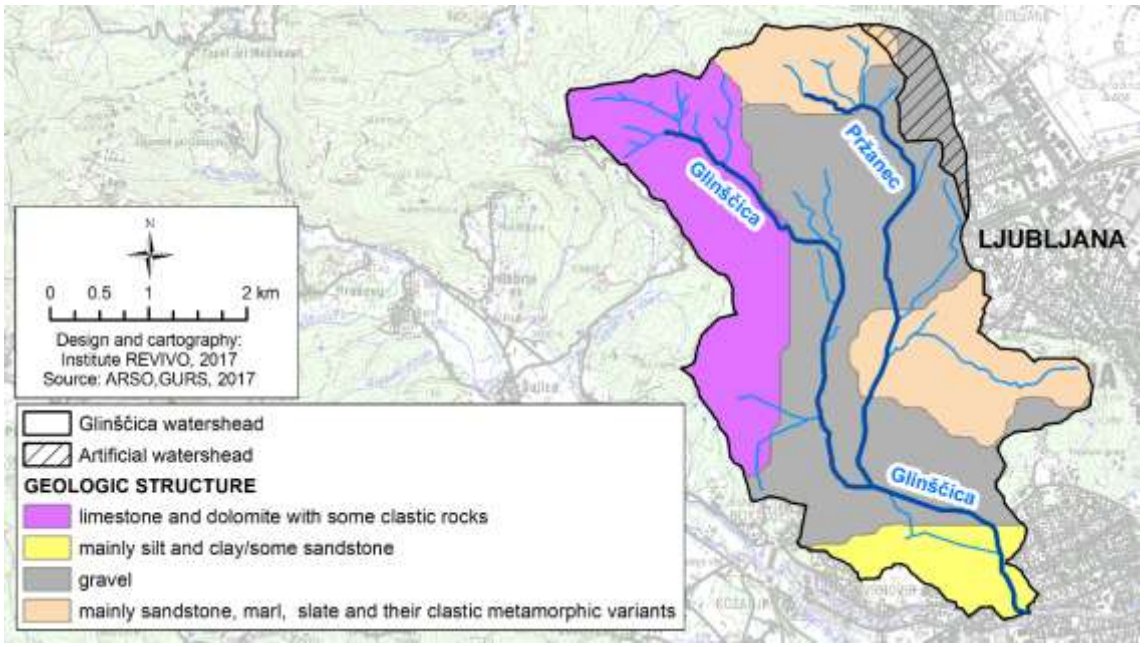


Figure 35: Geological map showing main geological features of the Glinščica catchment.

4.5.2.4 Land use

The Glinščica catchment is characterized by two distinct landscapes, conditioning land use. The natural headwaters, emerging in the steep Toško čelo (590m amsl) and Črni vrh (482m amsl) hills, are covered in deciduous and mixed evergreen forest, interrupted only by sporadic lodgings and occasional pasture. Individual patches of wet forests, preserved in the lower parts and unsuitable for settlement or agriculture due to huge amounts of water in the soil are protected as natural heritage. Finally, together with Rožnik and Šišenski hrib park area in the Eastern part of the catchment, the natural areas cover approximately 47 % of the catchment (Figure 36).

The land use changes dramatically as soon as the gradient recedes to the level suitable for agriculture and urbanization, which both compete for space throughout the rest of the catchment. While historically the agricultural land use predominated the catchment, it has been slowly giving way to urban land which now covers more than 30 % of the catchment, despite the Glinščica stream being one of the most important green wedges of the Municipality of Ljubljana.

The three city districts – Šiška in the East, Vič and Rožna dolina in the South – form the most densely populated, fully urbanized areas of the Glinščica catchment where the stream has been channelized and straightened between the years 1925 and 1970 (Šumer et al. 2004). Urban development of the upstream, suburban areas has been progressing steadily since then, but recent extreme flood events have raised concerns about appropriateness of these plans. Despite the high level of urbanization, the agricultural land, mostly on the flood plain, still covers more than 20% of the catchment area and offers opportunities for restoration and NBS implementation activities.

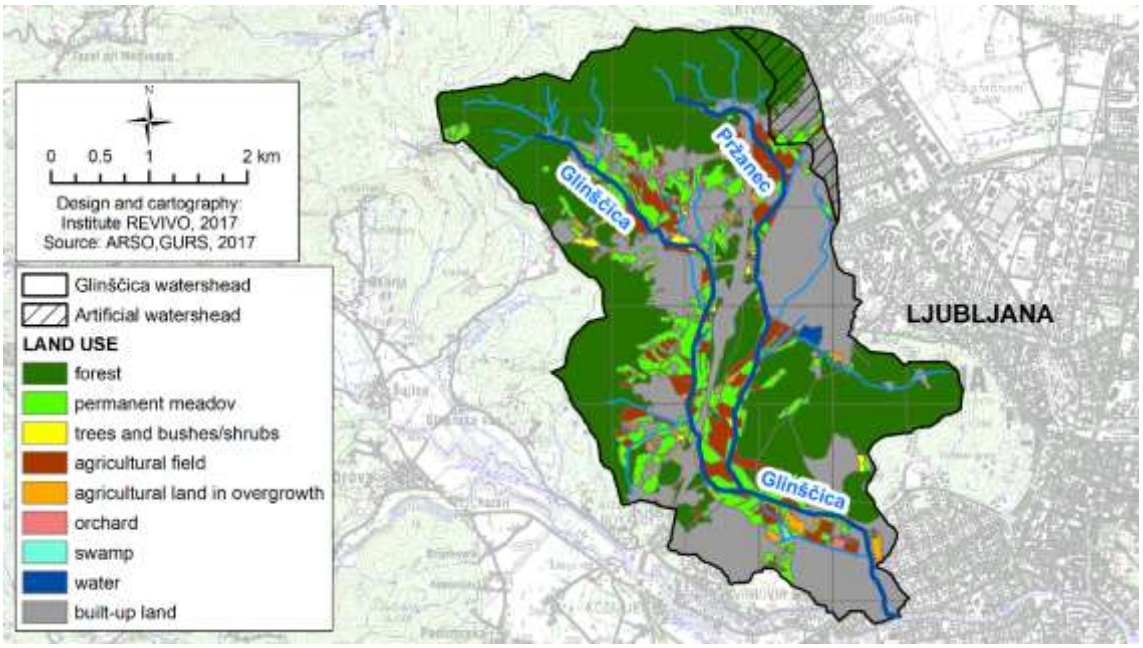


Figure 36: Land use map of the Glinščica catchment.

While natural green areas are generally believed to have the highest infiltration rates and hence, minimize the amount and speed of the runoff, the Glinščica catchment has, until now, experienced a reduction of roughly 52 % of natural or semi-natural land cover (Figure 36). A loss of 31 % of land cover to urbanization and 21 % to agriculture directly results in faster and higher runoff rates and consequent generation of flood waves on the one side, but also water scarcity on the other.

4.5.2.5 Water use

In light of the larger nearby Ljubljanica and Sava Rivers' aquifers that serve as the most important source of groundwater for the city of Ljubljana, the extractions from aquifers in the Glinščica catchment have been more sustainable. The groundwater retention capacity of natural, steep areas unsuitable for agriculture and urban development is low and extensive aquifer with high water quantities has only formed in the lower reaches of the stream (Figure 37).

Even though Glinščica catchment aquifers have not been tapped extensively yet by MOL, extractions for drinking water supply of several households are located in the outer reaches of the catchment. Dispersed pollution from agriculture and urban land drainage in the Glinščica catchment, affects not only the ecological status of surface water, but also the quality of groundwater.

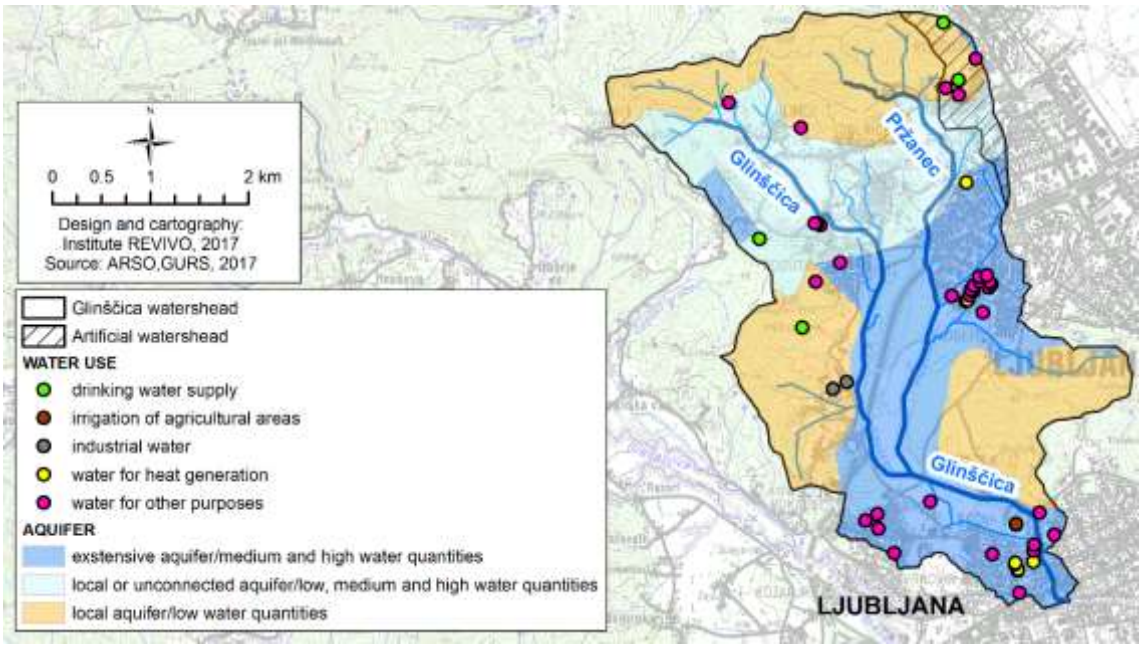


Figure 37: Groundwater distribution and water extractions in the Glinščica catchment.

Most (71%) groundwater extractions occur in the city of Ljubljana with the water use defined as "other purposes" (Figure 37). Together, these water allowances amount up to 1,065 m^3/s per year. Even though the technology for heat generation from water (heat pumps) has only become available in recent years, 10% of the groundwater in the Glinščica catchment is already used for this purpose. Since 2005, 5 extraction rights for heat generation have been granted, together extracting up to 53,552 m^3/s per year. Several (8%) water extractions serve to supply drinking water in the scarcely populated hilly headwaters where utilities infrastructure is not available, but the amounts extracted are low (2,95 m^3/s per year). Finally, 6 and 4% of groundwater in the catchment is used for irrigation purposes in agriculture (17,823 m^3/s per year) and industry respectively. Industrial water is used by two companies, both extracting water from the water distribution system and the outflow is connected to the Central water treatment plant of Ljubljana. First company is using up to 10,000 m^3/s of water per year for asphalt production and other up to 7500 m^3/s per year at the vehicle services centre.

4.5.2.6 Ecology

The Glinščica stream is not included in the WFD ecological status monitoring program, so only individual sporadic studies of its flora and fauna exist. On the other hand, it has been classified as the second most sensitive ecological type of water bodies (out of 4). Therefore, if any NBS measures are to be implemented in the Glinščica catchment, a preliminary ecological status assessment has to be performed in order to ensure NBS effectiveness monitoring.

The Glinščica stream flows past the Biotechnical Faculty of the University of Ljubljana, so several graduation thesis have been written on periphyton (Štendler, 2008) and macroinvertebrate (Kereži, 2007) as well as hydrological parameters (Koprivšek, 2006) of the stream. All of the studies confirm the deterioration of biotic and abiotic parameters along the stream due to the

combination of regulation and land use change in the drainage areas. In addition, a study was conducted in the framework of the URBEM project (Šumer et al. 2004) which also confirms the effects of regulations on fish community in Glinščica stream.

4.5.2.7 Hazard and risk mapping (WP2)

Ljubljana has several streams with high flood hazard potential of which Glinščica is the smallest and causes the least damage. Hence, Glinščica has never been seen as an important flood risk area despite its typical torrential character and the several large floods occurring in the last 10 years.

Water from an area of 17.4 km^2 in size naturally drains into the Glinščica streambed with an additional 1.9 km^2 added to this surface through the urban runoff drainage system for Šentvid district of Ljubljana, so that the overall catchment size is approximately 19.3 km^2. Runoff production and transport from a catchment area are mostly related to vegetation cover, soil permeability and size of paved, impermeable urban surfaces (Balant, 2006) which affect the runoff coefficient.

Steep slopes in the headwaters give rise to a fast and powerful water flow that historically dissipated in the meanders starting at the foothills and extending throughout the following forested flood plain before discharging into Gradaščica stream. Regulations on the Glinščica stream first started in 1925 and were completed through most of its course by 1970 (Šumer et al. 2004). The urban development is still claiming important flood plain areas every year. With the expansion of urban areas in the lowlands of the river basin, the hydrological regime of the river basin has changed dramatically, especially in the period of the last 20 years. By increasing the proportion of impervious surfaces (sealing, road surfaces) the rate of water runoff is increased. After the regulation and the land use change, the flood waters come rushing down straight to the confluence with Gradaščica, where the water builds up and eventually floods the surrounding areas now densely populated.

While the upper, forested part of the catchment remains largely uninhabited, rural agglomerations reach all the way to the foothills, followed by a stretch of semi-urban, densely populated areas mixed with patches of agricultural land. Extensive urban areas are spread mainly in the following districts of Ljubljana: Podutik, Dravlje, Koseze, Rožna Dolina in Brdo. Especially the Eastern part of the catchment is fully urban and the drainage from its impermeable surfaces adds considerably to flood hazard potential.

On top of that, additional 1.9 km^2 of urban drainage is rerouted to the Glinščica stream from the nearby areas and this urban drainage system that was designed to reduce the retention time of water in the catchment area is further pressuring the Glinščica discharge capacity (Balant, 2006). Despite the huge contribution to flood hazard, the Eastern part of the catchment is not vulnerable to flooding due to its relatively high elevation.

On the contrary, the most vulnerable part of the catchment is the area surrounding the confluence with the larger Gradaščica stream in the centre of Ljubljana. On the one hand, the flood plain has been deforested and land use management has caused the infiltration capacity

to diminish which raises the hazard potential. On the other hand, urban development has spread to the banks of the Glinščica stream without consideration of vulnerability to floods. The combination of all the above mentioned artificial modifications throughout the catchment has resulted in high flood risk of the lower most parts of the catchment.

4.5.2.7.1 Recent flood events

The two flood events of the recent years (2010 and 2014) have acted as a wake-up call to both, the residents and the responsible water management authorities. Both extreme events (September 2010 and October 2014) caused severe floods of SW part of Ljubljana when Glinščica flooded urban areas around Brdnikova cesta as well as urban districts Vič and Rožna dolina (Figure 38, Figure 39). Damage caused by floods to houses and buildings was estimated to 4.5 million €, to agriculture 33,000.00 €, to infrastructure 1.9 million € and to watercourses 8.31 million € (Benedičič, 2011). The City Municipality of Ljubljana allocated 5 million € to flood protection measures after the floods (Poplave v Ljubljani, 2014).

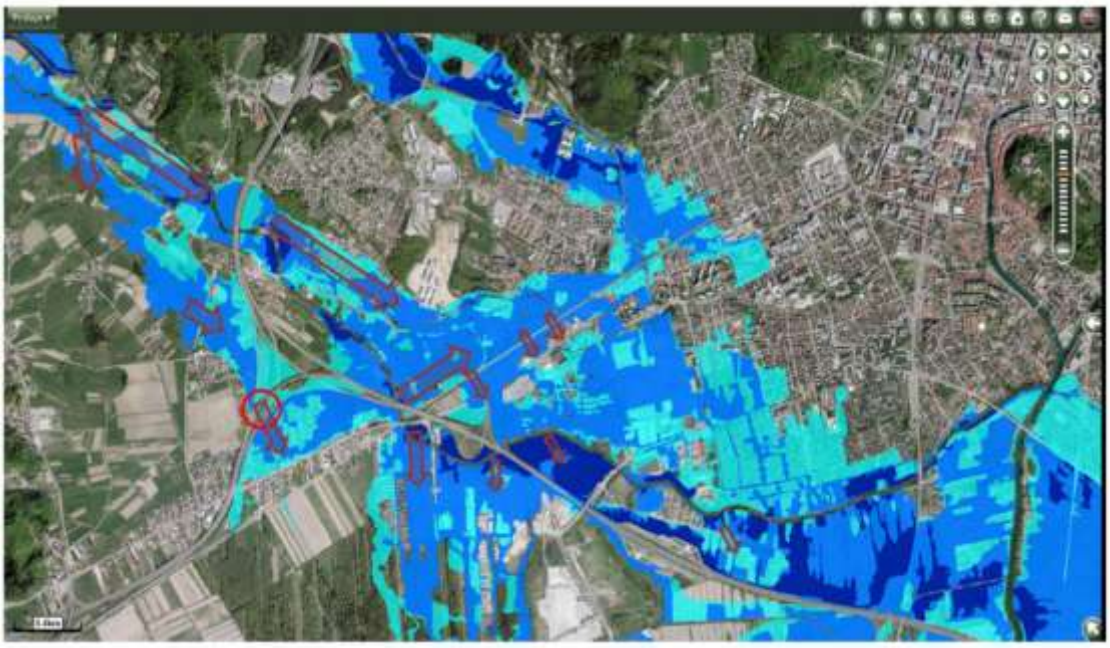


Figure 38: Flood extent at the south western part of Ljubljana on 22nd October 2014 (Fazarinc, 2014).

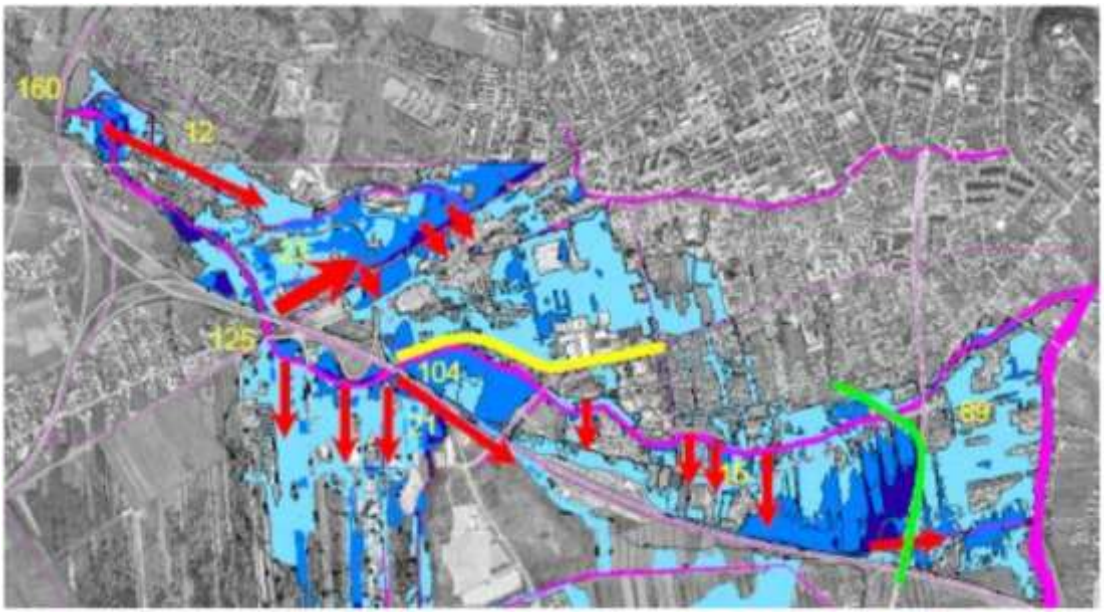


Figure 39: Flood extent at the south western part of Ljubljana from 17th to 19th September 2010 (Benedičič, 2011).

In 2014 flood waters of the Glinščica stream flooded Ljubljana`s urban areas Vič and Rožna Dolina as well as the upstream settlement Podutik. Around 900 objects were flooded (Poplave Ljubljani, 2014).

The recent extreme flood events of 2010 and 2014 have proven that the current estimates of flood hazard and vulnerability in the Glinščica catchment have not taken into account the climate predictive changes in precipitation. Therefore, the flood risk maps underestimate the extent or/and return periods of flood waters and consequently, the required capacity of flood protection measures is underestimated.

In addition, several policy and institutional barriers prevent the planning and implementation of NBS solutions for flood prevention, thus limiting the number and efficiency of available measures. To try to understand these barriers, risk perception modelling for Glinščica catchment is being performed in the framework of NAIAD within WP3 (see Chapter 5.5.3).

Ljubljana has spread extensively to the floodplains of the rivers Glinščica, Gradaščica and Ljubljanica during the past decades (Komac et al. 2008). Furthermore, the water management practice of leading the water out of the land as fast as possible has left no space for flood waters. Consequently, both hazard and vulnerability increased significantly, multiplying the flood risk in the catchment.

During flood events in the Glinščica catchment individual houses, apartment blocks, business facilities, other buildings, roads and railroads are affected. Approximately 8.24 km of roads, 0.47 km of railroads and 0.27 km^2 of houses and other buildings are affected during a Q100 event (Figure 6). Considering the flood maps with return period of 500 years (Figure 41) approximately 12.40 km of roads, 0.62 km of railroads and 0.43 km^2 of houses and other buildings are affected.

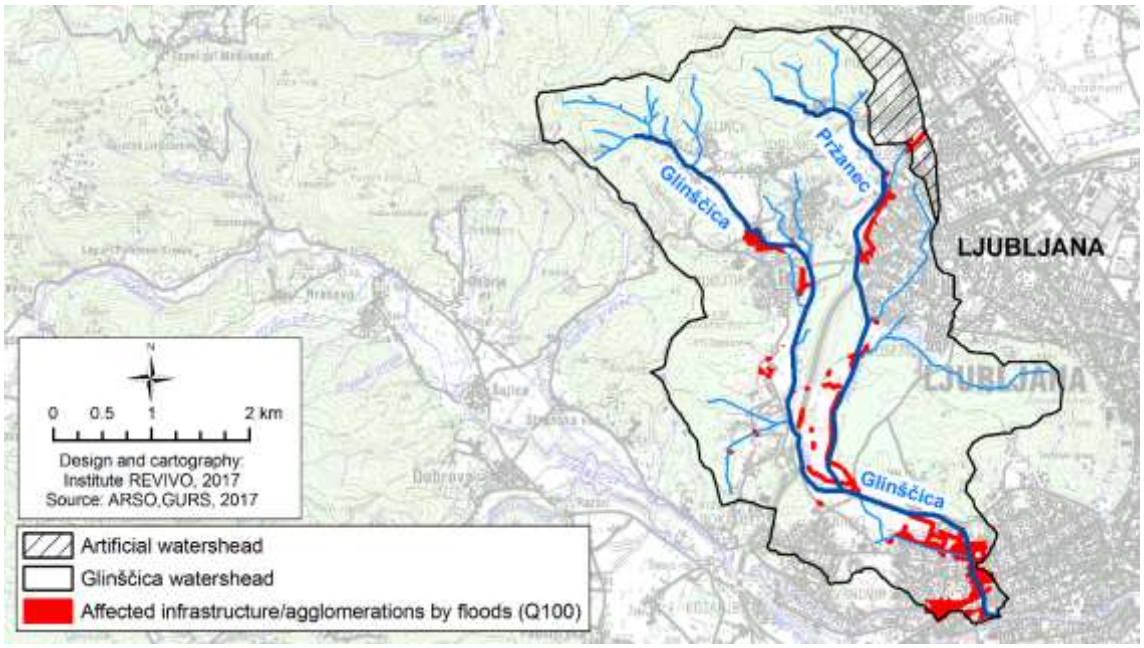


Figure 40: Infrastructures/agglomerations affected during one in 100 years flooding events in the Glinščica catchment.

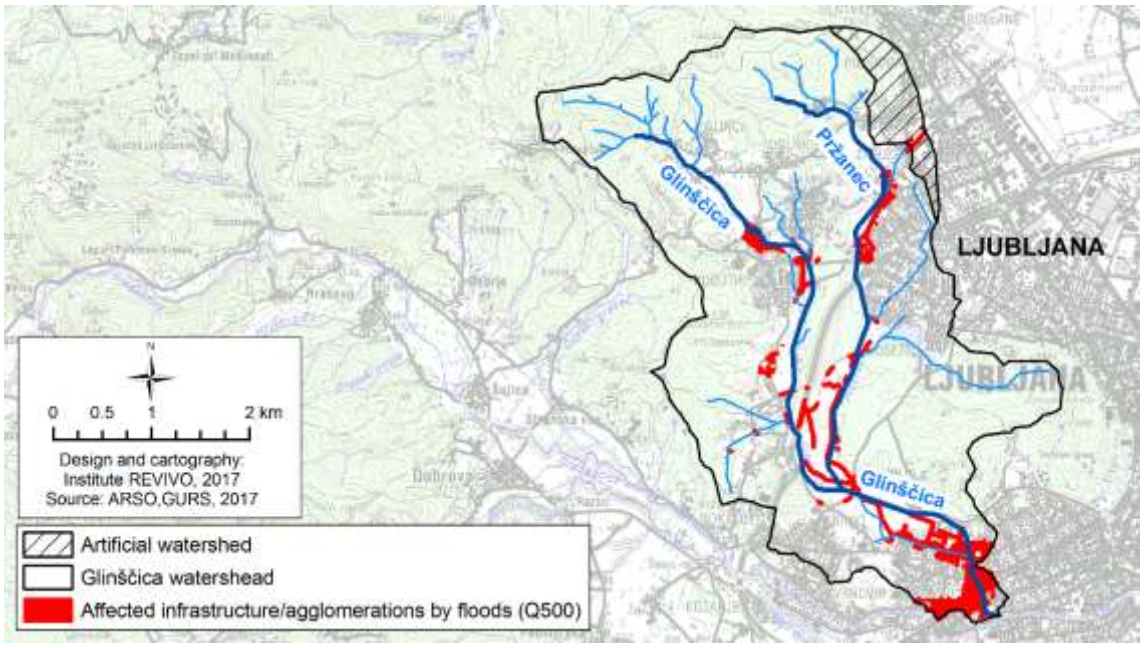


Figure 41: Infrastructures/agglomerations affected during one in 500 years flooding events in the Glinščica catchment.

4.5.2.7.2 Flood risk management plan

Water management on Glinščica has followed the general historical management practice, which is to get the water out of the land as fast as possible. With the occurrence of ever

increasing floods, a flood defence plan has been developed by MOL through the Detailed Municipal Spatial Plan.

The first and most important measure that was already implemented in 2017 is the Brdnikova reservoir (Figure 42). However, the plan predicts the need for construction of three additional dry retention areas (reservoirs Pot za Brdom (2) and Tehnološki park) and a number of dikes to protect from Q 100 floods. Additionally, construction of different bank protection measures are envisaged, including raising banks from Brdnikova street to Glinščica mouth to prevent flooding, bank failure and erosion. It is predicted that these measures would together be capable to retain flood waters from Glinščica and its tributary Pržanec and thus, significantly reduce the flood risk for existing residential and other buildings downstream in the wider urbanized area of Vič and Rožna dolina (SW part of Ljubljana). (Odlok *o* občinskem podrobnem…, 2012)

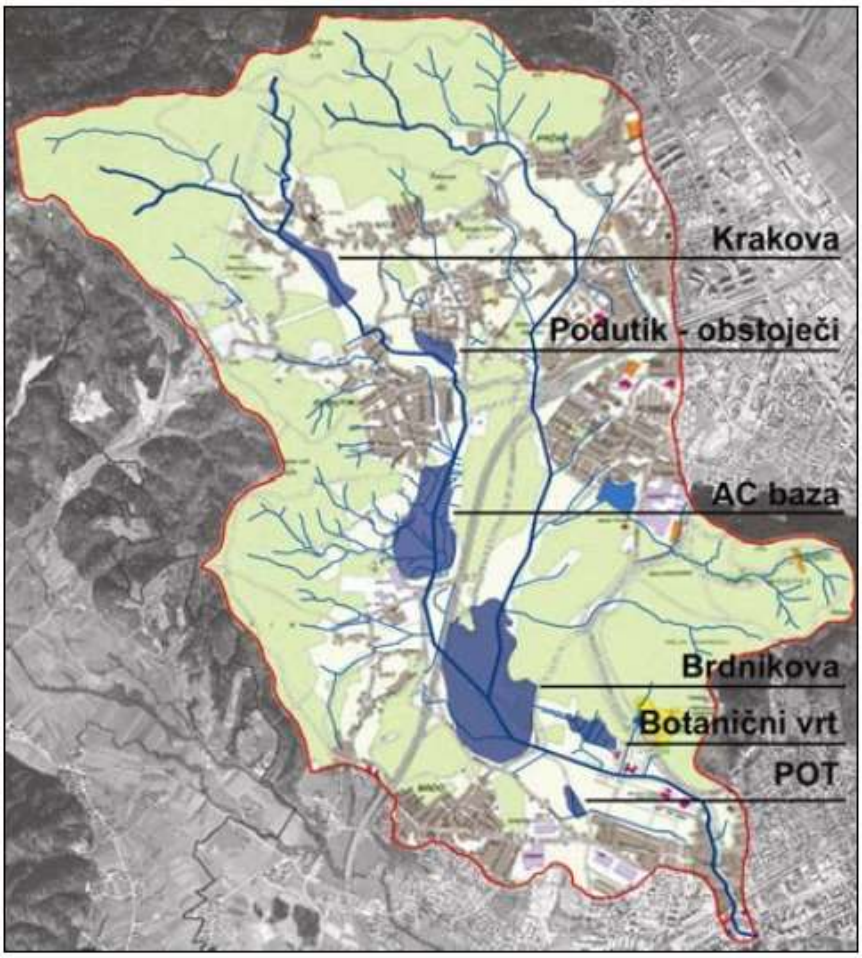


Figure 42: Locations of predicted dry retention reservoirs in the Glinščica catchment (Odlok *o* občinskem podrobnem…, 2012).

4.5.2.8 NBS proposed in NAIAD

Sustainable water management measures, such as reestablishment of the riparian vegetation, removal of concrete lining (riverbed is currently a concrete channel), re-meandering (where

possible), revitalization of a dead branch and creation of wetlands, a strategic placement of a series of small dry and wet retention ponds and barriers to surface flow production would limit water flow propagation and transfer and consequently reduce flood risk (Table 201).

Table 20: NBS proposed for Glinščica catchment with their function, capacity, intended form of modelling and co-benefits.

NBS category	NBS	Function for flood reduction	Capacity	Modelling of the NBS	Co-benefits
channel restoration	Renaturing urban waterbodies	Increasing water buffering in urban areas (transfer)	Peak discharge reduction	GIS modification of the LIDAR elevation data, update of the model (eventual meshing density update)	reaching better ecological status of water bodies and raising biodiversity, bringing semi-natural features closer to citizens to enable recreation and tourism, re-establishing infiltration capacity of urban land, therefore raising the water table and consequently mitigating heat island effect and augumenting drought, re-establish partial filtration and purification of polluted urban runoff
	Reduce canalisation of the waterbodies	Increasing water buffering in urban areas (transfer)	Peak discharge reduction	GIS modification of the LIDAR elevation data, update of the model	
	Re-establishing meandering and oxbows	Increasing water buffering in natural areas (transfer); erosion control	Peak discharge reduction	GIS modification of the LIDAR elevation data, update of the model	
	Renaturation of waterbodies	Connectivity of the main channel with side channels, wetlands and oxbow lakes	Discharge and volumes exchanges river - floodplains and peak discharge reduction	GIS modification of the LIDAR elevation data, update of the model (eventual meshing density update)	
	Removing crosswise barriers/dams	Decreasing water level during floods	Longitudinal profile and flooding extension analysis	GIS modification of the LIDAR elevation data, update of the model (eventual meshing density update)	establishing connectivity and reaching better ecological status and raising biodiversity
restoring vegetation	Restore riparian vegetation	Increasing water buffering in natural areas (transfer)	Peak discharge reduction	Local surface roughness changes	reaching better ecological status of water bodies, raising biodiversity, mitigating heat island effect by amplifying evapotranspiration and augumenting drought by establishing new water retention capacities of the banks, re-establish infiltration capacity of banks,
	Preventing bank erosion with short and forest vegetation	Bank erosion prevention	Model results extraction (shear stress) and comparison with design criteria	Eventually local roughness changes	

NBS category	**NBS**	**Function for flood reduction**	**Capacity**	**Modelling of the NBS**	**Co-benefits**
	Forest management	Increasing water buffering in natural areas (production)	Peak discharge reduction	Subtle modification of the hydrological parameter	filtration and purification of runoff, preventing bank erosion; augumenting aquifer recharge, enabling recreation and tourism development
retention areas	Construction of dry retention areas on flood plains	Increasing water buffering in natural areas (transfer)	Peak discharge reduction	GIS modification of the LIDAR elevation data, update of the model	amplifying aquifer recharge, restoring natural fertilisation processes
	Createing artificial waterbodies for short term water storage (ponds etc.)	Increasing water buffering in natural areas (transfer)	Peak discharge reduction	GIS modification of the LIDAR elevation data, update of the model	amplifying aquifer recharge
	Use of balancing ponds to release water slowly	Increasing water buffering in natural areas (transfer)	Peak discharge reduction	GIS modification of the LIDAR elevation data, update of the model	amplifying aquifer recharge
	Openning natural floodplains	Connectivity of the main channel with floodplains	Discharge and volumes exchanges river - floodplains and peak discharge reduction	GIS modification of the LIDAR elevation data, update of the model (eventual meshing resolution update)	securing continued provision of ecosystem services; ameliorating drought by re-establishing water retention capacities of the flood plains; securing water supply; raising biodiversity, restoring natural fertilisation processes and soil formation; enabling tourism development
	Preventing new build up areas on flood plains	Preventing vulnerability increase	Da**mage** GIS analysis (fragility curve: € of damage VS water depth)	GIS modification of the asset location and update of the model	

NBS category	**NBS**	**Function for flood reduction**	**Capacity**	**Modelling of the NBS**	**Co-benefits**
	Removing buildings from flood plains where possible	Diminishing vulnerability	Damage GIS analysis (fragility curve: € of damage VS water depth)	GIS modification of the asset location and update of the model	
	Wetlands restoration	Increasing water buffering in natural areas (production and transfer)	Peak discharge reduction	GIS modification of the LIDAR elevation data, update of the model (eventual meshing density update)	
	Rerouting floods to wetlands	Connectivity of the main channel with side channels, wetlands and oxbow lakes	Discharge and volumes exchanges river - floodplains and peak discharge reduction	GIS modification of the LIDAR elevation data, update of the model (eventual meshing density update)	
infiltration areas	Preventing soil compaction (forests, farm fields, urban areas, grasslands,...)	Increasing water buffering in natural areas (production); water retention	Peak discharge reduction	Subtle modification of the hydrological parameter	raising biodiversity in urban spaces, bringing semi-natural features closer to citizens to enable enjoyment of natural features and relaxation, re-establishing infiltration capacity of urban land, therefore raising the water table and evapo-transpiration, consequently mitigating heat island effect and augumenting drought, re-establish partial filtration and purification of polluted urban runoff
	Re-vegetation in urban areas (street trees, grasslands, green roofs, infiltration gardens etc.)	Increasing water buffering in urban areas (production)	Peak discharge reduction	Subtle modification of the hydrological parameter	

NBS category	**NBS**	**Function for flood reduction**	**Capacity**	**Modelling of the NBS**	**Co-benefits**
Woody log jams	Stopping water transportation of trunks, branches and leaves	Preventing bridge and culvert obstruction with solid transport	Peak and volume reduction	Eventual IBER-wood modelling, more probably expert assessment comparing bridge widths and tree heights	creating additional habitat diversity and slowing water flow
Surface flow formation barriers	Preventing new erosion ditches in upper parts of river basin	Erosion and solid transport supply prevention; slow overland flow.	Peak and volume reduction	Eventual IBER-sediment modelling, more probably GIS expert assessment based on geology, slope and existing data on Slovenian debris flow and soil erosion problems	

4.5.3 Risk perception modelling (WP 3)

Demo risk perception modelling in Glinščica catchment will be fully implemented with support from WP3. The goal is to detect and analyse potential barriers to collaborative decision-making processes for the selection and implementation of the most suitable NBS for reducing flood risk. To this aim, a multi-steps methodology will be implemented following four main steps described in detail in the Deliverable 3.1, due in M12.

The first two phases of risk perception modelling have been implemented in Glinščica demo in 2017 and preliminary results of the main differences in stakeholders' perception of flood risk are presented in detail in D3.1. However, the main findings of stakeholders mapping are presented below.

4.5.3.1 Stakeholders mapping

In the Glinščica catchment we first performed mapping of stakeholders by identifying a number of the most important national and local institutions responsible for the different aspects of spatial planning, water management and risk management in the Glinščica catchment. Following the methodology developed in WP3 we then followed the snowball approach by including additional stakeholders that were suggested by the interviewees to the preliminary list of stakeholders.

A list of 33 stakeholders emerged that have been contacted during the last 6 months (Table 212), of which:

- 13 interviews were successfully performed, reports are available and analysis has been performed,
- 1 interview was performed and we are in the process of drafting a report,
- 10 interviews were rejected after contact,
- no response was received from 5 stakeholders even after several written and phone attempts of contact and
- four additional stakeholders are being contacted.

The first result of stakeholder mapping shows that an important proportion of stakeholders (45.5 %) were unable or unwilling to participate in the participatory modelling for the Glinščica catchment. Given the fact that the interview takes approximately 1 hour and that all stakeholders were given the freedom to choose the date and venue for the interview, we presume that most of the stakeholders were unwilling to participate. From the responses of these stakeholders, two prevailing reasons for rejection emerged:

- Firstly, several stakeholders don't perceive themselves as stakeholders.
- Secondly, many stakeholders were afraid of the consequences of the interviews despite of our guarantee to protect their privacy. This is especially important for the private companies contracted for implementation of public services and public bodies under pressure from civil societies and/or initiatives.

Of the governmental institutions, the Ministry for Environment and Spatial Planning (MOP) was identified as the most important stakeholder in NBS solution planning in Glinščica catchment, since they are responsible both for transferring Water Framework, Floods, Birds and Habitats Directives into Slovenian legislation as well as implementing them 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 with whom the interviews were predicted. Unfortunately, only 3 departments agreed to participate in the interviews, 5 were rejected and one never responded. In addition, the Slovenian Water Agency initially suggested we should send the questions to their PIAR service who would provide the answers in written form, but later agreed to the interview with the Sustainable River Engineering Department. We are in the process of contacting the last 3 departments of the Slovenian Water Agency.

Table 21: List of stakeholders identified in the Glinščica catchment.

n°	Institution	Department	Role	Status
1	Ministry of the environment and spatial planning **- Slovenian water agency**	**Sustainable River Engineering Department**	public water management services; restoration after flood damage	Report available
		Water Protection and Water Use Department	protection and use of water; chemical and biological pollution control/management	to be contacted
		Spatial and Environmental Document Assessment Department	assessment of spatial and environmental documentation	to be contacted
		The Middle Sava River area division	no description available	to be contacted
2	**Ministry of the environment and spatial planning** - Water management division	**Water and Investments Directorate**	Water Management Division	Rejected
			Natural Disaster Reduction Division	Report available
			Division for Decision on the Use of Water and its Protection	Report available
		Spatial Planning, Construction and Housing Directorate	Spatial Planning Division	No response
3	Ministry of the environment and spatial planning **- Slovenian environment agency**	**Hydrology and state of Environment Office**	monitoring status of all waters, surface and underground; climate change mitigation	Rejected
		Environment and Nature Conservation Office	nature protection aspects of environment	Rejected
		Office of General Affairs	coordination of the work of Slovenian Environmental Agency	Rejected
		Water Management Office	water management of all water bodies in Slovenia	Rejected

n°	Institution	Department	Role	Status
4	**Administration for civil protection and disaster relief**	**Central or the Ljubljana Branch**	administrative and professional tasks of organization, preparation and implementation of protection against natural and other disasters	Report available
5	**City Municipality Of Ljubljana**	**Department of Urban Planning**	they are responsible for spatial planning of Ljubljana	Report available
		Department of Environmental Protectionhttp://www.ljubljana.si/si/mol/mestna-uprava/oddelki/varstvo-okolja/	responsible for nature conservation in Ljubljana	Report available
		Department for Protection, Rescue and Civil Defencehttp://www.ljubljana.si/si/mol/mestna-uprava/oddelki/zascita-resevanje-civilna-obramba/	protection against natural and other disasters for Ljubljana	Report available
		Department for Commercial Activities and Traffic	responsible for financial implementation of natural disaster measures	No response
		Office for Development Projects and Investments	responsible for projects and investments	No response
		Municipality Administration	Deputy mayor's office	Report available
6	**Institute of the Republic of Slovenia for Nature Conservation**	**Ljubljana Regional Unit**	leading nature conservation management on the national level	Report available

n°	Institution	Department	Role	Status
7	**Hidrotehnik - Water management company**	**Water Management Public Service department – Projektiva - Ljubljana**	maintenance of water infrastructure, implementation of emergency measures in times of floods and torrential outbreaks, rehabilitation work following natural disasters, investment maintenance of water infrastructure, dam operation	Rejected
8	**The Chamber of Craft and Small Business of Slovenia (OZS)**	**Counseling services of OZS – environmental protection**	consultancy relating to environmental protection for businesses	Rejected
9	**Ministry of agriculture, forestry and food**	**Agriculture Land Management Division**	management of agricultural land	Report available
		Climate Change, NGOs, Education and Accounts Division	impact of Climate Change on agriculture	Rejected
10	**Chamber of Agriculture and Forestry of Slovenia**	**KGZS – Zavod Ljubljana**	public service activities and professional tasks regarding agriculture consulting	Rejected
11	**Fisheries research institute of Slovenia**	**Freshwater Department**	fishery planning, fishing cataster, fisheries biology, expert opinions in water management	Report available
12	**Fishing club Dolomiti**	**Fish Manager**	management of fish in the waters under jurisdiction of Fishing club Dolomiti (fishing, fish stocking, fish farming…)	Report available
13	**Civil initiative for flood protection of SW part of Ljubljana**	**small, unstructured association**	enforcing public participation in the management processes led by governmental organizations	Report available
14	**Voluntary fire brigade Podutik - Glince**	**voluntary organisation**	firefighting, support and relief during extreme weather events,…	No response

n°	Institution	Department	Role	Status
15	**The Dravlje city quarter**	**voluntary association of residents**	enabling direct participation of residents in the management and development of their quarter.	Rejected
16	**Plan B**	**association of the largest environmental NGOs in Slovenia**	interpreting public opinion on environmental issues and suggesting policy change accordingly.	to be contacted
17	**Institute for spatial policies**	**an independent research institution and a think tank.**	to achieve synergies across a range of disciplines and practises dealing with space and place.	Drafting report
18	**Slovenia Forest Service**	**Slovenia Forest Service**	forestry management, wild animals management	No response

4.5.3.2 Specific questions in the demo

Two different questionnaires were developed and translated to Slovenian language for the Glinščica demo, one for institutional and one for non-institutional stakeholders. The preliminary analysis suggested the institutional setting is the most important barrier to NBS implementation in Slovenia, so the main goal of our demo is to raise awareness among governmental stakeholders and consequently drive the paradigm shift to enable implementation of innovative solutions in water management.

Therefore, one question was added to all interviews to understand how stakeholders perceive NBS. In Slovene language, the term NBS is not yet publicly recognized, but a different term has been used in the past - sonaravno - which would directly translate as "co-natural". The understanding of this term varies between the disciplines and no common definition has ever been proposed, so the extra question in the interview was: What does co-natural mean to you in the context of flood and water management? Stakeholders were also invited to give examples. Based on the responses received, we will suggest a different term for NBS in Slovene language and adoption of the EU definition of NBS.

4.5.3.3 Stakeholders workshop

A stakeholder workshop will be conducted on 21st November 2017 in Glinščica demo, hosted by the associated strategic partner of NAIAD, the City Municipality of Ljubljana. The aim of the workshop and the preceding meetings with key stakeholders is to validate the model developed from individual interviews as well as to raise awareness of stakeholders about the NBS and the main barriers hampering the interaction among decision actors and, thus, the collective decision processes for NBS selection and implementation.

Therefore, the workshop will first present the NBS and then the results of the ambiguity analysis, followed by guided discussion on the barriers identified. The next step will be to test a small number of pre-prepared scenarios for NBS implementation according to the stakeholders' suggestions, integrating the FCMs and elementary GIS-based hydrological modelling. This exercise will serve to explain and present the integration approach adopted in NAIAD and thus establish the foundation for the next workshop, in the framework of WP5, planned for 2018.

4.5.4 Economic assessment (WP4)

The Glinščica demo is awaiting instructions from WP4 leader on how to implement economic assessment in our demo.

4.5.5 Integration of methods and tools (WP5)

The Glinščica demo is awaiting instructions from WP 5 leader on how to implement integration in our demo. Several skype meetings were organized in 2017 by SLO demo leader between WP3 and WP5 task supporters to coordinate their work and ensure exchange of information.