Inventory of needs and approach for development and piloting Decision Support Tool

Aqua-Add Technical Report nº.01, prepared by:

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Aqua-Add project

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Executive summary

This report has been developed in the context of the international co-operation project Aqua-Add (Deploying the added value of water in local and regional development), aiming at the sharing of knowledge and experience between project partners as to better deploy the potential of 'water' (economically, socially and environmentally) in urbanised landscapes and to improve the implementation of water measures in local and regional spatial development. Aqua-add will not only collect, analyse, disseminate and promote the specific functions, services and values of green/blue spaces, but also develop and apply a Decision Support Tool (DST) that: i) demonstrates the (potential) social, environmental and economic impacts of different water management scenarios, and ii) facilitates the planning process and better informed decision making across stakeholders. The objective of this report is to identify, compare and discuss, across eight Aqua Cases, the key issues, proposed solutions and DST expectations – thus allowing for the development of a DST that is specific enough to meet the requirements of each case study and generic enough to be applied across all case studies. In turn, the approach to be practiced in the development and application of the DST across all Aqua Cases will be described.

Based on detailed descriptions of the two frontrunner Aqua Cases and summary descriptions of the six other Aqua Cases, it is shown that the DST to be developed needs to: i) address problems related to urban flood control and/or ecosystem services, ii) assess solutions that involve the development and/or renovation of urban green/blue space as well as the construction of built infrastructures, and iii) provide insight in the costs and benefits of urban development, flood management and green/blue space preservation/rehabilitation scenarios.

The following four-stage approach is proposed for the development and application of the DST to the eight Aqua Cases:

1. Preparation: Aqua Case study descriptions are specified, presented and analysed (Inventory of needs), as to identify a common framework of the DST that is generic when possible and specific where needed. In parallel, a stakeholder identification and analysis is performed across all eight Aqua Cases in preparation for effective stakeholder involvement (with Component 3).
2. Model development and implementation for frontrunner Aqua Cases: The DST is developed, applied and calibrated as well as tested and validated for the two frontrunner Aqua Cases (taking into account requirements for all Aqua Cases). Stakeholders will be involved in the development and application of the DST (providing input on the type and format of information to be produced), while data and information is collated and prepared for the remaining six Aqua Cases (facilitating efficient DST application).
3. Model improvement and implementation for remaining Aqua Cases: The DST is developed, applied and calibrated for the six remaining Aqua Cases (based on experience with the two frontrunner Aqua Cases). Stakeholders will be involved in the development and application of the DST (tailoring to end-users' needs), while Aqua Cases are presented locally/regionally to initiate participatory urban green/blue space planning (with Component 3).
4. Dissemination and follow-up: The final stage focusses on presentation (local, regional, national and international; with Component 2), dissemination (through web-based demonstration version and an e-learning module; with Component 2) and evaluation

(with project partners and pertinent stakeholders; with Component 1) of the DST development, application and implementation process.

Hence, Aqua-Add partners and stakeholders will use the DST in a spatial development process with a 'water challenge'. In these participatory processes, the social, environmental and economic impact of water challenge scenarios is determined and illustrated to all stakeholders. The DST provides information (visual and quantitative, in the form of tables, graphs and/or maps) that is normally not available to stakeholders in the urban planning process (e.g. on household welfare, land values, preferred locations, flood control and cost-benefit indicators). Use of this information, but also the joint collection of data as input, creates an open setting and invites stakeholders to discuss and express new ideas and insights. It facilitates the identification and communication of different views and interests among stakeholders. This process contributes, eventually, to common shared urban green/blue space development plans.

Acknowledgements

This report has been developed in the context of Aqua-Add (Deploying the added value of water in local and regional development), a 3-year co-operation project of 11 partners from 8 EU regions. The project aims to share knowledge and experience between the project partners, to better deploy the potential of 'water' (economically, socially and environmentally) in urbanised landscapes and to improve the implementation of water measures in local and regional spatial development. The project is co-financed by the European Regional Development Fund (ERDF) along with each of the 11 partners and made possible by the INTERREG IVC programme. The Interregional Cooperation Programme INTERREG IVC helps Regions of Europe work together to share experience and good practice in the areas of innovation, the knowledge economy, the environment and risk prevention.

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1. Introduction

European regions and cities face important challenges related to water, including water storage and discharge after (heavy) rainfall events, water quality and the impact of summer droughts on water supply. This sense of urgency is getting larger in the face of climate change. To address these challenges, it is evident that 'water' must become an integrated part of spatial development policies and their implementation. Unfortunately, until now, water management issues are often secondary. Although dealing with water does not seem urgent in the short term, it is clear that implementing measures in the short to medium term is necessary to prevent problems in the medium to long term.

There are, however, many obstacles to achieving medium-long term water management goals. First, water issues compete with other public concerns, resulting in insufficient public and political support. Second, stakeholders in the public domain are often not aware of the added value that effective water management can bring to spatial development. Finally, efficient water management will avoid high costs in the long term and, in turn, result in higher housing/real estate prices.

The objective of the Aqua-Add project is to "better deploy the potential of 'water' (economically, socially and environmentally) in urbanised landscapes and to improve the implementation of water measures in local and regional spatial development". To this end, Aqua-Add builds on exchange of experiences and good practices – including soft testing on:

1. Stakeholder involvement;
2. The added value of green/blue space in urbanised landscapes;
3. Practical and successful business models for 'water-projects'.

Knowledge on the functions, services and values of green/blue spaces is incomplete and not easily accessible for policymakers, spatial planners, developers, entrepreneurs and other stakeholders – especially when it comes to economic and social values. Aqua-add will not only collect, analyse, disseminate and promote the specific functions, services and values of green/blue spaces, but also develop and apply a Decision Support Tool (DST) that: i) demonstrates the (potential) social, environmental and economic impacts of different water management scenarios, and ii) facilitates the planning process and better informed decision making across stakeholders.

The DST will be developed and applied to eight Aqua Case studies (two frontrunner Aqua Cases[1] and six other Aqua Cases[2]), with input from partners that are knowledge institutions and based on the needs of the partners that are regional/local authorities. The objective of this report is to identify, across all Aqua Cases, the key issues, proposed solutions and DST expectations – thus allowing for the development of a DST that is specific enough to meet the requirements of each case study and generic enough to be applied across all case studies. In turn, the approach to be practiced in the development and application of the DST across all Aqua Cases will be described.

The structure of the report is as follows. In the next chapter the eight Aqua Cases are described, with detailed descriptions of the two frontrunner Aqua Cases and summary descriptions of the six remaining Aqua Cases. Chapter 3 summarizes the key issues,

[1] Frontrunner Aqua Cases include Aveiro (Portugal; PT) and Eindhoven (Netherlands; NL).

[2] Other Aqua Cases include Bremerhaven (Germany; D), Copenhagen (Denmark; DK), Debrecen (Hungary; HU), Imperia (Italy; IT), Lyon (France; FR) and Sofia (Bulgaria; BU).

proposed solutions and DST expectations across all Aqua Cases – providing a clear indication of what scenarios to be assessed and information to be generated with the DST. Based on this inventory of needs, the steps to be followed in the development and application of the DST are presented in Chapter 4. Finally, Chapter 5 summarizes the key results, and provides concluding remarks and observations.

2. Aqua Case study descriptions

The DST will be developed and applied to eight Aqua Case studies, including two frontrunner Aqua Cases (Aveiro PT; Eindhoven NL) and six other Aqua Cases (Bremerhaven D; Copenhagen DK; Debrecen HU; Imperia IT; Lyon FR; Sofia BU). This chapter provides detailed descriptions of the two frontrunner Aqua Cases (Section 2.1) and summary descriptions of the six remaining Aqua Cases (Section 2.2).

2.1. Frontrunner Aqua Cases

2.1.1. Eindhoven (NL)

Setting/Problem

The City of Eindhoven (~215,000 inhabitants and ~2,500 inh/km^2) is the main city of the Eindhoven metropolitan area (~750,000 inhabitants), and is situated at the confluence of various small rivers and streams. The Eindhoven metropolitan area and city have grown fast since industrial companies, like Philips, settled here in the 1920s.

The urban water system did not keep track with this growth, causing problems for water quality and quantity:

- Water on streets after heavy rainfall due to insufficient urban drainage capacity.
- Combined sewer outlets polluting vulnerable surface waters with higher ecological functions and values.
- Malfunctioning of the remaining surface waters due to closing of former streams or connecting these to combined sewer systems.
- A large waste water treatment plant, serving 750,000 inhabitants, discharging effluent on a small surface water area, with insufficient biological treatment capacity in periods of large sewage supply.
- Groundwater entering basements of houses due to building in former wetlands, combined with reductions in groundwater extractions.

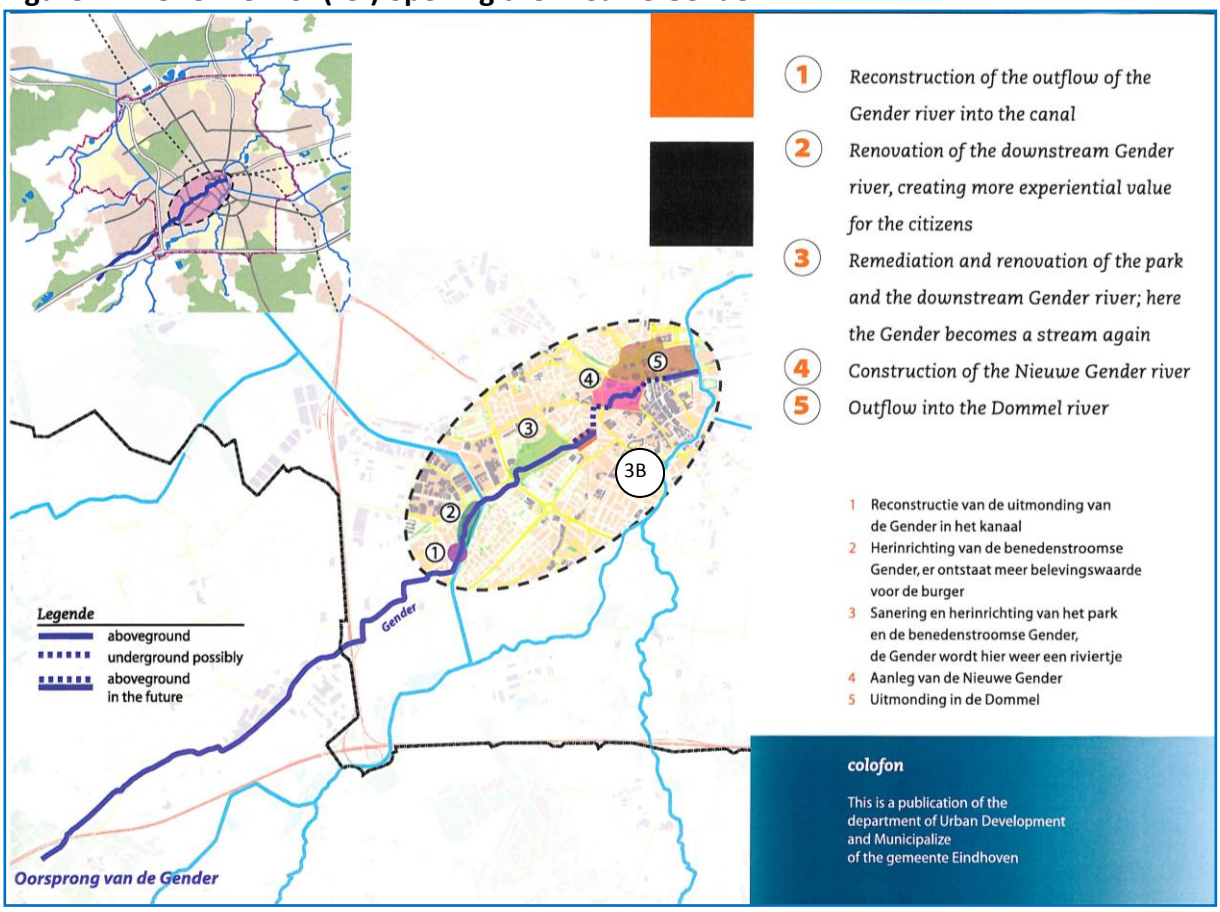
A long term programme has been developed to tackle these problems, including all water issues and linking it with the planning of other activities in the public space. These measures include: i) decoupling by changing the sewer system from combined to separate sewers, discharging rainwater from roads and roofs via a new drainage system on surface water, and ii) (re)opening a number of watercourses throughout the city. Most measures are executed until 2015, by then the abovementioned problems will have been reduced significantly. Recently, also climate change adaptation has been included in the development of future measures and in a research program.

Objective

One of the measures is the (re)opening of a watercourse, called the Gender, that has been closed down in the 1950s, and is planned to be reopened through the city centre. The reopening of the "Nieuwe Gender" aims to:

- Give a technical optimal contribution to the water goals, including space for maximum storage and discharge capacity (see Figure 1).
- Add maximum value to the public space (e.g. recreation and visibility).

Figure 1 Overview of (re-) opening the Nieuwe Gender.



The section of the watercourse to be studied includes de last 3 kilometres of the Nieuwe Gender, before it discharges into the Dommel river. Within this section, there are four interesting parts to be studied in more detail (see Figure 1):

- Section 3 – Gendervijver. Here the Gender is a pond in a park. Renovation of park and pond is planned. Two scenarios are studied: restoration to a more natural watercourse or maintaining the present configuration. Also a flexible weir system including water retention is planned here, to store rainwater and control discharge. This has consequences for the land use of the park.
- Section 3B – De Frederika van Pruisenweg. Some years ago the inhabitants of this street were asked to approve re-opening the watercourse in their street. A majority of citizens voted in favour, but for political reasons the plan was cancelled (in relation to expected complaints). There is a group of citizens asking to reopen the watercourse here, especially when there is a good perspective for the other sections to be reopened. The case study will investigate if reopening here adds value.
- Section 4 – Emmasingelkwadrant. This is a former industrial area to be redeveloped to housing, shopping and leisure functions. Three scenarios are possible here: an underground connection, a watercourse with a minimum of (functional) space to discharge water, and a watercourse in a spatial green setting.
- Section 5 – Stationsweg. The watercourse will be reopened and end in the Dommel river.

Outputs

Expected spatially explicit outputs using the DST will be:

- Information on the added value of the Nieuwe Gender for the various sections and for various scenarios.
- Information to provide, together with other case studies in the project, outcome and output that can serve wider and more general use.
- The (added) value of the various scenarios in terms of household welfare ('quality of life') and the (added) land value.
- Cost-benefit analysis of scenarios (e.g. based on the investment and maintenance costs of the scenarios and the added land value).
- Comparison of (added) value of the different scenarios for (re-) introducing green/blue space versus (added) value of built space, including scenarios of greening the urban areas and the added value of (different) green/blue qualities for citizens.

2.1.2. Aveiro (PT)

Setting/problem

The European Union has adopted the Directive 2007/60/EC on the assessment and management of flood risk (EC, 2007). The purpose of the directive is "to establish a framework for the assessment and management of flood risks, aiming at the reduction of the adverse consequences for human health, the environment, cultural heritage and economic activity associated with floods in the Community" and shall be carried out in coordination with the Water Framework Directives (2000/60/EC; 2006/118/EC). The Ria de Aveiro is a shallow coastal lagoon on the central coastal zone of Portugal, where three major rivers converge (river Vouga, Antuã and Boco) and that is connected to the Atlantic Ocean through a single inlet. The region is considered a flood-prone urban region, with much of the flooding events occurring when heavy rainfall (causing high river flows) coincides with low pressure systems N/NW of Portugal or high pressure systems S/SW of Portugal (causing S/SW wind related storm surges). Climate change is likely to amplify the effects of these forcings, due to an increase in rainfall depth and intensity, a rise in sea levels, and an increase in the intensity of extra-tropical cyclones in the North Atlantic (IPCC, 2007; Santos & Miranda, 2007).

Due to its favourable morphological and geological features, the Aveiro region underwent severe urbanization and industrialization over the last decades – in particular along the margins of the lagoon (Fidélis, 2007). This led to an increase in floods and flooding risk, affecting economic activities, biodiversity, people and infrastructures in one of the most important and fastest growing regions in Central Portugal (Pinto et al., 2009). Based on historical population growth data for the region, it can be expected that population growth and associated urbanization in the Aveiro region will continue over the next decades (Pinto et al., 2009) – although the current financial-economic crisis is likely to dampen population growth rates in the medium term.

Case study

Consequently, over the next decades continued urbanization in the Aveiro region will increasingly enter into conflict with green/blue space preservation/rehabilitation requirements for flood and storm-water control. While it is widely acknowledged that urban green/blue space provides multiple functions and benefits, the multifunctional character of

green/blue spaces is poorly integrated into urban design and planning practice. The question arises how urbanization needs and housing preferences can best be integrated with green/blue space preservation/rehabilitation requirements for flood and storm-water control in the Aveiro region.

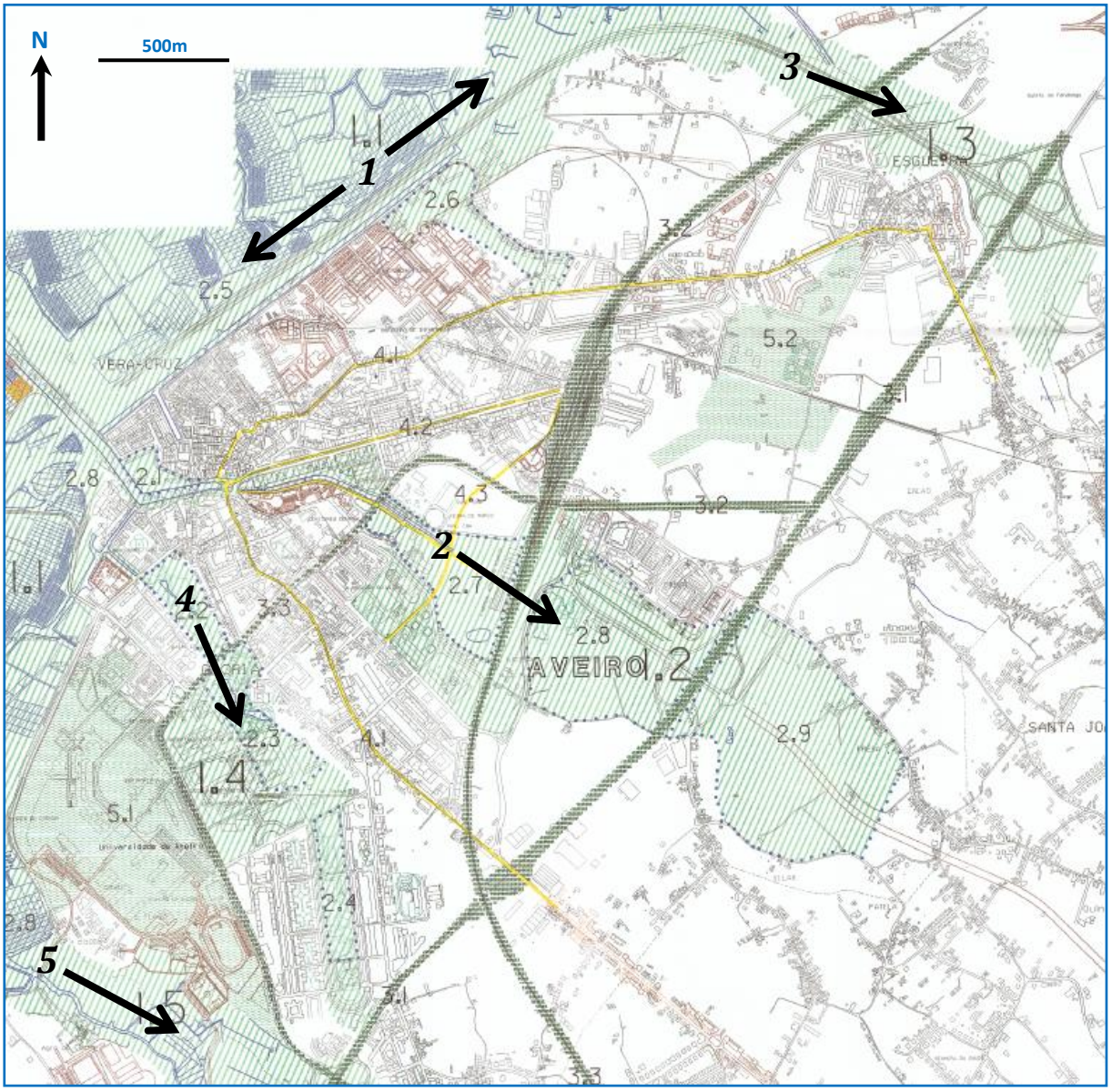
Figure 2 Portugal case study area: the city of Aveiro (Google maps, 2012).

The study area comprises the urban/urbanizing area of the city of Aveiro, with a surface area of about 15 km^2 and a population of 26,078 inhabitants in 2009 (INE, 2012; see Figure 2). Aveiro has had numerous floods over the last 100 years, caused by high water levels in the Ria de Aveiro and/or large river flows. Floods in Aveiro occur mostly during storms with heavy rainfall events affecting, in particular, the old city center which is of high historical, cultural and touristic value (MiSRaR, 2010).

In 1985 a hydraulic security system was implemented to protect Aveiro from inundations, including seven floodgates and one canal lock (MiSRaR, 2012). In response to a rise in water levels in the Ria de Aveiro, the gates were raised with 0.40 meters in 2001. In addition, a command and monitoring center was implemented in 2009, as to coordinate the operation

of gates in correspondence with tidal, wind and meteorological conditions. Hence, when heavy rains are forecasted the low tides are used to empty the channel system to a minimum water level of 0.66 meter and, in turn, the channel system is used as a retention basin. Finally, the highway to the north of Aveiro (built in 1995) acts as a semi-closed barrier between Aveiro city and the Ria de Aveiro in case of high water levels.

Figure 3 The Aveiro 5-Finger Plan (Municipality of Aveiro, 1997).



In anticipation of the European Floods Directive (2007/60/EC), the municipality of Aveiro developed a '5-Finger Plan' with the aim to increase the green/blue spaces in the city. The plan envisaged the preservation/rehabilitation of five green/blue strips ('Fingers') and was included in the 1997 urban development plan (Figure 3). Due to the lack of financial resources as well as urbanization pressure, only one green/blue strip got fully implemented (Finger-4) while for the other four green/blue strips only 'islands' were created.

In the 2009 urban plan for Aveiro, the 'Finger Plan' was re-introduced – now containing the remaining four fingers (Fingers 1, 2, 3 and 5). Finger-2 is considered of key importance for flood control, recreation, tourism and cultural activities (Polis, 2004), as the area forms part

of a 8 km^2 catchment area (generating peak flows during storm events), is at the centre of major residential areas (e.g. Beira Mar, Barrocas, Forca, Bairro do Liceu and Forum) and is close to the historic city center (750m). The development of an urban green/blue park as part of Finger-2 is, therefore, expected to reduce flood risks in Aveiro as well as to provide additional social, environmental and economic benefits (Polis, 2004).

Objective

As identified in the Polis Urbanization Plan (Polis, 2004), the Finger-2 plan comprises various green/blue space components – including: the Côjo canal, the Fonte Nova canal, the Fonte Nova lake, the Jerónimo Campos park and the Forca Vouga park. The objective of this Finger-2 case study is to assess what combination of green/blue space preservation/rehabilitation components best conciliates urbanization needs/preferences and flood/storm-water control.

Outputs

It is expected the DST will provide spatially explicit information on:

- The (added) value of green/blue space preservation/rehabilitation scenarios, in terms of household welfare, property values (halo-effect) and flood control (expert-based).
- The preferred locations and types of urban development needed to house the existing/growing population, for each of the green/blue space preservation/rehabilitation scenarios.
- Cost-benefit indicators for each of the green/blue space preservation/rehabilitation scenarios (e.g. based on investment and maintenance costs, property values, recreation values and flood mitigation benefits).
- The (added) value of green/blue space as compared to urban space (these values will highly depend on available green/blue and urban space – provides information to the definition of best practices).

The above mentioned information for each of the scenarios should, preferably, be provided in the form of tables, graphs and/or maps, as to inform resource managers, urban/rural planners and other relevant stakeholders in the planning, design and management of urban green/blue space.

2.2. Other Aqua Cases

2.2.1. Bremerhaven (D)

Setting/Problem

The city of Bremerhaven is addressing problems related to ecosystem services, namely recreation in the district of *Geestemünde*. The district is surrounded by water, but it is not easy to access or experience it as there are many barriers – both physically and in the people's minds. The area is characterised by abandoned port facilities and high vacancy rates due to outward migration. Hence, the city of Bremerhaven intends to use the potential of the river and harbour basins in order

to make the district more attractive, to contribute to quality of life, and to encourage small and medium enterprises (SMEs) and shop owners to stay in and/or move to Geestemünde.

Objective

The objective is to initiate and support testing strategies to improve the integration of water in spatial development processes – i.e. to make water-places visible and accessible in order to enhance the living conditions and the quality of housing and working in the district. This will allow the city to attain the following core objectives to the district: i) stabilisation of population figures, ii) stabilisation of the social structure, iii) increase in property values in the neighbourhood, iv) preservation of purchasing power in the district, and v) promotion of non-motorised transport.

The proposed solutions to this problem are defined in the Master Plan for the waterside in Geestemünde, and include:

- The development of urban green/blue space (establishment of natural riparian zones in the urban context).
- The development of an area for housing, shopping and leisure functions (creation of footpaths and public spaces).
- The construction of road and infrastructure connections (improvement of infrastructure connections from the district centre to the waterfront; creation of paths along the water; crossing facilities; relocation of car parking spaces).

Expected outputs

The DST is expected to provide spatially explicit information on the (added) value of green/blue space preservation/rehabilitation scenarios, in terms of household welfare, property values and flood control, as well as a cost-benefit analysis of different scenarios. Moreover, the objective is to develop a tool whose use can be replicated in other areas of the city: within Aqua-Add participatory approaches and strategies to improve the integration of water in the spatial development processes will be tested. Another expected output refers to the investigation of stakeholders' engagement in this process.

2.2.2. Copenhagen (DK)

Setting/Problem

The city of Copenhagen is addressing a problem of flooding in "Sct Kjelds Kvarter", an old and densely populated urban area located in the north eastern part of the city. The area is located closely to one of the most popular parks in Copenhagen, though neither has accessible green space nor recognizably culture, café life or tourist attractions in the neighborhood. In June 2011 the area experienced the most intense flooding during an extreme rain event and is, therefore, one of the areas identified in the Copenhagen Climate Adaption Plan (CAP) in risk of flooding due to increasing rainfall events and rising sea levels. In order to solve this problem, the city of Copenhagen initiated a pilot project in the area in 2012.

Objective

The main objective of the case study is to develop and implement best practice on how to innovate and integrate climate adaption in an existing urban area – with special attention on how to handle and manage increasing rainfall events while respecting the structure, history and architecture of the area. The City of Copenhagen and its Department for City Design and the Department of Parks and Nature, aim to increase the popularity of the Sct Kjelds Kvarter area and to motivate citizens to stay and take part in urban life. The area has an unused square area with potential for initializing urban life and private housing, which demands more green/blue space. In the short term (2014 to 2020), the area should attract urban planners and tourists to present at first Climate Neighborhood in Denmark and Copenhagen.

To prevent future flooding of the Sct Kjelds Kvarter area, the municipality of Copenhagen aims to implement a wide range of measures to address the focal issues of the city's CAP (related to increasing rainfall, rising sea levels and increasing temperatures), to reduce the risk of flooding and damages as well as to test and document potential benefits from new ways and methods in water management. Proposed solutions include:

- Decoupling surface rainwater from the sewer system and reconstruction of roads in combination with development of green/blue space.
- Creation of a sustainable drainage system (SUDS).
- Development of urban green/blue space for recreation, leisure and cultural activities.

To involve the stakeholders in this process from a grey city to a green climate neighbourhood, a public office of the Department for City Design and the Department of Parks and Nature has been established in the centre of the study area, which coordinates stakeholder involvement and gives room for cultural and art events.

Expected outputs

The DST is expected to provide spatially explicit information on the (added) value, for citizens, the municipality and house owners, of the different proposed strategies, as well as a cost-benefit analysis of investment and maintenance of combined sewer and SUDS solutions. In addition, it is expected that the DST can calculate the effects of the different projects in the area (new metro stations, CAP and Urban Improvement) simultaneously. Finally, it is expected that the DST contributes to the development of a locally adjusted tool whose use can be replicated in other areas of the city.

2.2.3. Debrecen (HU)

Setting/Problem

The city of Debrecen is addressing a problem related to ecosystem services, namely recreation along the Tócó creek on the west side of the city. The city is facing continuous urban growth, and the growth towards the west has reached the creek flow area. In addition, both the city and its flat surrounding areas are poor in watercourses and, hence, an overall plan for the Tócó creek's future role/status is necessary.

Objective

The main objective is the preparation of a Tócó basin development plan that focuses on the inner belt section of the creek (managed by the City), but not neglecting the upper and lower sections (managed by the Water Inspectorate), so that a new and valuable green/blue space will come into existence. In particular, the plan may address water flow, water quality, rainfall and wastewater partition, area use, stakeholder involvement and different solutions for creek sections with different characters. Possible solutions envisaged in this plan include:

- Development of urban green/blue space (with the rehabilitation of Tócó creek surroundings in the inner belt section).
- Development of an area for housing, shopping and leisure functions (so that the city can better accommodate current and expected urban growth).

Expected outputs

The DST is expected to provide spatially explicit information on the (added) value of green/blue space development scenarios, in terms of household welfare, quality of life and land value for the different sections of the creek, as well as on the preferred locations and types of urban development needed to house the growing population. A cost-benefit analysis of different development scenarios is also expected from the DST. Finally, the city of Debrecen intends to dispose of a tool that can be used in the future for the city's development to the east (namely Kondoros creek).

2.2.4. Imperia (IT)

Setting/Problem

The city of Imperia is addressing a problem of flooding in the districts of Oneglia and Castelvecchio di Santa Maria Maggiore – in particular in a critical area that can be considered as a five sided polygon bounded on the North by the Collette stream basin, on the West by the Impero river, on the East by the Santa Lucia stream and on the South by the harbour. The insufficient capacity of the urban drainage system combined with the transformations of the streams into culverts, cause problems for water quantity and quality. During heavy rainfall events, floods are frequent and furthermore the collapse of the combined sewer system produces shedding in the coastal bathing water. After the inundations in 1998 and 2000, the Municipality carried out a plan to change the sewer from combined to separate and to restore the flow rate of the streams/culverts. The general conditions have improved, but during heavy rainfalls events large parts of the town are still subject to flooding.

Objective

The objective is to adopt the most adequate technical solutions that allow for effective flooding control in the area. For each critical point, the following sets of technical possible solutions are considered:

- Collette stream. As the stream often overflows, it is proposed to increase the hydraulic section and consequently the flow rate. Given that the Collette stream is an underground culvert, however, the part of the stream corresponding to Via Issel could be reopened and the road system modified accordingly. As the upstream part is a scarcely urbanized area, renovation of green areas could be planned to create recreational values.
- Oliveto stream. As the major problems are an insufficient/inadequate hydraulic section and the presence of an ancient bridge that causes a sudden narrowing, it is proposed to enlarge/reshape the riverbed and to build concrete beds.
- Area between Via XXV Aprile and Via Fanny Roncati Carli. As the existing rainwater drainage system has become inadequate due to recent urban growth, it is proposed to build a new rainwater sewer system on both sides of the hill. In order to reduce the storm water management problems, stormwater discharges could be partially disconnected from the main drainage system and conveyed to the Municipal stadium.
- Area Cascine. As several flood events have seriously damaged the commercial activities in the area, it is proposed to divert rainwater of the Cascine stream basin into neighbouring drainage systems and waterways. Alternatively, an open channel could be planned along the old railway track nearby the Impero river (the new railway track should be in use before 2015) to collect storm water from this urban catchment and to discharge directly into the Impero river. The old railway station could be included as part of the new green corridor, while the renovation could also include the Toscanini Gardens as to provide a new recreation area (including, for example, bicycle lanes). Finally, remediation of the area nearby the outfall of the Impero river (where several bird species have settled) could be developed as fauna oasis.

Expected outputs

The output expected from the DST is a cost-benefit analysis of the different possible technical and natural solutions for each critical point, considering not only the costs and benefits of the drainage system but also the impacts on urban planning and on citizens' welfare. The DST is also expected to provide information on the best strategies to involve stakeholders in this process.

2.2.5. Lyon (FR)

Setting/Problem

The city of Lyon is addressing a problem related to flood control and ecosystem services – namely recreation and cultural activities in the Perrache peninsula. This area was long restricted to industry and transport facilities, but is now undergoing a transformation that aims at its renewal into a downtown district ("Lyon Confluence" project) – including a project of sewer network rehabilitation. The area

faces three major water management problems: maintenance difficulties due to pipes silting or too small infrastructures, nuisances and troubles for river side residents (rats, odor pollution, flooding) and pollution of the receiving bodies during storm events due to overflow devices.

Objective

The "Lyon Confluence" project aims at increasing its population to 25,000 by 2030, and to build new leisure and cultural infrastructures that should create 14,000 new jobs as well as new green/blue space. Concerning water management, the objectives are to improve the natural environmental quality (enhancing the receiving bodies' water quality and then protect the water resources), to reduce flood risks, to reduce investment and operation costs of technical solutions and to integrate storm water management in the cityscape.

Proposed solutions for the implementation of the "Lyon Confluence" project include:

- The development of urban green/blue space as well as areas for housing, shopping and leisure functions.
- The implementation of those technical options that best fit sustainability criteria among the 13 imagined possibilities for the rehabilitation/requalification of the sewer system. So far, the solution adopted is to build separate sewer systems only in new zones, where a complete sewer network reconstruction is necessary.
- The construction of swales for flood control and green/blue spaces for storm water management.

Expected outputs

The DST is expected to provide spatially explicit information on the (added) value of green/blue space preservation/rehabilitation scenarios, in terms of household welfare, property values and flood control in the peninsula, as well as on the preferred locations and types of urban development needed to house population. A cost-benefit analysis of the different imagined solutions for the sewer system rehabilitation and requalification is also expected from this tool.

2.2.6. Sofia (BU)

Setting/Problem

The city of Sofia is addressing problems related to flood control and ecosystem services – in particular regarding recreation along the Vladaiska river (the longest open water course running through Sofia). The Vladaiska riverbed is sectioned into earth levees, realigned riverbeds and natural river courses – for each section construction and non-construction works will be necessary to conciliate flood control, ecosystem services and quality of life.

Objective

The objective of the "Vladaiska Riverbed Realignment" project is, on the one hand, to consolidate the river banks (enhancing the conductivity of water flow and avoiding floods)

and, on the other, to modernize the city and improve quality of life of people living in the areas along the river through landscaping and the creation of new amenities (such as recreational facilities and bike lanes).

The Sofia Municipality constantly carries out project preparation works for the construction of non-realigned sections of the Vladaiska Riverbed, through land acquisition procedures and assignment of design works. The prepared projects are further included in the yearly investment programme. The Vladaiska Riverbed Realignment project aims to achieve:

- The consolidation of river banks (including dikes and levees).
- The development of urban green/blue space alongside the river (including recreational facilities and bike lanes).
- Construction of roads and rehabilitation of bridges to reduce traffic in the city.

Expected outputs

The DST is expected to provide spatially explicit information on the (added) value of green/blue space preservation/rehabilitation scenarios, in terms of household welfare, property values, flood control and cost-benefit analysis. Additionally, this tool is expected to contribute to investigate stakeholder engagement in the process.

3. Inventory of needs across Aqua Cases

The purpose of this chapter is to identify the common threads between the eight Aqua Cases, such that the DST to be developed shares the largest possible common framework while, at the same time, allowing for the inclusion of case study specific elements. To this end, the key issues, proposed solutions and DST expectations are summarized, compared and discussed, simultaneously, for all Aqua Cases (see Table 1).

Problems faced by the Aqua Cases relate to urban flood control and/or ecosystem services – the latter mainly related to recreation, tourism and cultural activities. While the Bremerhaven (D) and Debrecen (HU) Aqua Cases only identified ecosystem service issues, all other Aqua Cases identified both flood control and ecosystem service issues.

Table 1 Summary of problems, solutions and outputs expected to be addressed by the Decision Support Tool.

	Aveiro (PT)	Eindhov-en (NL)	Bremer-haven (D)	Copenh-agen (DK)	Debrec-en (HU)	Imperia (IT)	Lyon (FR)	Sofia (BU)
Problems								
Flood control	x	x		x		x	x	x
Ecosystem services:								
- Recreation	x	x	x	x	x	x	x	x
- Tourism	x			x				
- Biodiversity					x			
- Cultural activities	x			x			x	
Solutions								
Development/renovation of urban green/blue space	x	x	x	x	x	x	x	x
Re-opening of watercourses		x		x		x		
Development of areas for housing, shopping and leisure functions		x	x		x	x	x	
Construction of roads and infrastructure connections			x	x				x
Creation of sustainable drainage systems and other technical options	x	x		x		x	x	x
Expected outputs of DST								
The (added) value of green/blue space preservation/rehabilitation scenarios	x	x	x	x	x	x	x	x
Preferred locations and types of urban development to house population	x				x		x	
Cost-benefit analysis scenarios	x	x	x	x	x	x	x	x
Develop a tool whose use can be replicated in other areas of the city	x	x	x	x	x			
To investigate stakeholder engagement and find out the best strategies to involve stakeholders	x	x	x	x		x		x

A wide range of solutions are proposed to address these flood control and ecosystem service issues. All Aqua Cases propose the development and/or renovation of urban green/blue space to reduce flood risks as well as to enhance (other) ecosystem services in urban (-izing) areas. Flood control issues can be accompanied by the re-opening of water courses (Eindhoven, NL; Imperia, IT) and the construction of drainage infrastructure and other technical solutions (Aveiro, PT; Copenhagen, DK; Imperia, IT; Lyon, FR; Sofia, BU). Ecosystem services may need to be disclosed through the construction of roads and infrastructure connections (Bremerhaven, D; Imperia, IT; Sofia, BU) and the development of areas for

housing, shopping and leisure functions (Bremerhaven, D; Copenhagen, DK; Debrecen, HU; Lyon, FR; Imperia, IT).

Common outputs expected to be produced by the DST across all Aqua Cases, include the cost-benefit analysis of urban development and/or flood management scenarios in general and the quantification of the (added) value of green/blue space preservation/rehabilitation scenarios in particular. Aqua Cases facing urban growth would also like to obtain insight in the most strategic locations and types of urban developments to house population (Aveiro, PT; Debrecen, HU; Lyon, FR). Finally, most Aqua Cases express interest in applying the DST to other areas of their cities and are anticipative that the DST will facilitate effective stakeholder engagement that results in participative design of urban green/blue space development plans.

Hence, the DST to be developed needs to: i) address problems related to urban flood control and/or ecosystem services, ii) assess solutions that involve the development and/or renovation of urban green/blue space as well as the construction of built infrastructures, and iii) provide insight in the costs and benefits of urban development, flood management and green/blue space preservation/rehabilitation scenarios.

4. Approach to the development of the Decision Support Tool

The DST is based on an analytical urban economic model with environmental and urban amenities (see Mills, 1981; O'Sullivan, 2000; Wu & Plantinga, 2003), that allows for the assessment of sustainable landscape development patterns and/or scenarios, based on household preferences and constraints, availability and proximity to environmental and urban amenities, and construction costs. The model can be used in water related spatial planning processes in urban (-izing) areas. Based on scientific and stakeholder input (e.g. scenarios for climate change adaptation, population growth and household characteristics), the model assesses the economic and 'quality of life' benefits of green/blue space development and/or rehabilitation. Moreover, the model allows to:

- Localize where and which households would be affected by policy measures.
- Show consequences of urban development scenarios for social welfare, land value and hydrology.
- Visualise necessary measures to cope with climate change, and identify which type/size of green/blue space should be protected/created.
- Show the effects of market-based instruments on size and quality of green/blue spaces.

For these reasons, the model has a high potential to inform local/regional planning and policy decision making. While acknowledged in scientific literature, this potential has so far only modestly been used in real-world applications. In Aqua-Add, the analytical urban model will be developed into a Decision Support Tool (DST) that can be used by regional/local authorities, through the transnational development, parameterization and testing of the DST for country-specific circumstances.

The following four-stage approach is practiced in the development and application of the DST to the eight Aqua Cases:

1. Preparation: During this stage, case study descriptions are specified and presented for each of the eight Aqua Cases – with detailed descriptions of the two frontrunner Aqua Cases (Aveiro PT; Eindhoven NL) and summary descriptions of the six remaining Aqua Cases (Bremerhaven D; Copenhagen DK; Debrecen HU; Imperia IT; Lyon FR; Sofia BU). Thus the key issues, proposed solutions and DST expectations are identified across all Aqua Cases (Inventory of needs), allowing for the development of a DST that is specific enough to meet the requirements of each case study and generic enough to be applied across all case studies. In parallel, and in conjunction with Component 3 (Team stakeholder engagement), a stakeholder identification and analysis is performed across all eight Aqua Cases in preparation for effective stakeholder involvement.
2. Model development and implementation for frontrunner Aqua Cases: During this stage the DST is developed, applied and calibrated as well as extensively tested and validated for the two frontrunner Aqua Cases (Aveiro PT; Eindhoven NL). Building on the inventory of needs (Stage 1), DST-team meetings and Aqua-Forums, feasible model specifications and requirements for all eight Aqua Cases are considered and taken into account in the DST development as to make the DST readily applicable to the remaining six Aqua Cases. To assure the efficient application of the DST to these remaining six Aqua Cases in Stage 3, key data and information is collated and prepared (for input into the DST) during Stage 2 of the project. Relevant stakeholders will be involved in the development of the DST,

providing input on the type of information to be produced by the DST as well the way in which this information is presented (e.g. tables, graphs, maps and apps).

3. Model improvement and implementation for remaining Aqua Cases: During this stage the DST is developed, applied and calibrated for the six remaining Aqua Cases (Bremerhaven D; Copenhagen DK; Debrecen HU; Imperia IT; Lyon FR; Sofia BU). Based on the in-depth experience obtained with the two frontrunner Aqua Cases (see Stage 2), key model parameters, assumptions and improvements are identified and adopted – allowing for a DST that is (relatively) easy to apply while providing (sufficiently) relevant information. In this process, pertinent stakeholders will be involved in the development and application of the DST as to provide input on the type and format of information to be produced by the DST. Aqua Cases will be presented locally/regionally, with stakeholder-defined green/blue scenarios providing a basis for identification and communication of different views and interests among stakeholders (with Component 3).
4. Dissemination and follow-up: The final stage focusses on presentation, dissemination and evaluation of the DST development and application. Transnational presentation of Aqua Cases across project partners and stakeholders as well as at international meetings, workshops and conferences (with Component 2), allows for exchange of experience and feedback on the developed approach in general and the DST in particular. Dissemination of the DST beyond the project partnership and lifetime is guaranteed through the development of a web-based demonstration version (that can be used by other local and regional authorities in Europe) and an e-learning module (with Component 2). Finally, the DST development, application and implementation process is evaluated with project partners and pertinent stakeholders – with particular focus on the contribution of the DST in local and regional policy making (with Component 1).

Hence, Aqua-Add partners and stakeholders will use the DST in a spatial development process with a 'water challenge'. In these participatory processes, the social, environmental and economic impact of water challenge scenarios is determined and illustrated to all stakeholders. The DST provides information (visual and quantitative, in the form of tables, graphs and/or maps) that is normally not available to stakeholders in the urban planning process (e.g. on household welfare, land values, preferred locations, flood control and cost-benefit indicators). Use of this information, but also the joint collection of data as input, creates an open setting and invites stakeholders to discuss and express new ideas and insights. It facilitates the identification and communication of different views and interests among stakeholders. This process contributes, eventually, to common shared urban green/blue space development plans.

5. Discussion and conclusions

In this report we identified the common threads between the eight Aqua Case studies (two frontrunner Aqua Cases and six other Aqua Cases), such that a Decision Support Tool (DST) can be developed that shares the largest possible common framework while, at the same time, allowing for the inclusion of case study specific elements. To this end, the key issues, proposed solutions and DST expectations were summarized, compared and discussed for all Aqua Cases. In turn, we presented the four-stage approach to be practiced in the development and application of the DST across all Aqua Cases.

Based on detailed descriptions of the two frontrunner Aqua Cases (Aveiro PT; Eindhoven NL) and summary descriptions of the six remaining Aqua Cases (Bremerhaven D; Copenhagen DK; Debrecen HU; Imperia IT; Lyon FR; Sofia BU), it has become clear that the DST to be developed needs to: i) address problems related to urban flood control and/or ecosystem services, ii) assess solutions that involve the development and/or renovation of urban green/blue space as well as the construction of built infrastructures, and iii) provide insight in the costs and benefits of urban development, flood management and green/blue space preservation/rehabilitation scenarios.

The following four-stage approach is proposed for the development and application of the DST to the eight Aqua Cases:

1. Preparation: Aqua Case study descriptions are specified, presented and analysed (Inventory of needs), as to identify a common framework of the DST that is generic when possible and specific where needed. In parallel, a stakeholder identification and analysis is performed across all eight Aqua Cases in preparation for effective stakeholder involvement (with Component 3).
2. Model development and implementation for frontrunner Aqua Cases: The DST is developed, applied and calibrated as well as tested and validated for the two frontrunner Aqua Cases (taking into account requirements for all Aqua Cases). Stakeholders will be involved in the development and application of the DST (providing input on the type and format of information to be produced), while data and information is collated and prepared for the remaining six Aqua Cases (facilitating efficient DST application).
3. Model improvement and implementation for remaining Aqua Cases: The DST is developed, applied and calibrated for the six remaining Aqua Cases (based on experience with the two frontrunner Aqua Cases). Stakeholders will be involved in the development and application of the DST (tailoring to end-users' needs), while Aqua Cases are presented locally/regionally to initiate participatory urban green/blue space planning (with Component 3).
4. Dissemination and follow-up: The final stage focusses on presentation (local, regional, national and international; with Component 2), dissemination (through web-based demonstration version and an e-learning module; with Component 2) and evaluation (with project partners and pertinent stakeholders; with Component 1) of the DST development, application and implementation process.

So it is anticipated that the DST will facilitate effective stakeholder engagement that results in participative design of urban development plans. The DST provides and presents social, environmental and economic information that is normally not available to stakeholders in the urban planning process and, hence, enables the identification and communication of

views and interests among different stakeholders. This, eventually, contributes to the definition of urban green/blue space development plans shared by all stakeholders.

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