Development of PREPARED cities

Brand/Marquee and market research for the marque

SEVENTH FRAMEWORK PROGRAMME

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Summary

About PREPARED

Impact of climate change is evident: Changes to global water cycle, melting icecaps, extreme temperature changes and rising sea levels.

Utilities and local decision-makers will need to respond to these changes, while balancing between acceptable risk and justified investments.

PREPARED has worked with 14 urban utilities to develop advanced strategies to meet climate change induced challenges in the water supply and sanitation sectors.

PREPARED intends to demonstrate the capacity of cities' water supply and sanitation systems and their catchments to adapt and be resilient to the challenges of climate change. It shows how technological, managerial and policy adaptation of these PREPARED cities can be cost effective, carbon neutral and can be exported elsewhere.

Rapid Assessment Method to Develop PREPARED Brand Tool

The IWA, together with KWR has developed a rapid assessment tool to determine the level of preparedness of European cities in coping with climate change related challenges. Results of the assessment will be used to develop a 'PREPARED' approach to be applied to cities, to showcase successful examples.

The methodology covers the whole urban water cycle and helps local decision makers achieve a number of goals:

1. Determine what challenges there are to climate change and its related risks in the short and long term.
2. Assess the adaptation strategies that a city already has in place, and what may need to be developed.
3. Assess the implementation, viability and effectiveness of measures developed within the PREPARED project.

This methodology represents a baseline assessment of the preparedness of urban water utilities to climate change and does not include future projections.

The assessment consists of questions where respondents score their answers on a scale. E.g. *what is the projected change in extreme precipitation?* or *have measures been taken to prevent and handle water scarcity?* Responses are transformed using a 0 (poor performance) to 10 (excellent performance) scale and plotted on a spider diagram.

There are also open questions to gather details on the measures and infrastructure that will impact the adaptive capacity of a city. E.g. *what types of flood risk management measures are available to prevent/mitigate floods?*

Application of PREPARED Brand Tool

Results are being used to develop a 'PREPARED' brand for cities which will be used to:

- Set priorities for climate change response interventions and investment strategies
- Map climate change induced challenges and potential adaptation measures
- Contribute to policy development and decision making processes

The rapid assessment tool is providing the basis for a strategic and efficient planning framework for adaptation measures.

Contents

1 AIM

The impact of climate change is evident; changes to the global water cycle, the melting icecaps, extreme changes in temperature and rising sea levels. Utilities and local decision-makers will need to respond to these changes, while balancing between acceptable risk and justified investments. To identify the level of preparedness of cities to the cope with the impacts of climate change with respect to their water supply, sanitation and sewerage/storm water infrastructure, a methodology to determine the preparedness of the water sector to climate change was produced and tested.

Deliverable 7.3.3 addresses the development of a questionnaire, testing the questionnaire in two demonstration sites and summary of the methodology, gathered results and any gaps and recommendations.

2 METHODOLOGY

In order to determine the preparedness of cities to climate change, a vulnerability assessment was carried out (1). The main reason for conducting such an assessment is that in the near future, cities, due to their expansion and overpopulation, will become more susceptible to challenges brought about by a changing climate. As a result, climate change will have the strongest impact on urban citizens and especially on low-income residents of these cities. It can be said that global changes such as flooding and sea level rise are responsible for urban vulnerabilities that have to be prevented, protected and controlled (2). Therefore, risk prevention requires better knowledge of vulnerabilities which can be achieved through corresponding vulnerability analysis (1) and identifying areas with the highest vulnerabilities is vital to develop adequate climate change adaptation strategies (3).

According to the Intergovernmental Panel on Climate Change as cited in (2), vulnerability can be defined as "the extent to which a natural or social system is susceptible to sustaining damage from climate change" implying that not only exposure to hazard factors but also the capacity to recover from their effect should be taken into consideration when conducting the analysis (2). A vulnerability assessment process consists of such elements as determination of exposure and carrying out sensitivity and adaptive capacity assessments of population and infrastructure (Figure 1).

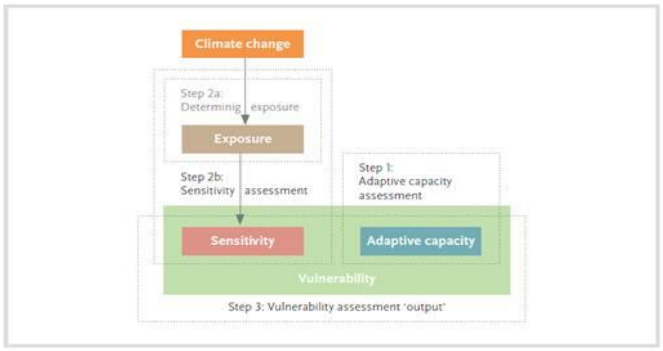

Figure 4: The vulnerability assessment process

Figure 1. The vulnerability assessment process

To assess vulnerability of population and infrastructure in urban areas to the impact of climate change, a qualitative methodological tool, i.e. a questionnaire, is developed. This tool has been developed to help local decision makers achieve a number of goals:

1. Determine the challenges they will have to face in the short and long term related to climate change and the related risks.
2. Assess the adaptation strategies that a city has in place, i.e. weaknesses and effectiveness of current prevention measures and policies, and will give an idea on the appropriate adaptation strategies that are still needed to be developed.

3. Assess the implementation, viability and effectiveness of measures developed within the PREPARED (1,3).

The problem of vulnerability and adaptation to climate change is broken down into subsets or indicators. The indicators are organised in several categories to allow an efficient analysis and consequent comparison.

In order to show the correlation and connection between them, these indicators are then presented using a graphic image, i.e. a spider web (Figure 3). The questionnaire intends to cover the whole urban water cycle, i.e. water source (springs, groundwater, reservoirs, etc.), water production (water treatment plant), water distribution, consumers and industry, sewer/storm water network, wastewater treatment, in accordance with Figure 2 (1). To answer all questions efficiently, the cooperation between the different stakeholders in the water sector, i.e. city management, water utilities (drinking water, storm water and wastewater), etc. is required.

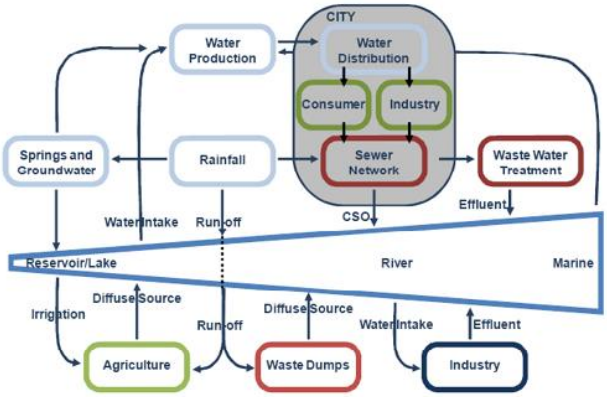

Figure 2. Water cycle interactions and the city (16)

The method for developing this questionnaire and selecting indicators is largely based on the City Blueprint approach developed by KWR Watercycle and Research Institute. It establishes a network (learning alliance) of European cities to share their best practices on Urban Water Cycle Services (UWCS) in their effort for a transition towards improving the sustainability of the UWCS of their city/municipality/region. Like the City Blueprint, this methodology allows a city to quickly understand its current adaptive capacity and to compare its status with other leading cities.

The methodology is an opportunity to identify climate change related risks and strive to improve a city's water steward-ship, to facilitate the design of adaptive water sensitive cities. All cities are different, some are advanced in certain areas while others have much to do. As with the City Blue print, the intention of this methodology is not to emphasise poor performance, but rather to help identify areas for cities to focus and improve on by learning from other cities while demonstrating and sharing their own best practices and knowledge.

The methodology is also based on other literature, including the following sources:

- Literature available on local level: websites and reports on local climate change adaptation strategies of the water sector (Rotterdam, the Netherlands, Copenhagen, Hamburg, Melbourne, Toronto);
- EU legislation and other EU documents: EU Floods Directive, EU Water Framework Directive, Guidelines on best practice to limit, mitigate or compensate soil sealing, Addressing the challenge of water scarcity and droughts in the EU, Best practices on flood prevention, protection and mitigation;
- Scientific literature: scientific peer-reviewed articles on climate change, climate change adaptation strategies, urban water cycle and management, vulnerability assessment methodologies, etc.;
- Research project reports: European Environment Agency's framework programme on climate change and related reports, SWITCH reports, TRUST (Transitions to the Urban Water Services of Tomorrow) reports;
- Case studies conducted within the framework of PREPARED: PREPARED website, poster booklets, newsletters, etc. (1)

Consultations with experts were also conducted to specify the questions and their scales (Katharine Cross, IWA, NL, Adriana Hulsmann, KWR, NL, Kees van Leeuwen, KWR, NL, Anders Lynggaard-Jensen, DHI, DK).

The process of developing a questionnaire to test the preparedness of cities to climate change involves, first of all, the summary of all significant climate-related challenges for the European water sector. Such challenges mainly include increasing temperature and change of precipitation patterns which will lead to increased flooding, water scarcity and heat waves (3).

According to (1), the magnitude and frequency of floods in Europe is increasing. At the same time, the intensity of precipitation can be observed in some regions. The situation becomes more complicated by the fact that flood prone urban areas become more and more attractive spaces for citizens, which can increase their vulnerability and corresponding risk. Therefore, improved knowledge about areas subject to flooding, and the percentage of population living in such areas is necessary to prevent negative consequences of this hazard. In addition, assessment of the level of implementation of flood protection measures can also help identify preparedness of cities and their adaptive capacity. The knowledge can then be incorporated into urban planning and territorial management and used for evaluation of new construction and flood protection projects (1).

One of the features of urban areas is the presence of impermeable surfaces; soil sealing, which is characterised by small capability of intensified rainfall absorption. This phenomenon can cause the increase in intensity of rainfall runoff and corresponding street flooding. Therefore, soil sealing should be considered as one of the problems for city authorities to deal with when working on climate change adaptation measures. (7, 17)

With changing climate, water availability becomes a serious problem. According to climate predictions, intensity of rainfall will lead to longer periods between rainfall events and, as a result, to water scarcity and droughts. In addition to that, reliable water supplies are endangered

by salt intrusions into aquifers and estuaries caused by sea level rise and increased temperatures which will increase evapotranspiration (7). One of the parameters used to assess water availability is called Water Exploitation Index that indicates different levels of water stress for countries (18). It also points out the necessity to implement and constantly monitor water efficiency and water scarcity prevention measures.

Climate change also intensifies the so-called urban heat island effect caused by urbanisation which also influences the water cycle. One of the options for cooling the urban environment is the creation of blue and green areas. These areas can help mitigate the warming effect and reduce the risk of flooding at the same time, and as such serving as a nature protection measure (3).

Combined sewer overflow is an important parameter that should be considered when talking about climate change. Cities with combined sewer systems can experience increased overflow due to heavy rainfall that overwhelms wastewater treatment capacity causing street flooding and pollution of surface water streams after being discharged into rivers. (7)

Taking into account the consequences of climate change for the urban water sector, as previously mentioned, particular attention should be paid to the adaptation measures in general and adaptation of urban water supply, wastewater and storm water infrastructure to climate change in particular since physical infrastructure will be most negatively affected by and increase in flood and drought conditions, as well as unforeseen changes in temperatures, etc. Hence, estimating the level of implementation of such measures could be a good indicator of preparedness of cities to climate change. (7)

In terms of adaptation measures, collaboration and public participation are extremely important for achieving effective results. According to the Third Assessment Report of the Intergovernmental Panel on Climate Change as cited in (8), one of the conditions for enhancing adaptive capacity is "active participation by concerned parties, especially to ensure that actions match local needs and resources". That is why questions regarding voluntary participation and external cooperation have been included in the methodology.

The questionnaire is also used to test the effectiveness of some of the instruments developed during PREPARED. They include, among others, toolbox for real time monitoring and modelling including monitoring of combined sewer systems, integrated monitoring systems, and creation of the concept of Water Cycle Safety Plan.

Finally, in order to fully identify areas within the urban water sector with climate change vulnerabilities and risks, the questionnaire includes aspects such as physical, socio-economic, land-use and infrastructure systems (2). The socio-economic aspect, as one of the more significant ones, tries to assess the influence of climate change on the most vulnerable groups which are more susceptible to floods and water scarcity and the measures cities implement to protect them.

This methodology represents a baseline assessment of a preparedness of urban water utilities to climate change; a static picture, and does not include future projections. In a nutshell, it consists of questions or indicators that are organised in several categories to allow an efficient analysis and followed by a comparison of cities. The key terms are added in the beginning to clarify the terminology for participating cities. The PREPARED questionnaire consists of a set of 18 indicators grouped into 6 categories, i.e. floods, water availability, temperature, soil sealing, infrastructure, and governance (Table 1). The questionnaire largely consists of closed questions on a scale that varies from 0 to 4 to 0 to 10. Before presenting the data in a spider web, all input will be transformed using the 0 to 10 scale (0 implies very poor performance which requires immediate attention and 10 excellent performance). A few open questions are also included for urban utilities to provide more detailed information about the measures and infrastructure that will help better assess their adaptation strategies.

Table 1. Indicators of the PREPARED questionnaire

Category	Indicator	Description
Floods	Flood frequency	Frequency of floods from rivers, mountain torrents, Mediterranean ephemeral water courses, and floods from the sea in coastal areas (19)
	Flood risk area	The proportion of the city area that would be affected by potential inundation caused by a sea level rise of 1m in combination with a 100 year coastal storm surge event (20).
	Flood affected citizens	number of people affected by flooding and wet mass movements, i.e. people who require immediate assistance during a period of emergency including displaced or evacuated people (21)
	Intensity of precipitation	Frequency of heavy, extreme single-day precipitation events (22)
	Flood prevention measures	Assessment of measures applied to prevent flooding
Water availability	Water exploitation index	the mean annual total abstraction of freshwater divided by the mean annual total renewable freshwater resource at the country level, expressed in percentage terms. (18)
	Water scarcity prevention measures	Assessment of the measures applied to prevent water scarcity
	Water efficiency measures	Assessment of the measures applied to improve water efficiency (5)
Temperature	Heat wave risk	Number of tropical nights (minimum temperature exceeding 20°C) and hot days (maximum temperature exceeding 35°C) (23)
	Green and blue areas	The share of green (vegetated) and blue (water) areas within cities (24)

Soil sealing	Soil sealing	The share of impermeable surfaces like buildings, roads, places and other artificial areas (25)
	Soil sealing mitigation measures	Assessment of the measures implemented to limit, mitigate or compensate soil sealing
Infrastructure	Frequency of combined sewer overflow	A number of discharges of untreated wastewater from a combined sewer system at a point prior to the headworks of a publicly owned treatment works (26)
	Infrastructure adaptation	Assessment of the adaptation of infrastructure design of water and wastewater utilities to climate change
Governance	Health risks	Assessment of the identification of potential health risks associated with climate change
	Climate change adaptation measures	Assessment of the measures applied to protect citizens against challenges brought about by climate change such as flooding and water scarcity (5)
	Collaboration	Measure of local. regional, national and international cooperation in the urban planning and development sectors in the city
	Public participation	Proportion of citizens voluntarily involved in different activities as an indicator of stakeholder equity in the planning process (5)

The questionnaire was sent to Waternet[1] and Wageningen Municipality for testing and feedback. The following section will address the results from Amsterdam and Wageningen. Keep in mind that the results are not a conclusive indication of the preparedness of Amsterdam and Wageningen. The results are merely a test to see the applicability of the questions for the methodology.

[1] Waternet supplies the city of Amsterdam and its surrounding areas with tap water and takes care of the discharge of wastewater.

3 RESULTS

In order to estimate the effectiveness of this methodology an attempt was made to analyse the preparedness of two cities by completing the questionnaire using the information from the public sources. After some consideration, the City of Amsterdam and Wageningen were chosen as demonstration cities.

3.1 Amsterdam

The data was partially taken from the City Blueprint (indicators 8, 14, 18) and the website of the European Environment Agency (indicators 2, 6, 9, 10, 11). An attempt to answer the other closed questions were done with information available on the Internet. One of the main limitations of this approach was that local data was not always publicly available for some of the indicators and national data for the Netherlands had to be taken into account which could bias the overall results. The scores for some questions (assessment of implemented measures) were subjective and based on found information and personal perception. (27)

The results of the baseline assessment for the City of Amsterdam are presented in Table 2.

Table 2. PREPAREDNESS of the City of Amsterdam

Q#	Indicator	Result
1	Flood frequency	2
2	Flood risk area	0
3	Flood affected inhabitants	10
4	Flood prevention measures	10
5	Intensity of precipitation	0
6	Water exploitation index	6
7	Water scarcity prevention measures	10
8	Water efficiency measures	10
9	Heat wave risk	10
10	Green and blue areas	2.5
11	Soil sealing	4
12	Soil sealing mitigation measures	10
13	Combined sewer overflow	6
14	Climate change adaptation measures	10
15	Health risks	N/A
16	Infrastructure adaptation	10
17	Collaboration	10
18	Public participation	7.7
	Mean	**9.8**

Flood frequency

Unfortunately, no specific information has been found regarding the frequency of floods in Amsterdam. However, according to different websites, the Netherlands experienced floods in 1953, 1993, 1995, 1998 (28) as well as in 2010, 2011, 2012. Therefore, it can be assumed that floods in the Netherlands occur once every year to 5 years, therefore, Amsterdam can score 2 in this category.

Flood affected inhabitants

According to the EU Floods Directive (19), each Member State is required to draw up a flood risk map by 2013 and among other factors, demonstrate the indicative number of inhabitants potentially affected. Flood Atlas published by the EEA (29), refers to the official flood map of the Netherlands (30). However, this map does not reveal the number of inhabitants potentially affected by flooding. Therefore, in order to find out the data, other sources had to be taken into account. One of the maps published by the EEA shows the number of people affected by flooding and wet mass movements per million population in the WHO European Region for the time period 2000-2011. The Map indicates that flooding had no effect on the population of the Netherlands and, therefore, on the inhabitants of Amsterdam as well (31). The same conclusion has been drawn from another flood map (32) that displays the number of citizens affected if the sea levels rise by 18 and 100 inches. Therefore, Amsterdam scores 10.

Water exploitation index

Since there was no data available for the City of Amsterdam regarding water exploitation index, national data had to be taken into account. Water exploitation index for the Netherlands for the year 2008 constitutes 10-20% (33). Amsterdam scores 6 out of 10 in this category.

Flood prevention measures

It is quite challenging to estimate the level of implementation of flood prevention measures using the scale provided and the data available. No explicit information has been found regarding a flood response and prevention plan or its equivalent in Amsterdam. At the same time, the Netherlands as one of the most vulnerable countries has a wide range of different programmes and plans regarding flood protection and the information about them can be found on different websites.

One of the most significant Dutch flood protection programmes is called "Room for the River" and is aimed at controlling flooding in river basins. It has been developed by the Dutch Cabinet with a budget of 2.2 billion Euros. The project time frame is 2006-2015 and was designed to implement measures such as relocation of dykes, depoldering, lowering the level of floodplains, etc. (34, 35)

More details about the project are available on its website. Despite the fact that no information has been found regarding the annual reporting on the progress of implementation, approval of this project by Dutch Government shows its high priority for the local communities.

In addition to that, the flood situation in the country is constantly monitored by meteorologists from the Royal Netherlands Meteorological Institute which shows the development of early warning and forecasting systems (4). Therefore, taking into account the national data it is possible to give Amsterdam 10 out of 10.

Intensity of precipitation

No information has been found regarding the increase in precipitation intensity in Amsterdam since 1961. However, according to the report produced by KNMI (36), in the Netherlands the number of days per year with a precipitation amount greater than 20 mm has increased by 44% from 1961 to 2009 and with more than 30 mm precipitation – by 53%. Therefore, it can be assumed that the average increase in precipitation intensity in the Netherlands and, thus, in Amsterdam for the period 1961-2009 constitutes 48.5%. Therefore, Amsterdam scores 0.

Water scarcity prevention measures

No information regarding water scarcity prevention measures in Amsterdam has been found. Therefore, the national data will be used.

Delta programme is a national programme funded by the Delta Fund and aimed at securing a sufficient supply of freshwater for future generations. It was launched in 2010 and annually provides reports regarding programme's measures in the field of freshwater supplies (37).

In addition, according to the report (38), a local website was designed for water users to find guidelines on how to take into account water shortages when developing implementation plans and which measures to consider in a time of water scarcity.

Therefore, Amsterdam scores a 10.

Soil sealing mitigation measures

Several measures have been implemented at the national level to limit soil sealing. They include quantitative limits for annual land take, creation of "green and blue areas" to protect land from infrastructure development, the Groene Hart in the Randstad Region of the Netherlands, etc.

In addition to that, some measures have been applied at the local level as well, such as Randstad programme in Amsterdam which is aimed at improving attractiveness of the inner urban areas that are in decline for new residents and creating new jobs (39, 40). Amsterdam is also one of the cities in the Netherlands that has policies to support the implementation of green covered roofs. (41)

Amsterdam has an excellent performance, with a score of 10.

Combined sewer overflow

Amsterdam has a combined sewer system which is 481 km long (42). However, no data has been found regarding the frequency of CSO in Amsterdam. Therefore, national data has to be taken

into account. According to (43), the frequency of CSO in the Netherlands is 5-10 times per year per location.

The City of Amsterdam scores 6 out of 10 in this category.

Health risks

Since Amsterdam is not one of the demonstration cities for the PREPARED project, it does not have a water cycle safety plan. Therefore, this indicator will be omitted from the analysis.

Infrastructure adaptation

The Netherlands has been actively adapting infrastructure to climate change based on long-term major investments. Urban innovations include Amsterdam's bike park stations (44), green roofs, the installation of the new sensor system to assess the stability of dikes (45), creation of so-called Delta Dykes ("unbreachable" dykes) to minimise the consequences of unexpected extreme conditions, etc. (46).

Therefore, a score of 10 is given to Amsterdam.

Collaboration

According to (47), Amsterdam has actively involved citizens in the long term urban planning process and in high levels of decision making regarding the future of the city. For this reason a score of 10 is given to Amsterdam.

The results of the questionnaire for the City of Amsterdam are presented in the following spider diagram (Figure 3).

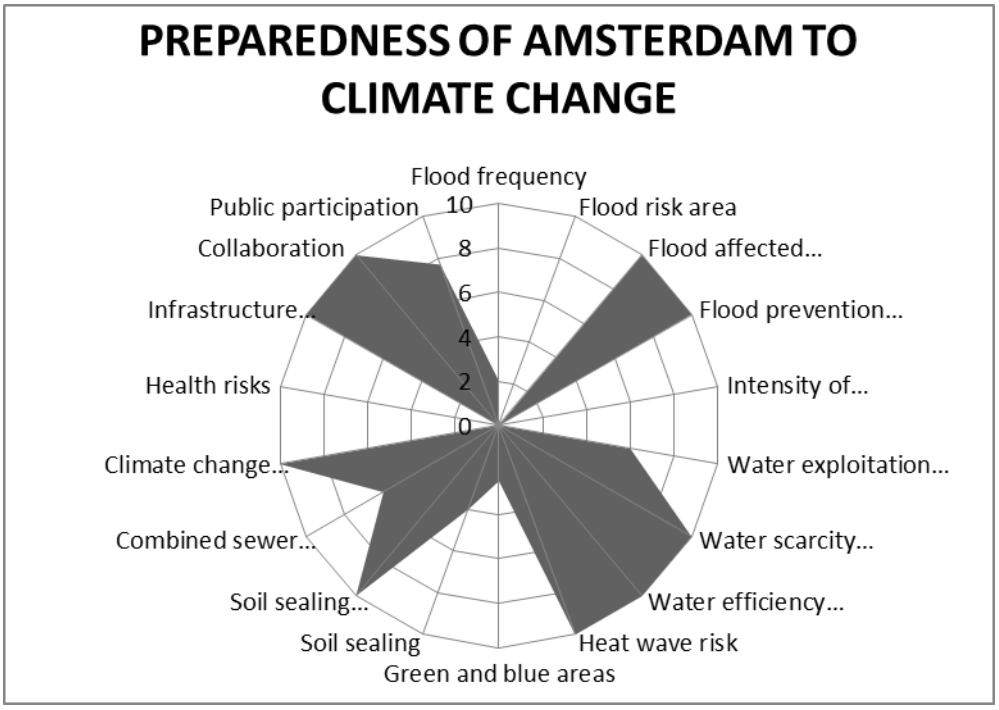

Figure 3. Preparedness of Amsterdam to climate change

Analysis of the spider diagram

- Amsterdam is vulnerable to flooding because of the high flood frequency and increased intensity in precipitation (50% increase). As a result, its flood risk area is quite extensive. However, Amsterdam is fully prepared for such events, implementing effective flood prevention and protection measures. At the same time, it should be noted that inhabitants are not affected by flooding which implies one of two things, one, the perfection of the flood protection measures or two, the error of this particular assessment.
- Currently, the Netherlands belong to low water stressed countries. Nevertheless, the level of implementation of water scarcity prevention measures and water efficiency measures is relatively high. This shows the preparedness of the city to possible future water shortages due to climate change.
- So far, climate change has not caused an increase in summer heat waves in Amsterdam. At the same time, green and blue areas in the city constitute less than 20% which can influence the urban heat island effect and in the future lead to an increase in temperature. Therefore, a particular attention should be paid to the development of these areas.
- Soil sealing in Amsterdam accounts for 25-49% of its territory which is pretty substantial and can increase street flooding. That is why, special measures have been introduced by the city authorities to control and mitigate this effect.
- The frequency of combined sewer overflow is quite low, 5-10 times per year. However, potential increase in frequency can be anticipated as a result of climate change which should be taken into account. It would therefore be good to know which measures the city plans to take to minimise its effect.

- It should be emphasised that Amsterdam prepares itself to climate change challenges by applying different climate change adaptation measures and altering its infrastructure. In addition to that, it fully involves citizen in the decision making process to maximise the effect. Nevertheless, the level of public participation can still be increased.

Therefore, according to this methodology, Amsterdam would be considered as a "fully prepared" city (mean score of 9.8) to the challenges brought on by climate change to its water supply and sanitation system.

3.2 Wageningen

As with Amsterdam, Wageningen is not a PREPARED partner, however, the questionnaire was sent to a contact person within the Wageningen Municipality. Some data was taken from the City Blueprint and the website of the European Environment Agency. The results are also based on an adapted version of the questionnaire after receiving input from Amsterdam and Kees van Leeuwen. It should also be noted that questions were filled in by the Municipality themselves, so it is more complete than the questionnaire from Amsterdam.

The results of the baseline assessment for the City of Wageningen are presented in Table 3. In the analysis of the questionnaire, it was decided to produce 2 separate diagrams, on the one hand show the risk (vulnerability and exposure) of climate change, on the other hand the adaptive capacity of the city, which can also be understood as the preparedness of cities to climate change. This will help present in a clear way the risk and adaptive capacities and avoid congestion of outputs in one diagram.

Table 3. PREPAREDNESS of the City of Wageningen

Q#	Indicator	Result
1	Flood frequency	8
2	Expected flood frequency	8
3	Flood prevention methods	6
5	Urban flood risk	2
6	Flood affected inhabitants	2
8	Change in annual precipitation	2
9	Intensity of precipitation	6
10	Change in extreme precipitation	2
11	Water exploitation index	9.5
12	Prevent/handle water scarcity	N/A
14	Improved water efficiency	8
16	Heat wave risk	9
17	Projected heatwave risk	8
18	Drought prevention	6
20	Share blue and green areas	7.5
21	Surface impermeability	4
22	Compensation measure soil sealing	2

23	CSO frequency	8
24	CSO prevention measures	8.5
27	Climate change adaptation	3
28	Health risk addressed	N/A
29	Infrastructure adaptation	8,5
32	Collaboration	6
	Mean (risk)	**5.7**
	Mean (preparedness)	**6.2**

Flood frequency

In 1995 the water level in the river Rhine was very high and there was a potential risk of the dikes not being able to retain the water. However, behind the dyke there were no problems and the situation was normal. The water level in the river was high due to a combination of heavy rainfall and large amounts of smelt water. The height of the water level was critical. For inundation water, water coming from waterways, safety calculations are based on events that occur less than once every 100 years plus a safety margin of 30% on top of that. With the current IPCC report, that might not be sufficient and the 30% might have to be increased to adapt to changes in the climate. The answer in question 1 is based on flooding caused by the river Rhine (inundation water).

Water on the street due to extreme rainfall events might happen more often but that is not considered to be a problem, where damage due to water on the street is a problem. The Council will now focus on the level of damage caused by water in the city. In 2002 there was a very extreme rain event at local level that did not fit any statistics on rain fall for the area concerned. In general water on the street due to extreme rainfall events occurs once every 1 to 5 years.

Therefore, a score of 8 was given to the city of Wageningen.

Flood affected inhabitants

The estimated percentage of inhabitants living in a flood prone area is 40%, giving Wageningen a score of 2.

Flood prevention measures

There is a national document which helped establish the Deltacommittee to advise the national government on the protection of the Netherlands against impacts of climate change. The underlying question is how the country can be best organised to be climate-proof, protected against flooding and an attractive place to live, work, recreate and invest.

Twelve measures have been identified to achieve this target and details measured at the regional level. The dike near the river Rhine at Wageningen (Grebbedijk) has been ear-marked as Delta dike. The local measures have been included in the local planning documents but are not yet implemented. The public documents (structuurvisie) are available on the council website. It will take up to 8 years to implement measures.

For this reason, a score of 6 is given.

Intensity of precipitation

The increase in frequency in intensity of precipitation itself does not say a lot about water on the street and necessary adaptation, more important is the timeslot in which the rain occurs and the peaks. In any case, the municipality gave Wageningen a score of 6.

Water scarcity prevention measures

In Wageningen, there is no structural water shortage, so the question is not relevant.

Soil sealing mitigation measures

There is no city policy with respect to soil sealing, however, measures are taken at an ad hoc level, for example, permeable bricks at some of the parking places. People are also informed not to completely seal infiltration areas and civil servants are aware of the issue.

Wageningen scored a 2, as there were no specific measures at the national level while the mean percentage of soil sealing of the urban area is as high as 25-49%.

Combined sewer overflow

CSO frequency is now 3 times per year but it used to be 30 times per year. Wageningen is not in PREPARED but the tools they used to reduce the frequency of CSO was done through a number of measures, such as three detention and settling tanks in the city and guiding the water away from low areas at risk of flooding to higher grounds and guiding the water to the Grift river in het Binnenveld.

For this reason a score of 8 (frequency of CSO) and 8.5 (measures to deal with CSO) was given to Wageningen.

Health risks

The Mucipality of Wageningen indicated that potential health risks with climate change in Water Cycle Safety Plan had not been considered. Additional information as to why was not included. Perhaps health risks are not a major concern for Wageningen or there are measures already in place that are not part of a WCSP. For this reason, this question was omitted.

Infrastructure adaptation

In Wageningen, climate change as very significantly impacted the infrastructure decision-making and investment strategy. Since the 2002 extreme event another approach was used. However, it is completely unclear what the future frequency of extreme events and the intensity will be. Instead of opting for wider sewers with a higher capacity (unrealistic) or more retention tanks (too expensive) the storm water is guided away from vulnerable areas and directed towards open water.

Wageningen scores a 8.5.

Collaboration

Participation of citizens in voluntary organizations shows their willingness to be engaged in different activities not associated with their professional life. The index of voluntary participation available only by country (http://www.eurofound.europa.eu/pubdocs/2006/76/en/1/ef0676en.pdf) shows some willingness for citizens to participate, however, the Wageningen Municipality indicated a low participation level form citiezens. Wageningen received a score of 6.

The results of the questionnaire for the City of Wageningen are presented in the following spider diagram (Figure 4a and Figure 4b).

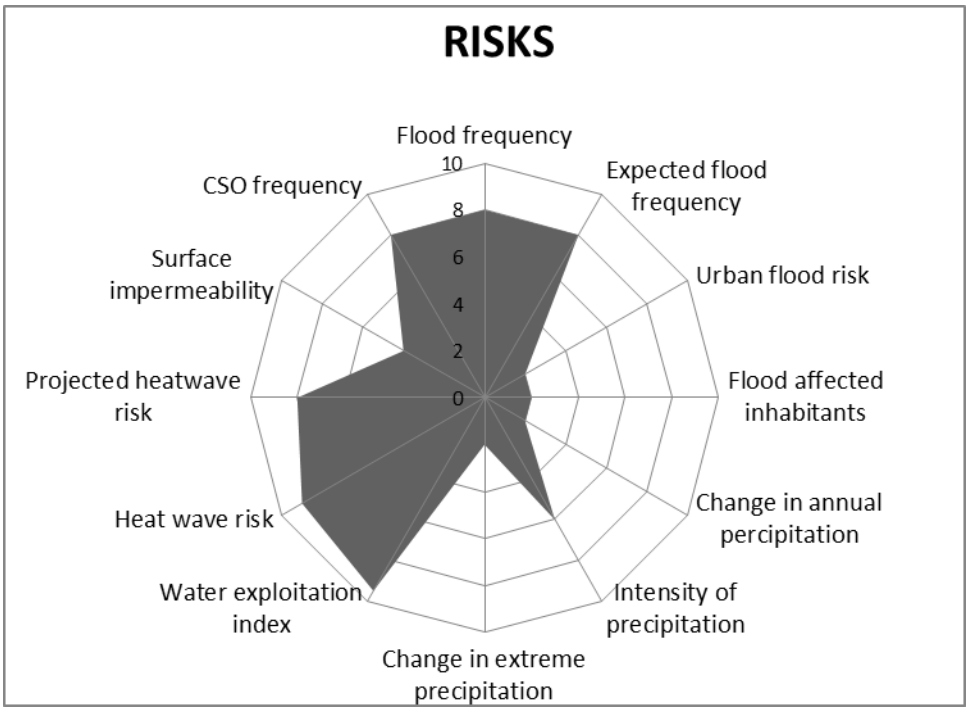

Figure 4a. Risk of Climate Change in Wageningen

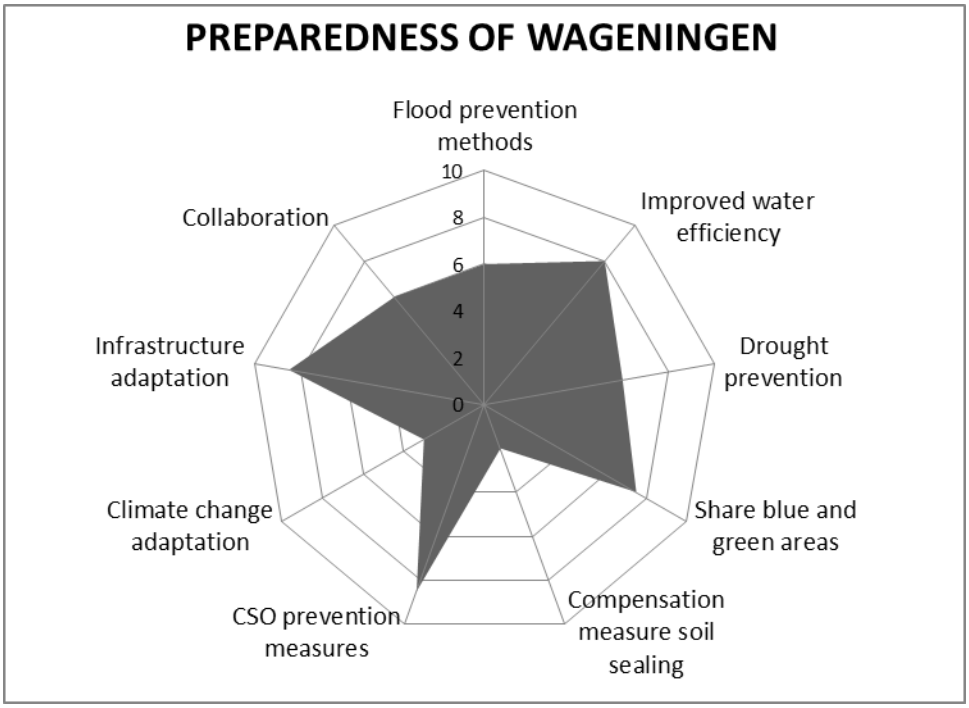

Figure 4b. Preparedness of Wageningen to climate change

Analysis of the spider diagram

- Wageningen is not very vulnerable to flooding because of the low frequency of flooding from the river Rhine and the low flooding of streets due to extreme rainfall events and projected frequency of flooding form the Rhine for the coming years are not expected to drastically increase any time soon and the Munciplaity is expected to adapt to change in the climate to keep the flood frequency due to extreme rainfall at the same level, with a desire in future to reduce water on streets to once every 5-50 years, however this will largely depend on political decisions, for instance. In any case, the city of Wageningen has the Deltacommittee in place to ensure measures are in place to protect Wageningen from potential future flood risks, with recommendations to strengthen the Grebbedijk, for example. Urban design is being looked at to direct water from rainfall events to storage infrastructure to avoid damage and further unnecessary challenges. Although 40% of the Wageningen population reside in flood prone areas, the measure in place and the low frequency of flooding could be the indication of proper measures in place to protect the citizens of Wageningen from potential flood threats.
- The Netherlands is among the low water stressed countries. Wageningen has no structural water shortage however, measures for the efficient use of water are in place such as water saving showerheads, rain water collection barrels, essentially issues at the local community level.
- Summer heat waves in Wageningen are relatively low, but, future projections are likely to increase, due to high level of construction in areas where green zones used to exist, people likely to look for measures in the form of energy consuming airconditioning. This could undermine Wageningen's ambition to become climate neutral by 2030. Several

technical measures are being put in place to mitigate these effects, for example, IF technology which has developed the Surface water energy concept or Aquifer Terminal Storage Systems for the cold winter months. Attention is also being put on green and blue areas within the core city.

- Soil sealing in Wageningen accounts for 25-49% having the potential to increase street flooding. However, with the low flood frequency and several design measures in place no specific measures are in place to limit, mitigate or compensate soil sealing.
- The frequency of combined sewer overflow is relatively low, with Wageningen putting in place the necessary measures to ensure a low frequency of combined sewer overflow with the changing climate.

Therefore, based on the assessment of this methodology, Wageningen would be considered as an "above average" city to the challenges of climate change on its water supply and sanitation system. However due to some indicators not applying to the city of Wageningen, thes results could be squed and not necessarily representative of the actual situation.

4 CONCLUSIONS

As part of the PREPARED project and the responsibilities of the International Water Association (IWA) in the work area 7 (Communication and Dissemination), IWA together with KWR Watercycle Research Institute (KWR) developed a methodology to assess the level of preparedness of the European cities in coping with the challenges of climate change. The results of this assessment are used to develop a brand 'PREPARED' to be applied to cities in order to showcase the most successful examples and accordingly, demonstrate European leadership in the area of preparedness to climate change.

The City of Amsterdam and Wageningen were chosen in order to try to estimate the viability and effectiveness of this methodology. Keeping in mind that the analysis is relatively subjective and should not be perceived as the true image of the city, and the time constraints when filling in the questionnaire, the findings would suggest Amsterdam to be a fully prepared city on its way to becoming and adaptive water sensitive city. In comparison, Wageningen has to consider some improvements to be better equipped to manage the future challenges of climate change on its water supply and sanitation systems.

Based on the results of the assessment it can be concluded that the methodology can be used as a rapid assessment of the current situation in a city determine what challenges there are to climate change and its related risks, assess the adaptation strategies that a city already has in place, and identifying areas that require some improvement. With the array of methodologies developed during PREPARED, measures can be put in place to better understand and move towards more adaptive solutions to cope with the challenges of a changing climate.

Nevertheless, the questionnaire should be further adjusted to better reflect the situation in cities. Further collaboration with the City Blueprint, and its developers would be hugely beneficial in attempts to move forward with the development and improvement of this methodology. Further tests in both PREPARED and non-PREPARED cities will provide useful and telling information on what questions are relevant and likely to provide significant indicators of a city's current situation. Furthermore, IWA with is vast membership data base provides a unique opportunity to tap into professional expertise valuable to make additional progress with the City Branding tool.

Lastly, questions should be chosen more carefully based on the information available and not on the desire of interviewer to know as much information as possible. Before sending it out, all efforts should be put toward answering the questions ourselves using information from public sources in order to prevent overloading of cities with unnecessary questions. Open questions should be limited and it is also recommended to consider risks and measures separately as was done for for Wageningen.

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6 ANNEX

6.1 Questionnaire on adaptation of the water sector of European cities to climate change

Key terms

Flood means the temporary covering by water of land not normally covered by water. This shall include floods from rivers, mountain torrents, Mediterranean ephemeral water courses, and floods from the sea in coastal areas, and may exclude floods from sewerage system (EU Flood Directive).

Water scarcity is defined as a situation where insufficient water resources are available to satisfy long-term average requirements. It refers to long-term water imbalances, combining long water availability with a level of water demand exceeding the natural recharge.

Drought can be considered as a temporary decrease of the average water availability.

The water exploitation index (WEI) is the mean annual total abstraction of freshwater divided by the mean annual total renewable freshwater resource at the country level, expressed in percentage terms.

Soil sealing is the loss of soil resources due to the covering of land for housing, roads or other construction work.

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Cities are requested to answer questions in bold (# 1, 3-4, 6, 7, 12-13, 15, 20-24, 26-28, 30). Remaining questions (# 2, 5, 8-11, 14, 16-19, 25, 29, 31) will be answered by IWA and KWR.

1. What is a frequency of floods in your city?

Indicate the frequency of floods in your city using the proposed scale (see the definition of flood under key terms):

0 = not applicable (no flooding)
1 = once in 100 to more than 500 years
2 = once every 50-100 years
3 = once every 5-50 years
4 = once every year to 5 years
5 = more than once a year

Your answer:

2. What is the projected flood frequency in your city for 2021-2050?

Indicate the projected frequency of floods in your city for 2021-2050 using the proposed scale:

0 = not applicable (no flooding)
1 = once in 100 to more than 500 years
2 = once every 50-100 years
3 = once every 5-50 years
4 = once every year to 5 years
5 = more than once a year

Your answer:

3. Have measures been taken to prevent flooding?

Assess the measures and indicate their level of implementation using the proposed scale:

0 – if no information is available on this subject
1 – if limited information is available in a national document
2 – if limited information is available in national and local documents
3 – if the topic is addressed in a chapter in a national document
4 – if the topic is addressed in a chapter at the national and local level
5 – if a flood response and prevention plan or its equivalent is provided in a publicly available document
6– as 5 and the topic is also addressed at the local website
7– if a flood response and prevention plan or its equivalent is implemented, clearly communicated to the public and early warning and forecasting system indicated in the plan is developed
8 – as 7 plus subsidies are made available to implement the plan and support the early warning and forecasting system
9 – as 8 plus annual reports are provided on the progress of the implementation and/or any other activity indicating that this is a very high priority implemented at the level of the local communities
10 – as 9 and the activity is in place for 3 or more years

Your answer:

4. What types of flood risk management measures are available to prevent/mitigate floods?

Indicate structural and non-structural measures you have in place to respond/prevent floods, such as dikes, levees, retarding basins, channel modifications, land use zoning, etc.

Please provide this information as text, as a report in PDF format or as links to corresponding websites.

5. What percentage of the urban area is under flood risk?

Indicate the percentage of the urban area under flood risk using the proposed scale:

0 = not applicable
1 = 0-5%
2 = 6-10%
3 = 11-20%
4 = 21-40%
5 = 41-100%

Information will be taken from the following website:
http://eyeonearth.org/templates/eoebasicviewer/index.html?appid=1867f796c7aa43b593fbdcc525f8bf15

6. What percentage of inhabitants lives in a flood prone area?

Indicate the percentage of inhabitants living in a flood-prone area according to the flood risk map required by the EU Floods Directive.

Formula for the indicator on a scale from 0 to 10: percentage/10

Use the proposed scale:

0 = not applicable
1 = 0-5%
2 = 6-10%
3 = 11-20%
4 = 21-40%
5 = 41-100%

Your answer:

7. Which measures are taken by the government to protect the most vulnerable groups affected by flooding?

Provide some information on the measures that are taken by the national, regional or local government to protect the most vulnerable groups affected by flooding such as, for example, neighbourhood planning, different funding mechanisms, etc.

Please provide this information as text, as a report in PDF format or as links to corresponding websites.

8. What are the observed changes in annual precipitation from 1961 till 1990?

Indicate the observed changes in annual precipitation (%) from 1961 till 1990 using the proposed scale:

0 = not applicable
1 = -20 to -12%
2 = -12 to -4%
3 = -4 to 4%
4 = 4 to 12%

5 = 12 to 20%

Information will be taken from the following website:
http://www.eea.europa.eu/data-and-maps/figures/projected-changes-in-annual-and-1

9. What is the observed increase in intensity of precipitation (%) since 1961?

Indicate the observed increase in the intensity of precipitation (%) since 1961 using the proposed scale:

0 = not applicable (no increase in intensity)
1 = increase from 1 to 10%
2 = increase from 11 to 20%
3 = increase from 21 to 30%
4 = increase from 31 to 40%
5 = increase by more than 40%

Your answer:

10. What is the projected change in extreme precipitation?

Indicate the projected change in annual mean number of days with extreme precipitation (>20 mm/day) for 2071-2100 using the proposed scale:

0 = not applicable
1 = -8 to -5
2 = -4.9 to -1.0
3 = -0.9 to 1.0
4 = 1.1. to 5.0
5 = 5.1 to 13

Information will be taken from the following website:
http://eyeonearth.org/templates/eoebasicviewer/index.html?appid=25dbcdaecec84e7aa58b5b64519e7ba4

11. What is a water exploitation index of your country?

Indicate the water exploitation index of your country.

Information will be taken from the following website:
http://www.eea.europa.eu/data-and-maps/figures/water-exploitation-index-based-on

12. Have measures been taken to prevent and handle water scarcity and drought?

Assess and indicate the level of implementation of measures to protect citizens from water scarcity related to climate change using the proposed scale:

0 – if no information is available on this subject

1 – if limited information is available in a national document
2 – if limited information is available in national and local documents
3 – if the topic is addressed in a chapter in a national document
4 – if the topic is addressed in a chapter at the national and local level
5 – if a local policy plan is provided in a publicly available document
6– as 5 and the topic is also addressed at the local website
7– if plans are implemented and clearly communicated to the public
8 – as 7 plus subsidies are made available to implement the plans
9 – as 8 plus annual reports are provided on the progress of the implementation and/or any other activity indicating that this is a very high priority implemented at the level of the local communities
10 – as 9 and the activity is in place for 3 or more years

Your answer:

13. Which measures have been taken by the city to prevent and handle water scarcity and drought during the last 5 years?

Select the measure(s) that has(have) been taken by the city to prevent and handle water scarcity during the last 5 years including measures imposed on water consumers using the proposed options:

- No measures have been taken

- "Grey" measures (construction measures such as buildings, technical and transport infrastructure, dikes and other technical protection constructions using engineering services. For example, water saving devices, rain water harvesting systems, grey water recycling systems, etc.)

- "Green" measures (interconnected network of natural and green man-made features, such as forests, extensive grasslands, wetlands, but in urban areas also parks, gardens, cemeteries, trees at streets, green walls and roofs. For example, rain water storage in wetlands and water bodies for later use)

- "Soft" measures (non-physical measures such as policies, plans, programmes, procedures. For example, drought and water management plans, forecasting and early warning systems, etc.)

14. Have measures been implemented to improve water efficiency in your city?

Assess and indicate the level of implementation of measures to improve water efficiency in your city using the proposed scale:

0 – if no information is available on this subject
1 – if limited information is available in a national document
2 – if limited information is available in national and local documents

3 – if the topic is addressed in a chapter in a national document
4 – if the topic is addressed in a chapter at the national and local level
5 – if a local policy plan is provided in a publicly available document
6– as 5 and the topic is also addressed at the local website
7– if plans are implemented and clearly communicated to the public
8 – as 7 plus subsidies are made available to implement the plans
9 – as 8 plus annual reports are provided on the progress of the implementation and/or any other activity indicating that this is a very high priority implemented at the level of the local communities
10 – as 9 and the activity is in place for 3 or more years

Your answer:

15. Provide more details on the type of measures implemented to improve water efficiency?

Indicate technology and infrastructure that are used to improve water efficiency.

Please provide this information as text, as a report in PDF format or as links to corresponding websites.

16. What is heat wave risk in your area?

Indicate the number of combined tropical nights (T>20°C) and hot days (T>35°C) for the past 40 years using the proposed scale:

0 = not applicable
1 = 0-9
2 = 10-21
3 = 22-29
4 = 30-37
5 = 38-50

Information will be taken from the following website:
http://eea.maps.arcgis.com/home/webmap/viewer.html?webmap=d4124af689f14cbd82b88b815ae81d76

17. What is the projected heat wave risk in your city in 2021-2050?

Indicate the projected number of combined tropical nights (T>20°C) and hot days (T>35°C) in 2021-2050 using the proposed scale:

0 = not applicable
1 = 0-9
2 = 10-21
3 = 22-29
4 = 30-37
5 = 38-50

Information will be taken from the following website:

http://eea.maps.arcgis.com/home/webmap/viewer.html?webmap=d4124af689f14cbd82b88b815ae81d76

18. What is the share of green and blue urban areas of core city (%)?

Indicate the share of green (vegetated) and blue (water) areas within the core city using the proposed scale:

0 = not applicable
1 = <20%
2 = 20-29%
3 = 30-39%
4 = >39%

Information will be taken from the following website:
http://eea.maps.arcgis.com/home/webmap/viewer.html?webmap=a2fb2779796a4b85bf6f7344fd13c4a5

19. What amount of the surface is impermeable (therefore, increasing flood risk), specifically what is the mean percent soil sealing of the urbanized area of the core city?

Indicate the mean percent soil sealing of the urbanized area of the core city using the proposed score:

0 = not applicable
1 = 0-6%
2 = 7-24%
3 = 25-49%
4 = 50-74%
5 = 75-100%

Information will be taken from the following website:
http://eea.maps.arcgis.com/home/webmap/viewer.html?webmap=36ca1efffcce4fd7ac7cab48df51e9c2

20. What types of measures are implemented to limit, mitigate or compensate soil sealing?

Indicate the level of implementation of measures to limit, mitigate or compensate soli sealing using the proposed scale:

0 – not applicable
1 – no specific measures at place at the national level
2 – first measures initiated at the national level (indicate the measures)
3 – several measures implemented at the national level (indicate the measures)
4 – as 3 plus first measures initiated at the local level (indicate the measures)
5 – as 3 plus several measures implemented at the local level (indicate the measures)

Your answer:

21. What is a frequency of combined sewer overflow?

Indicate the frequency of combined sewer overflow using the proposed scale:

0 = not applicable (separated infrastructure for storm water and wastewater)
1 = 1-4 times per year
2 = 5-10 times per year
3 = 11-20 times per year
4 = 21-30 times per year
5 = > 30 times per year

Your answer:

22. How do you use PREPARED tools to control and minimise with combined sewer overflow?

Indicate how you use PREPARED tools to tackle combined sewer overflow.

Please provide this information as text, as a report in PDF format or as links to corresponding websites.

23. How do you use technology to maintain water quality?

Indicate how you use technology to maintain water quality.

Please provide this information as text, as a report in PDF format or as links to corresponding websites.

24. What kind of monitoring equipment do you have?

Select the type of monitoring equipment(s) that is(are) used in your city.

- Water quality sensors
- Water discharge sensors
- Radars
- Rain gauges
- Rainfall measurements by network of cell phone antennas
- Real time decision support system

25. Have measures been taken to adapt to climate change?

Assess and indicate the level of implementation of climate change adaptation measures in your city (e.g. green roofs, water squares, climate change adaptation plan, etc.) using the proposed scale:

0 – if no information is available on this subject
1 – if limited information is available in a national document
2 – if limited information is available in national and local documents
3 – if the topic is addressed in a chapter in a national document
4 – if the topic is addressed in a chapter at the national and local level
5 – if a local policy plan is provided in a publicly available document
6– as 5 and the topic is also addressed at the local website
7– if plans are implemented and clearly communicated to the public
8 – as 7 plus subsidies are made available to implement the plans
9 – as 8 plus annual reports are provided on the progress of the implementation and/or any other activity indicating that this is a very high priority implemented at the level of the local communities
10 – as 9 and the activity is in place for 3 or more years

Your answer:

26. Do you address potential risk health associated with the climate change in a water cycle safety plan?

Climate change related challenges such as flooding, drought and increased temperature can cause potential risks to human health, such as drinking water quality, health risks related to combined sewer overflows on receiving surface water and bathing water, health risks of storm water/rainwater on the streets. All aspects of health risks are systematically identified in the so-called water cycle safety plans. This question aims to assess the preparedness with respect to the health risks associated with climate change.

Indicate to which extend are potential health risks associated with climate change addressed using the proposed scale:

0 – Not considered
1 – Limited to risks associated with drinking water quality
2 – Limited to risks associated with drinking water quality and of combined sewer overflows on receiving (bathing) waters
3 – Risks associated with drinking water, CSO's/receiving water and storm water on the streets
4 – Systematic approach to potential risks e.g. WCSP produced and in place.

Your answer:

27. How do you adapt infrastructure design of water and waste water utilities to climate change?

Climate change scenarios produced by the IPCC have a high level of uncertainty. This has an impact on the projected challenges at local and city level. The question is how far have climate change predictions - taking into account the level of uncertainty (balance between risk and cost) - affected the decision-making processes on adaptation of existing infrastructure and investment on renewal/enlargement of infrastructure.

Indicate, to which extend has climate change an impact on your infrastructure decision-making and investment strategy using the proposed scale:

0 – No impact at all on decision-making and investment strategy
1 – Some impact e.g. only investments with short return on investment decisions are made e.g. electronic equipment with short depreciation time
2 – Significant impact e.g. only investments with short to medium return on investment time decisions are made e.g. electronic and mechanical equipment. Long-term major investments are postponed.
3 – Very significant impact such as a completely new approach to decision-making and investment strategy based on 'no-regret' scenario and more adaptations are based on flexible and step-wise investments. This could also be adaptation measures involving hybrid solutions.

Your answer:

28. What type of climate proofing has been incorporated into infrastructure design of water supply, storm water and wastewater utilities?

Provide more detail on the type of climate proofing that has been incorporated into infrastructure design of water supply, storm water and wastewater utilities.

29. What is GDP per capita in the city?

Indicate GDP per capita in the city using the proposed scale:

0 = not applicable
1 = < 5 000 EUR
2 = 5 000 - 10 000 EUR
3 = 10,000 - 20 000 EUR
4 = 20 000 - 30 000 EUR
5 = > 30 000 EUR

Information will be taken from the following website:
http://eea.maps.arcgis.com/home/webmap/viewer.html?webmap=7194d938309b498a98e2ea5295178f31

30. What is the level of collaboration between different players in the urban planning and development sectors in the city?

Indicate the level of collaboration between different players in the urban planning and development sectors in the city.

0 – not applicable (no collaboration)
1 – local collaboration includes governmental organizations only
2 – collaboration also includes NGOs
3 – collaboration also extends to industry/private companies
4 – as 3 but also research organizations are involved

5 – as 4 but also citizens are involved

Your answer:

31. What is the public participation of the city?

Participation of citizens in voluntary organizations shows their willingness to be engaged in different activities not associated with their professional life. Index of voluntary participation is available only by country:
http://www.eurofound.europa.eu/pubdocs/2006/76/en/1/ef0676en.pdf