Application of Sustainability Indicators within the framework of Strategic Planning for Integrated Urban Water Management

A training manual for Process Facilitators of Urban Strategic Planning processes

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Sustainable Water Management in the City of the Future

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BACKGROUND OF THE TRAINING MANUAL

This training manual was prepared as part of the SWITCH[1] project. It is best read and used as an addition to the SWITCH Training Kit. The SWITCH Training Kit is a comprehensive training package for water managers, urban planners and engineers from local governments and water, wastewater and drainage utilities[2]. It covers the topic of Integrated Urban Water Management and includes modules on Strategic Planning, Stakeholder Involvement, Sustainable Solutions and Decision Making. This training manual is especially related to Module 1: Strategic Planning: Preparing for the future.

This manual contains an introduction to Integrated Urban Water Management (Chapter 1) and describes the steps that a local government or utility could take in order to select and implement a set of indicators to monitor, plan and manage the urban water system (Chapter 2). In Chapter 3 a set of indicators is presented that is relevant for most cities and that could be used as a starting for a city to define its own set of indicators.

The following resources are recommended to those that would like more information on the use of indicators for urban water management:

- A literature review on Sustainability Indicators for Assessment of Urban Water Systems by Torres (2011) can be found at: http://www.switchurbanwater.eu/outputs/pdfs/W1-1_GEN_RPT_D1.1.2a_Background_approach_-_Annexes.zip
- An interesting case is the city of Tel Aviv, where the strategic planning process and the development of indicators is well documented. For the Strategic Planning process see: http://www.tel-aviv.gov.il/english/StrategicProgram.htm . For the indicator selection see: http://www.switchurbanwater.eu/outputs/pdfs/W1-1_CTEL_RPT_D1.1.5_Strategic_Planning_Process_-_Tel-Aviv.pdf. And for a scientific publication on integrated urban water management and indicators in the city by Tong et al. (2011) see: http://www.tandfonline.com/doi/abs/10.1080/1573062X.2010.546861

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[1] SWITCH - Managing Water for the City of the Future' was an action research project, implemented and co-funded by the European Commission and a cross-disciplinary team of 33 partners from 15 countries around the world. The project ran from 2006 to 2011, and its aim was to bring about a paradigm shift in urban water managemetn away from existing ad hoc solutions towards a more coherent and integrated approach.

[2] Accessible through www.switchtraining.eu

1. Introduction to Integrated Urban Water Management

Integrated Urban Water Management (IUWM) is a concept that is based on the recognition that the urban water system is best designed and managed in a holistic manner. The urban water system comprises:

- water supply infrastructure
- sanitation infrastructure
- drainage infrastructure
- natural water bodies
- institutional and non-institutional stakeholders
- mechanisms for financing, operating and managing the infrastructure

Design and management of the above listed elements separately, or even in isolation of the other elements is likely to result in inefficiencies. Design and management of the urban water system based on an analysis of the entire urban water system will lead to more sustainable solutions than separate design and management of elements of the system (Van der Steen and Howe, 2009)

IUWM was first described by Mitchell (2004) as an approach in which:

- all parts of the water cycle are considered as an integrated system;
- all dimensions of sustainability are balanced;
- all stakeholders including all water users are involved;
- all water uses are taken into account; and
- all specifics of the local context are addressed.

1.1 A CHANGING WORLD; CHALLENGES FOR URBAN WATER MANAGERS

Increasingly, urban water managers all over the world are facing a series of global changes, that are mostly changes for the worse and therefore pressures on the urban water system. The changes include the following:

Climate change - Precipitation patterns are changing towards more intense storms at the one hand and longer periods of drought at the other hand. More intense storms lead to an increased risk of flooding because of non-existent or insufficient drainage system capacity. Cities in delta regions may also have to cope with sea level rises, while at the same time the fluctuations in river discharge are expected to increase. This may cause extreme high water levels and flooding, or during low river discharge it may also result in invasion of saline water.

Governance and policies - The trends in governance and policies may be different depending on the region in the world, but many local governments are faced by the results of decentralisation. Local government see that responsibilities in water management are transferred from higher levels of government to the municipal level. This requires an improved capacity at the municipal level for urban water management. In the European context the Water Framework Directive is prescribing an increased involvement of stakeholders in the management of water resources, at the scale of the river basin. Decisions and plans are no longer made top-down, but joint decision making involving citizens 'of age' is likely to increase. At the institutional level different forms of cooperation emerge. No longer are only government institutions providing water services to cities. There is a landscape of different models of governance and institutional arrangements. Lack of investment means by governments and the real or perceived inefficiency of public institutions has prompted the participation of the private sector. Whether this trend will continue will depend to a large extent on the ability of governments to establish effective regulators.

Population growth and urbanisation

An unprecedented growth of the urban population is a major driver for urban water management, especially in the developing world. Growth rates of up to 4% per year put cities in developing countries for almost impossible challenges. Cities, in principle, are vulnerable because they rely heavily on external resources (water, food, energy, etc.) that need to be imported from outside the city. Planning the cities expansion, providing shelter, energy, water, food and health care is needed (every year!) for numbers of people that equal the population of large towns. Population in urban areas in less developed countries will grow from 1.9 billion in 2000 to 3.9 billion in 2030. On the other hand, in developed countries, the urban population is expected to increase only from 0.9 billion in 2000 to 1 billion in 2030 (UN, 2006). Some European cities are even facing a decrease in the number of its inhabitants or a significant change in the composition of the population (less 'productive' people). Cities that face an increased urban water demand may decide to construct large infrastructural works to transport water from longer and longer distances, creating environmental damage in the cities hinterland. Groundwater table lowering due to overabstraction is already reality in many cities. Rapidly growing cities also generally face major difficulties in providing water services to especially the immigrants within their borders. Informal, unplanned areas generally lack basic water supply and sanitation and form an important target group for reaching the Milennium Development Goals on water and sanitation.

Deterioration of infrastructure systems

In those cities where major water infrastructure was put in place during the previous century, urban water managers will increasingly be confronted with deterioration of infrastructure, especially pipe networks. In many parts of Europe, pipes are over 100 years old and the cost of rehabilitation of water infrastructure system is increasing substantially. The amount spent on asset rehabilitation programmes will further increase over the coming decades due to the synergetic effects of infrastructure ageing, urbanisation and climate change. Infrastructure deterioration will impact on the public health, environment, and institutions in various ways. Higher rate of water leakage means higher water losses and higher chances of in-filtration and ex-filtration of water. This will create higher chances of drinking water contamination and outbreak of water-borne disease.

Changes in public priorities

Increasingly people in Europe express personal identity through the type of food they consume (regular, organic) and the energy supply source (green energy or private solar panels) they use. This could also affect the priorities of citizens towards water and it could result in a favourable attitude towards decentralised (therefore more personal) ways of water treatment and wastewater treatment. Though these decentralised options may not always be more environmental friendly or use less energy, personal preferences may still be more important in technology choice.

Emerging technologies

Technological innovation in the water sector is an on-going process which has changed the range of options for urban water management and will continue to do so. The improvement of membrane technologies, especially the reduction in energy requirements and the increasing robustness of these systems has changed already the water and wastewater treatment industry. Application of membrane technologies at decentralised scale in households, shopping centers, universities etc. could completely change the urban water system and open up possibilities for large scale decentralised urban recycling. Development of microbial fuel cells and other technologies to recover energy from wastewater may change the way we deal with wastewater completely.

Energy costs

Though water supply and wastewater management consume energy to the equivalent of not more than 5-10 % of total domestic electricity consumption, also the water sector can contribute to efforts to reduce overall urban energy consumption. More efficient pumps, low energy technologies for water treatment and energy recovery (thermal, chemical) from wastewater are the ongoing developments.

Given these changes, urban water managers are facing the challenge of planning for and managing an urban water system that provides safe drinking water, protects citizens from flooding and deals with wastewater in such a way that the health and environmental impact is minimized and resources are recovered. A truly sustainable urban water system would achieve those objectives not only in the present but also in a changing world, for future generations.

1.2 SUSTAINABILITY OF URBAN WATER SYSTEMS

Sustainability of an urban water system depends on how it functions in relation to social, economic, environmental and technical criteria. The system should be fit to deliver services to the inhabitants of the city, while preserving the integrity of the environment, especially the surface waters upstream and downstream from the city and the groundwater. Though many cities in the developed world do deliver these services, this not always happens in a truly sustainable manner, for instance because the services are delivered at the expense of relatively high energy consumption. Therefore it is important to develop or use technologies and methods that do deliver the services, but with a minimal negative or even positive impact on the environment and the socio-economy of a city.

In many cities in the developing world the service levels are so low, that operators, planners and decision makers are primarily concerned with service provision and the sustainability of the service itself on the short to medium term (5-15 years), and not so much with the long term sustainability (20-50 years) of the system in view of the global change pressures. Since the starting point is a very low service level, this is completely understandable. Still, not taking into account the long-term sustainability may also lead to malfunctioning of systems in the longer run and therefore inefficient use of budgets. It would therefore be better to include in the design of the system methods and technologies that are able to function and deliver services also under changed circumstances.

The following are examples of questionable sustainability:

- The construction of infrastructure funded by external funds (central government funds, international donors, etc.) that cannot be operated and maintained from local government budgets. For instance because cost-recovery from users is insufficient.
- The selection of technologies that cannot be operated and maintained by local government because of the complexity of the technology or because of reliance on non-available spare-parts, etc.
- The selection of technologies on the basis of capital costs, rather than total life cycle costs.
- The use of technologies which are affordable for only a (small) part of the population.
- The use of technologies that require high per capita water consumption(such as a water borne sewer systems), in situations where the water is not available or not delivered to customers
- The use of technologies that proliferate infectious diseases, such as the unimproved forms of water supply and sanitation
- The use of technologies that are not supported by the stakeholders (institutional or private) and therefore not well operated and maintained.
- Etcetera

Sustainable solutions[3] are on the other hand characterized by:

- Broad support by stakeholders, both institutional and private, government and NGOs.
- A match between the complexity of the technology and the technical skills of the local water sector. Capacity building must be given priority, not only on a project basis, but as an on-going strategic activity for the sector.
- Enhancing the efficient use of resources (water, chemicals, energy, space)
- Efficient in removing pollutants, or preferably in recovering resources (energy, nutrients and water) from wastewater.
- Reaching multiple objectives at the same time, such as protection health and safety, economic development, social development and environmental protection or enhancement.
- Flexibility, meaning that the solution will work not under only one expected future condition, but will still work under other future conditions.

[3] Sustainable solutions are explored in detail in SWITCH training kit modules 3, 4 and 5. Accessible at www.switchtraining.eu

1.3 STRATEGIC PLANNING FOR URBAN WATER SYSTEMS

Planning of the urban water system requires information on expected growth in population, per capita water demand and wastewater production, expected industrial developments, changes in government regulations, etc. In addition, the urban water sector needs a more strategic long term 'vision' of how one would like the urban water system to be shaped and to function in 30-50 years from now. Such a vision does not usually emerge from a technical planning exercise, but requires a strategic planning process.

The goal of a strategic planning process is to generate a plan that gives direction to masterplans, medium-term and yearplans of municipalities, utilities and waterboards. A strategic plan spells out the long term strategy that the public and private sector in a city will take towards achieving the objectives or the vision for the city's water system. If the plan is developed jointly by all stakeholders involved and there is general agreement on the strategy, then the plan may well become a powerful tool to steer the city towards sustainability.

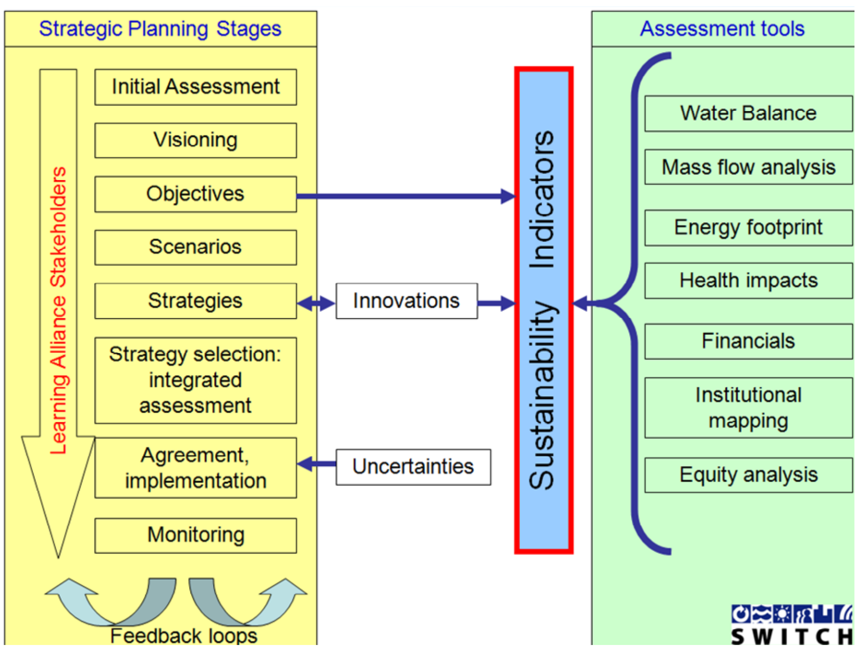

Figure 1. Overall SWITCH Strategic Planning framework

The steps and elements of the planning process are shown in Figure 1. The process starts by forming a Learning Alliance in which all stakeholders of the urban water sector are represented[4]. The Learning Alliance members jointly define a vision, which is a qualitative picture of the desired future for the water system. The vision is subsequently made operational through the formulation of objectives and sustainability indicators. Assessment tools can be used to score the indicators. After the objectives have been agreed, it is necessary to consider the external factors that are not controlled by urban water managers, but that are nevertheless very important for urban water management, such as climate change, population growth, customer preferences, etc.

Once the potential scenarios have been formulated, different actions or strategies can be considered. These may include for instance the application of Water Demand Management actions, or new technologies for wastewater collection and treatment, or the application of Sustainable Urban Drainage Systems[5]. It is important to include innovative strategies and not only repeat the application of known technologies.

Different possible strategies should be presented to decision makers, but in order for the plan to be implementable a choice must be made on which strategy to start implementing. An honest evaluation of uncertainties in both scenarios and the effect of strategies should be included in the decision making process.

The whole process of formulating the strategic plan may take 1-3 years, and may need an update every 5-10 years. The plan needs to take into account the uncertainty around the changes and therefore needs to be build on a flexible strategy, using technologies and methods that are flexible and that can be applied under different future scenarios. The nature of a strategic plan is cross-sectoral, it takes a broad view that includes all aspects of the urban water system and even aspects that traditionally are not considered to be the responsibility of the water sector, such as energy issues and urban planning. The plan can only address all aspects, if all stakeholders are involved in its preparation.

Implementation of the plan through the public and private sector will affect the general state of the urban water system. The developments in the state of the urban water system (rather than the performance of organisations) may be monitored in order to evaluate the effectiveness of the strategy and its implementation. A monitoring system based on data collection and the formulation of a number of indicators (such as the total discharge of nutrients from the system, or the total energy use in the system) will help the city evaluate whether it is moving towards its vision for a sustainable urban water system, or not.

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[4] Learning Alliances are discussed in detail in SWITCH training kit module 2. Accessible at www.switchtraining.eu

[5] Sustainable solutions are explored in detail in SWITCH training kit modules 3, 4 and 5. Accessible at www.switchtraining.eu

It is important to realise that the state of the urban water system and the score of the indicators supersedes the traditional sub-sectors. To achieve the desired state of the urban water system therefore requires an integrated strategy, that acknowledges that the various elements of the urban water system interact. The changes in the system elements and their effects are all interlinked. It is crucial that system boundaries are wide enough, not to externalize important effects, either in space or time. Too narrow system boundaries will result in 'harmful suboptimization' (Hellström et al., 2000).

2. PROCESS OF INDICATOR DEVELOPMENT AND USE BY LOCAL GOVERNMENT

2.1 DEFINITIONS OF INDICATORS, TARGETS AND PERFORMANCE

2.1.1 GENERAL DEFINITION OF A SUSTAINABILITY INDICATOR

An *indicator* that is used for purposes of urban water management indicates the state of the urban water system, or changes in the state of the urban water system. The state of the urban water system is here understood as the condition of the infrastructure, the quality of the ecological components, the water-related well-being of the population and the performance of its institutions. The state of these system elements is expressed by the indicators, preferably in a quantitative manner, but sometimes qualitatively.

Table 1 The PSR model applied to the problem of eutrophication

Issue	**PSR**	**Core indicator**
Eutrophication	Pressure	Emissions in water of N and P from point sources (untreated wastewater or effluent)
		Emission in water of N and P from diffuse sources such as agriculture and stormwater.
	State	Concentration BOD and DO in inland water or in marine waters
		Concentration of N and P in inland waters or in marine waters
	Responses	Population connected to sewage treatment plants
		Total fee charged for pollution discharged into municipal sewer
		Market share of phosphate-free detergents

The state of the various system elements may be 'sustainable', 'moving towards a sustainable state' or 'moving away from a sustainable state'. The latter two expressions are more suitable for practical use in urban water management, since it is doubtful whether it is possible to define what is a really 'sustainable state'. For example, in terms of energy use in water systems, one may argue that the only 'sustainable state' is a system that does not use any non-renewable energy. For practical purposes, it may be more beneficial to aim for a reduction in the use of non-renewable energy, i.e. aim to move 'towards sustainability'.

Elements of the urban water system are subject to cause-effect relations. For instance, the state of surface water quality is affected by natural causes, such as changes in precipitation patterns, but also by human causes, such as the provision of good collection systems and wastewater treatment plants. Indicators may describe either the causes or the effects. For instance, an indicator may describe the change in permeability (for rainwater infiltration) of an urban area, while another indicator may give the number of combined-sewer overflows. The first indicator describes a cause, while the second one describes an effect.

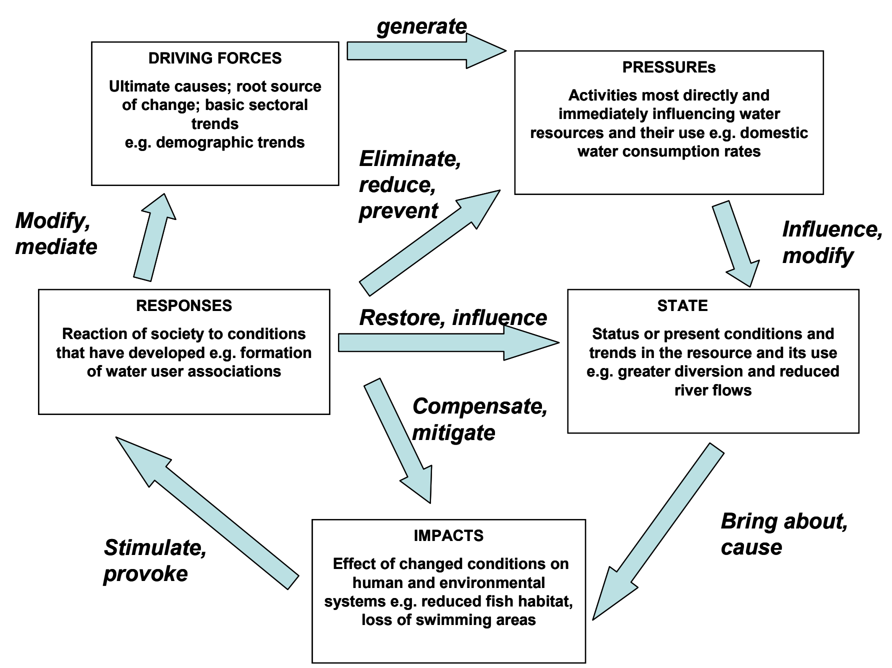

Figure 2. The DPSIR model

The cause-effect relations may be analysed in more detail by using a model that distinguishes *drivers*, which lead to *pressures*, which affect the *state* of the system. The state of the system then causes *impacts*, which trigger a *response* from society. This model is called the DPSIR model (Figure 2; OECD, 2003). The response then may again affect the drivers, the pressures, the state or the impact. Table 1 gives an example of a simplified model, the PSR model, applied to the problem of eutrophication.

Indicators are more than only 'pieces of data', rather indicators give information that summarise important properties of system elements, quantify trends and visualize and communicate them to relevant target groups (Lunding and Morisson, 2002). This communication can only be successful if the indicator condenses information, often large amounts, into a recognizable pattern (Bossel, 1999).

It is unavoidable that decision makers base decisions on a limited set of indicators and on indicators which use only part of the available information on the urban water system. Otherwise the whole procedure would become too complicated, cumbersome and expensive. Therefore, indicators and indicator sets are also filters that select what kind of data stakeholders choose to take into account and what data they wish to neglect (Baghery and Hjorth, 2006).

2.1.2 Measures of state and progress

A suit of expressions is used in the literature on measuring the sustainability of urban systems. It is important that it is clear to all stakeholders in a strategic planning process what the meaning of those words and expressions is. Therefore this paragraph discusses the various expressions and proposes which terminology to use.

Indicator, measure of performance, performance indicator

An indicator describes an attribute of the urban water system or of one or a group of its elements, at one point in time or as a time series. It is a neutral expression, which only gets a positive or negative meaning after comparing the value of the indicator with agreed objectives. Measures of performance or performance indicators have a very similar meaning, though they are usually only applied to measure the performance of an organisation. Indicators can be used to express the state of the system, as well as the performance of organisations.

> *It is therefore proposed to use the term 'indicator'.*

Objectives, targets, goals, vision

A vision is a narrative qualitative expression of the ambition of planners regarding the urban water system. It describes the desired future state, mostly in general terms (McIntyre and Butterworth, 2011). Goals and objectives are more precise, often quantitative, descriptions of the desired state of the system. The goal or objective also includes a statement on the timeline by which it is planned to be achieved. Targets are the fully quantifiable equivalent of goals and objectives.

> *To be in line with the literature on strategic planning, it is proposed to use the term 'objectives'.*

Indicator title, expression and unit

Indicators can be split in 3 elements, the title, a short expression and the unit. For instance, the title is 'Water quality', the expression is 'Extension of river stretches into water quality categories according to the official classification methodology', and the unit is 'fraction of total river length of a certain water quality category' (Ioris et al. 2008).

Criteria, benchmark, satisfactory ranges

Criteria specify the desired maximum or minimum values for indicators. Such criteria can for instance be specified for the concentrations of pollutants in wastewater. For other indicators, such as for instance the 'response time to customer complaints' a satisfactory range is more appropriate. Benchmarking is a process by which measures of performance of organisations delivering similar services, but in a different city or region, are compared. The results of the comparison are then used to identify room for improved performance at the weaker organisations.

Data in time series, reliability, resilience, vulnerability

The value or score of an indicator is not static but will change in time and therefore an indicator should be presented to decision makers as a time series. It was suggested by Loucks (1997; in Sahely et al., 2005) to analyze the time series using statistical measures such as:

- Reliability - probability that an indicator scores satisfactorily
- Resilience - indicates speed of recovery from an unsatisfactory condition
- Vulnerability - measure of the extent or duration of the unsatisfactory condition

These statistical measures are especially relevant for indicators with a relatively high frequency of being measured and reported. In case an indicator summarises the information of an entire year the variability from one year to another is expected to be small, and therefore these measures are less relevant for such long-term indicators.

In summary, indicators are used to monitor and measure the state of the environment by considering a manageable number of variables or characteristics (McLaren and Simonovic, 1999; in Sahely et al.2005). An indicator can be scored or quantified by comparing it to an objective. An indicator is expressed in a unit, for instance kgBOD/capita/year. The indicator may indicate whether an objective has been achieved or not (yes or no) or the extent to which a criteria has been achieved (for instance expressed as a percentage of the target).

When using indicators to compare different options, the value of an indicator for a certain option could be scored in relation to the value of the same indicator for other options. For instance, 'better than the business-as-usual-option', 'worse than the business-as-usual-option' or 'a score of 30% of the best scoring option'.

2.1.3 Examples

Probably the best known objectives are the Millenium Development Goals (MDGs). The MDGs have formulated objectives at the level of countries, to be achieved by 2015. UNHABITAT has developed, on the basis of the MDGs, a list of Urban Indicators. The Urban Indicators include 5 indicators that are directly related to the urban water system:

- Access to safe water
- Access to improved sanitation
- Price of water
- Water consumption
- Wastewater treated

The MDG indicator 'Access to safe water' is described in Box 1. Note that the goal in the indicator in this case is not quantifiable. The indicator description includes the methodology to collect data and to calculate the score of the indicator. Other relevant indicator lists were developed by UNDP, the OESO, the World Water Assessment Programme (see Box 2) and the UN Commisison on Sustainable development (Torres, 2011).

Box 1. MDG Indicator 4: Access to safe water

Habitat Agenda Goal: Promote access to basic services

Rationale

Water is one of the great necessities of human life, which is taken for granted in the developed world. A supply of clean water is absolutely necessary for life and health, yet almost 2 billion people lack access to adequate water supply or can only obtain it at high prices. In many cities, households in information settlements are rarely connected to the network and can only rely on water from vendors at up to 200 times the tap price. Improving access to safe water implies less burden on people, mostly women, to collect water from available sources. It also means reducing the global burden of water related diseases and the improvement in the quality of life.

This indicator monitors access to improved water sources based on the assumption that improved sources are likely to provide safe water. Unsafe water is the direct cause of many diseases in developing countries.

Definition

Proportion of the population with sustainable access to an improved water source, urban, is the percentage of the urban population who use any of the following types of water supply for drinking: piped water, public tap, borehole or pump, protected well, protected spring or rainwater. The water should be affordable and at a sufficient quantity that is available without excessive physical effort and time. Improved water sources do not include vendor-provided waters, bottled water, tanker trucks or unprotected wells and springs.

Methodology

This indicator requires definitions adapted to the local context for several elements:

- Affordable: water should not take an undue proportion of the household income, i.e. less than 10%
- Sufficient quantity: water should be available at a quantity of at least 20 liters per person per day
- Without excessive efforts and time: obtaining water for the household should not take an undue proportion of the household's time (less than one hour a day for the minimum sufficient quantity of at least 20 liters per person per day)

Data collection and sources: Two data sources are common: administrative or infrastructure data available from public, parastatal or private companies in charge of water supply, that report on new and existing facilities, and data from household surveys, including DHS, MICS, and LSMS.

Computation: The indicator is computed as the ratio is the number of urban population who use piped water, public tap, borehole or pump, protected well, protected spring or rainwater to the total urban population expressed as a percentage.

Gender

Women and men usually have different roles in water and sanitation activities. Women are most often the users, providers and managers of household hygiene. If the water system breaks down, women are more likely to be affected than men because htey have to use other means and travel in order to meet the household's water needs.

Comments and limitations:

When data from administrative sources are used, they generally refer to existing water sources, whether used or not. The judgment about whether a water source is safe is often subjective. Also, the existence of a water supply does not necessarily mean that it is safe or that local people use it. For these and other reasons, household survey data are generally better than administrative data, since survey data are based on actual use of sources by the surveyed population rather than the simple existence of the sources. While access is the most reasonable indicator for water supply, it still involves severe methodological and practical problems. Among them: the data are not routinely collected by 'the sector', but by others outside the sector as part of more general surveys, and water quality is not systematically addressed.

Box 2. Indicators of the World Water Assessment Programme (2006)

Challenge Area	Indicators	DPSIR aspect	Status
Global	Index of non-sustainable water use	Response	K
	Urban and rural population D B	Driving force	B
	Relative Water Stress Index S/P K	State / Pressure	K
	Domestic and Industrial Water Use D B	Driving Force	B
	Water Pollution Index P K	Pressure	K
	Sediment Trapping Efficiency Index P K	Pressure	K
	Climate Moisture Index (CMI) D K	Driving Force	K
	Water Reuse Index (WRI) P K	Pressure	K
Governance	Access to information, participation and justice R D	Response	D
	Progress toward implementing IWRM R K	Response	K
Settlements	Index of Performance of Water Utilities S D	State	D
	Urban Water and Sanitation governance index S D	State	D
	Slum Profile in Human Settlements P D	Pressure	D
Resources	Precipitation annually D B	Driving force	B
	TARWR volume (total actual renewable water resources)	State	K
	TARWR per capita	State	D
	Surface water (SW) as a % of TARWR	State	D
	Groundwater development (GW % of TARWR)	State	K
	Overlap %TARWR	State	D
	Inflow as % TARWR	State	D
	Outflow as % TARWR	State	D
	Total use as % TARWR	State	D
Ecosystems	Fragmentation and flow regulation of rivers	State / Impact	K
	Dissolved nitrogen (NO3+NO2)	State	K
	Trends in freshwater habitat protection	State	K
	Trends in freshwater species populations	State	K
	Biological Oxygen Demand (BOD)	State	K
Health	DALY (Disability Adjusted Life Year)	Impact	K
	Prevalence of underweight children < 5 years old	Impact	D
	Prevalence of stunting in children < 5 years old	Impact	D
	Mortality in children < 5 years old	Impact	D
	Access to safe drinking water	State	K
	Access to basic sanitation	State	K
Agriculture	Percentage of undernourished people	State	K
	Percentage of poor people living in rural areas	State	K
	Relative importance of agriculture in the economy	State	K
	Irrigated land as a percentage of cultivated land	State/Pressure	K
	Relative importance of agriculture water withdrawals in water balance	Pressure	K
	Extent of land salinized by irrigation	State	K
	Importance of groundwater in irrigation	State/Pressure	K
Industry	Trends in industrial water use	Pressure	K
	Water use by sector	State	K
	Organic pollution emissions by industrial sector	Impact	K
	Industrial water productivity	Response	K
	Trends in ISO 14001 certification, 1997-2002	Response	K
Energy	Capability for hydropower generation, 2002	State	K
	Access to electricity and water for domestic use	State	K
	Electricity generation by fuel, 1971-2001	State	K
	Total primary energy supply by fuel, 2001	State	K
	Carbon intensity of electricity production, 2002	State	K
	Volume of desalinated water produced	Response	K
Risk	Disaster Risk Index	State	K
	Climate Vulnerability Index (CVI)	Pressure	K
	Risk and Policy Assessment Index	Response	K
Sharing	Water interdependency indicator	State	C
	Cooperation indicator	State	C
	Vulnerability indicator	State	C
	Fragility indicator	State	C
	Development indicator	State	C
Valuing Water	Water sector share in total public spending	State	D
	Ratio of actual to desired level of public investment in water supply	Pressure	D
	Rate of cost recovery	State	D
	Water charges as percent of household income	Pressure	D
Knowledge	Knowledge Index	State	D

Notes:
Level of development, highest to lowest:
B = basic indicator;
K = key indicator, for which there is an Indicator Profile Sheet and statistical data at national level;
D = developing indicators for which there is an Indicator Profile Sheet* but not yet statistical presentation, and
C = conceptual indicator for which there is conceptual discussion only.

2.2 Steps in the process

The overall framework for indicator selection is a strategic planning process at the level of the city, as described in Chapter 1 and by McIntyre and Butterworth (2011). A local government that would like to select a set of indicators is recommended to go through a stepwise process, as indicated in Figure 3 and described in the paragraphs below.

Figure 3. Schematic of the indicator selection process

Step 1 Starting the process

A local government that is going to select indicators, first needs to check:

- Is there a context for the indicators, i.e. is a strategic planning process on-going in which the indicators are going to be used for reporting and/or for planning. Without such a context the effort to collect data to score indicators is a waste of time and money.

- What are the objectives that have been formulated in the strategic planning process?
- Is there commitment from the senior management? Since without such commitment strategic planning processes are likely to fail (Matos et al. 2003).

Then the local government must decide on:

- The level of effort it is willing and able to make in terms of input of staff-time and budget.
- The purpose of the indicator monitoring process, i.e. is it meant for reporting, for adjustment of strategic plans and/or for decision making on specific projects.
- Its own capacity to collect data (either primary data collection in the field or the collection of secondary data from other organisations), to maintain databases, to analyse the data and to communicate the results to the target audiences.

Step 2 The indicator implementation team

Figure 3 shows the steps in the process to select indicators, after the strategic planning process has progressed beyond the stage of Visioning and Objective formulation. The process is to be facilitated by an **indicator implementation team.** This team is an intermediate between senior management and the regular line departments. The senior management logically was involved in the strategic planning process and would therefore also back the objectives that were generated in that process. Now the senior management has to back the implementation team and provide them with sufficient resources for their tasks. The indicator implementation team needs to work with departments because of the need for data. But also because the implementation of activities coming from the whole exercise will be put into practice by those departments. Their involvement and support from the beginning is therefore essential.

The members of the implementation team would collectively have skills in strategic planning, management of public organisations, facilitation of stakeholder meetings, policy development and urban water management (water supply, drainage and wastewater treatment, environmental legislation etc.).

Step 3 The state indicators

The first task of the implementation team is to translate the strategic objectives into **state-indicators**. This is a rather straightforward task, since in most cases it requires the addition of a measurable unit to the objective only. For instance, if the objective would be to reduce the impermeability (sealing) of the city's surface, then the indicator could be "% of the total urban surface that is impermeable and generates stormwater runoff". Other objectives may be more difficult to translate into a measureable indicator, for instance the objective to raise awareness on water and environmental issues among the inhabitants of the city.

If a vision statement is available but no objectives have been formulated, then indicators can be developed by disaggregating the vision into elements and by reformulating these elements into measurable objectives. Subsequently the objective is formulated as an indicator and the associated unit of expression.

The indicators preferably are also used to get a better understanding of the urban water system. Especially of the cause-effect relations and how the implementation of strategies affects the system. Cause-effect relations can be described by the DPSIR model (Driver, Pressure, State, Impact, Response) or by the simplified PSR model. Pressures are changes in the urban water systems, such as increasing demands, which directly affect the state of the urban water system, for instance the water level in an aquifer. A societal response to this state could be a response like water demand management to reduce abstractions.

The trends or fluctuations in the state-indicator values may occur to the decision makers or the general public as arbitrarily and may not increase the understanding of the effect of responses (i.e. implementation of strategies). Therefore it is suggested that cities select a balanced set of indicators, consisting of not only state indicators, but also pressure and response indicators

STEP 4 CREATING A MIX OF PRESSURE, STATE AND RESPONSE INDICATORS

Most strategic objectives will probably describe the desired state of the UWS in the future. We may say that the objectives describe the desired state, but are not concerned with the Response or the Pressures. Indicators that are derived from objectives are therefore mostly state-indicators

However, good management information consists of an indicator set that covers pressures, state and responses. The objectives are about the state, but information on the state of the system is not sufficient. A decision maker or urban water manager would also like to know whether sufficient ‘response’ is in place.

There is a time lag between ‘response’ and the effect of these measures on the ‘pressures’ and on the ‘state’. Although state-indicators may still show a negative situation, i.e. not fulfilling the objectives, it may be that the response-indicators are already positive, but it takes time before the effect of the response on the state-indicators becomes apparent. Similarly for the pressure-indicators. For example, investment in nutrient removal (response), will reduce nutrient loads to surface waters (pressure) once the treatment plant has been taken into operation, but eutrophication in surface waters (state) will not disappear immediately.

The identification of a good response, requires a good understanding of the cause-effect relations in the system. Similarly, the identification of good pressure-indicators requires a good understanding of through which pressure the response affects the state. Analysis of the cause-effect relations is partly known from general literature on environmental sciences, but partly case-specific. The case-specific relations could be the topic of research by local academic research institutions and/or be investigated in workshops using for instance problem-tree techniques for analysis of the urban water system.

The DPSIR model does not distinguish between Driving forces that are (partially) controlled by urban water managers and factors that are external, i.e. not affected by decisions of urban water managers. Similarly, the Pressures in the model are a mixture of factors that are under (partial) control of urban water managers and factors that are not. The latter factors are in the strategic planning methodology related to the scenarios, while the former are related to strategies. The effect of external factors on the state may be direct (such as the effect of increasing rainfall intensity on flooding frequency) or indirect via the pressures, such as growing populations causing increasingly dense urban areas, reducing permeability and increasing flooding frequency. The external factors may be described by external-indicators.

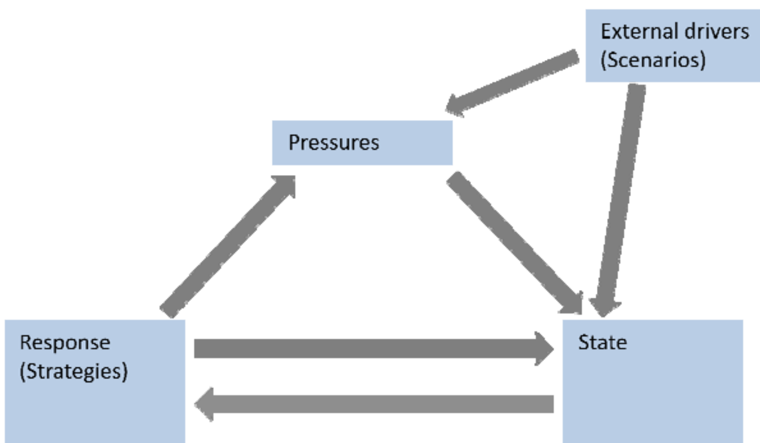

Figure 4 The PSR model, expanded with external indicators

STEP 5 DEFINE SUB-INDICATORS AND RULES FOR AGGREGATION

State, pressure and response indicators are generally formulated at a high aggregation level and are therefore often named core-indicators. For instance, a core-indicator such as '% of population with access to improved sanitation', could be disaggregated into sub-indicators on "% of population using some form of improved on-site sanitation", "% of population connected to water borne sewer" and "% of population using septic tanks". In this example the value of the indicator is just the sum of the three sub-indicator scores. For other indicators the aggregation of sub-indicators into a core-indicator may not be so straightforward. For instance, assume that the core indicator is: "Pollutant load from the urban water system to receiving surface waters", then the sub-indicators could be:

1. Load of COD from effluents of wastewater treatment plants
2. Load of heavy metals (Cd) from effluents of wastewater treatment plants
3. Load of COD from stormwater discharge through combined sewer overflows
4. Load of heavy metals (Cd) from stormwater discharge through combined sewer overflows
5. Total volume of effluent reused

First of all, the aggregation of the sub-indicators into a core-indicator requires weighing of the importance of the sub-indicators. Secondly, the aggregation of several sub-indicators into one core-indicator needs alignment of the units of the indicators. If all sub-indicators have the same unit, a summation is all that is required, but taking into account the weights.

$$\text{Core-indicator} = \Sigma \left(\text{sub-indicator}_i * \text{weight}_i \right)$$

If the units of the sub-indicators are different, then they can only be summed after normalising the sub-indicators all to the same scale, for instance by normalising to a scale of 0-1. If an indicator Z_i falls between Z_{min} and Z_{max}, then the following formula can be used:

$$Z_{i,normalised} = (Z_i - Z_{min})/(Z_{max} - Z_{min}).$$

This will make sure that $Z_{i,normalised}$ lies between 0 and 1. Z_{min} and Z_{max} may be the range of values based on historical data, or Z_{max} may be the desired value (a discharge standard for instance) and Z_{min} may be zero or a worst case situation (discharge of untreated wastewater, for instance) Some values when high may denote lower sustainability. They can be adjusted with the following formula:

$$Z_{i,normalised}{}^{*} = (1 - Z_{i,normalised})$$

The core and sub-indicators could be selected from published lists of indicators for the water sector, for example from the IWA publications on performance indicators for water supply and wastewater services (Alegre et al. 2006; Matos et al. 2003). The advantage of using those indicators is that they are internationally recognized and could be used in benchmarking activities. A disadvantage is that those indicators are especially suitable as performance indicators for utilities and they do not sufficiently cover the entire urban water system. Matos et al (2003) for instance, give the following indicator: "WWTP compliance with discharge consents". Though this is very relevant from the perspective of a utility, an indicator like "total pollution load from the urban water system" gives a more holistic picture, which would include other sources of pollution (stormwater overflows, on-site sanitation, industrial pollution, etc.), and is therefore more suitable for integrated management of the entire urban water system.

STEP 6 CHECK WHETHER SYSTEM BOUNDARIES FOR THE INDICATORS ARE APPROPRIATE

In the strategic planning process the system boundaries of the exercise are defined, and the indicators normally would use the same system boundaries. This means that the indicators for urban water management are relevant for management of the urban water system, and less for management of the river basin or other scales of management. For instance, "availability of irrigation water for agricultural areas that are located downstream of the city" is not a good indicator for management of the urban water system, because it depends on many factors outside the urban area. But an indicator like "fraction of treated urban wastewater reused in agriculture" is relevant for management of the urban water system.

Indicators for the utility level are usually named 'performance indicators'. These indicators are designed to measure the performance of the organisation, and therefore do often not measure 'externalities' such as the general state of the urban water system or responses that are implemented by other organisations (but that do influence the state of the urban water system). Regarding external pressures, these are included in the IWA system and named 'context indicators' (Matos et al. 2003).

The indicator team should check for each indicator, whether the system boundary that is inherent in the formulation of the indicator is equal to the system boundary used in the strategic planning process and is corresponding to the mandates of the joint organisations involved in the process.

STEP 7 REALITY CHECK FOR INDICATOR SELECTION

After the core-indicators and sub-indicators have been selected by the implementation team, it is necessary to check whether it will be possible to use the set of indicators in practice. The main questions to answer in this step are:

- Are the various organisations and stakeholders able and willing to supply the data to score the indicators, at the desired frequency?
- Is it possible to carry out additional data collection and maintain that activity over the years? (by the implementation team or by staff of the various organisations)
- Is the reliability and accuracy of the data sufficient?

STEP 8 CHECK RELIABILITY AND ACCURACY OF DATA AND INDICATORS

For proper decision making, decision makers need to be aware of uncertainties in the score assigned to indicators. The score of indicators may vary due to lack of data, or missing values in a timeseries of data. The quality of the data on which the indicator score is based is named the 'reliability' (Matos et al., 2003). Highly reliable data is for instance the number of official customers connected to the water supply system, as it is recorded in the audited yearly reports of a utility for a number of years in a row. This type of data is probably also accurate, i.e. correct. An example of data that is probably reliable, but less accurate, is for instance the total water volume consumed by households as registered by the meters. The inaccuracy of meters (especially at low flow rates) introduces an error in the data that reduces the accuracy of the total metered consumption. The IWA performance indicator system recommends to use a matrix developed by the UK regulator OFWAT to classify indicators based on reliability and accuracy (see Box 3 for the matrix table of confidence grades). UNHABIT (2004) recommends to use as much as possible "hard" data, i.e. published data, and only as a second option to use "soft" data, i.e. indirect evidence or the informed opinion of experts.

Box 3 - Confidence grades for indicators and underlying data (Matos et al., 2003; OFWAT, 2002)

Confidence grades for data used to score indicators is based on 'reliability' and 'accuracy'. Reliability bands are defined as follows:

A **- highly reliable** - based on sound records, procedures, investigations or analyses that are properly documented and recognised as the best available assessment methods

B - **reliable** - as in A, but with minor shortcomings, e.g. some of the documentation is missing, the assessment is old, or some reliance on unconfirmed reports or some extrapolations are made.

C - **unreliable** - data based on extrapolation from a limited sample for which band A or B is available

D - **highly unreliable** - data based on unconfirmed verbal reports and/or cursory inspections or analysis

Accuracy is defined as 'the approximation between the result of a given measurement and the correct value'. The table gives suggested confidence grades to label the quality of indicators and the underlying data.

Accuracy bands (%)	**Reliability bands**			
	A	**B**	**C**	**D**
0-1	A1	++	++	++
1-5	A2	B2	C2	++
5-10	A3	B3	C3	D3
10-25	A4	B4	C4	D4
25-50	++	++	C5	D5
50-100	++	++	++	D6

++ indicates confidence grades that are considered to be incompatible.

STEP 9 USING INDICATORS IN SELECTION OF A STRATEGY

Indicators can be used to present to decision makers the state of and pressures on the urban water system of the past, and as a time series leading to the present. It will show the effect of the responses, whether fully successful or only to a limited extent. Strategies should be adjusted in case the result is not satisfactory. However, from the indicators may not be directly clear what are the most important cause effect relations, and therefore it may not be obvious what kind of response is required. Moreover, different possible scenarios may affect the effectiveness of proposed strategies. Therefore it is recommended to use decision support tools that inform decision makers and planners about the score of the set of indicators, as a function of various optional strategies and various possible scenarios. Table x gives a simplified decision matrix. As an example, the indicator may be 'total water demand' and the scenarios may be concerning population growth scenarios and the strategies may be about various water demand management measures.

In a more advanced exercise, one may introduce the likelihood for each scenario and calculate the overall score for a strategy:

Strategy score = Σ (likelihood scenario) *(indicator score under scenario)

However, this may also introduce a false sense of certainty, since the likelihood for the scenarios are often very uncertain. It may be better to choose a flexible strategy, i.e. a strategy that is able to achieve the indicator target under most of the scenarios.

Table 2 A simplified decision matrix for selection of strategies

	Scenarios	**A**	**B**	
Strategies				**Total score per strategy**
1		Indicator scores, when Scenario A becomes reality and Strategy 1 is implemented	Indicator scores, when Scenario B becomes reality and Strategy 1 is implemented	Sum of row
2		Indicator scores, when Scenario A becomes reality and Strategy 2 is implemented	Indicator scores, when Scenario B becomes reality and Strategy 2 is implemented	Sum of row

STEP 10 STARTING IMPLEMENTATION

After the final selection of the indicators by the implementation team, the senior management of the participating organisations need to give their approval. This does not only concern the data collection process and the scoring method for the various indicators, but also the publication of the results. Ideally the indicator scores are published on a yearly or two yearly basis and accessible for everyone. Thus the use of indicators not only may improve technical management of the urban water system, but will also improve governance by increasing transparency in decision making.

It is recommended to start with a small set of indicators, to keep it practical and implementable. A group of cities that tested the IWA performance indicators for wastewater services, reduced the number of indicators by half of those originally specified (Matos et al., 2003).

3. Proposed indicator sets for cities of various types

3.1 A typology of cities

Cities are different all over the world, and therefore also the challenges to achieve a sustainable urban water system are different. Indicators likewise will be different in the various cities. An indicator that may be relevant in one city may be irrelevant in another city.

Though each city is different, one could group cities into certain categories, based on a number of city characteristics. It is proposed here to group cities according to the following characteristics:

- Cities where affordability of basic services is an issue
- Cities with strong capacity in the water sector
- Cities with a tropical rainfall pattern
- Cities with a moderate rainfall pattern, affected by climate change
- Cities with scarcity in water resources
- Cities with potential for reuse of treated wastewater

In Figure 5 a number of cities (participants of SWITCH) have been grouped based on the above mentioned characteristics. The table suggests that the cities can be divided in 3 groups, each with a separate typology:

Type 1 - Water management driven by basic service issues

Type 2 - Water management driven by water scarcity

Type 3 - Water management driven by climate change effects on rainfall patterns, flooding and water quality

As a comparison, Lunding and Morisson (2002) grouped cities based on the environmental sustainability of urban water infrastructure, as follows:

A. Infrastructure characterised by efficient resource use and waste minimisation. Clean technology, source separation and recycling are practiced. Management of the system is characterised by pro-active long-term planning and decision making and broad cooperation with stakeholders.
B. Cities that operate advanced end-of-pipe solutions for wastewater treatment with energy recovery. Quality of drinking water, stormwater and wastewater is regularly done and standards are met. Management of the system is based on legislation, standards and customer satisfaction.
C. Infrastructure is fit to meet minimum standards for environmental protection and health objectives. Management is reactive, relies on consumer complaints.

D. A continuous uncertainty in supply, water demand is not met. Sanitation provision is inadequate and environmental protection minimal. Management is ad-hoc and suffering from lack of financial resources and struggling to expand services to a growing population.

The Type 3 city suggested above, is similar to type D infrastructure and organisation suggested by Lunding and Morisson (2002). Type 1 and Type 2 cities, could by of the A,B or C type. A more complicated typology could be used, characterising cities as 1-A, 1-B, 2-C, etc.

City typologies	Tropical rainfall pattern	Moderate rainfaill pattern, affected by climate change	Water resource scarcity	Affordability of basic services is an issue	Wastewater after treatment reused (potential)	Strong capacity in the water sector		Type
Accra	■			■				1- a
Alexandria			■	■	■			2 - a
Beijing			■		■	■		2 - b
Belo Horizonte	■			■				1 - a
Birmingham		■				■		3
Cali	■			■	■			1 - b
Hamburg		■				■		3
Lima			■	■	■			2 - a
Lodz		■				■		3
Tel Aviv			■		■	■		2 - b
Zaragosa			■		■	■		2 - b

Figure 5 City typologies for cities participating in the SWITCH project

3.1 Suggested indicators by city typology

When a city is going to select a number of indicators, to be monitored during a long term process (probably > 5-10 years) of strategy implementation and strategy adjustments, it needs careful consideration how many and which indicators to be selected. The set of indicators should be in balance with the level of effort that a city (municipality, water utility etc.) is able and willing to invest in the monitoring programme. Moreover, because it should be sustained over a number of years to be meaningful.

One approach to select the appropriate indicators for a particular city is to go through a standard long-list of indicators and to select a set of indicators that is in balance with the required effort and that satisfies the following criteria:

- The indicator is relevant for the city, given its typology.
- The effort (cost) required to collect the data to score the indicator is reasonable.

- The indicator is relevant for planning, reporting, or both, depending on what the purpose of the monitoring programme is.
- The aggregation level is in line with the purpose of the programme
- The complexity of the indicator is fit for the target group

Reasonably, the number of indicators should not be more than 15-30.

Annex 1 shows a long-list of 68 indicators grouped into 5 main areas:

- Access to water of good quality, in sufficient qualities at affordable costs
- Access to affordable sanitation and waste management
- Surface and groundwater quality
- The risk of flooding in vulnerable areas in relation to a risk level that is acceptable to all stakeholders, even under future climate change scenarios
- Overall sustainability characteristics of the urban water system

These indicators are believed to be the most relevant for an overall sustainability of an urban water system. Obviously, for most cities it will not be possible to monitor all 68 indicators or some of them will be less relevant for their particular situation. It is therefore suggested that a city would select from the list about 20 indicators.

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Annex 1 Long list of indicators

External		Pressure		State		Response	
				Access to water of good quality, in sufficient qualities at affordable costs	% of the population		
Rainfall	mm/year	Per capita water consumption	m3/cap/ year	Availability of water resources	demand as % of sustainable yield	Water Demand Management Measures	Investment Euro/cap/year
Population growth	% increase in population			Treatment plant capacity	% of water demand	Expansion of treatment plant capacity	% of water demand / year
Macro economic situation	Gross Domestic Product			Condition of distribution network	% physical leakage	Renewal or repair of network	% of total network
						Provision of non-network access	additional number of people served/ year
		Treatment and distributions costs	Euro/m3	Price of water for households	% of household income	Cost recovery	%
		Pollution of water resource	FC /100ml	Raw water quality	% samples within standards	Water Resource protection measures	Investment Euro/cap/year

External Indicators		Pressure Indicators		State Indicators		Response Indicators	
				Access to affordable sanitation and waste management	% of the population		
Population growth	% increase per year	Tariff for sewer connection	% of household income	Population connected to sewer	% of the population	New sewer connections	% of the population connected per year
Macro economic situation	Gross Domestic Product	Per capita costs for VIP latrine	% of household income	Population using improved on-site sanitation	% of the population	New on-site sanitation systems	% of the population connected per year
		Per capita costs for septic tank	% of household income	Septage production	tons/year	Septage treatment capacity	% of septage production
						New eco-san systems	% of the population connected
				Disease incidence	# of intestinal infections originating from wastewater	Hygiene education	# of citizens trained

External Indicators		Pressure Indicators		State Indicators		Response Indicators	
		The net waste-output from the city to the receiving aquatic environment in relation to the carrying capacity		**Surface and groundwater quality**			
Population growth	% increase per year	Domestic waste production	tons pollutant/ year	Surface water quality status	EU Water Framework Directive indicators	Measures to reduce domestic waste production	kg pollutants prevented per year
Macro economic situation	Gross Domestic Project			Groundwater quality status		Wastewater collected	%
						Removal of pollutants from domestic wastewater	tons pollutant/year
						Domestic wastewater recycled	%
						Removal of pollutants from industrial wastewater	ton pollutants prevented/year
Growth of industrial production	Yearly turnover	Industrial waste production	ton pollutants /year			Industrial waste recycling or prevention	ton pollutants prevented/year
		CSO overflows	ton pollutants /year			Stormwater receiving treatment	%
		Untreated stormwater discharge	ton pollutants /year			Application source control techniques	Hectares connected to source control
				Amenity of local water bodies	population valuing water bodies for amenity	Local water bodies designed for asthetic and amenity purposes	% of total water bodies surface area

External Indicators		Pressure Indicators		State Indicators		Response Indicators	
				The risk of flooding in vulnerable areas in relation to a risk level that is acceptable to all stakeholders, even under future climate change scenarios			
		Increased soil sealing	in % permeability	% Permeability of urban area	%	Application of source control techniques for infiltration	Increase in % of rainwater infiltrated
						Application of source control techniques for retention	Total retention volume in m3
				Number of days properties are flooded	(#* days)	Construction of flood resilient residential buildings	Number of people
				Depth of flooding	Average depth in m	Improving drainage system capacity	Various
				Financial damage to properties	Euros	Construction of flood resilient shops/factories	Total turnover of flood resilient companies

External Indicators		Pressure Indicators		State Indicators		Response Indicators	
				Overall sustainability characteristics of the urban water system			
				Energy consumption in the water cycle	kWh/capita/year	Reduction of energy consumption by switching to energy efficient	kWh saved/capita/year
						Reduction of energy consumption by reduction of warm water consumption in the household	kWh saved/capita/year
				GHG emissions from the water cycle	kgCO2/capita/year	Reduction of GHG emissions through energy saving and energy generation within the urban water cycle	kgCO2saved/capita/year
						emissions through measures not related to the water cycle, such as using renewable energy	kgCO2saved/capita/year
				Citizens awareness on water related sustainability issues	Various	Involving citizens in awareness raising activities	Various
						Involving citizens in decision making	
				Equity in the access to water	Various	Selecting measures to spread investments over all income groups/city sections	Various
						Measures to reduce number of citizens that spent more than an agreed percentage of their household income on water and sanitation	
						Reducing the distance to green or irrigated areas	meters