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Sustainable Water Management in the City of the Future

Integrated Project
Global Change and Ecosystems

Deliverable D1.1.1
Report providing an inventory of conventional and of innovative approaches for Urban water Management

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SWITCH Deliverable Briefing Note Template

SWITCH Document **Deliverable D1.1.1** **Report providing an inventory of conventional and of innovative approaches for Urban water Management**
Audience The document was prepared for an audience inside the consortium. It was prepared to summarise the progress we have made in terms of the inventory of approaches. This inventory is a base-line on which we can develop our own, innovative SWITCH approach
Purpose The purpose of the document is to summarise the progress we have made in terms of the inventory of approaches. This inventory is a base-line on which we can develop our own, innovative SWITCH approach. The document has identified a number of limitations in the existing approaches, where SWITCH can offer improvements.
Background This research, a desk study, was needed to review the development of thinking about urban water management in the last decades. Only when this is fully understood, we will be able to bring development a step further, towards real Integrated Urban Water Management
Potential Impact The impact of this research is indirect, through its contribution to development of new approaches for IUWM within the project. As such it contributes to the overall impact of the project.
Issues Not applicable
Recommendations Other researchers in the project are encouraged to address the relevance of their work for the development of new strategies for UWM. How were overall UWM strategies taken into account when research questions and methods were developed? How can research results be used to develop new strategies?

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Abstract

This paper reviews the current approach to urban water management as advocated in international and European policy documents (The Dublin statement; Agenda 21; The Millennium Development Goals; World Bank Water Resources Sector Strategy; Vision 21; EC Urban Wastewater Treatment Directive/1991; EC Water Framework Directive). The policies are compared to the trends that can be observed in practice in European and non-European cities. The preliminary conclusion can be drawn that the international documents contain innovative ideas but remain rather general and are not widely translated into practice. The EC documents are much more concrete and their implementation will result in better water management at the river basin scale in the European Union. However, also the Water Framework Directive (WFD) does not include the most recent innovative ideas. It still focuses only on the water systems and only to a very limited extent includes integration of the agricultural and the energy sector in the analysis. Closing cycles of nutrients and water and energy implications receive very limited attention. This type of integration is addressed in approaches like the Bellagio principles, the Household Centered approach, the UNEP 3-Step Strategic Approach and the Swedish MISTRA project on Integrated Urban Water Management (IUWM). These documents and projects aim at the development of a truly sustainable urban water system (environment, economy, society). A systems approach is followed, where the system boundaries are wider than commonly used in urban water management and include the entire urban water cycle, as well as sludge disposal, materials consumption, energy consumption and agriculture. The SWITCH project builds on these initiatives by developing a methodology for a sustainability assessment for urban water systems that includes the three dimensions of sustainability. It will do so for existing urban water systems, but also for future urban water systems where technological and social-institutional innovations are applied. A number of these innovations are also developed within SWITCH. Physical models and decision support systems will be used and developed to allow planners to analyse urban water management options for the future, under different global change scenarios.

Keywords: integrated urban water management, sustainability, systems approach

[1] Part of this report was presented at the First SWITCH Annual Scientific meeting in Birmingham in January 2007, under the title "Integrated Urban Water Management: towards sustainability"

1 Challenges in urban water management

The challenges in urban water management are ample. In the developing world there is still a significant fraction of the population that has no access to proper water supply and sanitation. At the same time population growth, urbanization and industrialization continue to cause pollution and depletion of water sources. In the developed world pollution of water sources is threatening the sustainability of the urban water systems. Climate change is likely to affect all urban centers, either with increasingly heavy storms or with prolonged droughts, or both. To address the gigantic challenges it is crucial to develop good approaches, so that policy development and planning are directed towards addressing these global change pressures, and to achieving truly sustainable urban water systems.

2 Past and current approaches to urban water management

2.1 Current approach as described in international policy documents

The 'Dublin Statement' (International Conference on Water and the Environment, 1992) and the 'Agenda 21' (UN Department for Sustainable Development, 1992) unfold a vision about how water resources are best managed, to serve the people, without damaging the environment. The 'Dublin Statement' formulated a number of principles that since have formed the basis for Integrated Water Resources Management (IWRM). IWRM addresses the issue of water management from a river basin perspective, since this is the scale that includes (all) relevant cause-effect relations and stakeholder interests. The principles of the 'Dublin Statement' are:

1. Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment. Management of water resources requires linking social and economic development with environmental protection, within the river basin or catchment area.
2. Water development and management should be based on a participatory approach, involving users, planners and policy-makers at all levels. Decisions are taken at the lowest appropriate level, with full public consultation and involvement of users in planning and implementation.
3. Women play a central part in the provision, management and safeguarding of water. Institutional arrangements should reflect the role of women in water provision and protection. Empowerment of women to participate in decision-making and implementation, as defined by them, needs to be addressed.
4. Water has an economic value in all its competing uses and should be recognized as an economic good. Access to clean water and sanitation at an affordable price is a basic right of all human beings. Failure to recognize the economic value of water in the past has led to wasteful use and environmental damage.

These principles were applied to the urban environment as well and a future city was envisaged where appropriate water charges are in place, which will help reduce water scarcity and will reduce the need for developing ever more distant (and costly) sources. Waste discharge controls must be enforced and cannot be seen as reasonable trade-offs for prosperity brought by industrial growth (International Conference on Water and the Environment, 1992).

The 'Agenda 21' has worked out the 'Dublin Statement' in some more detail for urban areas. The objective of 'Agenda 21' is to develop 'environmentally sound management of water resources for urban use'. To achieve this the following is believed to be critical:

- The role that is played by local and municipal authorities in water supply, sanitation and environmental protection.
- Scarcity drives the development of new resources with escalating costs as a result
- Unsustainable consumption patterns need to be eliminated, in order to help alleviate poverty and improve the quality of life of urban poor.

A large number (26) of potential activities have been formulated. Some of these are very obvious ('Implementation of urban storm-water run-off and drainage programmes', others have become commonly accepted as good practice ('Initiation of public-awareness campaigns to encourage the public's move towards rational water utilisation'). Some of the more interesting activities are:

- 'Reconciliation of city development planning with the availability and sustainability of water resources'
- 'Adoption of a city-wide approach to the management of water resources'
- Inclusion of water resources development in land-use plans
- 'Basing of choice of technology and service levels on user preferences and willingness to pay'

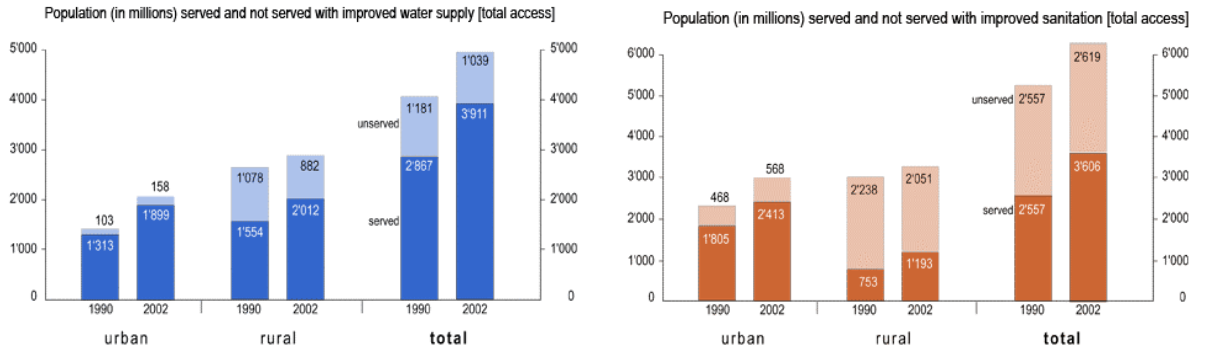

Figure 1. Global access to safe water and adequate sanitation in 1990 and 2002 (WHO-Unicef Joint Monitoring Programme, 2004)

The costs to implement the actions were estimated to be $20 billion total annual costs over the period 1993-2000. Governments were suggested to set targets, such as: 'By the year 2000, to have ensured that all urban residents have access to at least 40 liters per capita per day of safe water and that 75 percent of the urban population are provided with on-site or community facilities for sanitation'. Although the Action 21 principles are not usually questioned, the reality on the ground is that the targets have not been achieved by far. In the period 1990-2002 the urban population not served with improved water supply has increased from 103 million to 158 million people. For improved sanitation the increase in those not served was from 458 million to 566 million (see Figure 1). At the Millennium Summit in September 2000 world leaders adopted the UN Millennium Declaration, committing their nations to the Millennium Development Goals (MDGs) all with a deadline of 2015. Goal no. 7 (Ensure Environmental Sustainability) includes Target no. 10: "Halve the proportion of people without sustainable access to safe drinking water and basic sanitation". Improving urban water

management is crucial to achieve this goal, because it is in the urban areas that the number of un-served is still increasing.

2.2 European legislation on (urban) water management

Since 1976 the European Commission has issued a number of water related directives, which are aimed at protection of public health, at protection of nature and at mitigation of negative environmental effects of water use and wastewater production. The following directives have come into force:

i) Bathing Water Quality Directive (76/160/EC);
ii) Birds Directive (79/409/EC);
iii) Drinking Water Directive (80/778/EC), as modified by 98/83/EC;
iv) Directive on the control of major-accident hazards involving dangerous substances (Seveso-directive) (96/82/EC);
v) Directive on Environmental Impact Assessment (85/337/EC);
vi) Sewage Sludge Directive (86/278/EEC);
vii) Urban Wastewater Treatment Directive (91/271/EEC);
viii) Plant Protection Products Directive (91/414/EEC);
ix) Directive on nitrate from agricultural sources (91/676/EEC);
x) Habitats Directive (92/43/EEC);
xi) Integrated Pollution Prevention and Control Directive (96/61/EC).

Urban (waste)water management is mostly addressed in the Urban Wastewater Treatment Directive (91/271/EEC, 1991). This directive regulates the collection and treatment of urban wastewater and the disposal of sludge produced in the process of wastewater treatment. Urban wastewater is defined as the mixture of domestic wastewater, industrial wastewater and/or run-off rainwater. The directive stipulates:

- A time schedule for the construction of collection systems to collect urban wastewater from agglomerations of more than 2000 inhabitants (PE's) (31st of December 2005 as deadline for implementation).
- That individual treatment systems that achieve the same level of environmental protection can be used (decentralized systems), where the establishment of collection systems is not justified because it would generate no environmental benefits or because it would involve excessive costs,
- That receiving waters are classified as either 'sensitive' or 'less sensitive'. Sensitive areas are waterbodies with poor water exchange and that are prone to eutrophication.
- Effluent standards for both 'sensitive' and 'less sensitive' areas for BOD, COD, TSS, total nitrogen and total phosphorous.
- That the disposal of sludge to surface waters should be phased out.
- That treated wastewater shall be reused whenever appropriate. Disposal routes shall minimize the adverse effects on the environment.
- That sludge produced while treating wastewater shall be reused whenever appropriate. Disposal routes shall minimize the adverse effects on the environment.

The measures of the Urban Wastewater Treatment Directive are now part of common practice in most European countries. The measures are quite straightforward: setting standards by government bodies, implementing end-of-pipe treatment for domestic and industrial wastewaters, sampling, monitoring

and publication of water quality results and enforcement. The prevention of pollution in industry and/or the domestic sector is not addressed at all. The directive is limited to an end-of-pipe approach.

The EC directives shown above have all been integrated in 2000 into one new piece of legislation, the Water Framework Directive. This framework aims to integrate all previous directives into a more holistic approach. New in this document is that the River Basin becomes the unit of analysis. The reason for this is that at this scale all interests come together (upstream, downstream). The framework requires the formulation of River Basin Plans for each river basin, also if this requires cross border cooperation. Here one sees clearly the application of IWRM principles as previously formulated in the 'Dublin Statement'. The River Basin Plans will contain:

- Analysis of the river basin's characteristics
- Review of the impact that human activity has on water
- Economic analysis of the water use

The major objective of the framework is to achieve 'good status' for all European waters by 2015. What 'good' means is to some extent defined by the framework, for both natural and human-influenced waters, but also depends on how the stakeholders in the basin will define this. Active participation of all stakeholders, including NGOs and local communities is prescribed. The Framework Directive clearly is different from the Urban Wastewater Treatment directive, in that it aims to prevent pollution at source and sets out control mechanisms for management of pollution sources. There has been a shift from 'treatment' to 'environmental management'. Some other areas of attention in the WFD are:

- Water pricing policies and polluter pays principle
- Balancing interest of environment with those who depend on it.
- Integration of policies: agriculture, industry, consumers
- Best possible reduction of emissions and a minimum quality threshold for water quality in receiving environment
- Phase out of discharge of priority contaminants in 20 years.
- Water pricing is an incentive for the long-term sustainable use of water resources
- Prices should be set in a transparent way, appropriately integrating economic, environmental and social principles.

2.3 Reflection

Have international implementing organisation, such as the Word Bank and other development banks incorporated the Dublin Principles/Agenda 21 in their projects? Have the SWITCH demonstration city utilities and municipal departments implemented these principles?

The current World Bank Water Resources Sector Strategy is from 2004, the previous one was published in 1993. The 1993 document contained the worldwide consensus on the Dublin Principles and the 2004 document states that these principles remain powerful, appropriate and relevant, but that even the most advanced countries are far from full compliance with these principles. The new strategy states also that no major changes of course are required for most WB activities. It is not so much a new vision or new principles that are required, but the patient and pragmatic implementation of solutions tailored to specific, widely varying circumstances (World Bank, 2004). It would be very useful to evaluate how the Dublin principles are implemented in World Bank funded projects. From only one example from a SWITCH demonstration city, the Alexandria Growth Pole Project (AGGP, 2006) it seems that:

- At the one hand a type of integrated approach is taken, since the project objectives include (1) Improving the water quality of Lake Mariout, (2) Improving the business climate in Alexandria and (3) Improve the living conditions of residents in settlements.
- At the other hand the approach to achieve objective (1) seems traditional. Basically it entails the upgrading of the existing primary wastewater treatment plants. A treatment technology is selected (chemically enhanced primary sedimentation, followed by aerated lagoons and effluent irrigation) that produces large quantities of polluted sludge, does not recover the energy contained in the wastewater and that is relatively energy and chemical intensive. An overall analysis of the urban water system was not included in the EIA report, neither a careful consideration on how investments in the urban water system could be tailored to maximize cost effectiveness. Marino and Boland (1999) stressed the importance to prevent investments that are poorly targeted and that may only provide abatement for low priority effluents, while more hazardous discharges may go untreated. Many of these investments, responding to a piecemeal approach to river basin pollution problems, may also result in costly and ineffective solutions.

The European WFD is an important improvement of the Urban Wastewater Treatment Directive. However, but the development of new concepts on urban water management has progressed and these new concepts (see paragraph 3) are to a certain extent lacking from the WFD. The WFD is very much focused on a narrowly defined 'water-system'. Although it mentions integration ('dialogue') with other sectors like energy, transport and agriculture, it does not prescribe:

- The application of infrastructure/technologies/methods that minimise the consumption of energy and materials, or other negative environmental impacts.
- The evaluation of effects on investment in wastewater treatment technologies, in comparison to the same effects that could be achieved in other sectors (agriculture, urban design, pollution prevention etc.)
- It does not require reuse and recycling of wastewater for appropriate purposes. The document mentions 'reuse' only once (for industrial water use).

3 Innovative approaches in urban water management

3.1 The Bellagio Statement

Several projects, programmes and approaches go a step further than the WFD. One of these is the 'Bellagio Statement', formulated by the Environmental Sanitation Working Group of the WSSCC (Water Supply and Sanitation Collaborative Council) in 2000. Its principles are believed to be essential for achieving the objective of worldwide access to safe environmental sanitation and a healthy urban water system (WSSCC, 2000):

1. Human dignity, quality of life and environmental security should be at the centre of the new approach, which should be responsive and accountable to needs and demands in the local setting.

• solutions should be tailored to the full spectrum of social, economic, health and environmental concerns
• the household and community environment should be protected
• the economic opportunities of waste recovery and use should be harnessed

2. In line with good governance principles, decision-making should involve participation of all stakeholders, especially the consumers and providers of services.
• decision-making at all levels should be based on informed choices
• incentives for provision and consumption of services and facilities should be consistent with the overall goal and objective
• rights of consumers and providers should be balanced by responsibilities to the wider human community and environment

3. Waste should be considered a resource, and its management should be holistic and form part of integrated water resources, nutrient flows and waste management processes.
• inputs should be reduced so as to promote efficiency and water and environmental security
• exports of waste should be minimised to promote efficiency and reduce the spread of pollution
• wastewater should be recycled and added to the water budget

4. The domain in which environmental sanitation problems are resolved should be kept to the minimum practicable size (household, community, town, district, catchment, city) and wastes diluted as little as possible.
• waste should be managed as close as possible to its source
• water should be minimally used to transport waste
• additional technologies for waste sanitisation and reuse should be developed

Box 1. A cleaner production approach to Urban Water Management (Nhapi and Gijzen, 2005)

The cleaner production concept, developed over the last two decades, has brought some innovative environmental thinking into the industrial sector. If we apply some of the basic principles of cleaner production to the current practices in urban water services, we may realise the need for drastic changes:

Principle 1: Use lowest amount of input material, energy or other resources per unit of product.
Practise: We supply between 130 and 350 l of drinking water per capita per day, while less than 2 litres are actually used for drinking

Principle 2: Do not use input materials of a higher quality than strictly necessary.
Practise: We use water purified to drinking water standards to flush toilets, clean floors, wash cars or to irrigate the garden.

Principle 3: Do not mix different waste flows.
Practise: Already in the household various wastewater flows are combined (urine and faecal matter, grey and black water). After disposal into the sewer this combined waste is mixed further with industrial effluents, and often times also with urban runoff. Obviously this practise makes re-use of specific components in the mixed waste flow less attractive and less feasible.

Principle 4: Evaluate other functions and uses of by-products before considering treatment and final disposal.
Practise: Domestic sewage is discharged into open water resources either with or without prior treatment. Only few examples of wastewater re-use or (by-)product recovery from wastewater exist.

3.2 The UNEP 3 Step Strategic Approach

The UNEP 3 Step Strategic Approach (Nhapi and Gijzen, 2005) is based on the application of the 'Cleaner Production approach' that has been so successful in the industrial sector. The authors evaluated the current urban water management system from a cleaner production point of view, and made clear the urgency to re-think our current practises in the light of sustainability (Box 1). An assessment of methods applied in industries and in solid waste management for pollution prevention and control reveals a systematic approach that is useful to wastewater management as well. A 'translation' of the cleaner production principles outlined in Box 1 to the water sector led to the development of the so called 3-Step Strategic Approach for urban water management. This approach strongly focuses on sewage management, but also considers water supply, nutrient uses and other material flows associated with the urban water cycle. The three steps include: 1) prevention, 2) treatment for reuse, and 3) planned discharge with stimulation of self-purification capacity. The steps should be implemented in chronological order, and possible interventions under each step should be fully exhausted before moving on to the next step. This strategic approach is summarised in Figures 2 and 3.

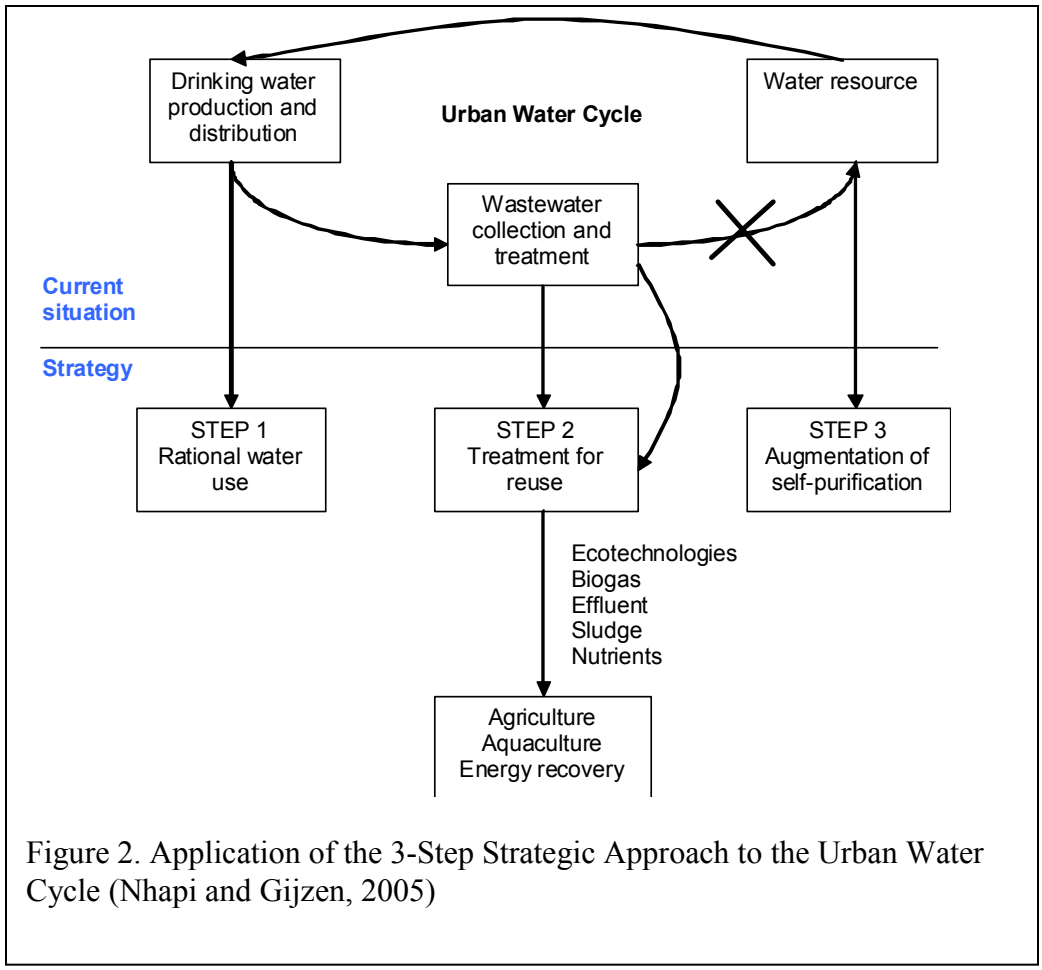

Figure 2. Application of the 3-Step Strategic Approach to the Urban Water Cycle (Nhapi and Gijzen, 2005)

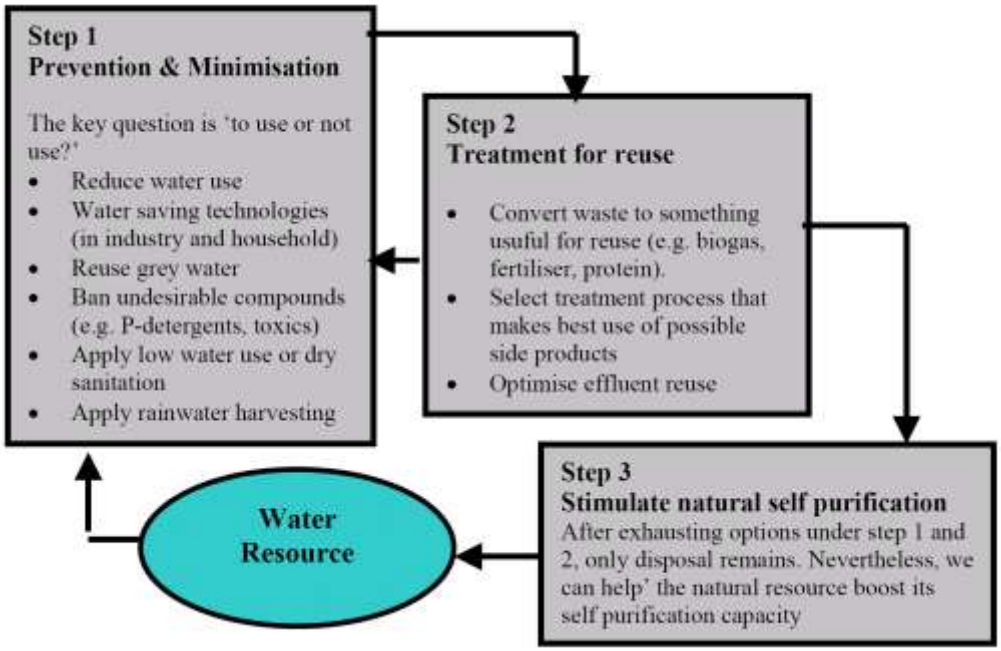

Figure 3: Schematic representation of the 3-Step Strategic Approach to wastewater management (Nhapi and Gijzen, 2005)

3.3 Assessment of sustainability of urban water systems

Implementation of the 3-Step Strategic Approach and/or the Bellagio principles would create an urban water system that is based on recycling (waste = resource) and therefore reduce the need for external inputs (water, energy, chemicals). The pollution being generated in the system would also be reduced. However, principle number 4 of the Bellagio Statement is questionable. It seems to be based on the assumption that decentralised systems for sanitation (and water supply) are by definition more sustainable (environment, health, socio-economy). True, some literature reports have shown that under certain conditions this is the case, for instance for urine-separation systems (Jeppsson and Hellström, 2002). However, in many other cases it is the economies-of-scale of centralised systems that is more advantageous. Principle number 4 could better be replaced by a more general statement that the sustainability of systems needs to be optimised, based on some kind of 'sustainability assessment'. This would also make the discussion between 'centralisers' and 'de-centralisers' more rational.

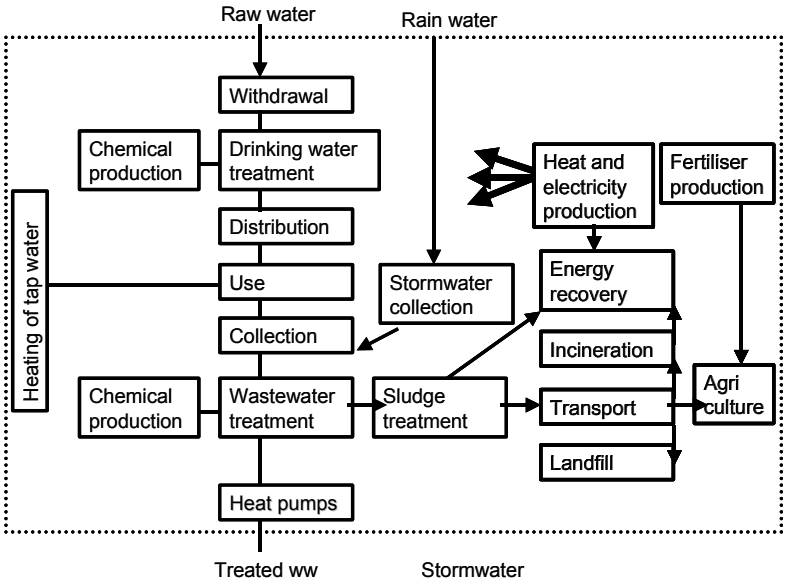

Fig 4. Urban Water System from Lundin and Morrison (2002)

This sustainability concept for the urban water system is worked out by Lundin and Morisson (2002), who developed a LCA type of method to evaluate the environmental sustainability of urban water systems. In their work the system boundaries were chosen wider than common (see Figure 4). In their view the urban water system includes the entire urban water cycle, as well as sludge disposal, materials consumption, energy consumption and agriculture. The assessment of the sustainability of this system is based on the identification (by all stakeholders) of a set of 'sustainability indicators'. The scoring of the indicators can then be used to decide on different water management options. Some type of Multi Criteria Analysis then defines the best option, by giving weights to the different criteria and indicators. Models can be used to do the sustainability assessment of different options and to develop strategies for planning of urban water management (Malmqvist et al., 2006).

3.4 The Australian experience

Such an integrated approach has shown its value already in some practical cases, as for instance described by Andreson and Iyaduri (2003) for a case in New South Wales, Australia. They

investigated for a number of towns, where new water plans were developed, what options for innovations would be identified if the various water institutions would have planned alone (as they did so far) and what options would be identified if they would jointly do the planning exercise. The following innovations came up from this integrated approach:

- In some cases water demand management (WDM) measures would reduce water demands by up to 20%, reducing the size of water supply works and allowing to postpone capital investments. But also: sewage flows would be reduced, such that the flows remained within the capacity of the existing sewage collection and treatment system, and thus preventing capital investments for system expansion.
- In cases where the treatment plants were hydraulically limited, WDM would allow the treatment plant to carry even additional loading.
- Treated wastewater could be reused for (urban) landscaping and thus could reduce the demands on the water supply system and lead to further water supply savings.
- Alternatively, a lower loading of the WWTP leads to improved nutrient removal and therefore better water quality in the receiving waters.
- Urban landscaping with effluent was more cost effective than agricultural reuse.
- With additional treatment, the effluent would be able to be distributed for residential garden watering through the existing non-potable dual reticulation pipework.
- Collected stormwater runoff could be used for irrigation of recreation areas, in some cases.

It was concluded that an analysis of the entire urban water system lead to the identification of opportunities that are not apparent when separate strategies were developed for sub-systems. In one town, this integrated urban planning exercise identified potential cost savings of up to 50% of the capital costs of the system upgradings identified through separate water and sewerage strategy studies (Anderson and Iyaduri, 2003).

The application of Integrated Urban Water Management (IUWM) in Australia was reviewed by Mitchell (2004). The specific feature of IUWM is that the entire water system for an urban plot (block, cluster of blocks, neighborhood, etc) is analysed as one integrated system (Figure 5). This allows the analysis of options to use local water sources (rainwater, groundwater, stormwater, treated wastewater) for various purposes (like garden irrigation, toilet flushing) and this will reduce the import of reticulated water. And therefore will reduce the environmental impacts associated with large water abstractions and transport over large distances. Similarly, the amount of stormwater generated in an urban plot can be substantially reduced by replacing imported water by stormwater collection, storage and use or wastewater recycling.

The principles of IUWM were summarized as (Mitchell, 2004):

- consider all parts of the water cycle, natural and constructed, surface and sub-surface, recognising them as an integrated system
- consider all requirements for water, both anthropogenic and ecological

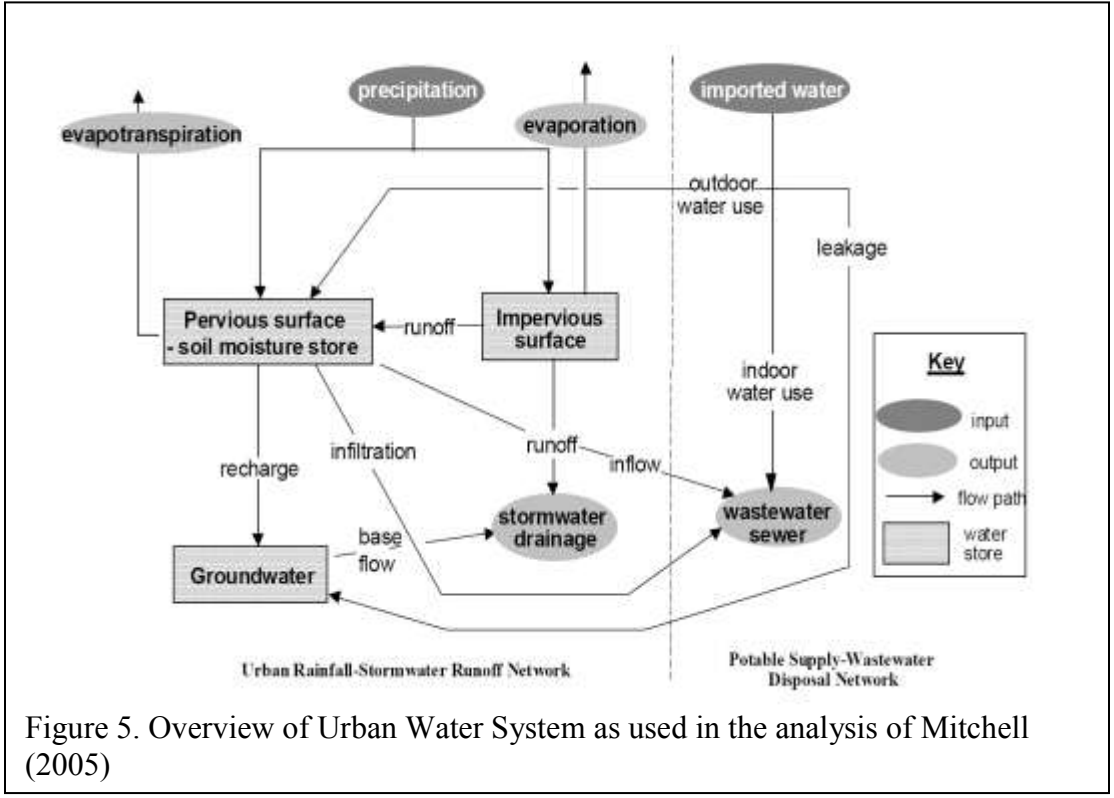

Figure 5. Overview of Urban Water System as used in the analysis of Mitchell (2005)

- consider the local context, accounting for environmental, social, cultural and economic perspectives
- include all stakeholders in the process
- strive for sustainability, balancing environmental, social and economic needs in the short, medium and long term

A large number of case studies were reviewed, and good examples of barriers and drivers for implementation of innovative IUWM schemes were identified. It was noted that there is lack of skills and experience with most water sector organisations to implement IUWM schemes. Also existing legislation and design-standards are barriers for implementation. Therefore involvement of all stakeholders, especially regulating authorities is essential. Finally, the lack of a commonly agreed, robust, assessment tool or framework that could be used to assess IUWM schemes in terms of environmental, social and economic criteria is missing. One of the objectives of SWITCH is to provide such a tool.

4 IUWM and SWITCH

The SWITCH project wants to develop a new approach to Integrated Urban Water Management. This approach will have to result in new ways of planning the urban water system for the future, to address adjustments needed to address global change pressures. All this aimed at increasing the sustainability of the UWS and reducing the risks. Based on the above review these goals are most likely to be achieved if the following approach is taken:

- The physical system boundaries will be chosen as in Lundin and Morisson (2002), as to be sure that positive and negative impacts that traditionally are seen as 'external' will be included in the analysis, and in the decision making.
- A method for the 'sustainability assessment' of the urban water system will be developed together with the partners in the demonstration cities (Torres, 2007)
- A model of the Total-Urban-Water-Cycle type (Mitchel and Diaper, 2003) will be developed. This model will describe the physical urban water system and will be able to analyse the application of different (technical) innovations in UWM, under different scenarios of global

change. The model outputs will be used to score a set of sustainability indicators. The model will also be integrated in a GIS based Decision Support System

- The model will also be used as a tool for urban planning, especially to evaluate how the application of (technical) innovations in the current Urban Water System will affect the overall system performance. This will also be used to develop a strategy to develop the current UWS into the sustainable system of the City of the Future.

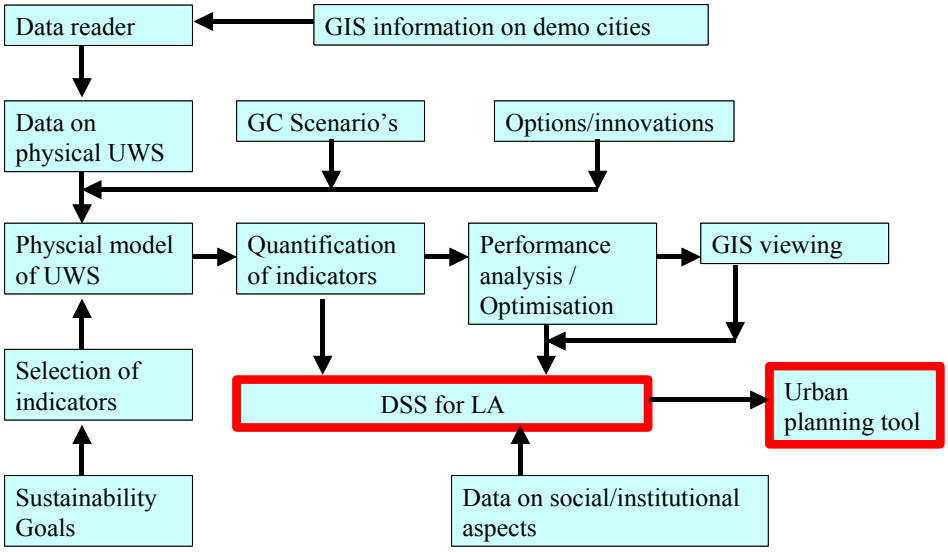

Figure 6. Summary of activities and products of SWITCH Theme 1

5. Conclusions

The approach to (urban) water management has developed over time, with the Dublin Statement and the EU Water Framework Directive as important milestones. SWITCH wants to build on idea's from the 'Bellagio Statement' and the 3-Step Strategic Aproach, but wants to add a thorough and scientific 'sustainability assessment' of new approaches and new technologies. By doing this the SWITCH approach will be developed. Models and decision support systems will be used in order to evaluate (technological) innovations for IUWM under different future scenarios.

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