Integrated Urban Water Management (IUWM) Training Overview and Case Studies

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DR. KIRAN C. PATEL COLLEGE OF GLOBAL SUSTAINABILITY

Global Water Partnership

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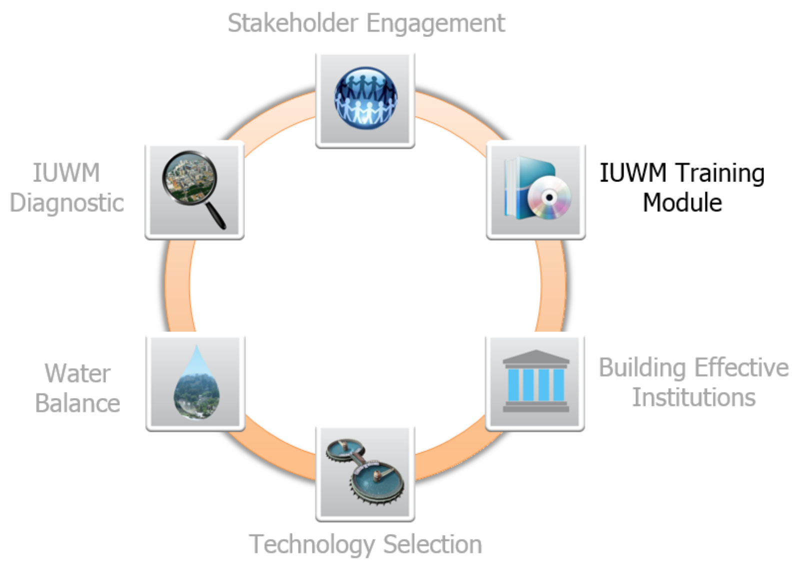

Prepared for the Global Water Partnership

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Global Water Partnership

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Preface

This document presents an introduction to the concepts and principles of Integrated Urban Water Management (IUWM) along with best practice examples that provide some evidence to help understand the challenges in the implementation of IUWM. It will serve as reading material for the training that will mainly be done in the form of lectures and workshop sessions. The lectures will be based on PowerPoint presentations and discussions from experts in different aspects of IUWM. The workshop session will use the tools that are developed as part of the IUWM Toolkit project. Tools will be introduced to participants through demonstrations, which will generate discussions on how to apply outcomes from the tools in decision making for the implementation of IUWM in the participants' area. The document also includes case studies that provide background of the challenges, implementation of the IUWM approach and lessons learned from the practice. An outline and content of the training session are included in the annex of this document.

Introduction

It is widely accepted that one of the major challenges of the 21st century is to provide safe drinking water and basic sanitation for all. Currently, more than 750 million people lack access to improved water sources, and over 2.6 billion people lack access to basic sanitation – nearly all of these people live in developing countries. Providing adequate water supply and sanitation, particularly in urban areas, is a challenging task for governments throughout the world.

The inadequate water and sanitation services affect mostly the poor. Failure to address such a challenge creates a myriad of health risks and often prevents the poor from integrating with or contributing to the urban economy. In urban areas such conditions are often prevalent in informal settlements (slum areas). It is evident that slum residents can be highly efficient contributors to local economic growth. However, failure to provide them with basic water and sanitation services often limits their ability to engage and contribute to the larger urban area.

The current models of urban water systems, and their corresponding infrastructure, are based on the approaches of the 19th century that considered small population was relatively small, abundant water sources and benign environment (Zhou et al., 2009). Today, cities all over the world are facing a range of dynamic regional and global pressures, such as climate change, population growth, urbanization, deterioration of urban infrastructure systems and more (see Figure 1). Due to these pressures cities of the future will experience difficulties in efficiently managing scarcer and less reliable water resources

Despite all these challenges water management in urban areas has so far been considered as the management of the different components of urban water cycle independently. The traditional approaches of ad-hoc responses (driven by incidents), to the problems arising from conventional urban water management, will not be sufficient to cope with these challenges. There is a need for a fundamental change in the way we manage urban water based on a foundation of research, technology and innovation. Sustaining healthy environments in the urbanized world of the 21st century represents a major challenge.

Figure 1 Current and future global challenges

To ensure a more sustainable future there is a need for more drastic measures - a paradigm shift. This paradigm shift should be based on key concepts of Integrated Urban Water Management (IUWM) including: interventions over the entire urban water cycle; reconsideration of the way water is used (and reused); and greater application of natural systems for water and wastewater treatment. IUWM provides an alternative to the conventional approach for an effective and efficient management of scarce water resources. Through coordinated and flexible planning among water using sectors, IUWM allows for the optimal sequencing of traditional and new infrastructure with alternative management scenarios that leverage efficiencies and promote conservation. The IUWM approach offers a more diverse and versatile set of options for dealing with larger and more complex urban water challenges.

There is a great opportunity to address IUWM in emerging towns as they do not currently have developed infrastructure. Studies predict that the majority of urban population growth in developing countries will occur in small towns. For example Pilgrim (2007) reported that for every large town there are an estimated 10 small towns, which are expected to increase four-fold in the next 30 years. These new cities can employ innovations from the beginning and reap maximum benefits from technologies that promote more efficient use of water and generate entrepreneurial solutions. These emerging areas in developing countries could potentially provide a blueprint for livable and healthy resilient cities of the future and become grounds for multidisciplinary approaches for a new development paradigm. It is important to note that, the window of opportunity for doings things differently is small. Quick action is needed to prevent these emerging areas from following the traditional 19th century practices that will result in unsustainable conditions.

The IUWM approach also create opportunities to develop pro-poor approaches due to the fact that it looks at diverse water sources some of which are cheaper sources and locally available and considers the whole urban catchment as a unit of management. IUWM attempts to exploit local resources (such as local groundwater, surface water, rain/stormwater, wastewater), that can be available for all residents. Such an approach makes provision of water supply affordable to the poor. At the same time this requires that local water sources are well protected and thus proper sanitation and drainage services need to be provided to all communities in the urban area including the urban poor. For example, providing sanitation and drainage services to informal settlements could be beneficial to an urban area in terms of avoiding flooding and minimizing pollution of potential local water sources (surface and groundwater). This has a mutual benefit to the urban area at large and the poor.

The new thinking of urban water management calls for a new generation of urban leaders with radically different thinking to deliver a real paradigm shift in urban water management. This lecture note is part of the training module for decision makers and senior managers that will discuss topics such as future change pressures, the conventional approach to urban water management, the principles and approaches for implementation of IUWM, frameworks for IUWM, challenges and opportunities in emerging and existing cities. It will present the different tools of decision making necessary for implementing IUWM, and will include examples of best practices (case studies) to help participants get an impression of how IUWM can be employed to enhance urban water management practice.

“ *The new thinking of urban water management calls for a new generation of urban leaders with radically different thinking to deliver a real paradigm shift.*

Conventional urban water management and its challenges

Safe water supply and reliable sanitation are fundamental to a community's health and development. However, providing adequate water supply and sanitation, particularly in urban areas, has been and still is a challenge in many countries throughout the world. Currently, more than half (54%) of the world's population lives in cities and the number is expected to grow to 66% by 2050 (UN DESAPD, 2014), most of which have virtually no infrastructure or only inadequate infrastructure, and limited resources to address water and wastewater management in an efficient and sustainable manner.

In the case of developed countries , the current practice of urban water management has managed to provide the required services to urban areas, as institutions are well established and adequate financial and human resources are available. However, the conventional approach is not an efficient method to manage the urban water system and is not able to address issues such as water scarcity. In the case of developing countries, where institutions are weak and sufficient financial and human resources are unavailable, the conventional approach to urban water management faces huge challenge. Many cities in the developed and developing countries are already struggling to operate water systems effectively based on conventional approach and many more will struggle in the future if current management solutions and technological interventions are not seriously reformed.

In general urban water issues often remain disconnected from broader urban planning processes on the one hand, and basin-level management on the other. Urban master plans have not accounted for the various infrastructural components of urban water management (water supply, wastewater, non-waterborne sanitation, stormwater drainage and solid waste management). Furthermore, although water supply, sanitation and urban settlement planning may be incorporated into basin-wide management plans, these often neglect to acknowledge the cross-scale interdependencies in freshwater, wastewater, flood control and stormwater (Tucci, 2010).

Zooming into the urban water management, the conventional approach has been found wanting in its ability to address key interactions between water, sanitation, stormwater management and water resources protection. In general, the management of water supply, sanitation and stormwater has not occurred in concert; instead, each has been planned and delivered as an isolated service (see Figure 2) – thus interconnections among problems and potential solutions are missed.

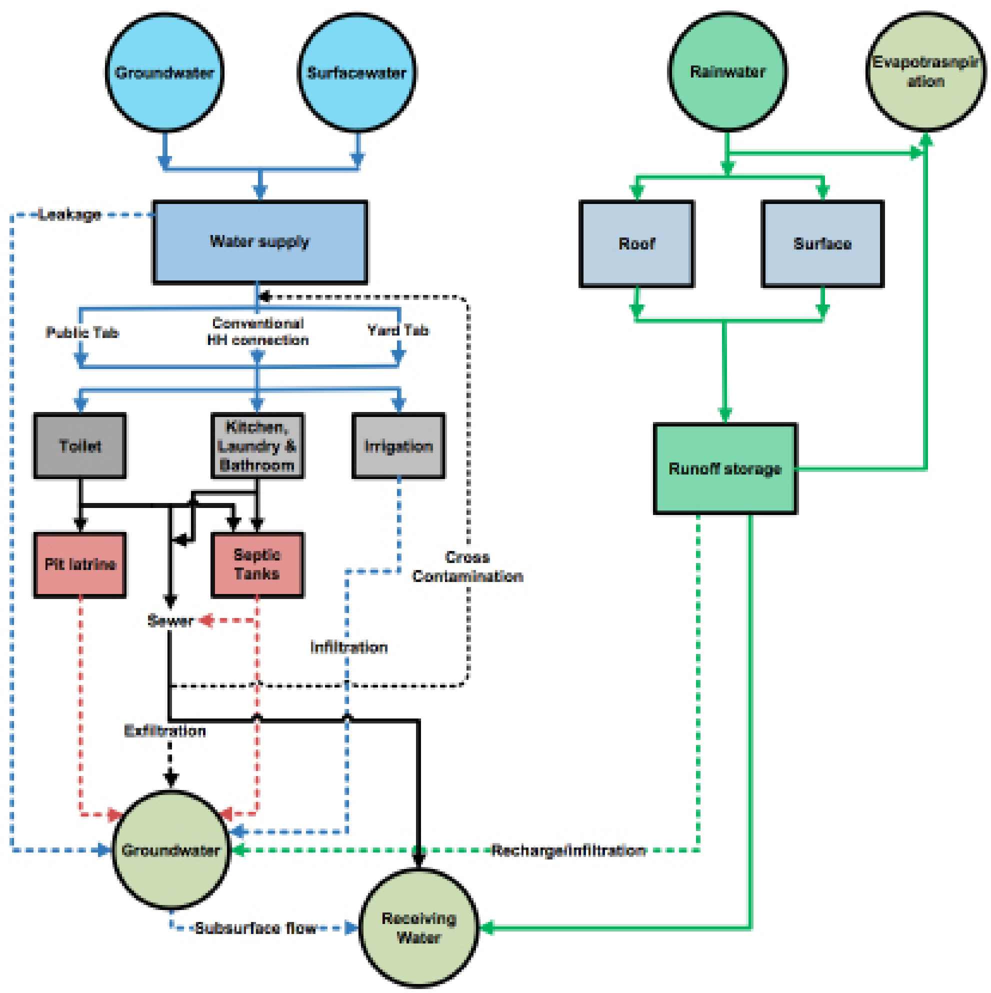

Figure 2 Conventional Urban Water Management

The conventional urban water management model has failed to distinguish between different water qualities and to identify uses for them. As a result, high-quality water has been used indiscriminately for all urban water needs, in the process contributing towards resource scarcity (Van der Steen, 2006). With scarcer and less reliable water resources current models of urban water management and their corresponding infrastructure have already failed or are on the verge of collapse from the perspective of cost effectiveness, performance and sustainability. Moreover, a range of authorities, each guided by distinct policies and pieces of legislation, continue to oversee water sub-sectors at the city level. As urban governments become more complex and specialized, sectoral integration within government and scalar integration between levels of government is becoming increasingly important.

Today, cities all over the world are facing a range of challenges due to dynamic regional and global pressures that impact the way urban water systems are managed. The most important of these global change pressures are population growth, urbanization, climate change, aging infrastructure and emerging contaminants. These change pressures will exacerbate the challenges of conventional urban water management problems in addition to their inherent drawbacks. It is expected that with the increasing global and local change pressures the business as usual approach will be unsustainable and not suited to achieve the goal of global coverage of water and sanitation resulting in the danger of a steady decline of the health and well-being of citizens.

Population growth, urbanization and industrial activities are leading to a dramatic increase in water use and wastewater discharge. Global population is expected to exceed nine billion by 2050 (UN, 2010). The urban population is projected to double from the current 3.4 billion to 6.4 billion by 2050, with the number of people living in slums increasing even faster, from 1.0 to 1.4 billion in just a decade (UN 2010). In addition, technological and financial constraints are challenges in maintaining and upgrading infrastructure assets to deliver water to all sectors while maintaining the quality of water distributed to the various users. Climate change is another global pressure that is predicted to cause significant changes in precipitation patterns and their variability, affecting the availability of water. And yet the infrastructure for conventional urban water management is planned as a rigid structure that lacks flexibility and a very energy intensive system. Due to these future change pressures, cities of the future will experience difficulties in efficiently managing scarcer and less reliable water resources and to protect public health and environment in a sustainable way.

It is not possible to address the current and future challenges by the conventional current practice of UWM. In order to address these challenges the new paradigm of urban water management Integrated Urban Water Management (IUWM) need to be discussed (Mitchel et al., 2004; Jacobsen et al., 2012). The IUWM approach has advanced sufficiently and provides the potential to satisfy the water needs of communities at the lowest cost while minimizing adverse environmental and social impacts.

Integrated Urban Water Management (IUWM)

General overview

Water scarcity in urban area is projected to get worse over the next century and will require integrating solutions across scales (household, neighborhood, city, catchment, and transboundary), domains (economic, social, and environmental), and institutions (government, private sector, and civil society).

Integrated Urban Water Management (IUWM) is an approach that includes: interventions over the entire urban water cycle; reconsideration of the way water is used (and reused); and greater application of natural systems for water and wastewater treatment. It provides an alternative to the conventional approach for an effective and efficient management of scarce water resources.

IUWM is an adaptive approach in which decisions—reached by consultation with all stakeholders—are part of a long-term vision (Howe et al., 2011). It seeks to provide sustainable solutions that can respond to the increasing uncertainty about future conditions created by climate change and rapid growth (Khatri and Vairavamoorthy, 2007). The rapidly expanding cities in developing countries are particularly suited to IUWM solutions because new infrastructure and management frameworks can be designed from the scratch using IUWM principles.

> *"Integrated Urban Water Management (IUWM) is an approach that includes: interventions over the entire urban water cycle; reconsideration of the way water is used (and reused); and greater application of natural systems for water and wastewater treatment.*

Compared to the conventional approach, the manner in which water is produced, used and returned to the environment has to be substantially changed. There is a need to look for a new paradigm of IUWM that can help improve the health and livability of cities of the future.

Jacobsen et al. (2012) states that "Integrated urban water management (IUWM) seeks to develop efficient, flexible urban water systems by adopting a holistic view of all components of the urban water cycle (water supply, sanitation, storm water management), in the context of the wider watershed." (Jacobsen et al., 2012)

Mitchell (2004) describes IUWM as a new approach for urban water management that takes a comprehensive perspective to urban water services, viewing water supply, wastewater and storm water as components of an integrated physical system recognizing that the physical system sits within an organizational framework and a broader natural landscape.

These perspectives lead to an integrated approach of urban water management, where integration is achieved in relation to:

Integration of all parts of the urban water cycle: IUWM considers all subsystems in the urban water cycle such as water supply, wastewater, stormwater and solid waste management. IUWM aims to take advantage of positive interactions between the different subsystems of the urban water systems and to minimize negative impacts.

Integration of all water uses: IUWM takes all water uses into account both human and ecological. The objective is to provide water services to communities while at the same time ensuring ecological integrity of the natural environment (Maheepala, 2010). IUWM aspires integration across all social, economic and environmental dimensions, looking for approaches to optimize water use for different sectors.

Integration of all institutions, stakeholders and water users: IUWM aims institutional integration which enhances communication, collaborative organizational relationships, sectoral coordination, community participation and stakeholder engagement and information sharing.

Integration of all urban services: IUWM addresses the complex interactions of urban infrastructure systems, the physical environment, the level of services and social factors. The interactions between the different urban services like urban water system, transport, housing, communication and other utilities are considered (ICLEI, 2011).

Integration of different spatial scales: IUWM considers different spatial levels from the whole region down to the single site to address the complex interactions of the urban water system (Mitchell, 2004). In this regard individual sites fit as incremental parts in the management strategy of the catchment.

> *"Manage water supply, wastewater stormwater together (one urban water cycle) and think creatively about what potential water sources might exist (don't limit your focus to the obvious ones)*

The key to IUWM is integration at each stage of the planning process. Thus planners should consider the full range of challenges related to water management and their interactions within cities and the wider watershed, addressing issues such as:

- How is upstream land use (e.g. irrigation) impacting downstream water availability and quality?
- How will future urban development impact water management challenges?
- What are the sources of pollution (e.g. sanitation) to surface and groundwater sources?
- How is solid waste management affecting urban drainage system?

Decision-makers must also consider a broad range of solutions to these problems, including the following:

- Do institutions adequately consider urban needs and impacts in terms of the broader watershed?
- Can alternative water sources such as rainwater harvesting and greywater recycling be harnessed in addition to traditional surface and groundwater sources?
- Is water quality optimized for its intended use (e.g. potable and non-potable)?
- Can wastewater be exploited to produce cost-efficient energy?

Because both the challenges and solutions cross geographic boundaries and affect mandates across institutions, IUWM can only be implemented if institutions agree to work together. Examples of concerns that span such boundaries include making sure building codes do not impede rainwater harvesting, addressing health regulations that prevent greywater reuse, and ensuring that urban planners consider water as a key component in their plan.

Guiding Principles

IUWM is about achieving better outcomes in the future by acting now and drawing on good practice from many cities around the world. It is not a method or technique but rather a perspective on the urban water cycle that draws upon a number of key guiding principles.

These key principles should be considered when planning urban water systems and they include the following (Jacobsen et al., 2012):

Consider the entire water cycle as one system: The water sources, water supply, wastewater and storm water should be contextualized within an integrated urban water framework as this allows us to understand the relationship between the various components of the urban water system (see Figure 3). For examples such an approach allows to identify negative interactions such as cross-contamination of drinking water supply from leaking sewers and foul water bodies, particularly in the case of intermittent water supply (Vairavamoorthy et al., 2007). Positive interactions include opportunities for considering a portfolio of water sources, reuse, recycling and the cascading use of water (Mitchell, 2004; Van der Steen & Howe, 2009).

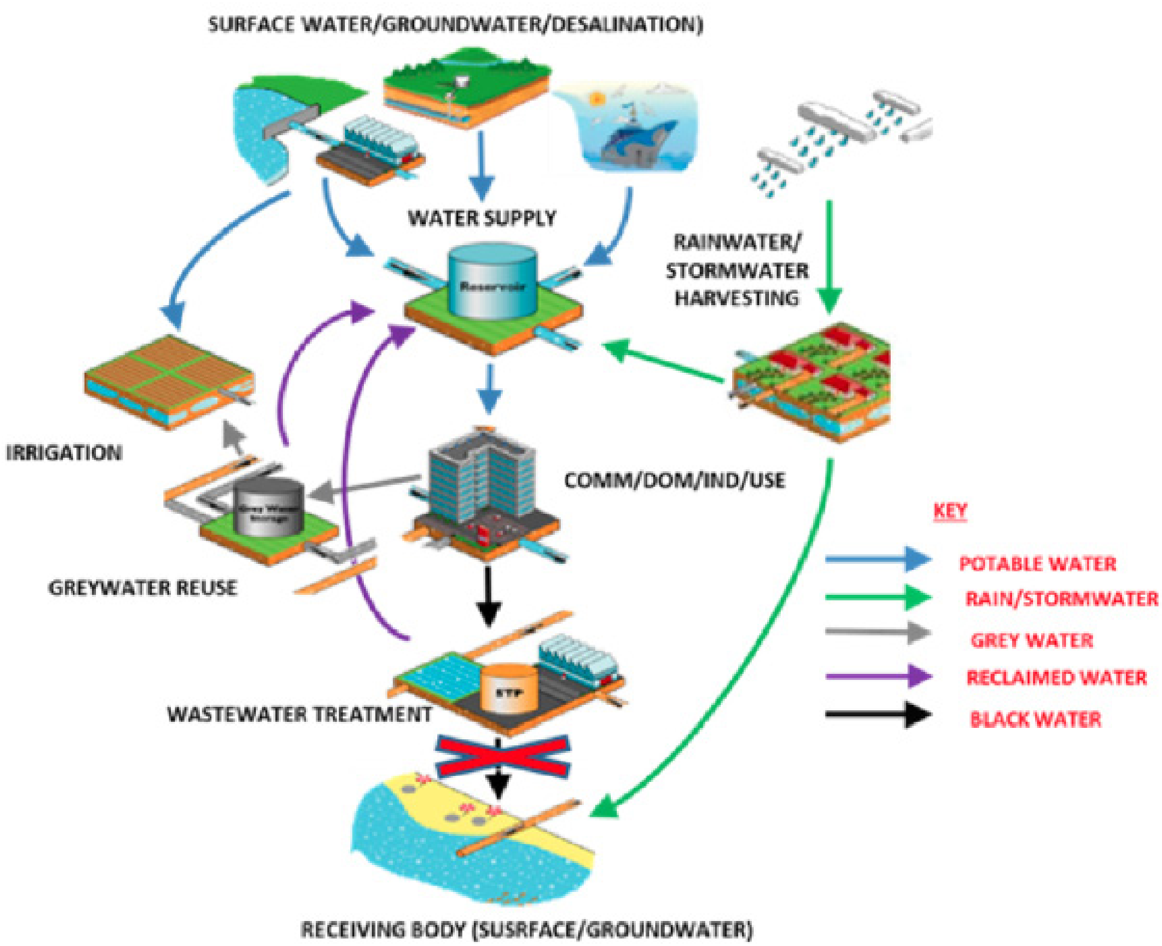

Figure 3 Closing the urban water loop (Vairavamoorthy et al., 2011)

Provide water fit for purposes: When considering the demands for water, it is important to match water quality for its intended use. The application of this principle exposes alternative sources of water that can be safely used for different purposes. Some examples include greywater reuse for toilet flushing, gardening or non-process industrial demand. The new perspective avoids the need for the highest level of treatment for uses that require low grade water, hence avoiding high treatment costs.

Diversify water sources: A portfolio of water source options such as the conventional surface water groundwater sources and the non-conventional options such as rainwater/storm water, greywater and blackwater should be considered as potential sources (see Figure 4). One should consider the potential to use water multiple times by cascading it from higher to lower-quality needs. The objective is to diversify water sources and increase the reliability of water availability (security through diversity) rather than depending on limited options of water sources (Alcamo et al., 2008, Gleick, 2009).

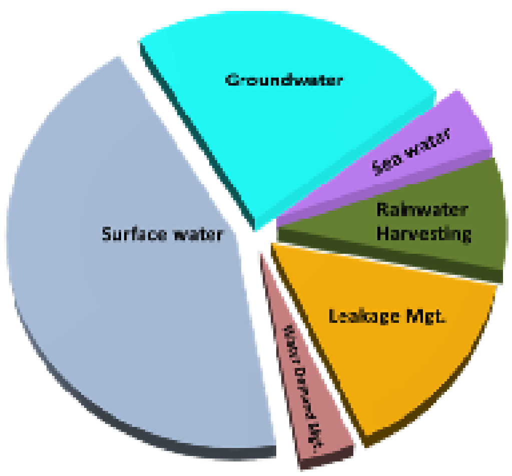

Figure 4 Diversified water sources

> *The objective of diversifying water sources is to increase the reliability of water availability (security through diversity) rather than depending on limited options of water sources*

Develop adaptive/flexible systems: When developing an IUWM strategy, it is important to recognize uncertainty that exists within the future change pressures. There is a need for flexible systems that have the ability to cope with uncertainties and hence have the capability to adapt to new, different, or changing requirements (Ref). The application of this principle fosters a more modular, decentralized approach to urban water management and a clustered growth approach to urban development (Bieker et al., 2010). The clustered approach to urban development allows optimizing the adaptive capacity of the emerging urban space by allowing infrastructure provision to be staged in a way that traces the urban growth trajectory more carefully.

Consider innovation in urban water technologies in planning and development: Recent advances have generated technologies that are extremely effective and efficient, while being simple, low-cost and having limited energy dependence. A new perspective to treatment is emerging based on innovative technologies such as membranes, that will allow to produce different water qualities from inflows of different sources within a single system (Otterpohl et al., 2002; Bieker et al., 2010; Cornell et al., 2011). In addition energy efficient treatment options have been developed around natural systems such as constructed wetlands and soil aquifer treatment. Innovations in membrane technology have also enable to scale down treatment processes and apply them in clusters for decentralized approach.

Maximize the benefits from waste water: The main driver for water management should be beneficiation – maximize value added approaches. By employing innovative treatment technologies, water, energy and nutrient can be reclaimed from waste streams and reused locally (Otterpohl et al., 2002; Bieker et al., 2010; Cornell et al., 2011). A new perspective to treatment is emerging, based on the concept of beneficiation, where we aim to maximize the benefits harvested from every drop of water (Vairavamoorthy et al., 2011). Such an approach allows addressing the global sanitation challenge and change public perception of wastewater as an opportunity rather than a burden (Vairavamoorthy et al. 2011). Wastewater treatment and reuse in agriculture can provide benefits to farmers in conserving fresh water resources, improving soil integrity and improving economic efficiency. In addition, wastewater has the potential to extract renewable energy and nutrients and will convert current liabilities (e.g., energy required for wastewater treatment) into assets (e.g., energy from wastewater treatment). Phosphorous in the form of struvite is another example of resource harvesting from wastewater. An example of struvite production in West Boise Canada is shown in Figure 5.

> *The main driver for water management should be beneficiation – maximize value added approaches*

The urban water cycle is closely linked to the watershed: The city depends on and impacts the broader watershed. There is a strong need for a close coordination of water management at the catchment and city scales. Measures and activities at the catchment scale are crucial for urban areas to get access to sufficient good quality water and to get sufficient protection from flooding. On the other hand, negative impacts of cities on the watershed have to be contained. This may refer to the efficient use of the water resources within cities as well as reducing contaminant loads from cities to downstream users in wastewater and storm water discharges. This principle highlights the link between IUWM and IWRM that should be strengthened to facilitate an equitable allocation of water resources between the different sectors and facilitate the protection of the watershed (Gleick et al., 2011; Anderson and Iyaduri, 2003).

Recognize the importance and impacts of Urban Planning: To implement IUWM, there is a need for a new paradigm in urban planning. It is important that water professionals, understand and appreciate the significant role of urban planning in potentially supporting the optimization of their water systems (conversely hindering or constraining it). The importance of urban planning to water management requires close coordination, early in the development stage, between planners and water professionals (Brown et al., 2008). Carefully selected systems can enhance stormwater management; allow reuse of treated wastewater for environmental uses, while at the same time enhancing landscape design.

Involve all the players: Critical, to the success of IUWM is the early and continuous integration of all stakeholders in the planning, decision and implementation process. The stakeholder participatory process is required to understand the priorities of potential users. The stakeholder process intends that all stakeholders look at the urban water system with common objectives and facilitates the development of innovative solutions and opportunities to optimize the whole urban water system (van der Steen & Howe, 2009).

Strive for conducive institutional environment: The main barriers to achieving IUWM are institutional in nature because of a highly fragmented division of responsibilities and tasks (Ref). Regulatory changes are required to avoid sectoral perspective and to promote a more integrated approach. This principle promotes coordination of the highly fragmented institutional divisions of responsibilities and tasks that exist during the entire process of planning and implementation (van der Steen & Howe, 2009). A reformed institutional structure will allow institutions to deal with water supply, wastewater, stormwater and solid waste management collectively, enabling them to coordinate their plans and actions in a way that recognizes and reconciles the important interrelations and interdependencies that exists between each of these subsystems (Post, 2011).

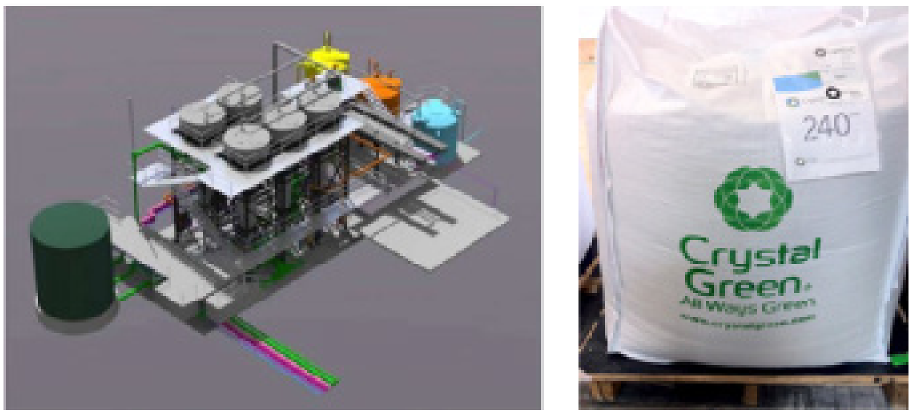

Figure 5 Full-scale struvite production facility, West Boise Canada (Pharmer Engineering)

Comparison of Conventional and integrated urban water management

The IUWM and conventional approaches of urban water management differ in a number of ways. A comparison between the two approaches is provided in Table 1 (Based on Pinkman, 1999):

Table 1 Comparison of a conventional approach to urban water management with an IUWM approach

Conventional approach	IUWM approach
Water supply infrastructure developed first followed by sanitation and drainage	Planning for all urban water components simultaneously.
Water is supplied from conventional surface and groundwater sources	Water is supplied not only from conventional sources but also from alternatives sources such as rainwater harvesting or wastewater reuse.
All water supplied is of potable quality.	Demand is multifaceted allowing to match water of a certain quality for its intended use.
Wastewater is a health hazard and therefore needs to be removed as quickly as possible and disposed straight after treatment.	Wastewater can be treated and reused for other purposes such as gardening or toilet flushing. In addition wastewater has the potential to be a source of renewable energy and nutrients.
Stormwater is considered sources of flooding and needs to be removed from urban areas as quickly as possible.	Stormwater should be seen as a resource. It can be collected and used for non-portable purposes.
Centralised systems are best for supplying and treating water guaranteeing public health.	Decentralised/clustered systems are considered to support the reuse of water, and to provide higher flexibility
Integration happens by accident - wastewater, water supply and storm water are managed by independent agencies.	The physical systems of urban water cycle and their management are integrated with one another. Institutional integration is actively promoted through coordinated management.
Different urban water components are planned independently by different institutions. Stakeholders are approached for approval of pre-selected solutions.	All relevant stakeholders are represented in urban water decision-making processes. Stakeholders and citizens must be included and consulted in the discussion and in the search for appropriate solutions.

Integrated urban water management framework

An integrated urban water framework is an important instrument to consider when operationalizing IUWM. The IUWM framework provides opportunities to think creatively about water sources and to tailor quantity/quality for different purposes. It facilitates a structured and holistic analysis of water management strategies.

By improving the understanding of the complex interactions that exist between the different components of the urban water cycle, it allows to make decision that look at the whole urban water system together. For example, experience has shown that poor sanitation has a major impact on the pollution of water sources and water supply. And the integrated framework exposes these negative interactions. In addition, an integrated framework highlights positive synergies such as the potential for providing more people with water and sanitation services, while using less resource. For example, it highlights opportunities for reuse, recycling and the potential of alternative sources for water, such as stormwater and wastewater. In addition, it allows identifying positive interactions such as the recovery of energy and nutrients.

Figure 6 presents an integrated framework for water systems in low-income neighborhoods in developing countries (illustrating typical elements such as onsite sanitation and negative interactions due to cross-contamination).

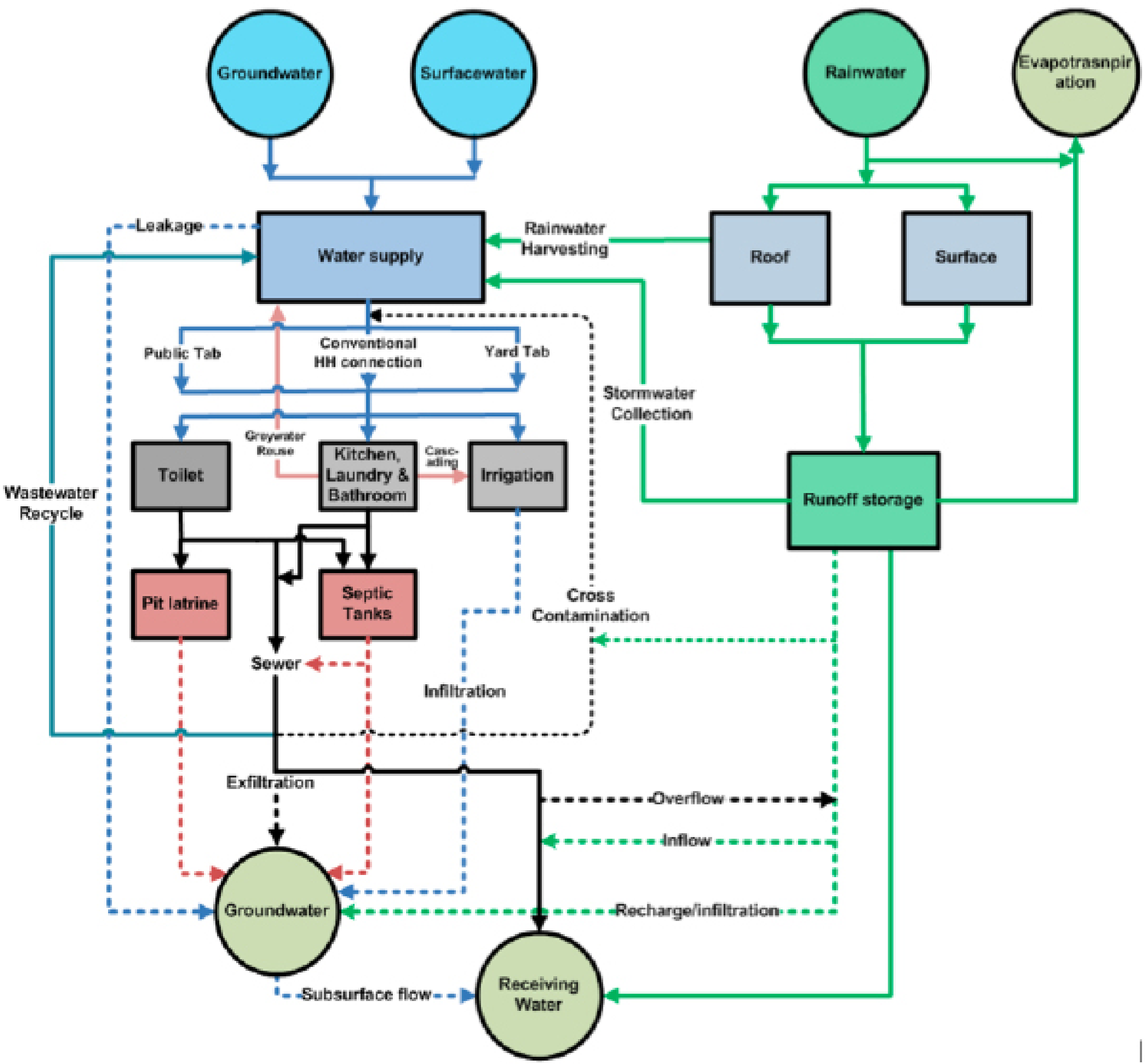

Figure 6 Integrated urban water framework for low-income urban areas (Tsegaye et al. 2012)

The integrated framework needs to be applied at different spatial scales, namely the neighborhood/cluster scale and the city scale (see Figure 7). The consideration of the different spatial scales facilitates the assessment of the different threats and opportunities for urban water management. It is expected that optimal solutions are likely to be a combination of interventions across these scales. Let's see how the framework can be applied at each scale.

Neighborhood/cluster scale: this scale allows water and other resource flows to be described between the various components of the urban water system at community level that may comprise groups of houses. At this scale interactions between sanitation, water sources, water supply and drainage systems are analyzed that start at and beyond the household level. A city may be divided into several neighborhoods/clusters.

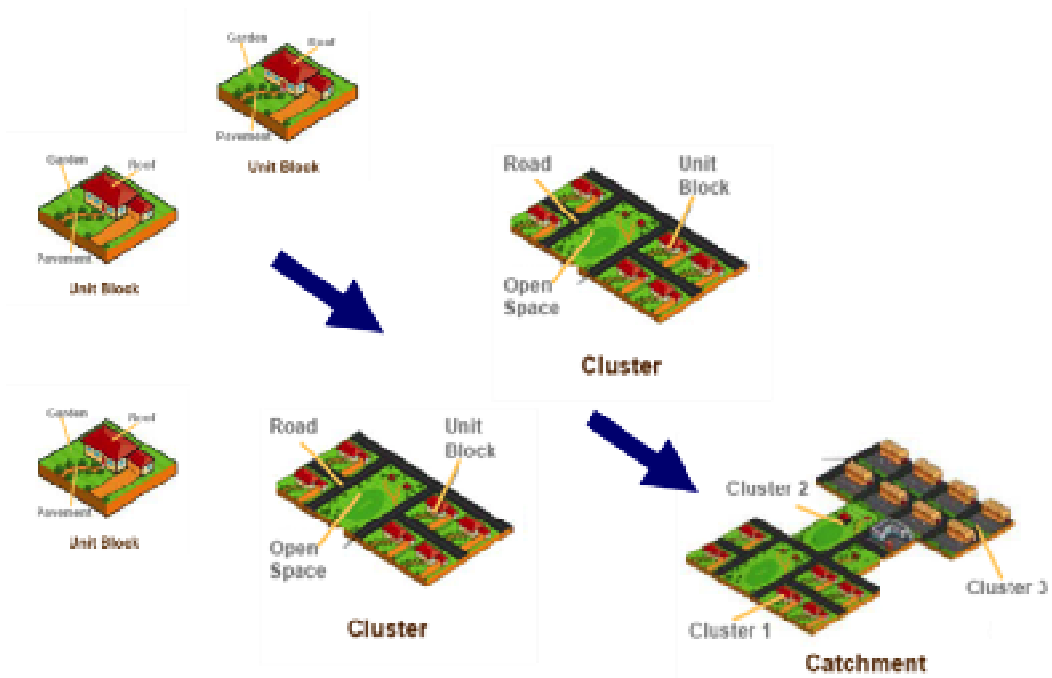

Figure 7 Different scales of urban water management

Urban/city scale: this scale describes water and other resources flows between different neighborhoods and clusters within an urban space/city. For example, negative interactions on the city scale include: lack of drainage provision in one cluster (e.g. a slum) impacting the performance of drainage in the entire city; lack of sanitation in one cluster (e.g. slum) degrading the quality of water sources in other clusters etc. Positive interactions that could be articulated at this scale include: cascading use of water between clusters (e.g. wastewater from one cluster being used for urban agriculture in another cluster); arguments for integrated infrastructure provision among clusters (i.e. all communities including low income groups and slums), where service provision for the entire city benefits both individual clusters and the greater city (i.e. an integrated drainage network that includes all clusters makes more sense than one that intentionally avoids some clusters (i.e. slum clusters). Figure 8 presents a diagram of the flows between clusters which illustrate the mentioned positive and negative interactions.

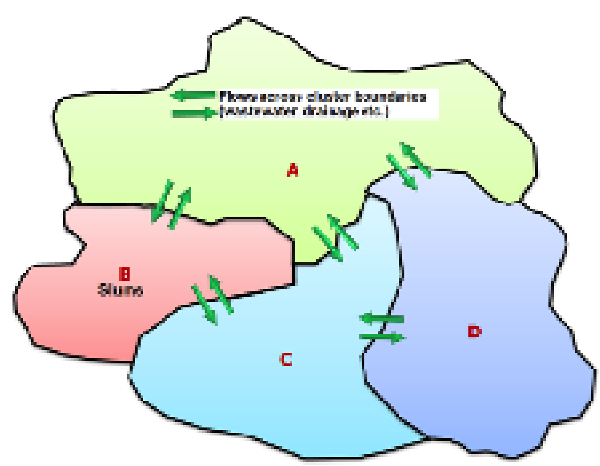

Figure 8 Schematic depicting flows between neighborhoods/ clusters in an urban area (Vairavamoorthy et al., 2012)

IUWM approach fosters decentralization

The application of an integrated approach to urban water management and in particular, harvesting of resources, appears to foster a more decentralized approach to urban water management. Clustered approach allows us to grow our systems in stages and in line with urban growth (less anticipation required), creates greater benefits from improved urban water management as it encourages resource recovery, it creates a diversity of solutions that allows exploitation of local sources. In decentralized systems, water is abstracted, used, reused and discharged within short distances. For example recycling and reuse of wastewater is effective if the distances between the households and the treatment units are minimized to reduce pumping energy demand; the potential of small local water sources (such as small streams or rainwater harvesting), which are often neglected in central schemes, could be utilized in decentralized systems, energy recovery and reuse (such as heat recovery from greywater) is more efficient when the distance between the user and sources of heat is short to avoid losses during transport.

In addition to being more efficient, decentralized systems are generally more resilient – better equipped to withstand or bounce back from major disruption – than centralized systems. Decentralized systems are smaller and easier to locate in less flood prone areas, and it is generally easier to maintain power for distributed systems using back-up generators. And in some cases they can generate their own power such as through biogas generation. During Hurricane Sandy, for example, several decentralized systems in the region (Northeast USA) remained operational throughout the event while many centralized systems suffered severe damage and operational failures. Ridgewood, New Jersey's water pollution control plant, equipped with an on-site biogas-fired turbine system, functioned throughout the entire event (Johnson Foundation report)

When decentralized systems are linked with to broader or more centralized infrastructure, they become part of "networked" solutions with beneficial redundancy built into the system. If a distributed system does fail, it is easier to identify and isolate the problem to prevent cascading failures and direct resources to repair assets.

Linking or networking distributed systems with centralized water infrastructure produces redundancy that can mitigate the potential for cascading failures and service interruptions. Moreover, if a distributed system does fail, their smaller size makes it easier to identify, isolate, and repair problems. Distributed systems offer communities and utilities more flexibility and adaptive capacity in how they provide service to new developments. In contrast to large-scale centralized systems that are typically built based on long-term demand projections and optimized at higher population density, distributed approaches can be designed and implemented in a more incremental or modular manner as demand develops over time or used to intentionally manage development for lower population density. This reduces investment costs and makes the project easier to manage.

Decentralized approaches not only provide the advantages of flexibility and dealing with uncertainties of future challenges, but also it improves the resilience of urban water system. For example by planning distributed (decentralized) infrastructure the impact of extreme events can be significantly lower compared to that of a centralized system.

> *“Clustered approach allows us to grow our systems in stages and in line with urban growth (less anticipation required), creates greater benefits from improved urban water management as it encourages resource recovery, it creates a diversity of solutions that allows exploitation of local sources*

Challenges of IUWM

Although the concept of IUWM is very interesting and many will agree to, there are still many challenges to the implementation of IUWM. Some of these major challenges are discussed below.

One of the major challenges to the implementation of IUWM is the lack of clear performance indicators Hence there is no clear idea on what the approach of IUWM means in operational terms. Some state that in the absence of both an operational definition and measurable criteria, IUWM is not possible to identify how water should be managed to achieve the intended integration. Similar critiques have been made to the approach of IWRM (Biswas, 2004, 2008). This critique expects that IUWM ought to be reduced to a clearly defined methodology with defined characteristics. Jacobsen et al. (2012), on the contrary, refer to the approach of IUWM as changes to the mindset; a different way of thinking about the urban water cycle that is influenced by guiding principles. Hence, there is no general state of integration which should be achieved. Rather, there is a set of guiding principles of IUWM that can be considered in the design of urban water systems and applied when appropriate.

Existing education systems and training programs are still based on conventional approaches to urban water management. And most practitioners are still being trained in conventional approaches. Hence there is a lack of sufficient knowledge on IUWM approach among practitioners that hinders them to move away from conventional practices. For example, there are several innovative technologies that can help implement the principles of IUWM, such as water demand management, greywater recycling, cascading water use and water neutrality. The potential of these game changing technologies for IUWM strategies has not been fully explored, though, due to the fact that many practitioners are either not aware about these technologies or do not know how to apply them. Much has to be done to educate the practitioners and convince them on the need, viability and feasibility for a paradigm shift towards IUWM. Capacity building is needed for water professionals, urban planners and engineers from local governments and water utilities.

There is a lack of understanding on how to contextualize water supply, sanitation and stormwater within an integrated urban water framework that will allow water professionals to articulate the relationship between the various components of the urban water system. There are already some IUWM scoping models, such as City Water Balance, AQUACYCLE, UWOT, etc. (Mitchell et al., 2007). These models provide quantitative frameworks that allow the exploration of IUWM options for water supply, wastewater treatment, drainage, wastewater reuse, demand management, etc. However, these tools have not been widely used by urban water practitioners. Therefore, the application of these IUWM models in real-world planning situations ought to be promoted.

Many of the barriers to adopting the IUWM approach are institutional in nature. The institutional structure for UWM is still characterized by departments with a narrow field of responsibility. This “silo mentality” results in several institutions taking responsibility for the different parts of the urban water cycle without coordinating their activities and strategies with each other on a regular basis. Even if communication between

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the different institutions exists, an overview about the whole urban water cycle usually lacks. In order to facilitate the implementation of the IUWM approach, improvement within this institutional structure is required. This could be achieved with a new institutional set up through changes in governance, policy and regulation that ensure operationalize IUWM. Based on current experiences, there are no prescribed governance models which are best for IUWM (i.e., they either need to be centralized or decentralized). Instead, appropriateness and successful institutional setup and governance based on the principles of good governance have to be identified for different local conditions. In his criticisms of IWRM, Biswas (2008) raises the concern that the development of integrated institutions is not practical. This perspective reflects the complex management processes, in which the required expertise in different areas of urban water are very different, resulting in the large and unmanageable institutions. What is needed is not integration in terms of managing the whole water system in one institution, but rather a close collaboration and coordination between the involved institutions and stakeholders who may not be used to working together on a regular basis (Biswas, 2008).

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The implementation of IUWM requires comprehensive stakeholder engagement as well as strong political commitment, which could be difficult to garner. Early and continuous engagement of all stakeholders in the planning, decision and implementation process is critical for the success of IUWM. Effective stakeholder involvement can help reduce vertical and horizontal barriers to the implementation of IUWM. Consensus is required to ensure that the stakeholders assume ownership and are willing to support decision that relate with their own fields of responsibility. Despite growing awareness of the merits of IUWM, however, in many planning processes, decision makers are still focused on retrospective communication with stakeholders to obtain approval of already agreed-upon solutions, rather than practicing continuous and early involvement with transparent process. A further criticism of IUWM is that it ignores politics (Gyawali & Allan, 2006; Watson & Wester, 2003), which is one of the main mechanisms in society for organizing participation. The water crisis, for example, is often arguably more a function of unfair distribution than an absolute shortage of resources, and politics is the main process that determines how water is shared between potential users. A close coordination – stakeholder engagement with the political decision makers – is required. Additionally, “real” participation, as opposed to token participation, is always political because it implies a legitimate sharing of power in decision making.

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When examining the feasibility of implementing IUWM strategies, there are many economic and financial considerations that must be taken into account. A clear picture of the economic realities of a conventional approach compared to the new IUWM paradigm is required. However, there are no sufficient and detailed cost figures available for IUWM solutions, while this type of data does exist for conventional solutions. This makes it difficult to estimate – at least upfront – the costs and benefits of IUWM solutions. In addition, there are challenges such as how to measure the changing economies of scale for innovative treatment technologies and the harvesting of resources as part of the concept of beneficiation. Decision-makers need to have the ability to identify specific economic challenges of IUWM strategies, such as coping costs of insufficient water and sanitation services as well as the price of inaction. They need economic evaluation techniques, such as cost benefit analysis and cost modeling, as well as cost information to effectively address these challenges.

Potential of IUWM in different types of cities

Currently, there is no a single city that has embraced the approach of IUWM in its entirety. However, in some cities such as Singapore, Windhoek and Melbourne, initial approaches of IUWM are being implemented. In most of these cases, components of the IUWM approach have been implemented as needed. In general, IUWM strategies are driven by necessity, such as water scarcity and/or impacts on water supply sources (Lekkas et al., 2008; Mitchell, 2004).

What types of cities are ready or with good potential to implement IUWM strategies? In order to get a good idea of this it is necessary to study the characteristics of the urban water management that provide a good potential for IUWM based on indicators. So far there are no well-developed indicators that are used to assess performance or potentials of cities to implement IUWM.

However, one can discuss the potential or readiness of cities to adopt IUWM approach in terms of city typologies. Currently city typologies that describe urban water management are mainly based on characteristics such as the size of population (e.g., rural area, town, city, mega-city), level of infrastructure services and gross income level (Vorosmarty et al., 2000) and water resources availability (water stress and water abundance). However, these conventional typologies do not sufficiently represent the multiple dimensions of IUWM. There needs to be typologies that can be useful to categorize cities depending on the potential for IUWM. Tsegaye et al. (2012) proposed classification of cities into existing cities with well-developed infrastructure systems and emerging cities without mature infrastructure that can be helpful to differentiate the potential for IUWM.

Let's look at the opportunities and challenges of existing and emerging cities towards IUWM.

Emerging cities

In many emerging towns and villages in developing countries, there are good opportunities for implementing an IUWM paradigm. It is in these emerging areas where most of the rapid expansion of urbanization in developing countries is taking place. Pilgrim (2007) reported that for every large town there are an estimated 10 small towns, which are expected to increase four-fold in the next 30 years. The fact that these emerging urban areas often don't have mature infrastructure and governance structures and that urban planning for these areas has not yet been developed provides real opportunities for include innovative solutions for the provision of water and sanitation based on an integrated perspective. They provide a "blank page" for the development and implementation of innovative IUWM strategies. Development plans in these emerging areas may allow direct implementation of radically different system configurations where: surface water, groundwater and stormwater are combined as potential sources; innovative solutions are applied that allow source separation of wastes and implementation of reclamation schemes; and mixed land-use development that promotes cascading water uses between domestic, industry and agriculture sectors is considered. It is much more practical to adopt an IUWM approach in these emerging urban areas than in already existing cities.

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An example for the application of the IUWM approach in an emerging town is the case study of Arua, Uganda (Jacobsen et al., 2012). Arua, a rapidly growing town, is facing severe water scarcity because of limited availability of existing water resources. This water scarcity will even increase in future because of high (4%) annual population growth rates. A centralized water supply system exists only in the center of the town, covering 60% of the population. Furthermore, there is no sewerage system in the town. A traditional approach for managing the expected urban growth would be to develop a conventional sewer system and to extend the existing central water supply system to the new emerging/developing areas. Experiences show that there is a danger in simply expanding the existing water system because doing so will eventually lead to a dysfunctional system in the whole town because of a finite supply of conventional water resources, as well as the inability of the existing networks to carry additional flows to meet the demand from the new areas. Based on IUWM principles, an alternative approach for provision of water and sanitation has been proposed. Instead of increasing the centralized urban water system, a clustered water and sanitation system was considered. The existing urban water system in the inner city would be "ring-fenced" instead of extending to the new clusters (see Figure 9). For the new emerging areas (as well as areas which do not have an appropriate water supply or sanitation at the moment) several clusters of a semi-central water and sanitation system would be developed. The clustered water and sanitation system would be planned to facilitate the use of new alternative water resources and the reuse of water, as well as the recovery of energy and nutrients from wastewater. The potable water for the cluster will be provided by conventional water resources outside the cluster, as well as the use of local groundwater sources within the cluster. The wastewater streams from different sources – greywater and blackwater – will be collected separately, treated at the cluster and then reused. As a result, the clustered system can provide water supply to more people with reduced bulk water transfer from conventional water sources, while at the same time, providing safe sanitation. This new approach offers water security for Arua because of the diversified water sources and provides a viable alternative to the costly construction of conventional centralized systems (Jacobsen et al., 2012).

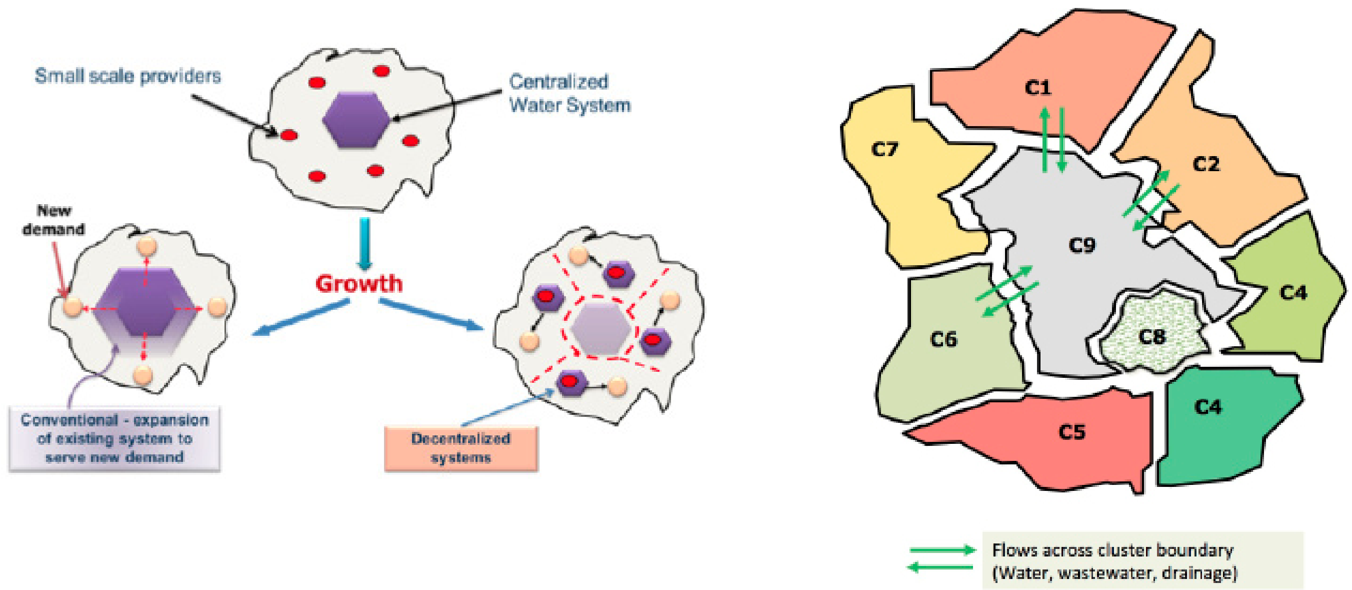

Figure 9 Decentralized growth of urban water infrastructure - the importance of ring-fencing

Existing cities

Compared to emerging towns, existing cities provide limited opportunities to rethink urban water management, as the built environment already exists and often has a long-term, locked-in infrastructure operated by silo institutions. Hence implementing a new approach that deviates from the existing system becomes challenging. The urban water management practices of such cities follow a conventional approach that relies on extensive infrastructure development and does not integrate different urban water sub-systems. The level of infrastructure and institutional development limits the extent to which IUWM approaches can be implemented. One of the major hurdles is the need to transition the infrastructure and institutions from a conventional to a more integrated urban water system. On the other hand, despite some of the major challenges, there are opportunities to apply IUWM approaches in urban areas, growing on the boundaries of existing cities, by conceptually "ring-fencing" the infrastructure of the existing city (and not extending it further into the growing areas), and then considering the growing areas as independent clusters that can be developed according to the integrated paradigm.

An example for the implementation of IUWM strategies in existing cities is the case of Nairobi. In Nairobi, Kenya high population growth and urbanization are continuously putting more pressure on limited water resources (Jacobsen et al., 2012). With a population growth of between 6.4 to 11.2 million inhabitants in 2035, the water demand of Nairobi will double or triple within the next 20 years. To meet its future water demands, the city has developed plans to use more diverse water sources. Whereas the suggested conventional approach for addressing a future water shortage would be to increase the yield of new groundwater resources and to provide bulk transfer of surface water from distant sources, an integrated framework considers the reduction of the future water demand by demand management strategies and leakage management in order to more efficiently use and reuse existing sources. In addition, the potential for alternative water resources is explored. For instance, rainwater harvesting on a cluster scale is a cost effective water resource, as well as unconventional water resources such as greywater harvesting or wastewater reuse (however, these last two alternatives are more expensive than the conventional surface and groundwater sources and hence not considered). Instead, a limited amount of new surface and groundwater resources is recommended. As a result, the future water demand of Nairobi could be provided at a significantly lower cost and expensive investments in water transfer schemes can be postponed. In addition, water security increases because the diversity of water resources is increased significantly (Jacobsen et al., 2012).

"Compared to emerging towns, existing cities provide limited opportunities to rethink urban water management, as the built environment already exists and often has a long-term, locked-in infrastructure operated by silo institutions

Assessing the potential of implementing IUWM in cities

There is still a need to identify cities that are best suited for implementing IUWM approaches. Otherwise, there is a risk that the limited available funds will not be utilized in an optimal fashion. Opportunities can be missed in places where the right conditions exist or resources could potentially be invested in places which are not quite ready for IUWM. In order to support the decision making process, a systematic approach for determining the right conditions for a city's investment in IUWM is presented. Using a method for identifying cities where the implementation of IUWM strategies will be feasible will likely result in long-lasting and sustainable improvements of urban water management.

Different approaches for measuring the suitability of IUWM approaches exist, such as the index approach for IUWM (Carden et al., 2009) or the city blueprint indicators for the sustainability of urban water systems (van Leeuwen, 2012). Furthermore, the World Bank Latin America and Caribbean Region (LCR) IUWM group (Jacobsen et al., 2012) proposed an IUWM index tailored for the rapid review of urban water management practices of cities. The index is based on aggregating different indicators for the physical, institutional and social attributes of a city. As a result, a typology of cities with good or bad potential for IUWM is provided.

This section will describe the IUWM index developed by the World Bank.

The first step of this approach is to assess whether a city faces current and future challenges which would require the application of IUWM strategies. Factors such as water scarcity, gap of sanitation coverage, pollution of water sources or expected future change pressures are used to assess the need and urgency for implementing IUWM strategies. Indicators used for calculating the physical attributes include: annual fresh water resources availability in a city per person (m3); water quality in a country that has been proposed by the United Nations Global Environmental Monitoring System (GEMS) Water Program; water supply and sanitation service coverage (in percentage); and flood risk index, as developed by the University of Tokyo. A score of 0 to 5 (worst to the best) is assigned to represent the city's condition. The values are simply aggregated and plotted in a Y-axis (see Figure 10). In addition, this method attempts to identify dynamic emerging areas without mature infrastructure and institutions, which better facilitate the implementation of IUWM strategies.

The second step is to describe the opportunity for implementation; to determine whether the institutional and regulatory environment is suitable for IUWM strategies. The indicators used to measure the social and institutional attributes include: institutional strength of water utility; existence and practices of urban management plan; GDP per capita (US$0-20,000); and existence and status of river basin agency in a city.

Finally, both categories of indicators are combined using methods of multi-criteria analysis. (Details on the calculation procedures and data sources are available in (World Bank, 2010)). The two indices are plotted in a two dimensional graph (see Figure 10). The plotted position of a city is used to review the existing practices of urban water management and its potential opportunities of IUWM intervention. The IUWM index provides the following categories for the potential for IUWM:

- Limited potential for IUWM (top left corner): Cities in this category are characterized by weak institutional and economic attributes but do not have many physical challenges (sufficient fresh water resources). There is no urgent need for IUWM in these cities.
- High hurdles for IUWM (bottom left corner): Cities in this category have high physical challenges, like water scarcity, combined with significant institutional and economic weaknesses. These cities require urgent actions for IUWM for improving existing water systems, but the current institutions are ill-equipped for addressing the challenges. With a combination of both technical and institutional improvement investments, however, IUWM solutions could potentially be implemented.
- High Potential for IUWM (bottom right corner): These types of cities have strong economic and institutional capacities but are confronted with many physical challenges to urban water management. These cities have strong potential for IUWM interventions due to their strong institutional capacity, combined with pressing needs.
- Good practices of UWM (top right corner): This category of cities combines both strong institutional and economic capacities with low level of physical challenges overall. These cities have developed good practices for managing their urban water systems. This category describes optimal situation for practicing UWM. Nevertheless, the index does not indicate if these cities take a conventional UWM approach or have already started implementing an IUWM approach.

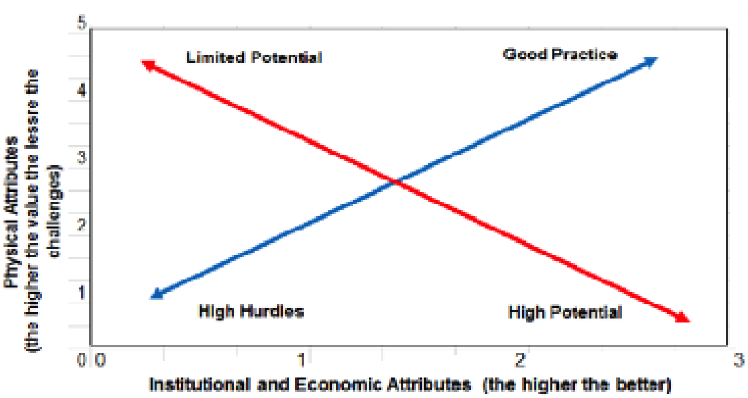

Figure 10 Category of cities for IUWM intervention

Decision Making Tools for IUWM

No one argues against the concept of IUWM that has guiding principles which make good sense to everyone. The problem lies in its implementation. One of the reasons why implementing IUWM is very challenging is because of the lack of tools and guidance documents that help decision makers understand and make informed decisions.

While IUWM provides a good framework for identifying strategies and interventions to meet current and future challenges faced by cities, there is a lack of effective tools to assess and evaluate the performance of urban water management. To date there are limited number of tools that are used for analyzing water flows in urban areas. It is important that a comprehensive set of tools that look at technical, social and economic aspects of urban water management are utilized. This section presents some of the IUWM tools that have been developed by the Patel College of Global Sustainability (PCGS). The tools include: i) a diagnostic tool, ii) resources flow balance model, iii) technology selection tool, iv) stakeholder engagement guidelines, and v) institutional arrangement tool.

During the training, a workshop will be organized to apply these tools for selected urban areas to help participants understand the tool box. Based on the input and output of the tools they will interpret the results and discuss how this can be useful in developing strategies for IUWM and make important decisions.

Brief descriptions of the different tools are provided below.

Diagnostic tool

The diagnostic tool aims to analyze existing urban water management situation in cities and identifies challenges that affect performance of the system. Based on key indicators, the diagnostic tool first assess the water management conditions in a city to determine the status such as water resources, water supply, wastewater and stormwater water management, socio economic conditions, institutional and regulatory aspects and environmental considerations. This assessment will help identify potential problems and specific issues that are failing to deliver the required performance. Such an analysis will help understand the extent to which a city is facing current challenges and will face future pressures. For example in terms of technical aspects, the diagnostic tool will assess parameters such as water scarcity in terms of supply demand gap, extent of water supply and sanitation coverage and water quality issues in water sources and supply. In addition, it will help identify opportunities available in a city for improving existing institutional, economic and regulatory frameworks.

The output of the diagnostic tool will be an aggregated index of the status of urban water management of a city that will help to describe performance in each of the categories. It will help identify categories that score poorly initiate discussions one how they can be addressed before investment is made.

The diagnostic tool will also help compare performance of a given city compared to benchmarks of best practices.

Water balance tool

The water balance tool aims to model and asses water flows based on multiple and alternative service delivery strategies, for successful Integrated Urban Water Management (IUWM). The tool enables water professional and decision makers to look on the urban water system in an integrated way and provides the capacity to predict the impacts of interventions throughout the urban water system. The tool allows modelling the different streams of the urban water cycle of stormwater, waste water, water supply, rainwater harvesting and re-use/ recycle options. As these streams are intrinsically related, the water balance tool allows water professionals explore the interaction between these elements over a range of spatial and temporal scales, and lets them explore questions such as what is the best balance between piped water and alternative supplies—such as rainwater tanks, greywatere recycling—to give the best outcome in terms of water security, and hydrological impacts. Water balance tool is designed to evaluate system performance at a range of scales– from the single household through a neighborhood/cluster to study area levels. Furthermore it provides the opportunity to optimize the whole urban water system to maximize efficiency, and minimize water consumption and environmental impact.

The tool will provides users to make two level of assessment: macro and micro.

- Users will be able to make macro level assessment of the city (study area) urban water system. Macro level assessment involves a quick analysis of the whole urban water system at study area scale. This allows water professional and decision makers to have an understanding of whole urban water system and examine the performed of the existing systems and identify potential options for a city.
- Users will be able to make micro level assessment of the city urban water system. This involve modelling and analysis of the different streams of the urban water cycle of stormwater, waste water, water supply, rainwater harvesting, and re-use/ recycle options at a household and cluster scale. This will help water professionals to simulate different scenarios that involve end-use efficiency, system efficiency, reuse and recycling strategies to meet the water supply demand of their city with improved environmental impact.

The water balance tool is also designed such that a number of water and sanitation practices in developing countries can be modelled and analyzed. One of the developing countries specific conditions includes a huge disparity of water consumption, ranging from 40 to 255 litres per person per day, depending on the type of service provision and the socioeconomic status of the household. In addition to these household consumption patterns, the water balance tool capture the consumption from different supply modes such as private house connections, yard taps, public standpipe, and private wells. It also accounts for a variety of different on-site and off-site sanitation options such as pit latrines, septic tanks and the (often missing) wastewater treatment. Cascading use of wastewater for irrigation of urban agriculture is also a common practice in many cities in developing countries. Thus the water balance tool designed for developing countries also allow exploring solutions for cascading use of wastewater for urban agriculture.

Technology selection tool

The technology selection tool consists of i) comprehensive catalogue of technologies for the entire urban water cycle and ii) decision-support tool to select potential technologies suitable for a local condition in developed and developing countries.

The technology catalogue has been developed based on peer reviewed literature and other publications on best practices. The catalogue includes technologies that range from simple to advanced systems for water, wastewater and stormwater management at different scales (Household, cluster and city level). Some of the examples include: Biosand filter, ceramic filter, membrane technologies for brackish and seawater; natural treatment systems such as bank filtration, soils aquifer treatment; greywater and blackwater treatment; wetlands, stabilization ponds; and emerging technologies for resources recovery such as energy and nutrient harvesting technologies. The information for each of the technologies is related to the design criteria, unit costs, suitability for the application, scalability, reliability, working principles, pros and cons of development and relevant resources for further information.

The catalogue is imbedded in the technology selection tool as a database, where users can search specific technology and its related information such as description, design criteria, cost, and operating principles. The tool allows for offline search, save and change options for the specific search during the search process.

The technology selection tool is used for selecting an appropriate technology suitable for a local condition. It is framed around different objectives of urban water management that include addressing issues of water scarcity (water reuse), energy harvesting and nutrient harvesting. It is based on a multi-criteria decision-support system that analyzes a wide range of indicators, such as water quality, economic conditions of households, size of population, access to advanced technologies and skilled manpower, availability of land, institutional set up, regulatory condition and more.

Stakeholder engagement guidance

The development of IUWM strategies requires a participatory planning process. Currently there is a lack of guidance documents tailored for the hosts and coordinators of stakeholder engagement processes for IUWM. In this task a manual for stakeholder engagement for IUWM will be developed that will be a useful guide for coordinators of such processes, particularly local agencies responsible for strategic planning in urban water management. The manual will be structured according to the different phases of the stakeholder process and it will provide: i) an overview of the objectives and expectations for successful stakeholder engagement in the preparation of the stakeholder process, ii) guidance on the start of the stakeholder process such as identifying the right host organizations, developing the objectives of stakeholder process, identifying the required facilitation resources and relevant stakeholders; iii) a description of the main steps of the stakeholder process such as developing common vision, rapid city assessment, scenario building and strategy development, and iv) guidance on the finalization of stakeholder engagement processes including process documentation, monitoring and evaluation and the use of the results of the stakeholder process.

The core of the manual is a description of the individual process steps with their objectives, tasks, outcomes and instruments. This description will be complemented by practical check lists as well as a list of the "do's and don'ts" for coordinators. The manual will also include a collection of templates and sample supporting documents for the different process steps such as: task description for facilitators, format for stakeholder analysis, monitoring schemes, templates for project documentation and tools for monitoring and evaluation. The manual will include case studies on stakeholder engagement for IUWM in order to demonstrate the different process steps.

In general the manual will do the following:

- The manual provides the skills and knowledge required to start, manage, control and utilize the stakeholder engagement process. It enables to coordinate the different steps of the stakeholder engagement process for integrated urban water management strategies.
- The manual helps to understand the benefits of stakeholder engagement and helps to build realistic expectation what can be achieved by such a process.
- The manual supports the development of an engagement plan including the development of a work program for the engagement process, the start of the engagement, the identification of the right stakeholders, the management and supervision of the facilitators, process documentation, monitoring and evaluation and the implementation of the results of the process.
- The manual helps to streamline the stakeholder engagement process according to a set routine and sound practice to make it of higher quality. It provides the right mindset, general rules and guiding principles for high quality engagement processes.
- The manual provides practical support for the engagement process presenting relatively simple, user-friendly and manageable tools, methods and practices, which can be used by practitioners and field-level project staff from a wide range of organizations.
- The manual provides adaptable tools, methods and practices which could be applied in different socio-cultural settings. The provided methods can be modified in response to different local circumstances and basic conditions.

Institutional mapping tool

As a basis for developing a tool for institutional mapping in the urban water sector an attempt will be made to formulate a number of principal typologies of water governance. Special attention will be given to the sharing of mandates and tasks between public institutions at the national and sub-national levels; the role of the private sector and the level of stakeholder participation allowed in the governance model. It will also define some characteristics that are required for a water governance system to be a suitable framework for initiating, managing and sustaining integrated solutions in urban water management in the long run.

The tool will provide a methodology on how to map out the landscape of water institutions in a given urban context. It will be based on stakeholder analysis, but will also examine the official mandates of water sector institutions. It will look at how they perform their official duties and whether there are discrepancies between their duties and their performance as well as the reasons behind these discrepancies. Finally, there will be guidance on how to compare the existing system of water governance with the hypothetical institutional structure as required for an integrated approach.

In combination with stakeholder engagement, this tool will enable the users to compile:

- A list specifying who the stakeholders in the urban water sector are and differentiating between formal and informal institutional agencies,
- An overview of all formal rules related to water as well as the respective formal institutional agencies enforcing them (at municipal, regional and national level),
- A table analyzing the performance of the formal institutional agencies as well as discrepancies therein,
- An overview of all informal rules related to water and – if possible – the informal institutional agencies enforcing all or some of them,
- A map displaying which formal as well as informal institutional agencies there are and how they cooperate with each other, and
- a graph illustrating the level of power as well as interest of formal and informal institutional agencies – as well as other stakeholders where applicable.

Based on this output, the users will come to know which rules apply in the urban water sector and who has a say in it. With this information at hand, they will be able to identify gaps and/or overlaps in the institutional set-up and spot where changes could be made to improve their cities' water governance system.