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IS ADOPTING IUWM TOOLKIT THE CONVENIENT APPROACH TO SMOOTH IMPLEMENTATION OF IUWM?

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Is adopting IUWM toolkit the convenient approach to smooth implementation of IUWM?

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ABSTRACT

Integrated urban water management (IUWM) is concept through which the management of the urban water subsystems (i.e. water supply, wastewater, sanitation and, stormwater) is integrated to enable meeting urban and peri-urban water demands for residential, agricultural, industrial and ecosystems while taking into consideration technical, social, economic, institutional and environmental interests to ensure water security and sustainability. Hence, rather than emphasizing on single-sided water management options that only focus on part of the problems, the IUWM approach seeks for solutions that are as must as possible holistic and viable in the long-term. This implementation process is flexible enough to respond to change and enables stakeholders to foresee the effects of interventions, leading to improved sustainability.

Though of great relevance, implementation of IUWM especially in developing countries have shown some important shortfalls. In order to facilitate the adoption and implementation of IUWM, five toolkits have been developed in recent times by various organizations. They aim not only at guiding the implementing of the IUWM approach but also at assisting stakeholders in tackling the complexity of managing the urban water systems in a systematic, sustainable and inclusive manner.

This report presents and compares the currently existing toolkits and how they can or they have been used to implement IUWM in several cities in the past. It highlights the benefits and gaps associated with each toolkit and informs practitioners in selecting and using the most appropriate toolkit for each case.

INTRODUCTION

Since ancient times, water and urban environments have coevolved constantly through complex interrelationships. Water has been and remains a vital driver for the formation, growth, and development of every urban settlement (UN-HABITAT, 2011). Today, adequate urban water management (UWM) is considered a globally urgent need. It involves the planning, policy decisions, design, and construction of infrastructure needed to meet drinking water and sanitation demands in urban areas, controlling infiltration and stormwater runoff, and for recreational parks and maintenance of ecosystems' health (Mitchell, 2004). Therefore, it requires mechanisms to monitor and sustainably reduce environmental impacts and waterborne diseases as well as important funds for investment, operation, and maintenance (O&M) of related infrastructure. Moreover, each of the urban water systems (UWS) components (i.e. water supply, wastewater, sanitation and, stormwater) undergoes stress related to impacts of population growth, rapid urbanization and climate change such as depreciating water resources, intensifying temperatures, changes in precipitation patterns, etc., which can accentuate water scarcity (United Nations Economic and Social Commission for Western Asia, 2011; Rodriguez & Gambrill, 2015). Traditional UWM practices and institutional setup have a linear focus, i.e. where UWS components are managed by isolated entities despite their interconnectedness. But the linear UWM approach is on the verge of failing from perspectives such as technical performance, cost-effectiveness, social equity or environmental sustainability. The approach is also impeded by complexities of the organizations' structures and governance. Sustainable UWM requires a paradigm shift to an 'Integrated Urban Water Management' (IUWM) approach, as acknowledged by many policymakers and water managers (Loucks & Beek, 2017).

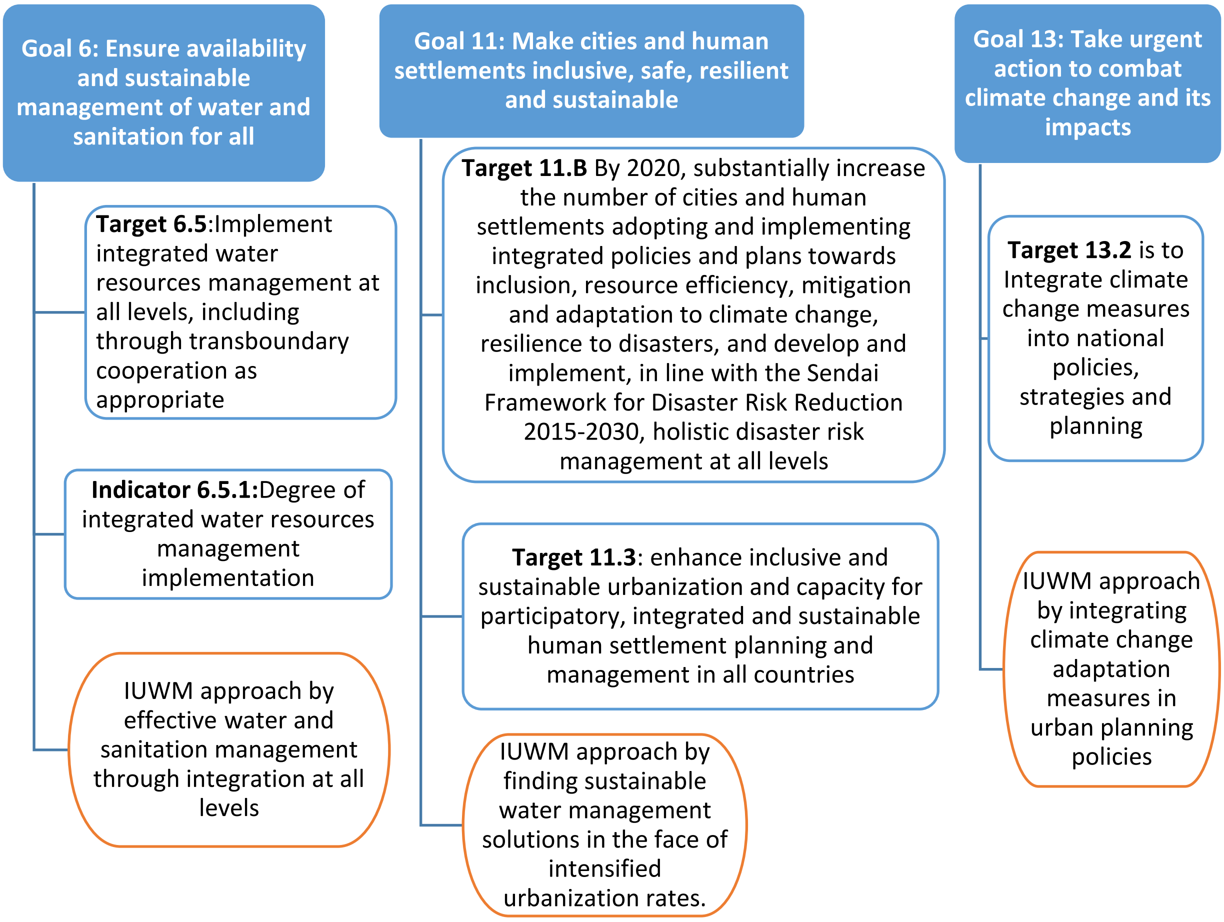
Implementation of the IUWM concept formally started about two decades ago. The process was formally launched by Australian Commonwealth Scientific and Industrial Research Organization (CSIRO) through a striving program aiming at improving the sustainability of Australian's UWS. As a result, in 1998, CSIRO developed jointly with the Water Research Foundation (WRF) a framework to enforce the IUWM approach for strategic planning of UWS management in selected Australian cities. Subsequently, the World Bank gave a strong push to the IUWM concept by implementing several projects building on the same concept while drawing knowledge and inspiration from many other initiatives, particularly from the SWITCH project.

This explains in part why several definitions are proposed in the literature, in relation to IUWM. For CSIRO, IUWM is an approach that "takes a comprehensive approach to urban water services, viewing water supply, drainage, and sanitation as components of an integrated physical system, and recognizes that the physical system sits within an organizational framework and a broader natural landscape"(Mitchell, 2006). However, the World Bank, through the Blue Water Green Cities Initiative of 2009, has adopted the following definition for IUWM, "IUWM is a flexible, participatory and iterative process which integrates the elements of the urban water cycle (water supply, sanitation, stormwater management, and wastewater management) with both the city's urban development and river basin management to maximize economic, social and environmental benefits in an equitable manner" (Schuring, Rodriguez, & Closas, 2012).

From all these definitions, it is obvious that IUWM incorporates the management of the urban water subsystems to enable meeting urban and peri-urban water demands for residential, agricultural, industrial and ecosystems (Mirza et al., 2013) while taking into consideration technical, social, economic, institutional and environmental interests to ensure water security and sustainability (Global Water Partnership, 2013). Therefore, IUWM lies within the wider framework of Integrated Water Resources Management (IWRM), which calls for an integrated adaptive, coordinated and participatory approach for management of UWS components (Brown & Farrelly, 2009; Global Water Partnership, 2013) taking the whole water cycle into consideration (Karka, Manoli, Lekkas, & Assimacopoulos, 2007; Maheepala, 2010).

Rather than emphasizing on water management options that only focus on current one-sided problems, the IUWM approach seeks for solutions that are viable in the long-term. The process is flexible enough to respond to change and enables stakeholders to foresee the effects of interventions (Bahri, 2012). By involving all stakeholders, IUWM provides a framework for planning and implementing sustainable UWM interventions (Global Water Partnership, 2013) such as water-sharing and reuse mechanisms (Otoo and Drechsel 2018). Since sustainability is usually defined through five major dimensions (i.e. financial (or economic), institutional, social, technical and environmental), the key target of IUWM is to ensure that water management meets current requirement "while laying out the ground work that allow these needs to be met in the future as well" (GWP, 2000; UNESCO, 2015).

As shown in Figure 1, the IUWM approach could help achieve several Sustainable Development Goals (SDGs) and their targets by e.g. helping to ensure universal access to water, building resilient cities or addressing climate change impacts.



Note: SDGs are made up of 17 goals, 169 targets and 230 individual indicators

Figure 1: Sustainable development goals and targets affected by the implementation of IUWM

Overall, though of great relevance, implementation of IUWM especially in developing countries have shown some important shortfalls. For example, in many African countries and cities, Bahri et al. (2016) report that many IUWM projects remained at a pilot-scale while their success and potential for replication remained questionable. In an attempt to develop mechanisms to increase the uptake and scaling up of IUWM adoption, toolkits have been developed in recent times by various organizations. These toolkits aim not only at guiding the implementing of the IUWM approach but also at assisting stakeholders in tackling the complexity of managing the UWS in a systematic, sustainable and inclusive manner (Institute for Resources Analysis and Policy, 2010).

The main objective of this work is to present and compare the currently existing toolkits and how they can or they have been used to implement IUWM in several cities in the past. From there, we aim to assess the benefits and gaps associated with each toolkit to inform any end-user (practitioner) in selecting and using the most appropriate toolkit for each case.

Most of the IUWM toolkits have been developed as a part of a donor-funded project. Therefore, beyond the lifetime of the project, there is very little support to those who intend to use them. To date, there is no such comparative review of the IUWM toolkits available in the literature. On the contrary, we found that the selection of a toolkit for use is mostly based on basic and convenience factors where each lead institution tends only to promote its own toolkit. Through our theoretical comparative assessment, we managed to compile key facts concerning each of the existing toolkits and evaluated them against several criteria. The multiple criteria assessment we propose has to be taken through a dynamic selection exercise, which will lead to the adoption of the toolkit, which appears to be the most suitable to the particular context as well as the locally relevant needs. The information and comparison would be useful to practitioners by informing the toolkit selection process and ensuring therefore a transparent and effective selection process.

METHODOLOGY

In order to identify existing IUWM toolkits, a thorough web search was carried out. The manuals of each toolkit were downloaded from the respective organizational websites. A theoretical review was carried out on the toolkit manuals based on eight (8) criteria which are:

- Adaptability and user-friendliness of the toolkits and their manuals
- Data and information requirement of the toolkits
- Spatial scale to consider in IUWM implementation
- Water balancing models used to enable or improve integration of UWS
- Strategy and ease of community engagement and integration of stakeholders
- Strategy of integration of climate change impacts and adaptation measures
- Tools used for analyzing economic viability of IUWM interventions
- Context-specific and tested methodologies by the toolkits

This criteria selection was done based on the performance expected of each toolkit. Issues such as approaches to integrate water supply systems, improve coordination between stakeholders must be considered in analyzing the toolkits as these stand to be the foundation of implementing IUWM. To assess the performance of toolkits, a three-level grading system was adopted: 0 if criteria is not met, 1 if criteria is partially met and 2 if criteria is fully met. The average of these numbers was taken as the toolkit score.

On the other hand, to further strengthen the review, five IUWM experts were selected based on their expertise on IUWM and the toolkits and interviewed during the period of 30th April - 15th June 2018 using a structured questionnaire to gather and validate key information related to the development and use of the toolkits.

RESULTS

PRESENTATION OF THE TOOLKITS

Following the literature review conducted, five toolkits have been identified. Each was developed by different organizations under different projects.

CSIRO IUWM toolkit

This toolkit has been developed in 1998 by CSIRO and the Water Research Foundation (WRF) (CSIRO, 2010). It aims at providing urban planners guidance and assistance to formulate a strategy to implement IUWM. The CSIRO toolkit guides the stakeholders in three phases, i.e. pre-feasibility, feasibility assessment and implementation. To begin the process, a 'Key Stakeholder Group' (KSG) responsible for overseeing the IUWM planning process must be set up. It consists of officials representing critical organizations involved in urban water systems. Once the KSG is formed, the toolkit guides though an implementation process which comprises of three phases, each involving five sets of activities, as presented in Figure 2.

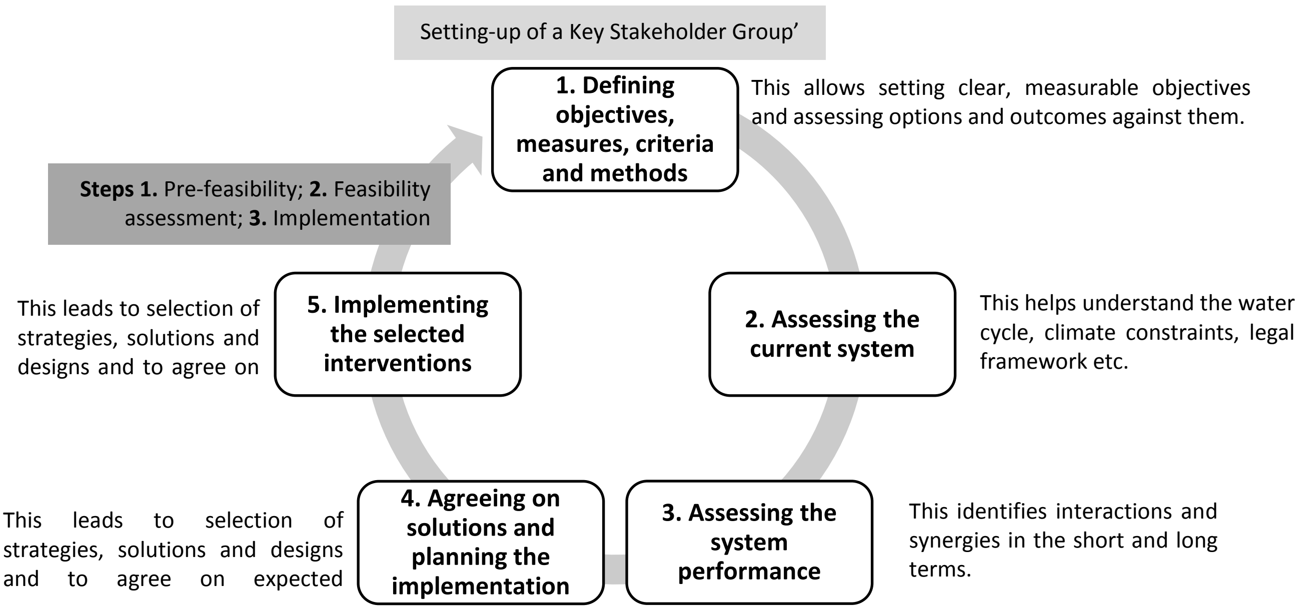


Figure 2. CSIRO toolkit implementation methodology

Reference: CSIRO, 2010

SWITCH IUWM toolkit

This toolkit has been produced between 2006 and 2011 as part of the implementation of the SWITCH project which involved 33 partners from around the world, including the International Water Management Institute. It is mostly designed for training those directly in charge of UWM or have an interest in water use in general. It intends to improve the scientific basis and to aid knowledge sharing in order to ensure that UWS are robust, flexible and adaptable. It consists of six modules presenting a) the overall SWITCH IUWM approach (Modules 1 and 2), b) the sustainable water management solutions (Modules 3 to 5) and c) helping the decision making process (Module 6). The IUWM implementation builds on Learning Alliances through which key stakeholders are brought into a forum for trainings, knowledge sharing or implementation (Figure 3).

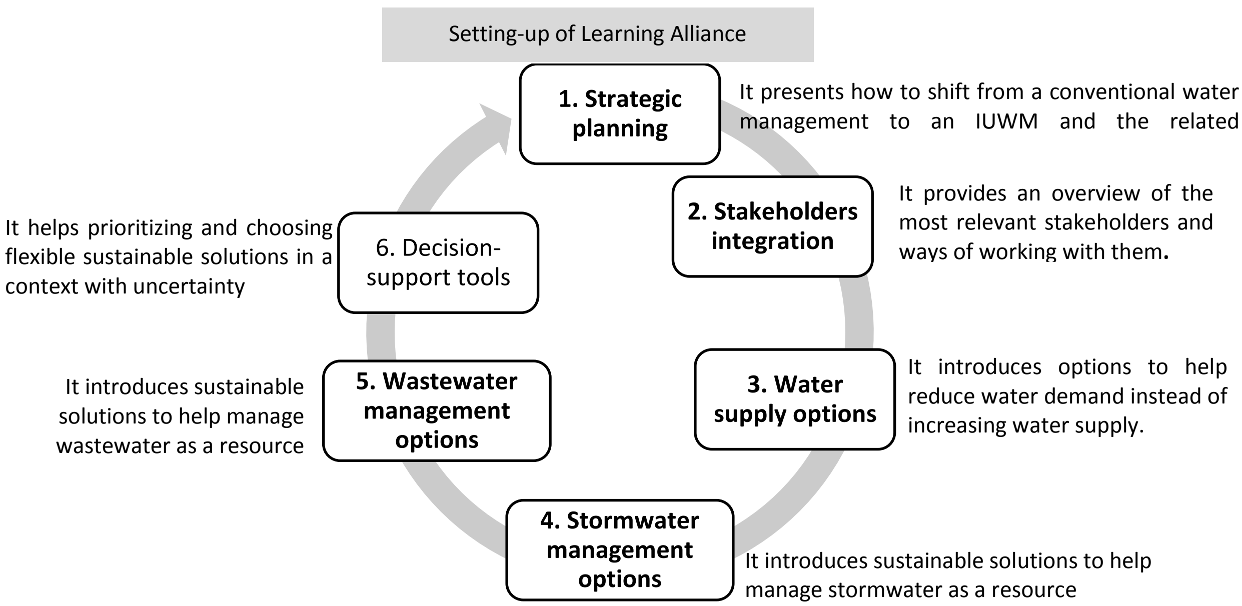


Figure 3. SWITCH training modules

Reference: SWITCH, 2010 and 2011

IRAP toolkit

This toolkit has been produced in 2010 by Institute for Resource Analysis and Policy (IRAP) and Arghyam Trust. It is meant for use by policy-makers and managers involved in UWM programs. It comprises of 31 individual tools and can be characterized into five different sets (Figure 4). The first set offers analytical procedures for projections of population and urban water demand under different socio- economic scenarios. These tools are useful in planning decisions. Next are environmental management tools, comprising tools for choosing urban water supply augmentation strategies, wastewater treatment technologies and methods, and storm water management practices. The third set of tools deals with capacity building and organizational change issues while the fourth set relates to community interface. Finally the last set of tools pertains to issues on good governance, covering the practical suggestions for improving the key areas of urban water governance, and the legal and policy framework able to affect implementation of UWM interventions.

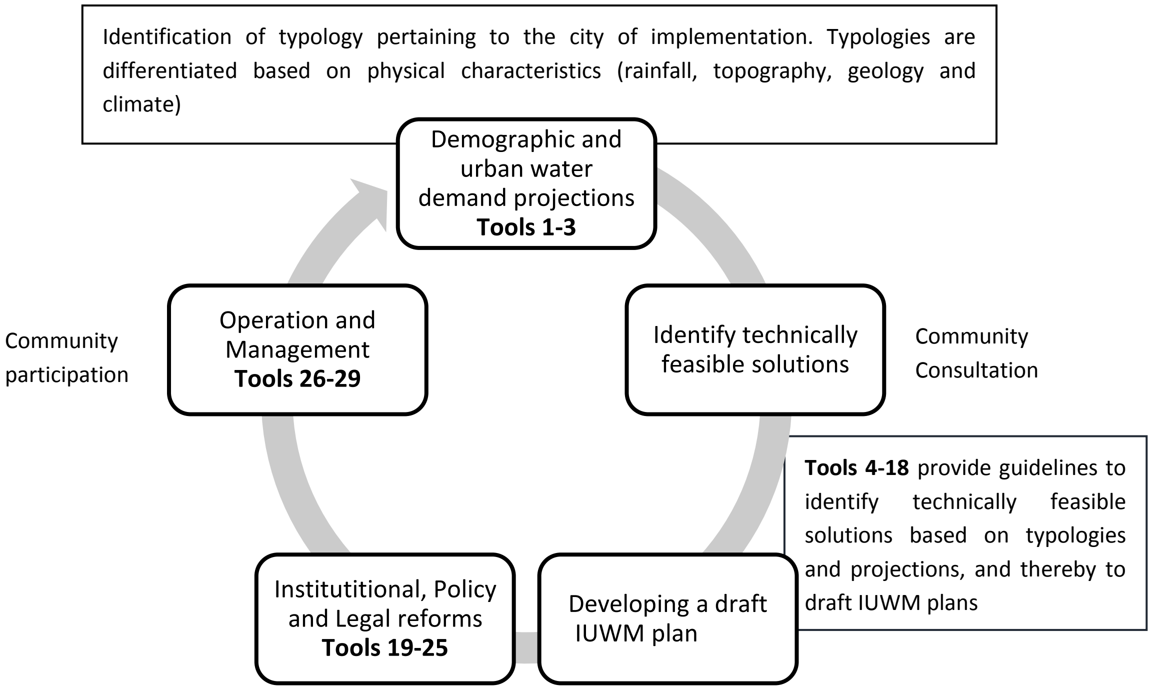


Figure 4. Stages of IRAP toolkit implementation

Reference: IRAP 2010

AdoptIUWM toolkit

The toolkit has been produced between 2013 and 2016 by ICLEI South Asia with ICLEI European Secretariat (ICLEI ES) and VVSG (Association of Flemish Cities and Municipalities, Belgium). It was adapted from the SWITCH toolkit to become specific to the Indian context. It aims at building the capacity of Indian local authorities (LAs) to undertake UWM reforms through the adoption of IUWM principles and practices in their planning and implementation processes. It enables stakeholders to formulate the IUWM strategy in six stages as mentioned in Figure 5.

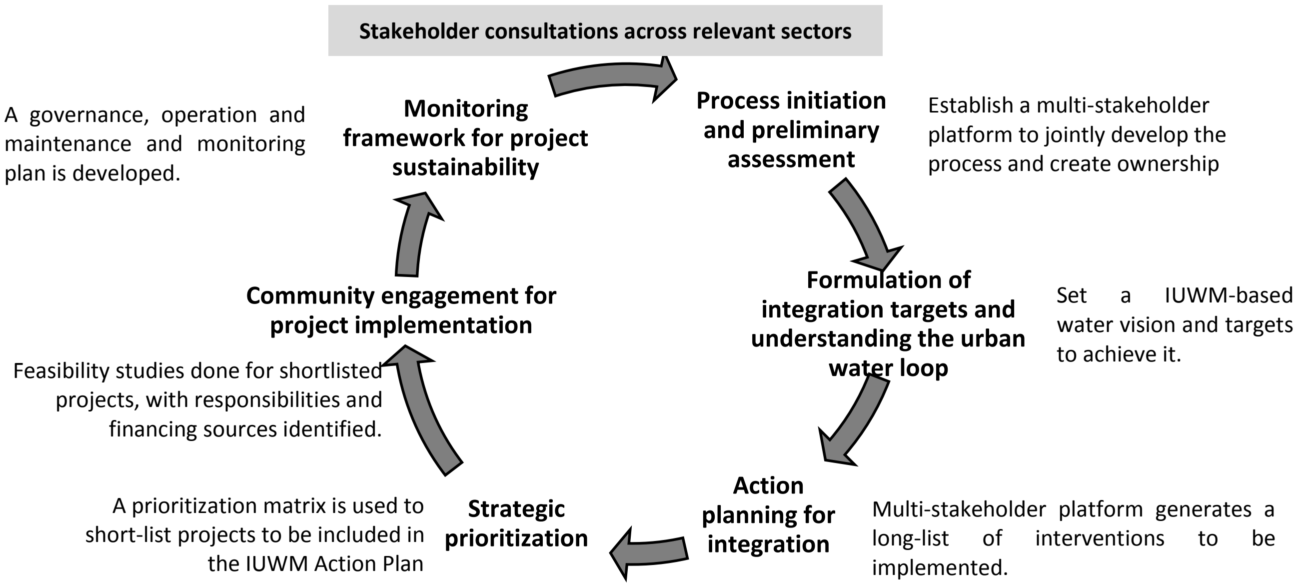


Figure 5. The stages involved in implementation of IUWM using the AdoptIUWM toolkit

Reference: AdoptIUWM, n.d.

GWP toolkit

The toolkit was produced in 2015 by Global Water Partnership (GWP) and the Capacity Building Initiative, in collaboration with a range of partners, including the International Water Management Istitute. It aims at facilitating the Implementation of IUWM on the ground. It aims at providing the assistance required by the urban policy and decision-makers to formulate an IUWM strategy. It follows six key implementation steps and is led through a platform meant to address the needs of IUWM assessment and implementation (Figure 6).

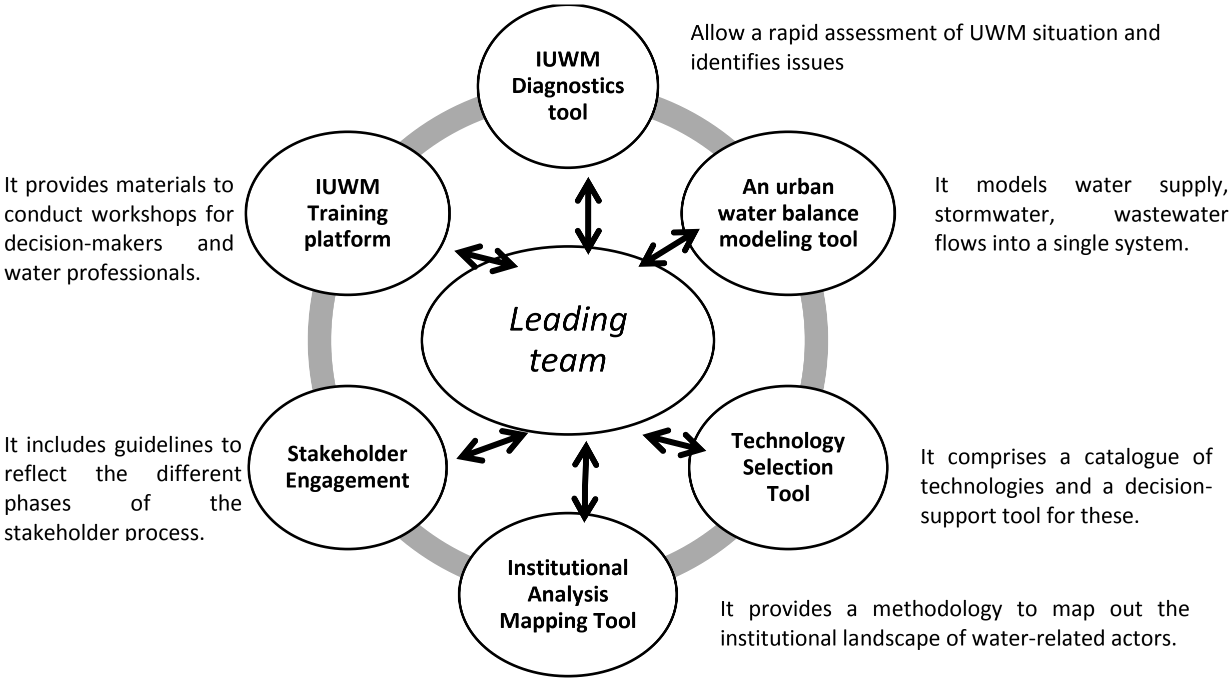


Figure 6. The stages involved in implementation of IUWM using the AdoptIUWM toolkit

Reference: GWP 2018

COMPARISON BETWEEN THE TOOLKITS

Adaptability and User-friendliness of the toolkits

The complexity of UWM makes it almost a prerequisite that the toolkits are user-friendly. User-friendliness is a subjective parameter. In our case, we assessed it from the presentation and content of the user manual. Indeed, to reach a larger audience, it is critical that the instructions are easy to read and to understand by different stakeholders. However, some toolkits can be highly technical because they only target an audience of highly qualified personnel. Also, our review considered the adaptability of a toolkit to different contexts to maximize benefits of the toolkit. Commonly, toolkits are developed for a particular city or a country. However, there are contextual differences between these cases due to economic, environmental, social and technical factors, and challenges such as access to reliable data sources.

Table 1 presents the outcome of the assessment of the toolkits while Figure 7 presents the overall score attained by each toolkit.

Table 1. Is the toolkit user-friendly?

Toolkit	Usability	Key limitations	Computer-based	Available experience on toolkit adoption at various scales			
				General	**Pre-feasibility**	**Pilot**	**Implementation**
AdoptIUWM toolkit	Provides matrices to guide the stakeholders.	Specifically designed for use in India.	No	The cases illustrate previous examples and successes.		Jaisalmer, Kishangarh, Solapur	
CSIRO toolkit	Provides a clear guideline for the KSG to formulate an IUWM approach.	Methodology is theoretical, i.e. only a conceptual starting point.	No	The cases illustrate previous examples and successes.	Calgary		South East Queensland, Camberra, El Paso
GWP toolkit	• Has a user-friendly interface • Training module included can be downloaded. • Each tools has a guideline.	Not yet tested at beyond prefeasibility	Yes	Case studies from water scarce cities are available.	Kinshasa, Marondera		
IRAP toolkit	It is includes information and data relative to India.	Highly theoretical Available guidance is limited Specific to the Indian context	No	It has never been implemented in any city.	None		
SWITCH toolkit	• Has a very structural methodology • Seems to be easy to adopt • It comes with a website containing extensive resources and knowledge materials.		No	It includes case studies from several countries on different continents of various economic levels.	Accra, Beijing, Cali, Hamburg, Lima, Lodz, Tel Aviv, Zaragoza	Lima	

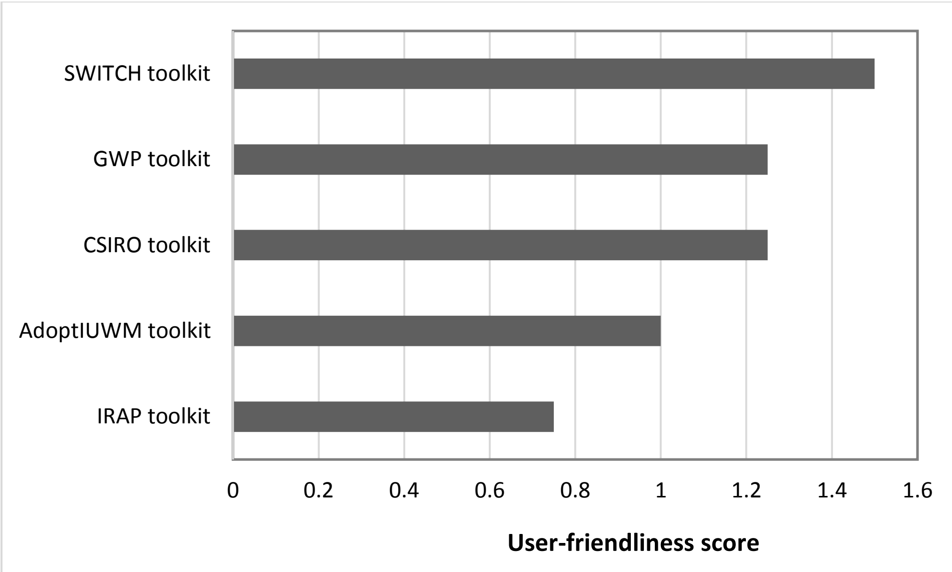


Figure 7. User-friendliness score and ranking of the ranking

Overall, the IRAP toolkit which appears to be one of the most complex toolkit (Kumar 2018), stood out as the least user-friendly. Indeed, it requires users to have advanced expertise in water management hydrology and economics to effectively use this toolkit. It has also never been implemented in any city. However, lack of context-specific experiences in implementing IUWM is a barrier when attempting to mainstream IUWM strategies. The SWITCH toolkit appeared to be one of the best in terms of user-friendliness. It has a very structural methodology and it comes with a website containing extensive resources and knowledge materials which support IUWM implementation. It also includes case studies from several countries on different continents of various economic levels which shows the potential for its use under various contexts.

In between the two extremes, the remaining toolkits display similar scores. The CSIRO toolkit which is the first of the kind is viewed by some as only a conceptual starting point (Furlong et al. 2016). However, the GWP toolkit displays interesting features, but is yet to be used for actual implementation and demonstration. Concerning the Adopt IUWM toolkit, its main limit could be that it is so far only applicable in India.

Data and information requirement of the toolkits

When utilizing all the five toolkits, it is a pre-requisite that input data are available and accessible. Overall, it appears that data required as input to the toolkits are similar as presented in Table 2. For example, all toolkits rely on data on the current individual water cycle systems, population, weather patterns etc. However, the extent of data required by each toolkit varies. Unavailability of consistent and robust data to identify the potential for IUWM is a critical barrier that makes it difficult for the decision-makers to implement IUWM, especially in the developing countries (World Bank 2012; University of South Florida 2017). Inadequate globally accepted data and information could result in misconceptions among stakeholders on urban water cycle interactions and this is reported to act as a key barrier in formulating an IUWM framework (University of South Florida 2017). But the adding of extensive data collection studies and participatory approaches to the process could increase the time of implementation and cost of IUWM adoption (Global Delivery Initiative 2017).

Table 2. Data requirement of the toolkits

Toolkit	**Data requirement**
AdoptIUWM toolkit	One has to go through a 'tedious' data collection process, which is not be not supported by the toolkit.
CSIRO toolkit	Availability and accessibility of good quality data on supply, distribution and wastewater generation is a critical requirement in utilizing the toolkit as a thorough analysis is carried out to understand the current system and to project future possible scenarios.
GWP toolkit	The diagnostic tool requires comprehensive data (water supply, socio economic conditions, environmental considerations and institutional and regulatory aspects)

Toolkit	Data requirement
	to identify the challenges cities are facing based on key indicators.
IRAP toolkit	It provides an extensive amount of data on India. In developing the toolkit, there has been collection of primary and secondary data collected for 327 Indian cities. The data have been used to delineate 16 typologies based on mean annual rainfall, evaporation and soil type. Therefore, data collection need should be limited for the Indian context.
SWITCH toolkit	Data such as rainfall, runoff patterns a water demand influences are required for successful modelling.

From Table 2, it seems obvious that only the IRAP toolkit requires minimum data input. This is due to the fact that it is already adapted to the Indian context. Also, beyond data input, some tools encourage monitoring of interventions, as discussed in previous sections.

Spatial scale to consider in IUWM implementation.

One key challenge faced in implementing IUWM is defining the spatial boundaries. A city is usually defined by one or several administrative boundaries such as a municipality. However, the hydrological boundaries do not always align with the administrative boundary. In fact, each of the UWM subsystems has a different boundary. Thus, there is a dilemma between choosing administrative boundaries versus hydrological boundaries. None of the toolkits has given a clear definition for the spatial scale for implementation of IUWM, as presented in Table 3. So, it is important that the stakeholders have clarity and a mutual agreement regarding the spatial scale when implementing the IUWM strategy.

Table 3. Approach to the delineation of the target area for IUWM interventions.

Toolkits	Review outcome
AdoptIUWM	It identifies the scope of the IUWM project and then jointly decide upon the area or site in which the intervention would be carried out. It also identifies and maps the immediate impact area of the project. Some of the criteria considered when selecting a site are the administrative city limits and the political will towards implementing IUWM.
IRAP tool	It considers hydrological boundaries and other environmental factors when dividing the typologies. The initiatives and the solutions differ from typology to typology. However, the toolkit guides in the identification of the typologies, based on pre-defined criteria.
CSIRO toolkit, GWP toolkit, SWITCH toolkit	While acknowledging that the hydrological boundaries spread far beyond administrative limits, these toolkits do not specify any spatial boundaries for IUWM implementation. Therefore, decision is expected to be made by the implementing authorities.

Water balancing models used to enable or improve integration of UWS.

Water balance models are used to simulate hydrological cycles and forecast changes in discharges based on historical data. Three out of five toolkits have recommended a particular water balance while the remaining others (i.e. AdoptIUWM and CSIRO toolkit) were flexible and allowed the toolkit users to select their preferred model. A summary of the recommendation for a water balance model is presented in Table 4.

Table 4. Assessment of the water balance model achieved by the various toolkits

Toolkit	Review outcome
AdoptIUWM toolkit	The stakeholders can opt for less detailed to complex models, based on their preference, which can be informed by factors such as data availability.
CSIRO toolkit	It does not recommend any particular model, software or approach to model the urban water use. Instead, the KSG is responsible for choosing the most suitable model for each activity, including for the water balancing component.
GWP toolkit	It has an inbuilt water balance tool, which is designed to model and assess water flows, based on multiple and alternative UWM strategies.
IRAP toolkit	It considers the Water Evaluation And Planning (WEAP) model to simulate interactions of the urban water subsystems. In addition, Tool 17 of the toolkit defines the inputs and the potential outputs as well as the benefits of the model. However, the toolkit does not provide guidelines on how to use the WEAP model.
SWITCH toolkit	It considers the "Aquacycle daily urban water balance model" for water balancing. Guidelines for urban water managers to use the model are provided in module 6 of the toolkit. This model intends to integrate the stormwater- rainfall runoff system with the urban drinking water supply-wastewater system.

Strategy and ease of community engagement and integration of stakeholders

To come to the realization of a holistic and integrated planning approach, IUWM requires a substantial analysis of institutional capacities, financing options, technology options, and urban/basin-level water balance/resources. For instance, Bahri et al. (2016) recognize that there is usually a lack of coordination between institutions responsible for UWS management in, e.g., African countries. The same limitation also exist between water management bodies and different activity sectors that have a stake in water use such as housing, transport, energy and urban planning (Bahri et al. 2016). Fragmented institutional settings shared between national, provincial and municipal levels of government slow down policy implementation and causes inefficient urban services planning and management (World Bank 2012).

The core principle of IUWM is to integrate the management of the UWS and this is acknowledged in all the toolkits**.** We found that all toolkits lay out guidelines to assist stakeholders overcome the challenges faced when planning and strategizing IUWM with improved coordination among themselves. However, the practical approach to integration differs from one toolkit to another. While the IRAP toolkit focusses on the integration of UWS management, etc. all other promote the integration of fragmented institutions. In the latter case, common platforms are defined to facilitate multi-stakeholder engagement processes, enabling a collective formulation and implementation of the sustainable waster management solutions. Targeted stakeholders include public sector actors (e.g., line ministries, municipalities, educators, utilities, regulators, research institutes), the private sector actors (e.g., consultants, contractors, financial services), and civil society agencies (e.g., unions, professional bodies, NGOs, media, and advocacy organizations). These stakeholder platforms are important to maintain ongoing and meaningful communication for stakeholders to contribute to the decision making process as well as technical experts. The summary of our assessment is provided in Table 5.

Table 5. Assessment of the stakeholder integration achieved by the various toolkits

Toolkit	**Review of the institutional coordination mechanism**	**Review of the social and ecological integration**	**Decision-support tool available**
AdoptIUWM toolkit	Promotes institutional integration through stakeholder workshops at each stage of the project. This is accompanied by	• Community is involved in decision-making. • Considers impacts of interventions on the	A technical feasibility assessment tool is available.

Toolkit	Review of the institutional coordination mechanism	Review of the social and ecological integration	Decision-support tool available
	the appointment of a nodal officer as the key contact.	ecosystems as well as the relationship between upstream and downstream.	
CSIRO IUWM toolkit	Done through setting-up of KSG.	Community consultation is done throughout the three phases of implementation.	There is no decision support tool available.
GWP toolkit	The toolkit includes a stakeholder engagement guidelines tool, which is a structured set of guidelines to reflect on the different phases of the stakeholder engagement process, with a list of the "do's and don'ts" for coordinators. By describing their objectives, tasks, and outcomes, the "Institutional mapping tool" of the toolkit provides a methodology on how to map out the interconnectedness of water institutions.		Yes. It helps in selecting suitable technologies.
IRAP toolkit	The main focus of integration is through the technical amalgamation of the physical UWS (i.e. catchments, surface water, groundwater, stormwater, wastewater outflows).	The toolkit recognizes in theory the need for community involvement in formulating IUWM strategy (when the urban water demand is projected, and the vulnerability to water and sanitation is assessed. However, the community engagement is less	There is no particular decision support tool. However, the toolkit provides feasible solutions for each urban typology.

Toolkit	Review of the institutional coordination mechanism	Review of the social and ecological integration	Decision-support tool available
		than for the other toolkits.	
SWITCH IUWM toolkit	By forming Learning Alliances, which are facilitated by a Focal Point. A learning alliance involves key stakeholders who are directly involved in UWS research institutes, government officials and farming cooperatives schools, communities, etc.		A decision-support systems software is available.

Figure 8 presents the comparison of the toolkit against 3 sub-criteria, namely UWS integration, institutional coordination and finally the social integration.

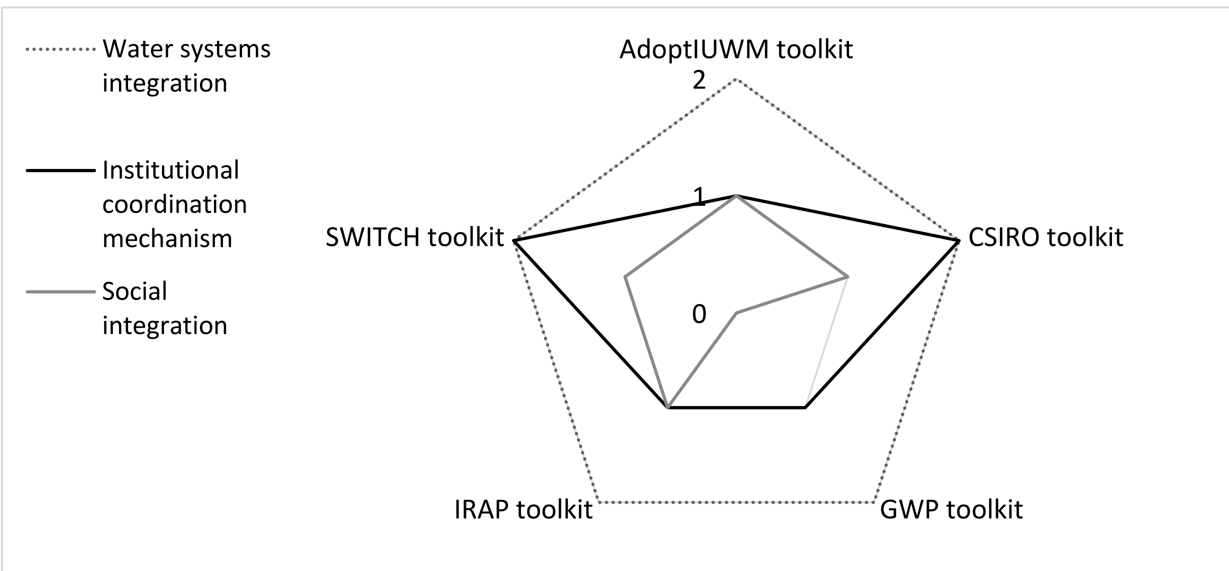


Figure 8: Stakeholders integrated into the implementation of the toolkits ranking

Strategy of integration of climate change impacts and adaptation measures

Climate change has imposed an uncertainty in water security posing a threat to water availability for human consumption and environmental services (Maheepala et al. 2010). When developing IUWM strategies, it is important to factor into the modelled dynamics of water usage and availability not only the population growth but also the projected impacts of climate change. Urban areas, while rapidly increasing, face unique risks such as the effect of urban heat islands. Therefore, it is important to consider context-specific adaptation and mitigation strategies when implementing IUWM. The projections of future climatic conditions help policy makers to make decisions that have the potential to sustain future conditions.

All toolkits integrate strategies to better capture the potential impacts of climate change. A summary of the climate-resilience strategies per IUWM toolkit is given in Table 6.

Table 6. Approach to the integration of climate change impacts and adaptation strategies.

Toolkit	Review outcome
AdoptIUWM toolkit	It highlights the importance of discussing the local-level observations of the community in terms of impacts of climate change and trends over time, especially temperature variations, changes in precipitation and extreme events. Projections are done to calculate the future water availability and potential disasters as floods. The stakeholders are guided to discuss the impacts of these projected trends and manage potential disasters.
CSIRO IUWM toolkit	It promotes understanding the current trends in climatic conditions (rainfall, wind, humidity) to compare past records and to make future climate projections (probable extreme climatic conditions). The data obtained is expected to allow the KSG to formulate climate change-resilient IUWM policies and to ensure that decisions are made to adapt to climate change. Scientific projections for higher temperatures, water availability and unpredictable rainfall patterns are taken into account in assessing the sustainability of the UWS.
GWP IUWM	It treats climate change impacts as uncertainties and tries to build flexible systems that

Toolkit	Review outcome
toolkit	can cope. In particular, integrated flood management, in order to strengthen the resilience to extreme weather events and carrying out vulnerability assessments are promoted by the toolkit. The diagnostic tool uses both qualitative and quantitative indicators to predict future pressures such as climate change. Through the diagnostic tool water scarcity can be projected via: the water supply-demand gap; water supply and sanitation coverage; and water quality issues; providing opportunities for the city to improve the existing institutional, economic, and regulatory framework.
IRAP toolkit	It does not have a specific tool to tackle climate change adaptation. However, a training module on risk management is recommended as part of tool 29, which is a module on practices for improving urban water governance. The trainings are to equip decision and policy makers in climate change adaptation. The specific topics covered under this module, which are linked to climate change, include: • Prevention, mitigation and preparedness for water and climate-related disasters • Extension of water and sanitation facilities according to the growth of population and migration.
SWITCH toolkit	Within the framework of module 1, targets are set for water saving, reduction of wastewater and improving stormwater-quality with the overall aim of improving the health of the local waterways, reducing the dependency on vulnerable water supplies and preparing the city to mitigate climate change impacts. In addition, Module 3 of the toolkit aims at showing how a demand management approach can lead to environmental improvement and greater resilience to climate change. Finally, the module 4 promotes climate change adaptive methods in stormwater management. It

Toolkit	Review outcome
	points out that the rapid removal of stormwater from urban areas lessens evapotranspiration and results in increased 'heat island' effect.

The toolkits provided similar support for climate change impact predictions, so the decision makers are able to incorporate them into the planning. However, based on the outcomes of the review, both SWITCH toolkit and the CSIRO toolkit give a higher priority to incorporate climate change in the planning.

Tools used for analyzing economic viability of IUWM interventions

Transitioning from a conventional to a holistic water management system requires strategic and workable planning to ensure financial and economic sustainability. From our assessment, we could establish that the different toolkits take different approaches when analyzing the economic and financial aspects of implementing IUWM.

Table 7. How the various toolkits assess the economic benefits of IUWM interventions.

Toolkit	Review outcome
AdoptIUWM toolkit	It analyses the economic feasibility using both a participatory approach and the estimated financial sustainability of each option suggested. This helps the planners decide on a methodology to achieve cost recovery (e.g. from water sales) and to stimulate the private-sector involvement. However, there is no method for evaluation of implementation.
CSIRO toolkit	It begins with the establishment of a baseline related to the economic and system performance analysis during Phase 1 of implementation. Then, in phase 3, a detailed

Toolkit	Review outcome
	economic analysis is carried out by KSG. This latter is mainly for funding purposes and aims at evaluating the impacts of proposed interventions (e.g., return on investments and cost-benefit analysis) and at comparing impacts of different interventions, to guide final selection.
GWP toolkit	It analyses the economics of IUWM through the diagnostic tool. The two indicators used in this tool are Gross Domestic Product in the city and GINI index. The ultimate goal is to accurately price water in order to encourage all users to manage it wisely. The tool also aims at promoting different tariffs that account for water quality.
IRAP toolkit	It gives a comprehensive list of theoretical benefits and viability conditions for different water management options. This can be useful in pre-selecting the interventions to adopt. It also analyzes the technical feasibility of different management options (e.g. water supply, desalination and wastewater treatment), and then provides the economic feasibility of them as well.
SWITCH toolkit	It relies on the lifecycle cost analysis (LCA) in order to obtain an estimation of economic value of a pre-selected water management option or scenario. Therefore, it tends to emphasize on the social and environmental costs and benefits for the explored options. The results of the LCA are typically given as a Net Present Value (NPV), allowing easy comparison of alternative solutions.

The content in Table 7 confirms that all models are quite similar in terms of their ability and performance in assessing the economic and/or financial viability of the IUWM interventions. However, the types of indicators and methodologies are different, advising for a selection that is context specific.

HOW TO SELECT A TOOLKIT TO USE (DISCUSSION)

There is no one-size-fits-all approach to the implementation of IUWM; rather, the mix of principles should be adapted to local sociocultural and economic conditions (Bahri 2012). Even within a country, the context from city to city or state to state can have many differences in terms of demography, hydrology, governance, and so forth. Therefore, when selecting an IUWM toolkit, it is important to possess a sound understanding regarding the ability of the toolkit to match with the local context and capacity as well as the targeted objective of the exercise.

Table 8 presents an overview of the attributes of reviewed IUWM toolkits, as discussed in previous sections. All toolkits presented in this review provide great guidelines to assist formulate IUWM approaches in cities. They provide the necessary guidelines to integrate UWM institutions and urban water subsystems, which otherwise are often managed in isolation. Using the IUWM toolkit, it becomes easier to consider problems of both water quantity and quality, as pollution of water sources poses major problems for water users as well as for maintaining natural ecosystems.

The selection of the right toolkit could act as a first step and the foundation towards successful IUWM implementation. Most of the toolkits are helpful in providing guidance for creating platforms for multi-stakeholder groups to come together and have mutual agreements when executing IUWM. On the other hand, a fragmented approach can result in technical choices based on the benefits to an individual part of the system, but may neglect the negative impacts caused elsewhere. The IUWM approach implemented with the help of a toolkit can prevent such impacts. In addition, using structural guidance of a toolkit, the local community participation could provide experience and ideas that could generate relevant, practical, feasible and acceptable solutions to water-related problems.

The IUWM toolkits also enable planners to select and implement suitable water management technologies or solutions that have been selected following a comprehensive assessment of the water cycle and the long-term sustainability of the whole system. The strategies adopted using IUWM toolkits are well suited to respond to pressures such as climate change, population growth and aging infrastructure, enabling the matching of water demand with available water supply, while taking into account spatial, scale and temporal issues.

Table 8: Overview of attributes of IUWM toolkits.

Criteria / Name of the toolkit	Allows multi-level stakeholder integration	Is computer-based	Includes climate-change adaptation	Includes a methodology for boundary delineation	Includes a Water Balance Model	Allows economic analysis
CSIRO	Yes	No	Yes	No	No	Yes
GWP	Yes	Yes	Yes	No	Yes	Yes
SWITCH	Yes	No	Yes	No	Yes	Yes
AdoptIUWM	Yes	No	Yes	No	No	Yes
IRAP	Yes	No	Yes	Yes	Yes	Yes

While some gaps are specific to a toolkit, there are also general challenges that can be experienced in the course of the use of a toolkit. For instance, data collection to enable using the toolkit for planning an IUWM strategy can be a very vital yet tedious part of the IUWM implementation, especially in developing countries. When selecting a toolkit, it is important to understand the context and accessibility to required input data.

One of the biggest reasons why IUWM initiatives fail is the lack of political commitment. But in order to make these initiatives sustainable, it is vital that the related processes and strategies are institutionalized, to be taken into consideration in regular planning. This could be achieved by the inclusion of policymakers throughout the decision-making process. Cost of implementing IUWM in a city could also be non-negligible. Therefore, it is essential to ensure upfront sustainable and long-term inflow of financial resources to become able to achieve a notable impact. Deep involvement of local communities is also essential to success. Finally, regular monitoring and evaluation of the IUWM implementation is beneficial to ensure constant improvements.

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