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A STUDY OF COMPARATIVE ANALYSIS FOR DIFFERENT INTEGRATED URBAN WATER MANAGEMENT SYSTEM (IUWM) FOR URBAN REGIONS.

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Abstract: Contemporary era is facing many critical issues like rapid urbanization, increasing environmental problems, economic concerns and climate change too. Along this basic infrastructure for habitat is also facing many problems like inefficiency and restrictions of traditional water management practices and thereby many challenges for urban water management. In both, theory as well as practical approach required to be addressed challenges related to water sector for twenty-first century should be more integrated way. While demand and necessity for integration is noticeable, but research and applications has challenging due to complexity and uncertainty of current situation along with future changing methods of behavior for development.

Water sector comprise of further sub sectors and each sub sector is having different issues and short-coming. Though every city or urban area are also having specific issues and problems with respect to water sector even if they are they come under same zone. Consequently, it cannot deliver single output even if integrated urban water management system is applied. It has to be updated or changed as per need of that urban area.

In this article, first steps to study and analysis of different Integrated Urban Water Management System (IUWM) systems are available, developed by different organization under diverse conditions and parameters. Then second steps to research how these systems are appropriate for different urban areas. In so doing, it has to be critically seen applicability for these system on urban areas, whether they can be adopted directly or need to be refine as per geographical, hydrological, sociological, environmentally and economical point of view too.

Key Words: ***Integrated Urban Water Management, Urban Water Management, Urban areas, Water Sector, Traditional Water Practices, Urbanization***

Introduction: Water resource are under severe pressure from universal drivers like rapid urbanization, climate change, economic development, changing shift of behavior pattern of people, while water is a limited, still need to serve to maximum people usages without compromising quality of water and even to maintain stability all the connected environmental situations. ***(The handbook on water information systems, 2018).*** It has well defined, urban water management (UWM) is measured a universally crucial requirement for land use development and properly working for a city function. It includes the planning at both level water supply and water drainage, policy making, construction and design of infrastructure needed to fulfill water supply demand (i.e., drinking & sanitation). Along this managing infiltration of water into ground and stormwater runoff. It also includes management for recreational spaces like open areas, parks and maintenance of ecosystems, human health too. ***(Mitchell, 2004).*** Therefore, it needs some instruments to monitor and reduce environmental impacts and effects in sustainable manner. Its further includes many things like water borne diseases, operation and maintenance, new infrastructure for proposed upcoming cities, Likewise, every urban water system (UWS) component (i.e., water supply, wastewater, sanitation and, stormwater). experiences stress. This stress is due to impacts from population growth, climate change such as depreciating water resources, escalating temperatures, fluctuations in different precipitation patterns, etc., which is directly stress for water scarcity. ***(United Nations Economic and Social Commission for Western Asia, 2011; Rodriguez & Gambrill, 2015).*** Conveniently UWM applies and a formal setup has a direct focus, i.e., where UWS workings are managed by individual entities in spite of their interrelation. As a result, this approach is failing from many perspectives like technical efficient performance, cost-effectiveness, socially and even environmental sustainability. This method is also delayed due to difficulties of the inorganizations' structures and governance. Urban water management requires a complete shift to an 'Integrated Urban Water Management' (IUWM) approach. It is defined and accepted by many water experts and policy makers too. ***(Loucks & Beek, 2017).*** The process for implementation of the IUWM concept officially started around 20 to 25 years ago. A formal policy and toolkit are launched by Australian Commonwealth Scientific and Industrial Research Organization (CSIRO) concluded a motivated program directing at enhancing and advancement for sustainability of Australian's urban water system. Beside this, in 1998 CSIRO developed a frame work of enforce water Research Foundation along spatial planning of urban water system management in recognized Australian cities. Here we can see many definitions are proposed in literature with respect to IUWM. World bank has given Blue Water Green Cities initiative 2009 and approved the definition for IUWM, "IUWM is a flexible, participatory and iterative process which integrates the elements of the urban water cycle (Water supply, sanitation, storm water management and waste water management) along both city's urban development and river resource management for optimum use, that can maximum benefit for environmental, social and economic benefits". ***(Schuring, Rodriguez, & Closas, 2012).*** CSIRO and integrated urban water management is a method 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 4 landscape" ***(Mitchell, 2006).*** Apparently IUWM incorporates the management of the urban water system, urban resource system and their subsystems to allow to meet, urban and semi-urban water demands for all sectors. (i.e., residential, agricultural, industrial and ecosystems) ***(Mirza et al., 2013)*** while taking into attention for technical aspects, social parameters, economic factors, institutional and environmental interests challenge to safeguard water security and sustainability ***(Global Water Partnership, 2013).*** As a result, integrated urban water management comes under the wider framework of Integrated Water Resources Management (IWRM), which calls for an integrated adaptive, coordinated and participatory approach for management of urban water

system components ***(Brown & Farrelly, 2009; Global Water Partnership, 2013)*** and also taking the whole water cycle system into consideration ***(Karka, Manoli, Lekkas, & Assimacopoulos, 2007; Maheepala, 2010).***

Along this IUWM approach also help for achieving many Sustainable development goals. Even helping to confirm access to water and building reselling cities. By using IUWM strategies, we can also significantly contribute on impact and adaptation for climate change. The main objective of this study to analyze and compare the currently available toolkits. How they are used in various urban area and cities worldwide. What is the shortcoming in using and implementing of this different type of toolkits? It's a comparative review between all these available and focus on application to Indian Cities.

Methodology:

This paper reviewed and analyze previous published research paper focused on urban water management, water sensitive planning, sustainable water development. Study and analyze available IUWM toolkit worldwide along with their respective urban area where they are using these toolkits. How much these toolkits are efficiently working towards initially described goals. Critically analysis Indian IUWM toolkits proposed in different urban areas. A theoretical evaluation is carried out on the IUWM toolkit instructions based on following criteria:

- Adaptability and flexibilities for IUWM Toolkit
- Raw data and Information
- Applicable Area
- Strategy for water resources
- Integration in demand & supply
- Financial Feasibility
- Context – Specific

Tool kit:

There are some toolkits regarding IUWM, five are identified for doing study. Each was developed from different institutions for different cites and having a unique type of goal for better solution in water sector.

CSIRO IUWM Toolkit: It is developed by CSIRO and WRF in 1998 ***(CSIRO, 2010).*** It goals to assist to planners to formulate strategy for implementation this toolkit. The CSIRO toolkit director us the majorly three phases, i.e., pre-feasibility, feasibility assessment and implementation.

A 'Key Stakeholder Group' (KSG) accountable for supervision the integrated urban water management planning process. It involves of officials representing critical organizations involved in urban water systems. After KSG formations, the toolkit guides provide an implications process which are having majorly three phases, every phase comprise of five sets of activities as described in Figure 1.

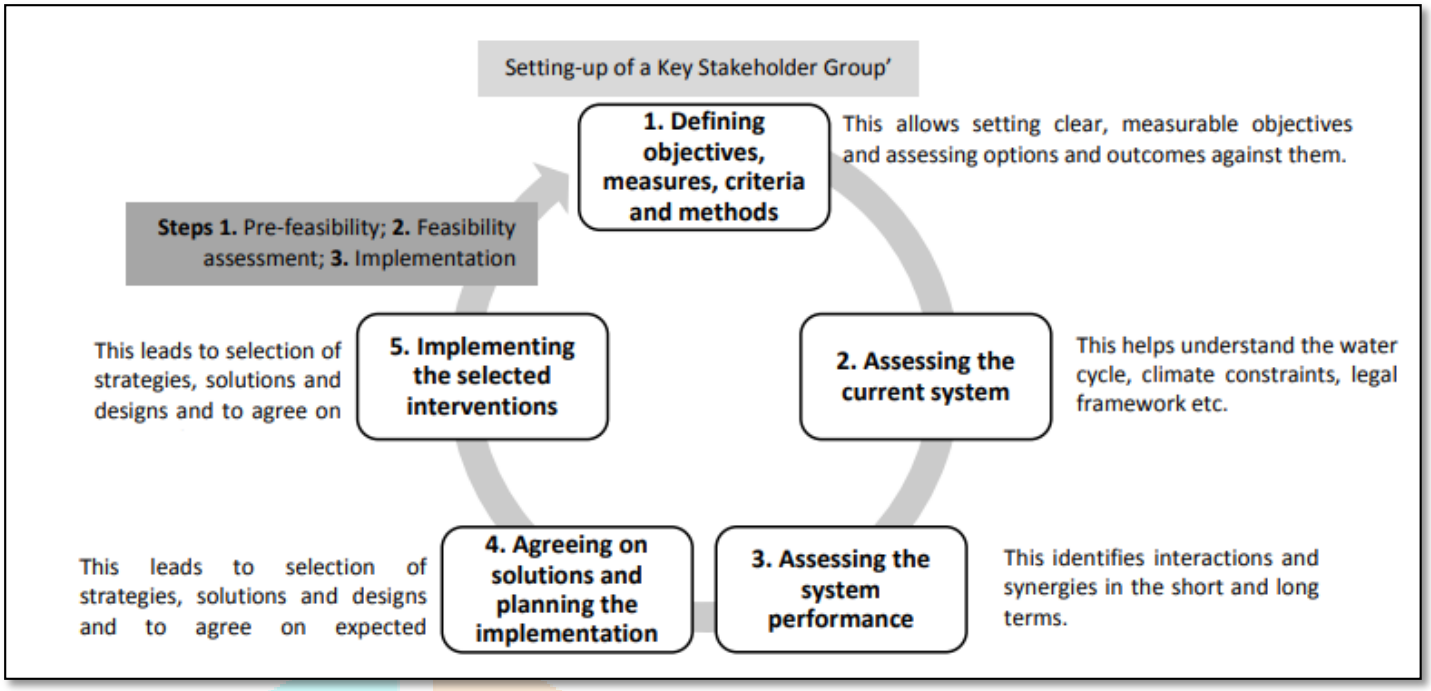

Figure 1. CSIRO toolkit implementation methodology (Source – CSIRO,2010)

GWP Toolkit: This toolkit was formed in 2015 by and global recognize firm Global Water Partnership (GWP) and the Capacitive building initiative, in collaboration with many other stake holders, including the International Water Management Institute. It focused at facilitating the applicability and implementation for integrated urban water management on practical approaches. It focused at facilitating the support required from the urban policy and decision-makers for developing an IUWM strategy. It comprises six key implementations, these stages are led through a platform meant to address the needs of IUWM valuation and implementation (Figure 2).

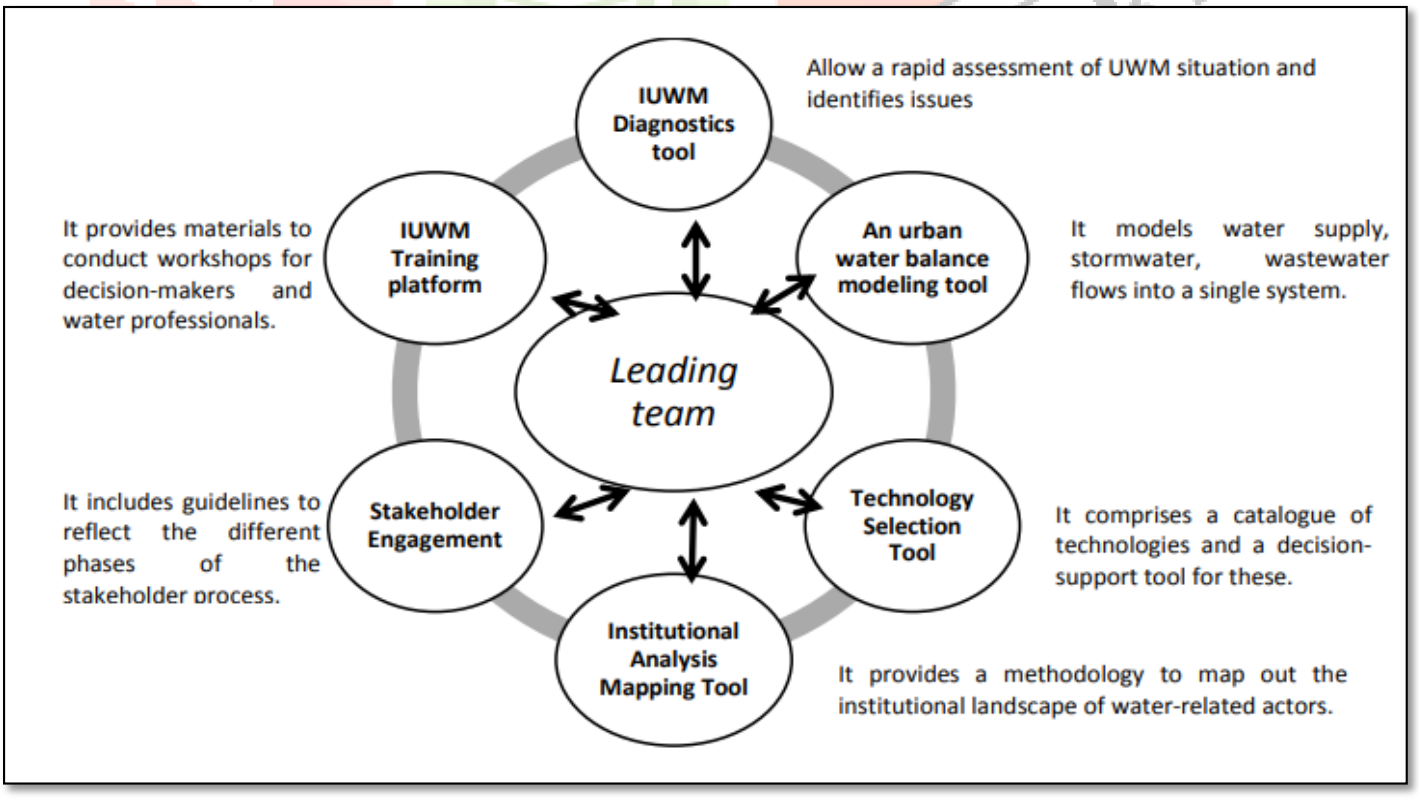

Figure 2. The stages involved in implementation of IUWM using the Adopt IUWM toolkit (Source – GWP,2018)

SWITCH IUWM toolkit: This toolkit has been developed between 2006 and 2011. It was a part of the implementation of the SWITCH project which further involved thirty-three stake holders globally, including the International Water Management Institute. This is mostly considered for training those directly in control for urban water management or having personal interest in water management or water related issues. It has a proposes to advance the scientific basis and to aid knowledge developing and sharing in order to confirm that urban water system is healthy, flexible and adaptable. It is made of of six components presenting

a) the overall SWITCH IUWM method (Modules 1 and 2),

b) the sustainable water management solutions (Modules 3 to 5) and

c) this system helping the decision-making process (Module 6).

The IUWM implementation builds on Learning Alliances over which key stakeholders are brought into a environment for trainings, knowledge sharing or implementation (Figure 3).

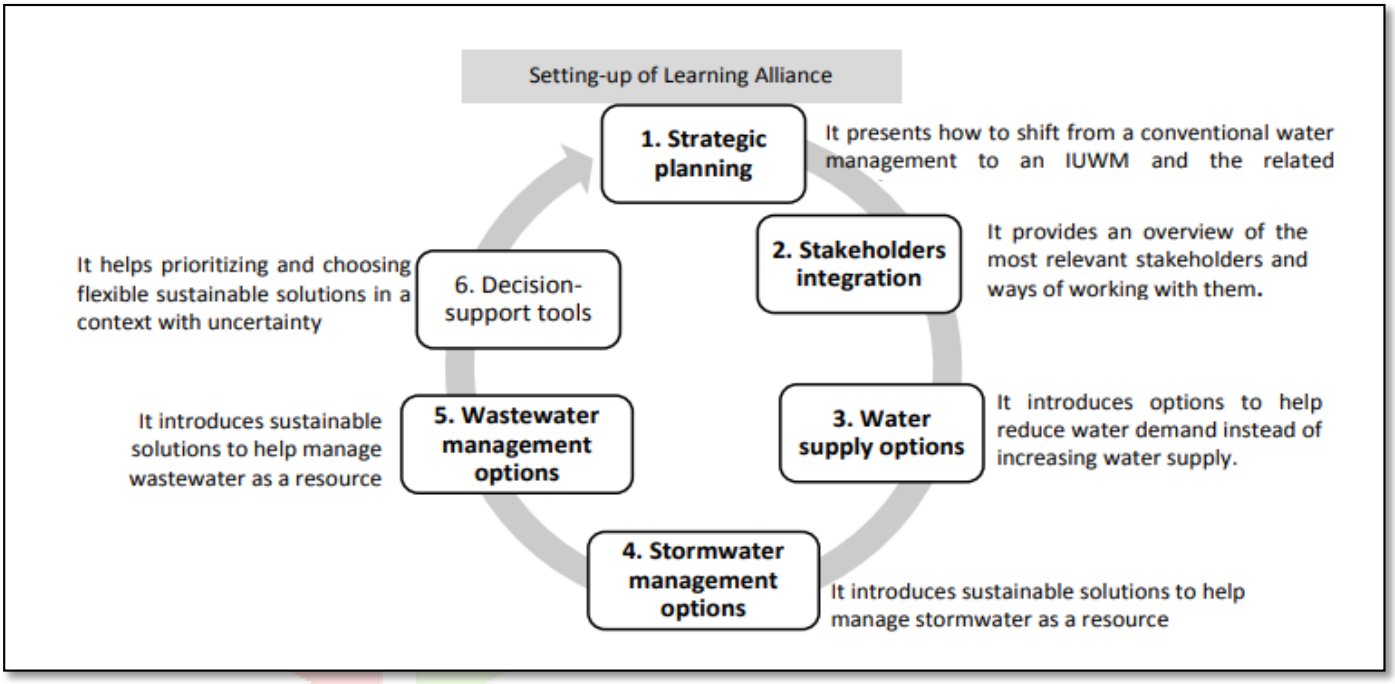

Figure 3. Switch training modulus (Source – SWITCH, 2010 and 2011)

IRAP toolkit; This toolkit developed in 2010 by Institute for Resource Analysis and Policy (IRAP) and Arghyam Trust. It is developed for use by policy-makers and managers involved in urban water management programs. It includes of thirty-one individual tools. Further, it can be divided into five different sets as per shown in Figure 4. The first set offers investigative procedures for forecasts of population and urban water demand. These are on different socio- economic scenarios. These tools are useful in planning decisions. Next or second set is for environmental management tools, covering tools for selecting urban water supply expansion strategies, wastewater treatment technologies and methods. Beside that this also include storm water management practices too for urban areas. The third set of tools deals with capacity building and its organizational change problems, while the fourth set tells to community interface. In the end, the last set of tools relates to issues on good governance, covering the practical suggestions for improving the key areas of urban water governance. The legal and policy framework are also main part of it, they are also able to disturb implementation of urban water management interferences.

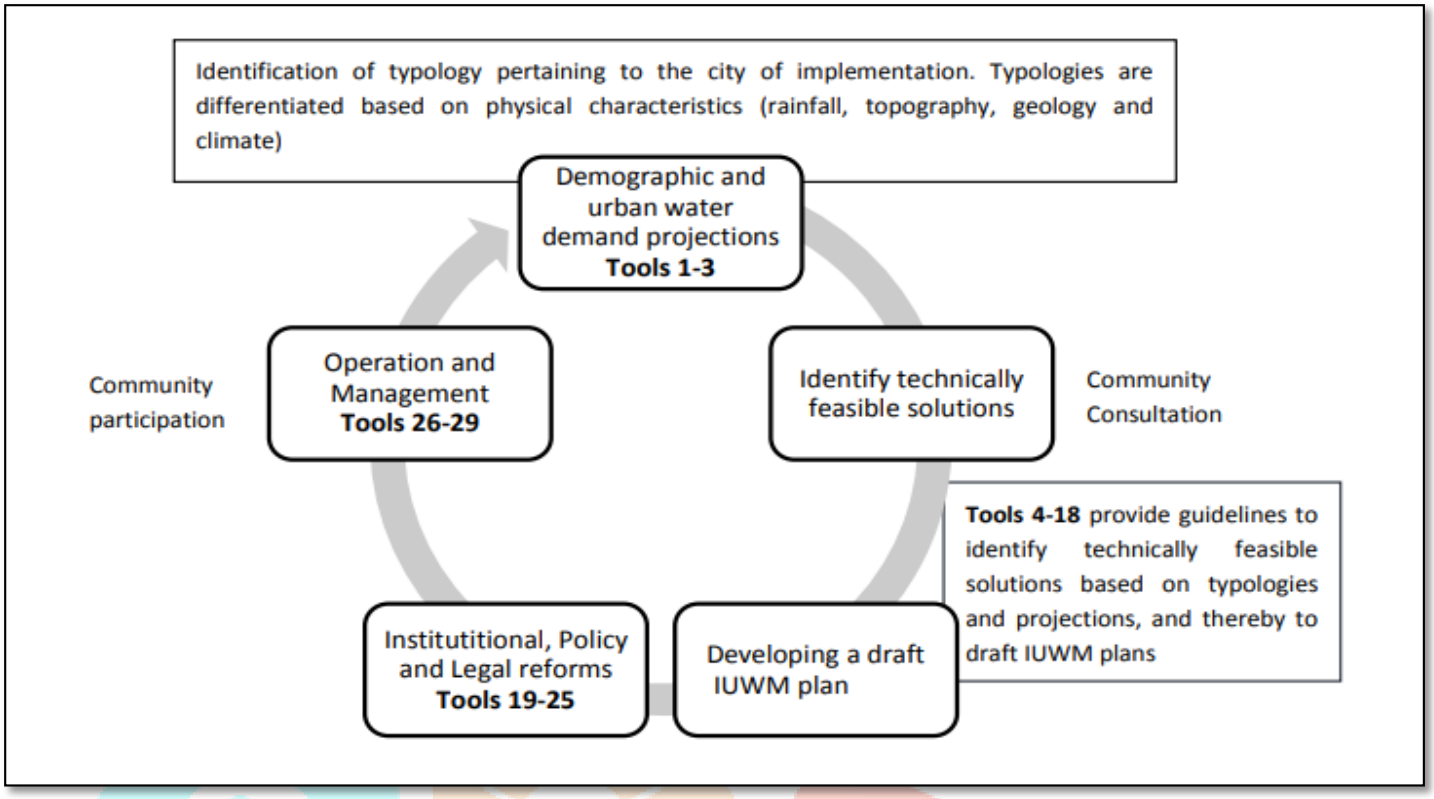

Figure 4. Stages of IRAP toolkit implementation (Source – IRAP, 2010)

Adopt IUWM toolkit: The toolkit has been developed between 2013 and 2016. It is created by ICLEI South Asia with VVSG (Association of Flemish Cities and Municipalities, Belgium) along with ICLEI European Secretariat (ICLEI ES). It was based on the SWITCH toolkit to focused and more precise to the Indian context. It goals at building, the capacity for Indian local authorities (LAs) for undertake urban water management modifications through the adopted of integrated urban water management guidelines and application on planning and implementation processes. It enables stakeholders to formulate the integrated urban water management system strategy in six stages as shown in Figure 5.

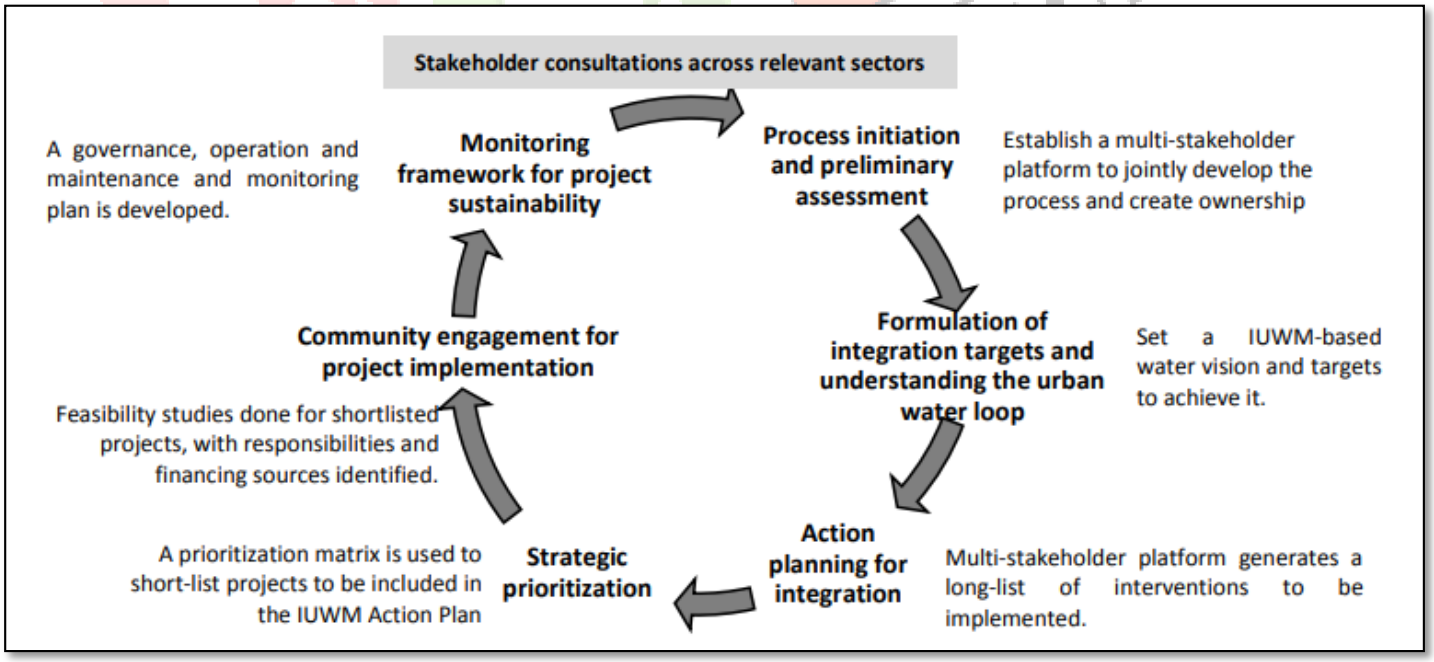

Figure 5. The stages involved in implementation of IUWM using the Adopt IUWM toolkit (Source – Adopt IUWM)

Comparison:

Adaptability and User-friendliness of the toolkits: The complexity of urban water management makes it almost a requirement, that the toolkits are manageable from the point of view of stake holders. User-friendliness is an individual parameter. This paper, we measured it from the arrangement and content of the user manual. Certainly, to accommodate larger population, it is serious that the instructions and commands are in a very common way to read and follow by stake holders. Though, few toolkits can be highly technical Leading team IUWM Diagnostics tool. An urban water balance modeling tool Technology Selection, Tool Institutional Analysis Mapping, Tool Stakeholder Engagement, IUWM Training platform allow a rapid assessment of UWM situation and identifies issues. It models water supply, stormwater, wastewater flows into a single system. It provides a procedure to map out the official landscape of water-related players. It includes guidelines to reflect the different phases of the stakeholder process. It comprises a catalogue of technologies and a decision support tool for these. It provides materials to conduct workshops for decision-makers and water professionals. 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. Following outcome of the assessment of the toolkit. (Table – 1)

Table – 1

Parameters		**CSIRO toolkit**	**GWP toolkit**	**SWITCH toolkit**	**IRAP toolkit**	**Adopt IUWM toolkit**
Usability		It delivers firm rules and guidelines for the KSG to develop an Integrated Urban Water Management Approach.	• This is much user friendly. • In this module training can be easily saved on soft and hard copy. • Every tool has their rules and framework.	• This tool follows a strong methodology. • It appears to be easy to adopt. • It derives from website based data and resources though it is a very extensive detailed materials	It is including material and statistics relative to India.	Provides matrices to guide the stakeholders.
Key limitations		It has more theoretical methodology, only from conceptual starting point.	It still needs to be tested at beyond prefeasibility		This tool is more theoretical. Output and guidelines are limited This tool is based on Indian context.	Specifically designed for use in India.
Computer - based		No	Yes	No	No	No
Available experience on toolkit	General	The cases illustrate previous examples and	Case studies from water scarce cities are available.	It includes case studies from many nations from different	It has never been implemented in any city.	The cases illustrate previous examples and

adoption at various scales		successes		continents. These are based on different economic factors.		successes.
	Pre- feasibility	Calgary	Marondera, Kinshasa	Accra, Hamburg, Beijing, Tel Aviv, Cali, Lima, Lodz, Zaragoza	None	
	Pilot			Lima	None	Jaisalmer, Solapur, Kishangarh
	Implementation	South East Queensland, Camberra, El Paso			None	

Inclusive, the IRAP toolkit, it seems to be greatest complex toolkits among all toolkits (Kumar 2018), but also look like as the least comprehensible. Certainly, it needs users to have progressive ability in water management hydrology and economics to successfully use this toolkit. This has never been implemented on any city. Though, here are lack of context-specific practices for implementing Integrated Urban Water Management.It 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. 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 - 2.

Table – 2

S.No.	Toolkit	Conclusion
1	**Adopt-IUWM 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.
2	**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.
3	**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.
4	**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.
5	**SWITCH toolkit**	It considers the "Aqua cycle 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.

Conclusion:

There is no thumb rule for adopting and implementation of IUWM; relatively, the mix of principles should be adapted to local sociocultural and economic conditions for better water management ***(Bahri 2012).*** Even within a same continent, the context from place to place or state to state can have significant differences in terms of demography, hydrology, governance, and so forth. So, when choosing an IUWM toolkit, it is important to have appropriate knowledge & understanding with respect to match with the local context and capacity as well as the targeted goal and objective of exercise. Every toolkit presented in this review are having great guidelines to assist develop IUWM approaches in urban area or cities. They provide the necessary guidelines to integrate UWM institutions and urban water subsystems, else they are often managed in individually. It becomes easier to consider problems of both water quantity and quality while using the IUWM toolkit, in natural ecosystem water pollution possess a great threat for water resource. The selection of the right toolkit could act as a first step and the foundation towards successful IRWM 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. Besides that, an individual or conventionally approach can result in technical choices based on the benefits to an isolated part of the system, but may unavoidable impacts have 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 empower 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.

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