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Review Paper

Exploring Indicators for the Assessment of Urban Water

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Abstract

The increasing scarcity of fresh and clean water is one of the central issues of the century in context of growing population and urbanization. Imbalances between water availability and growing demand are a rising concern but our ability to accurately assess availability as well as demand put on this precious resource is quite limited. Issues related to water as resource, its accessibility, management, demand, consumption, wastage have been discussed in different literature. Present study explores various indicators, tools and models through literature review and identifies research opportunities to develop indicators for assessment of different dimensions related to urban water. The study would be useful for urban planners and researches engaged in urban water development.

Keywords: Urban, water, tools, model, methods.

Introduction

Water as a resource is critical for healthy ecosystems, socio-economic development, and even human survival itself depends on water[1]. Availability of water in the natural environment makes sure the delivery of a number of ecosystem services to meet basic human needs as well as provide support to various economic and cultural activities[2]. Development of new sources of water thus should form a vital component of any country's national water plan[3]. The challenge for twenty-first century governance as declared by UNESCO is also to place water at the core of decision-making at all levels whether horizontally across departments and sectors, or vertically at local, national, regional and global levels[2]. Today, water as well as the other resources has become the victim of man's negligence. The outcomes of such conclusiveness towards the precious resource water, for the present as well as the future, have caused a water crisis world over[5].

About one-third of the world population already faces moderate to high water stress. An estimated 90 per cent of the three billion people that are expected to be added to the population by 2050, will be living in developing countries many in the region that are already struggling with water scarcity[4]. The world population estimated as to grow from 6.8 billion in 2010 to 8.3 billion in 2030 and to 9.1 billion in 2050[2]. As per UNDESA, 68% of these 9 billion people of 2050 will reside in urban area. Thus, for the upcoming four decades the population growth will be condensed in urban areas of the world. Moreover, the cities and towns of less developed region will hold this thriving population of urban area[5]. The main reasons which are adding to the pollution of available water resources in India are huge increase in population, industrialization, agricultural run-off[6]. Availability of fresh water which is less than three per cent of global water is another concern. 87% of the world population gets its drinking water from improved sources, and also the developing region has high correlative figure of 84%., In urban areas access is far greater, 94%, while only 76% of rural populations have access to improved sources[7].

Thriving populations and improving fundamentals of living go hand in hand. Such factors assorted with other factors of transformation are putting demand on local, national and regional water required for various sectors including irrigation, industrial uses and environment, as well as for the domestic purposes. These factors are experiencing unpredictable, fast changes, creating new worries for water managers and adding risks and at the same time crafting new opportunities for all water users. The different level of quality, opportunity, receptiveness etc. should be urgently checked as the water resources are at alarming condition. There is a need to identify and develop indicators for water resources which could be implemented at various levels. Periodic valuation of water status at global, regional, national and local level could be helpful to take mitigation measures for the threat of alarming condition of water.

Study significance

The freshwater in the world is neither consistently distributed nor readily existing for different human use leaving many areas suffering from water shortage. Around 60% of the world's population is residing in the Asia-Pacific region which has only 36% of global water resources[8]. It is expected that 50% of the Asian population will live in urban areas by 2020[9]. Presently about 48 per cent of the world population is urban, which is expected to increase to 70 per cent by 2050. It is well recognized that urban development is taking place at a comparatively faster rate in the less developed than in developed countries[9]. Fewer people will be living in rural surroundings than that of urban areas by 2030. Similar trend is seen in India, where 31 percent population of India is living in urban centers as per census 2011. No wonder that in developing countries water withdrawals are projected to rise by at least 25%[10]. Only 4% of the urban population depends on unimproved sources till 2008, but in spite of the high coverage rates for urban drinking-water, issues of service quality remain[11].

Quality of water is also an important concern. Over 80% of used water worldwide is not collected or treated[12]. The disease like Diarrheal disease is related to contaminated drinking water and it is reported that every year more than 1.5 million children below 5 die because of contaminated water [13].

Water related issues have different dimensions. Availably of resources, availability of fresh water resources, water quality, water accessibility, water quantity, service management and urban water supply are the major concern areas of water from literature. These issues sound high particularly in urban areas due to high concentration of people in smaller areas. Concentrating population in cities and marginal regions and disproportionate growth of services and urban infrastructures, particularly in developing countries, transformed urban regions to unhealthy and polluted places and faced them with problems such as sewage and waste disposal, providing healthy water etc[14].

Thus initiatives are required to address urban water problems at different levels. Literature suggests that research and studies have been made to assess the depth of water related problems like water crises, shortage, scarcity etc. Some indicators and measuring tools have also been proposed in this direction. These indicators are always at the top of research arguments. Most of these indicators are useful at global level which is difficult to manage. There is a need to study such indicators together and discuss their applicability and find research opportunities for development of water related indicators.

Water related assessment comprises reliable assessment on availability of water, quality of water, water shortage and water needs[3]. These tools address different concern of water. Indicators for depletion of water resource, accessibility gap, decreasing average availability, loss of water in supply system have been suggested in literature. Many indices which have been developed to assess various dimensions of water resources are reviewed and discussed below.

Earth's Human Carrying Capacity and per Capita Water Availability

The carrying capacity as a concept was initiated by Thomas Malthus in the year 1798. He observed that population growth if unchecked, grows exponentially against arithmetic growth of subsistence and predicted that the earth can only hold a definite amount of human growth for a definite time. Earth human carrying capacity is the calculation of available resource and the consumptions. It suggest the time period for which resource could be used for the growing population[15]. This eventually leads to per capita resource availability.

India houses about 16 per cent of the world's population and has only 4 per cent of its water resources leaving it with per capita water availability of nearly 1,170 cu m/person/year considering its population as greater than 1,000 million. It is very much likely that by the years 2020-2025 India will be facing water stress[16]. The calculations of per capita water availability do not include disparity in water appropriation and access. This divergence is identified as a major determining factor for water usage. The per capita water availability does not consider the temporal and spatial variability in a vast country like India[17]. Thus the basic difference between per capita availability and earth carrying capacity is temporal measurement. Population is the common factor between these two indicators. Carrying capacity suggests the future duration till those resources could be used while per capita give the available resource for a person at some specified time.

Water Scarcity

Water scarcity is observed when supply is decreased to a level that cannot satisfy existing water demands. Many factors including but not limited to natural forces, failure of system component or interruption, or even regulatory arrangements may cause water shortages. Shortage, stress, crisis could be discussed together and can be categorized as water stress. Water stress, water shortage and water crisis are caused due to scarcity of water. Limitations in getting fresh water sources may result in further depletion and worsening of available water resources. Climate changes further add to water shortages. A water crisis can be termed as a condition where the region's demand of water is more than the available palatable, hygienic water within that region. Water scarcity is actuality caused by combining thriving freshwater use and reduction of useful resources of freshwater.

As a result of hike in population the per capita average annual water availability is compressing constantly. A per capita availability of less than 1700 cubic meters (m3) is labeled as a water-stressed condition while per capita availability below 1000m3 is termed as a water scarcity condition[17]. Water scarcity is basically the deficit of adequate accessible water resources to satisfy the demands of water in a particular area. A country's viable fresh water availability should be at least 1700 m^3 on an annual per capita basis for it to be sufficient, as per the World Business Council for Sustainable Development (2005). If this value falls between 1000 and 1700 m3 the country is said to be experiencing water stress, whereas the country experience water scarcity when the value falls below 1000 m3. Water scarcity can be defined as economic or physical. Physical scarcity is available where water supply cannot meet the demands of a country's populations[18]. Economic scarcity may occur in a country where there is uneven distribution of water and shortage of investment in infrastructure. Economic water scarcity can be managed through better governance and investment in infrastructure, but physical water scarcity is destined to grow in context of mentioned cumulative effects of urbanization, population growth and climate change.

Falkenmark, Lundqvist, and Widstrand also specify water scarcity in same direction. The per capita annual water supply is considered as basis of measuring water scarcity. If it falls below 1,700 cubic meters (m3), a country is considered water-scarce Below the 1,700 m3 level a country faces seasonal or regular water-stressed conditions. If the annual per capita water supply falls below 1,000 m3, water shortages start affecting the health and wellbeing of human beings Below 500 m3, is categorized as life thretening[19]. In another study scarcities of countries are ranked according to their future development needs. A country is severely water-scarce in an economic sense, if the future demand is more than double the present withdrawal level[20]. Thus per capita water availability, percent withdrawal and future water needs are the measuring unit of water scarcity. Different sources have suggested different scale for water scarcity.

Water Indices

During the last two decades, many indicators particularly related to human water requirements and water resources vulnerability has been developed to evaluate water stress. Different aspects that characterize water resources like usage, supply, availability, shortage, etc. have been integrated for calculating water scarcity [21]. Poverty Index and Rural water livelihood Index are some of them.

Rural Water Livelihood Index, which is one of composite indices addresses four key aspects of rural livelihoods, mainly access to basic water services; crop and livestock water security; clean and healthy water environment; and secure and equitable water entitlement[17]. Water resources have been considered for its accessibility to people. Thus the increase in the coverage of the population to the water resource gives good result in terms of these indices. Water Poverty Index (WPI) is another attempt to design an integrated indicator to assess water scarcity and accessibility to water of poor populations by Sullivan. As a tool it takes into account all important issues and relates physical, social, economic information with water resources. Availability of water resources, ability of humans to get and maintain access to water including its use for productive purposes, and the environmental aspects which impact on the ecology on which water sustains, all are incorporated in its theoretical framework. WPI has been proved to be significant at all different levels. However, the index falls short to conveniently handle the problem of temporal scale.

Looking to the ability in addressing poverty linkages to water the WPI performs as a holistic tool. The component variables and its structure are evolved through discussions with a comprehensive range of stakeholders in a participatory way. The visionary framework approved for the enhanced WPI comprises two different scopes, bringing together the organization of issue with a classification in terms of the position along the underlying sequence is based on the original structure of the index[22]. Measures of people's capacity to access water on a sustained basis, water availability, access, use of water, and environmental factors that affect water quality and ecology all are integrated in WPI and resulted in an improved index which accounts social, physical and economic dimensions of water. Beside the above discussed tools and indicators, many other indicators have been proposed in literature.

Satisfaction level for water needs

A pilot study on consumer satisfaction was done by INRA and Deloitte in 2003 and 2004 for the Health and Consumer Protection Directorate-General of the European Commission. The focus of the study was to develop a procedure for deriving consumer satisfaction indicators in the European Union. The 'consumers' were described as "people (18+) having used the service in the past 12 months", for the purpose of survey. "The consumer's assessment of a product or service in terms of the level to which that product or service has met his/her needs or expectations was explained as 'Satisfaction' Consumer satisfaction could be evaluated by both directly ('observed satisfaction') and after the statistical analysis of responses to specific questions ('calculated satisfaction')[23]. The consumer's satisfaction for water could also been examined assuming water as a product and user as consumers. Study has been made to check the satisfaction level of water resource.

Level of satisfaction of people's basic needs can be measured through the indicator 'Percentage of people using an improved drinking water source' which have been used to measure progress in achieving the Millennium Development Goals 7-Target 7C[24]. Satisfaction level of the people could be checked for all aspects of water like access to water source, 24X7 supply and quality water supply etc. The problem associated with the study of satisfaction level is its sample. Sample size increases with the increase in the level of geographical area for more confidence level. Thus the satisfaction level sound good at local level where maximum percentage of population could be included into sample. At national or regional level, satisfaction level doesn't give true picture due to complication of disparity of water resource condition and sample selection as per this disparity.

Water Footprint

A.Y. Hoekstra is credited for introduction of water footprint

(WF) in 2002 from the University of Twente and has been developed as a discrete indicator altogether, measuring human share of freshwater resources. The WF accounts for the total volume of freshwater that is used to produce the goods and services consumed by an individual or community. When compared with other members of the "footprint family" it focuses to capture the virtual (embodied) use of water along the production life cycle and elaborately distributes the total to consumption[25]. WF is the per capita consumption of water. Mostly it is used at nation level as basis to discuss the change in footprint of developed and developing country. Study of water foot print from last few decades suggests that the water footprint is higher for higher economic class.

Water Security

Water security is expressed as the "reliable availability of an acceptable quantity and quality of water for health, livelihoods and production, coupled with acceptable level of water-related risks". Water security can be achieved through investments in infrastructure to store and transport water as well as treat and reuse waste water; including strong institutions to make and implement choices; and information and the capability to predict, design and cope[26]. Proportion of households that obtained a sufficient quantity of water from a "safe" source, for x days a year; Proportion of population at risk (below a particular flood line (100 year, 10 year), or with rain-dependent livelihoods at risk of drought); and Percentage of available water stored are suggested to assess the status of water security in a particular region.

Looking to quality aspects Water quality is defined as the chemical, physical and biological characteristics of water[27]. To determine a representative water quality profile in India no guidelines in context of minimum number of water sources to be tested are available[28]. In Indian context CPCB categorizes water for its quality check. It recommends water quality for designated best uses into five categories of A, B, C, D and E classes. Water quality criteria have been defined for these classes. These criteria are the chemical composition of water. The presence of oxygen, coliforms organism, and pH are major concern of these criteria.

Findings and Interpretation

From the above review it is clear that there are two faces one is available resource and other is requirement. If resource is more than the requirement, the status is known as secure opposite to it if the resource is less than the requirement it is categorized as scarcity. Indicators can lead to better choices and more effective actions and movements. Many useful ideas, thoughts and values get effectively communicated through a scientifically designed tool. The proportion of total water resource available and the proportion of total water human use can be measured by these indicators. Freshwater resources and freshwater use can be understood as water resources and water use respectively. Similarly indices aim to provide compact and targeted information for management and policy making. With respect to decreasing per capita availability of freshwater, water availability, allocation and quality are identified as the major issues which need attention.

The major components contributing in the increase in per capita use of water are population dynamics and associated increasing consumption as a result of rising per capita incomes-better lifestyles, longer life expectancies, population growth, and globalization of trade and advertising. An indicator like per capita does not present an authentic picture particularly in large urban areas having diversified level of quality and quantity and consumption pattern of water.

Population-water equation is used to assess water scarcity by the Hydrologists. They basically compare the amount of total water resources available per year to the population of a country or region. 'Water poverty index has several applications at international and regional scales. This tool is used to analyze the links between poverty, social deprivation, environmental integrity, water availability and health by both water resource managers and policy makers. This index is useful at a bigger scale like country level where the data is usually available.

Several methodologies have been developed by researchers, government agencies, and consumer groups for assessment of water resource status. Water-related social, economic and environmental components of the performance are often not considered in the methodologies developed by different agencies and cannot be used to assess the extent to which household water status should be measured. There is a concern for water security, but the problem is only perceived as that of water supply and management particularly in developing countries. In all of the above studies related with estimation of the quantitative characteristics of water resources, interactions among the relevant factors of water are not evidently addressed. The important temporal and spatial dynamics of factors are also not discussed.

Conclusion

Imbalances between water availability and growing demand at local as well as global level have received attention of concerned planners and researchers. Population of a settlement interacts with water through its use for various purposes. Planning strategy for ensuring availability and judicious water use demands systematic analysis of this dynamic interaction, There is a need to maintain certain standards for development, as well as use of this renewable but limited resource.

Increasing demand for water, the reduction of river flow volumes, the unsustainable exploitation of aquifers at rates higher than natural replacement, water pollution, user's satisfaction are some of the challenges which require immediate actions. One of the significant steps in addressing the crisis is an accurate assessment and prediction of water resources and their use.

Cities have complex systems that provide vital goods and services to a large and concentrated population, and can be thought as unique ecosystems. In context of water related functions such as provision of drinking water, water supply for production and cleaning, removal of fecal matter and handling of wastewater, concern of flooding by drainage of water, are performed by urban water systems. Provision of water for urban agriculture and for pleasure as well as recreational aspects which support urban culture should also be considered. It is important to recognize that the entire urban water scenario is linked not just to infrastructure, finance, and governance, but to urban developmental choices. There is an urgent need to develop indicators for global context of water issues but functioning at local level. Looking to the urbanization trends, urban sector should be kept at prime attention. The performance of urban water system should also be checked. Indicators of WPI and satisfaction level are very useful to discuss urban water problems. There is a tremendous opportunity of research in this direction which is also the need of the decade.

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