Research Journal of Applied Sciences 13 (10): 610-615, 2018
ISSN: 1815-932X

Developing Indicators for Slum Water Poverty Index

Deen Maqbool Ahmed, Natraj Kranthi and Minakshi Jain
School of Planning and Architecture Vijayawada, Andhra Pradesh, India

Abstract: The problem of water scarcity is presently a global phenomenon. Measuring water poverty helps in assessing the water scarcity and in turn for addressing the issue. Calculation of Water Poverty Index (WPI) particularly for the urban poor settlements such as slums may enable concerned authorities to prioritize the investments. However, the concept of water poverty is usually associated to macro level context , i.e., country or region a land not to micro contexts such as slums. In general, the existing water poverty index frameworks include indicators/parameters at macro level but not at micro level. Given this background, calculation of WPI for slums is a challenging task. This study is a scholastic attempt to develop indicators of Slum Water Poverty Index (SWPI). An assessment through SWPI can particularly be helpful in identifying the service delivery related issues. For this purpose, various relevant concepts and WPI Models were reviewed. After a review of various research approaches to address water issues in slums, slum specific indicators of WPI were derived. As a result, a conceptual framework for SWPI was developed.

Key words: Water scarcity, global phenomenon, water poverty, conceptual, identifying, purpose

INTRODUCTION

During 2001-2011, the urban population in India increased to 377 million with a growth rate of 2.76% per annum while the urbanisation increased from 27.7-31.1%. Increased pressure on water can be attributed to rapid increase of urbanisation. Cities in developed countries often struggle with high operation and maintenancecosts and the decay of existing infrastructure, rapid urban growth in the developing world is seriously outstripping the capacity of most cities to provide adequate services for their citizens (Cohen, 2006). This phenomenon is particularly can be witnessed with respect to the water service delivery. One-seventh world's population lives in urban tenements or informal settlements that lack reliable piped water supplies and good provision for sanitation, drainage, health care, schools and other essential services. By 2050, the world's urban population will swell to 6.25 billion with 5.1 billion people living in cities in the developing world. Of these, as many as two billion peoplewill live in slums (Florida, 2014). Assessment of water poverty is therefore, vital to address water scarcity issues for future sustainability of water in slums.

In general, the existing concepts and models of WPI are associated with the macro and not micro level contexts. Micro level application of the concept of WPI has its own ambiguities. The existing literature is not robust enough to relate to the local contexts.

MATERIALS AND METHODS

Water poverty index: Water poverty refers to the varied conditions where individuals are not provided with sufficient water either in terms of quantity and quality or not able to afford to purchase water from informal and formal service providers. Understanding poverty in general is important to understand the concept of water poverty. Poverty is usually associated with deprivation, deficiency, lack of needs for human survival and welfare. There is no unanimity on constitutes basic needs. Some services could be more 'basic' than others as most often it is a matter of political decision.

Therefore, the conception of water poverty can be an initiating point to explore 'water poverty'. Existing literature on water poverty majorly focuses on the basic norms and standards, coverage, access to water at household level, i.e., minimum water needed by a person per day. A review of various relevant definitions (Table 1) reveals that different parameters such as availability, affordability, access, connection, etc. were used in defining the water poverty. It is observed that for defining water poverty, most frequently context specific parameters were considered.

The urban water poverty is not only the resultant of resource scarcity or poorly managed utilities but rather a socially constructed process produced and reproduced through multiple socio-political processes of exclusion and discrimination, spanning from the country/region to

Corresponding Author: Deen Maqbool Ahmed, School of Planning and Architecture Vijayawada, Andhra Pradesh, India

Table 1: Definitions and key parameters of water poverty

Definition by	Key parameters of the definition
Sen	Exclusion, discrimination, deficiency of entitlements
Savenije	Neglected connection, water availability, socio-economic dimensions
Salameh	Inefficiency of existing water resources, high water demand, water usage type (domestic, irrigation, etc.)
Sullivan (2002)	Lack of adequate and efficient water supply
Meigh	Lack of physical access, insufficiency of water, non-affordability
Feitelson and Chenoweth	Non-affordability for clean water, non-availability for all people at all times
Lawrence *et al.* (2002)	Lack of access to water, insufficient water availability
Chenoweth	Number of people supported by each flow unit
Fenwick (2010)	Limited technological capabilities, limited managerial capabilities
Allen	Resource availability, concerned with political, social, economic and institutional dimensions

Ahmed and Kranthi

the community level. Urban water poverty is above all a 'deficiency of entitlement'. According to Savenije water poverty is a new concept. It is described as a concept of water poverty that bridges gap between water availability and socio-economic dimensions. Salameh defined water poverty as insufficiency of existing water resources for domestic use, food production to meet domestic, production needs and occurs when the water demand is less than the availability for the population of a certain area but it does not account for the social causes of water shortage. Here, water poverty is viewed in terms of its usage and depends on the link between demand and availability.

Feitelson and Chenoweth defined water poverty as a situation where a nation cannot afford the cost of sustainable clean water to all people at all times. This definition emphasizes on the accessibility to safe water. It also, indicates that the water poverty is based on the availability, affordability and quality of drinking water while Sullivan (2002) defines water poverty as a lack of adequate and efficient water supply that links physical estimates of water availability with socio-economic variables. Further, Lawrence *et al.* (2002) defined water poor in two different ways:

Those who lack access to water or have insufficient water availability to meet their basic needs. Those with insufficient income to access water even when the supplies exist. In this definition, water is viewed as a survival need indicating poverty as one of the key determinants of water poverty.

Meigh describes 'water poor' in terms of physical access, income and sufficiency of water. People can be 'water poor' in the sense of not having sufficient water for their basic needs. They may have to walk a long way to get it or even if they have access to water nearby, supplies may be limited for various reasons. People can also be 'water poor' because they are 'income poor', although water is available, they cannot afford to pay for it. It is interesting to note from the definition that in general, 'water poor' are not always dependent on the poverty or affordability of the people. However, people who can afford may still be 'water poor' if they cannot have access to water.

Allen urban water poverty is concerned with the political, social, economic and institutional dimensions. Urban water poverty is distinct from water scarcity. While urban water poverty is concerned with the political, social, economic and institutional dimensions, water scarcity is related to the resource availability. Water scarcity is defined as a state of insufficient water to satisfy normal requirements. Besides, a number of other terms such as water crowding and water stress are also used to describe the water related issues. Fenwick (2010) defined 'water stress' as the number of people that a flow unit of fresh water can sustain. Conversely, water stress is also, defined as how many people can be supported by each flow unit within given technological and managerial capabilities? (Fenwick, 2010).

The purpose of the WPI is to express an interdisciplinary measure which links household welfare with water availability. WPI indicates the degree of water scarcity impacting human population. The primary focus of the index is on poor people, who suffer most from inadequate access to water. It is a combination of physical, social, economic and environmental information associated with water scarcity (Lawrence *et al.*, 2002). Sullivan (2002) defined WPI is a composite index based on the HDI expressed as follows:

$$WPI = \frac{\sum_{i-1}^{N} w_i X_i}{\sum_{i-1}^{N} w_i}$$

Where:

WPI = The Water Poverty Index value for a particular location

X_i = To indicator i of the WPI for that location

w_i = The weight applied to that indicator

For the indicators listed above, equation can be re-written as:

$$WPI = \frac{w_r R + w_a A + w_c C + w_u U + w_e E}{w_r + w_a + w_c + w_u + w_e}$$

The above formula is a weighted average of the five indicators i.e., Resources (R), Access (A), Capacity (C), Use (U) and Environment (E). 'w' is the weighing factor for each indicator. Each of the indicators is first standardized in the range of 0-100, thus, the resulting WPI value is between 0 and 100. The highest value, 100 is taken to be the best situation (or the lowest possible level of water poverty) while 0 is the worst.

The WPI allows the use of different scales to be applied for different needs based on the following five key indicators:

- Resources: water availability or quality across different seasons
- Access: the accessibility of water for human use
- Capacity: capacity is interpreted as income to allow purchase of improved water, education and health which in turn indicates a capacity to lobby for and manage water supply (Lawrence *et al*., 2002)
- Use: actual amount of water being used and extracted from the system
- Environment: environmental impact of water management (Lawrence *et al*., 2002)

The WPI as discussed have five indicators: resource, access, capacity, use and environment. It is measured based on the above-mentioned key indicators and is usually helps in indicating the existing status of water condition. It can be also, used as an interdisciplinary and monitoring tool that expresses precisely the water situation in various areas (Sullivan, 2002). The concept of WPI can be applied to assess the water poverty at various levels, i.e. from community to country level. Most often, WPI is used for macro level applications (country/regional/state/district) than micro level (area/neighborhood/community). The indicators of WPI vary for each of these levels.

The above discussed indicators are particularly relevant to a macro scale, however, to address micro scale specific problems, context specific parameters need to be developed.

Slums: Census of India defines a slum as a compact area with a population of at least 300 or 60-70 households of poorly built congested tenements in an unhygienic environment, usually built with inadequate infrastructure and lacking in proper sanitary and drinking water facilities. The definition of slum is not however universal.

'Slum' in simple way is stated as a heavily populated urban area characterized by poor housing and squalor' (De Sampaio, 1994). It summarizes the basic characteristics of the slums that includes high densities and poor quality of housing (structure and urban services) and 'squalor'. The first two criteria are physical and spatial while the third is social and behavioural. The spatial nature of slums refers to the size and location of the slum areas, thus, determining the vulnerability due to changes in jurisdiction or spatial aggregation.

Slums are the by-products of poverty and inequality. However, all urban poor do not accommodate in slums, nor all residents of slum are always poor. They are formed due to lack of strong institutional support, improper, regulatory framework, poor governance, impassive financial systems and lack of political support.

In 2001, about 23.5% of the urban households were living in slums which significantly reduced to 17% in 2011. However, the absolute number of households living in slums has increased from 10.15 million in 2001-13.75 million in 2011, leading to increased pressure on the basic services, particularly on water consumption. This phenomenon is even higher in million plus cities/mega cities such as Greater Mumbai, Delhi NCR and Kolkata where about 42-55% of their population lives in slums, (Anonymous, 2016).

RESULTS AND DISCUSSION

Slum water poverty index: A review of literature revealed that assessment of water service levels at City/Urban level has been extensively studied. Various national and international governments/funding agencies are providing funding water services for the urban poor in the developing countries through various development schemes. However, in a country like India, there are no realistic tools to assess water condition in slums apart from service level benchmarking for urban areas. Because of this, cities are unable to prioritize investments in urban slums. Developed countries like United States of America and United Kingdom have already developed context specific water poverty parameters. Given this background in order to contextualize WPI indicators and parameters particularly to slums an expert opinion survey was conducted through Delphi method. Based on this method parameters of SWPI were identified as below:

Through a review of literature, 27 parameters were identified. These include: source of water, water quantity, water sufficiency, alternate sources, altitude, reliability, ground water level, household with potable water access, frequency of water supply, time spent to collect water, distance travelled to collect water, queuing time, women engaged in water collection, children engaged in water collection, distance from natural source, maintenance of water supply, maintenance of water source, household

Table 2: Process of identification of SWPI parameters

Indicators key parameters	Overall score	Overall rank	Identified parameters
Resource			
Source of water	50	26	
Water quantity	89	1	
Water sufficiency	77	7	
Alternative sources	74	10	
Altitude	71	12	
Reliability	68	14	
Ground water level	66	15	
Access			
Household with potable water access	86	2	
Frequency of water supply	64	16	
Time spent for water collection	78	6	
Distance travelled to collect water	75	9	
Queuing time	63	17	
Women engaged in collecting water	62	18	
Children engaged in collecting water	60	19	
Distance from natural water source	72	11	
Capacity			
Maintenance of water supply	59	20	
Maintenance of water source	57	22	
Household income	58	21	
Expenditure spent on water	54	25	
Education	55	24	
Employment	52	26	
Expenditure on water related illness	85	3	
Use			
Domestic water consumption	84	4	
Potable water consumption	56	23	
Environment			
Water quality	82	5	
Household level water treatment	76	8	
Type of water borne diseases	70	13	

income, expenditure spent on water, education, employment, expenditure on health due to water illness, domestic water consumption, potable water consumption, water quality, household level water treatment, type of water borne diseases.

The identified parameters were sent to a panel of 10 subject experts from academics, research and industry for prioritisation of parameters.

The parameters were given scoring from a range of 1-10 where 1 is the least important and 10 is the most important. Based on the expert opinion, 15 parameters were prioritised.

First 15 high scoring parameters were selected. Among them, 'water quantity' scored the highest and 'ground water level' the least. The details of indicators, key parameters, scores, ranks and identified parameters (green colour) are in Table 2. The details of each indicator are discussed:

Water resource: A review of relevant literature reveals that amongst all the sub indicators of water resource, water source has been discussed extensively than others such as water quantity, sufficiency, alternate sources, altitude, reliability and ground water levels that are most important at slum level were not considered.

Access: Among all the sub-indicators of water access, potable water access, i.e., in-house water access is discussed at various levels rather than time spent for water collection, distance travelled to fetch/collect water, queuing time, etc. It is inferred that slum specific parameters were often not considered.

Capacity: Literature review reveals that among all the parameters of water affordability, expenditure spent on water is not used to assess capacity. Social aspect, education and health are the major parameters to be added. As the social aspect, United Nations points out that children play a major role in the household chores often contributing to water collection which in turn affects their education. Also, working population apparently send a substantial time in collecting water leading affecting their earning. Investing their working hours to collect water often reduces income generation.

Usage: For measuring WPI, water consumption has been usually referred in the context of consumption of water for agricultural, industrial, domestic, livestock, etc., purposes. However, domestic water consumption at slum level has not being considered.

Table 3: Key parameters identified for slum water poverty index

Indicators code	Key parameters
Resource	
R1	Water quantity
R2	Water sufficiency
R3	Alternate water sources
R4	Altitude
R5	Reliability
R6	Ground water levels
Access	
A1	Potable water
A2	Time spent for water collection
A3	Distance travelled to collect water
A4	Distance from natural water source
Capacity	
C1	Expenditure on water
Use	
U1	Domestic water consumption
Environment	
E1	Water quality
E2	Household level water treatment
E3	Water related illness

Environment: In general, key environment parameters include water quality, household level water treatment and water borne diseases. However, these parameters do not seem to be frequently used for assessing water poverty in slums. Therefore, there is a need to consider in measuring water poverty. Key parameters identified through the expert opinion survey are presented in the Table 3.

Water is a major source of for human survival. This abundant resource eventually became scarce due to over exploitation of the water resources. Due to rapid industrialization and urbanization world over, misuse of water became rampant. As a result, repercussions led to haphazard development which in turn had impacted the climate change. The implications of rapid urban growth and haphazard development affected quality of life. This phenomenon is most frequently prevalent in slums. Sullivan (2002) first proposed the WPI as an integrated approach to water poverty (where water poverty is defined as a lack of adequate and efficient water supply) that link [s] physical estimates of water availability with socio-economic variables. Further, the WPI is developed with a purpose of identifying water scarce communities, towards achieving more equitable distribution of water. Around a billion people live in slums (Anonymous, 2001, 2016). The concept WPI is usually applied at a regional/macro scale with parameters that are not relevant to community/micro scale. Therefore, such parameters cannot be considered to address the micro level issues.

It is in this context, the concept of Slum Water Poverty Index (SWPI) becomes relevant as it can be used to address community related issues. SWPI is developed with the same indicators and formula of WPI (resource, use, capacity, access and environment), however, the parameters used are more specific to slums. For developing the SWPI, indicators and key parameters through a review of literature were identified. The parameters used to calculate the WPI are replaced with the parameters mentioned in Table 2:

$$\left[SWPI = \frac{\sum_{i=1}^{N} w_i X_i}{\sum_{i=1}^{N} w_i} \right]$$

SWPI, thus, developed may enable a better understanding and analysis of the slums. SWPI is vital in perceiving various ground realities associated with slums. The utility and the context specific usage of each of the parameters are elaborated below:

Resource: This indicator includes source of water, water quantity, water quantity sufficiency, ground water level, altitude and reliability of water supply:

- Water quantity is measured in liter per capita per day (lpcd) and intricately linked to the living standards of people. The quality of life is directed impacted by the water quantity
- Water sufficiency is measured in lpcd and compared with the required standard so as to ascertain the sufficiency
- Alternate water sources refer to community taps, bore water and packaged water. These sources are directly linked to the water quality depending on the type
- Altitude refers to the elevation at which the settlement is located and the terrain type including the slope, aspect, etc
- Reliability of water supply usually refers to piped water supply. Through this parameter, frequency of the piped water supply can be assessed. This is applicable predominantly to the slums where the dependency on the community taps is higher
- Ground water level is useful in assessing the underground depth of the existing ground water levels of the settlement. It is usually measured in feet/meters. The data can be used for analyzing the dependency of the settlement on the ground water

Access: This indicator includes household with potable water access, time spent for water collection, distance travelled to collect water and distance from the natural water source.

Potable water refers to the percentage of households having access to potable water with in the premises. Individual piped water connections may enable to reduce the water related issues. Time spent for water collection involves travel and queuing time to collect water. This usually refers to the number of trips that the individual's make during the operational hours of water supply.

Distance travelled to collect water: in case of non-availability of water connections within the house premises, the inhabitants may have to travel longer distances to collect water. Millennium Development Goals specified the water point to be within a to and fro walking distance of 30 min. Distance from the natural water source usually refers to distance from water ponds, lakes, rivers, etc. Natural sources of water may enable to overcome extreme water poverty.

Capacity: This indicator includes expenditure spent on water.

Expenditure spent on water: In case of water insufficiency, the dependency on the packaged water or private tankers increases which in turn impacts the expenditure for water. As per the World Health Organization an individual should not spend more than 3-5% of the income for the purchase of water.

Use: This indicator includes domestic water consumption. Domestic water consumption-As per the URDPFI guidelines, the minimum norm against which the gap assessment done is 135 lpcd.

Environment: This indicator includes water quality, household level treatment, water related illness affecting the population.

Water quality: In the case of piped water supply, the water is generally treated by the urban local bodies. However, the quality does not vary much with the seasonal variations. As per the CPHEO standards, the water quality can be assessed based on the service level benchmarks.

Household level water treatment: Poor water quality affects health. Boiling, bleaching, etc. are common methods for water treatment and may help in improving water quality to an extent.

Water related illness: Consumption of untreated water most often can result in the water borne diseases such as cholera, diarrhea, malaria, etc.

CONCLUSION

Water poverty is one of the most pressing global/local issues. The role of the water poverty index in water poverty alleviation has been widely recognised. Inherent flexibility of WPI (in terms of scale, indicator choice and data sources) ensure that its possible applications are nearly endless (Van Der Vyver, 2013). The identified parameters of SWPI (the oretical and empirical) provide a new dimension towards understanding water poverty in the context of slums. Further, these parameters may be useful to increase theoretical and statistical soundness of the index at micro level.

REFERENCES

Anonymous, 2001. Public-private community partnerships in urban services for the poor. Asian Development Bank, Mandaluyong, Philippines. https://www.adb.org/projects/documents/public-private-community-partnership-urban-services-poor-tcr

Anonymous, 2016. India habitat III national report. Ministry of Housing and Urban Poverty Alleviation, New Delhi, India. http://www.indiaenvironmentportal.org.in/content/437407/india-habitat-iii-national-report/

Cohen, B., 2006. Urbanization in developing countries: Current trends, future projections and key challenges for sustainability. Technol. Soc., 28: 63-80.

De Sampaio, M.R.A., 1994. Community organization, housing improvements and income generation: A case study of favelas in Sao Paulo, Brazil. Habitat Intl., 18: 81-97.

Fenwick, C., 2010. Identifying the water poor: An indicator approach to assessing water poverty in Rural Mexico. Ph.D Thesis, Unviversity College London, London, England.

Florida, R., 2014. The amazing endurance of slums. City Lab, The Atlantic Monthly Group Inc, Washington, DC., USA. http://www. citylab. com/work/2014/01/amazing-endurance-slums/8120.

Lawrence, P.R., J. Meigh and C. Sullivan, 2002. The Water Poverty Index: An International Comparison. Keele University, Keele, England,.

Sullivan, C., 2002. Calculating a water poverty index. World Dev., 30: 1195-1210.

Van Der Vyver, C., 2013. Water poverty index calculation: Additive or multiplicative function?. J. South Afr. Bus. Res., 2013: 1-11.