Comprehensive Assessment of Household Potable Water Security in Lowland Urban areas - A Case Study of Kozhikode, Kerala

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Abstract: Water security is one of the key issues addressed in water Infrastructure planning and management globally. India being the second largest in population in the world, water security planning play a significant role in its overall development. This concept will help to analyse total amount of water used, efficiency of water usage and to reduce water pollution. Water security index can be used as a base for water security planning and for administering better water management. This study attempts to analyse the potable water security in selected regions of Kerala. Household water security index will be calculated using a mixed method approach including both quantitative and qualitative indicators. Kerala located in the South-western part of India, is divided into three physiographic zones parallel to the coastal line: high lands, midlands and lowlands. Selected study area falls in low land region. Water has traditionally an abundant resource in Kerala with its 44 rivers, backwaters and annual rainfall amounting to more than double the national average. But as a result of global climate change it is facing recurring drought due to reduction in annual rainfall. Situation is getting worse with each consecutive year .State was declared drought hit in 2017 by the State Disaster Management Authority (SDMA) and was faced massive flood in 2018 in these contexts Kerala faced potable water crisis. In this study we are analysing lowland regions with higher urban population according to census 2011. A comparison of situation in the selected regions of few districts in Kerala will be done to derive region specific issues in generating index. Furthermore this index system will give impression of the indicators threatening security of potable water, and will be helpful to assess the progress of the state towards water security. Urban regions of these districts are located along the coastal line of Kerala. Through this study we can arrive at a conclusion that potable water security Index along with well-established Integrated Water Resource Management approaches along within good governance process is necessary for securing water for basic needs.

Keywords: Potable water security indicator, Water stress, Water scarcity, Integrated Water Resource Management

1. Introduction

Water security as defined by UN Water 2013is "*the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability*"[1]. This study outlines a scientific approach used for assessment of potable water security in urban areas of Kozhikode, located in low land region of Kerala. Rapid urbanisation and increasing issues due to climate changes had resulted in potable water crisis in this region. Household Water Security Index (HWSI) uses a mixed method approach involving quantitative and qualitative indicators for effective evaluation of water network system.Indicators are used to simplify the understanding of household water security to end users or public.This study identifies the probable indicators which threaten the security of potable water.The aim of this paper is to consolidate a list of indicators (n=113) from a wide range literature review consisting of varied spatial level indices relevant to the urban areas of Kozhikode. A five dimensional framework adopted in this study along with detailed discussion on each are outlined in the following session. This paper brings out general observation on essential indicators used for potable water security evaluation.

2. Study Area and Methods

Area selected for the study is confined to Kozhikode urban area being one of fastest growing urban area in the state of Kerala. On the basis of census data 2011, the study area comprises regions within Kozhikode Corporation and seven municipalities of Kozhikode district [2]. Urban areas of Kozhikode receive its potable water supply primarily from Perumanamuzhi reservoir with support from Japan International Bank aided drinking water scheme. In the context of increasing urbanisation and climatic change the potable water status evaluation and management assumes significance.

Literature review was conducted to identify relevant indicators and indices for potable water security. Articles from the Web of science database for the time period 2009 to 2019 were identified using various permutations of key terms in the subject. A comprehensive list of all relevant indicators and indices affecting household water security were identified and categorized into five dimensions with sub-categories for each dimension.

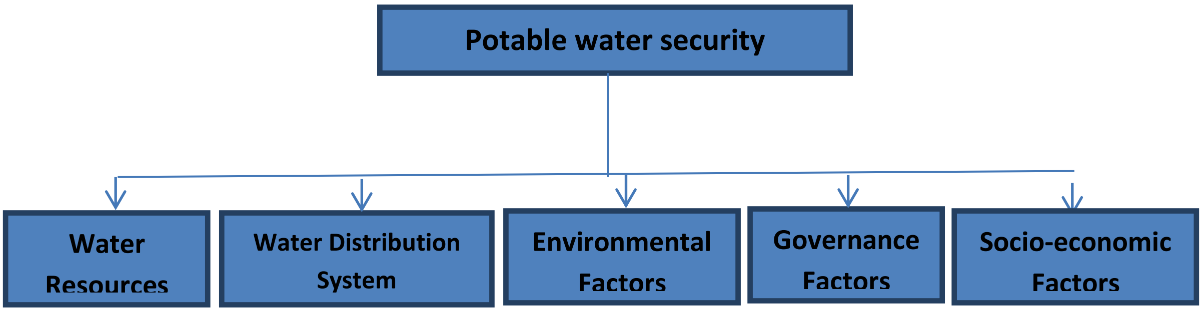

Figure 1: Five dimensional frame work for potable water security

The list of indicators identified under each category of varied dimensions.

1. Water Resources

This dimension consists of three sub categories namely quantity, quality and variability. Water resource quantity consists of nine indicators, water resource quality consists of seven indicators and water resource variability has eleven indicators as listed below.

1.1 Quantity

i. Mean annual river flow[3]

ii. Local availability[4][7]
iii. Water resources per capita (demand)[5]
iv. Water resources per unit area (supply)[5]
v. Captured water (hydraulic) availability [7]
vi. Urban water consumption per capita [5]
vii. Mean annual precipitation[3][9]
viii. Aridity Index[9]
ix. The dependence on imported water on centralised or externally sourced supply[11]

1.2 Quality

i. Drinking water quality standards compliance rate[12]
ii. Upstream development sites[3]
iii. Pollution sources near water source[13]
iv. BOD5, basin long term mean[14]
v. BOD5, variation in the basin, relative to the long-term mean (%)[14]
vi. Integrated pollution index of surface drinking water[15]
vii. Industrial wastewater[16]

1.3 Variability

i. Resilience[8]
ii. Water Stress[8]
iii. Groundwater overdraft rate[6]
iv. Supply/demand ratio of water[5]
v. Months per year with water River flow variations[17]
vi. Groundwater resources reliable year-round[18]
vii. Per capita quantity variation in comparison with the long-term mean[14]
viii. Annual precipitation variance[3]
ix. River runoff variance[3]
x. Change in storage[3]
xi. The ratio of annual water consumption to renewable surface flow

2. Environmental factors

Seven indicators were identified under the dimension of Environmental factors risking potable water security. Since the study area was put to face intermittent drought and flood recently, the indicators pertaining to potable water security during these disasters are also included under this session.

i. Environmental flow requirements- for maintaining water quality of the source[7]
ii. Percentage land use or land cover change[11]
iii. Soil erosion[9]
iv. Percentage area subject to drought[19]
v. Percentage area subject to flooding and waterlogging[19]
vi. Rate of flood disaster area[5]
vii. Risk of floods (and/or sea-level rise)[27]
viii. Rate of drought disaster area[5]

3. Water distribution system

The third dimension of water distribution system is subdivided into five categories namely system capacity, human resource management, quality & reliability of network, finance and local impacts. Nine indicators were identified under system capacity category and eight indicators were identified under the human resource management category. Quality and reliability of water distribution system is under third category with seven indicators under this session. The fourth and fifth categories finance and local impacts have four and two indicators respectively. The indicators under each of these five categories are listed below.

3.1 System capacity

i. Yield per supply [3][17][20]
ii. Network diversity[27]
iii. Rainwater harvesting potential[21]
iv. Age of system[22]
v. Leaks[22]
vi. Historical disruption frequency [27]
vii. Maximum number of people per water source[13]
viii. The time before water service capacities are exceeded by pop. Growth[23]
ix. Perceived future (1, 5, 10 years) functioning of piped water systems[22]

3.2 Human resource management

i. Water operator(s) level of training[23]
ii. Skilled labour and maintenance personnel availability[18][20]
iii. Compliance of drinking water quality standards after treatment

iv. Water Quality Acceptability[27]
v. Level of administration[20]
vi. Level of governance [20]
vii. Documentation[3][18]
viii. Community engagement [12]

3.3 Quality & Reliability

i. Sanitary inspection risk score [24]
ii. Treatment technology scale at the point of extraction[3]
iii. Flexibility for treating raw water of different qualities[13]
iv. Compliance of drinking water quality standards after treatment[12]
v. Water Quality Acceptability [22]
vi. Present operational state[22]
vii. Extent and accessibility to the water distribution system[27]
viii. Water source diversity[3]

3.4 Finance

i. Perceived revenue sufficiency for operation and maintenance [22]
ii. Costs[3][20] [25]
iii. HH income[3]
iv. Tariff structure[22]

3.5 Local impacts

i. Percent of beneficiaries [13]
ii. Rate of increase in beneficiaries' income, including savings[13]

4. Governance factor

As major water supply of the study area is managed by Government of Kerala, the governance factor is listed as fourth dimension which comes under planning potable water security. Indicators identified under this dimension are listed below.

i. Local Policies[3]
ii. Water management policies[25]
iii. Number of administrative-related visits from the external organization(s)[22]
iv. Number of engineering-related visits from the external organization(s)[22]
v. Extension officer visit (government or NGO) [26]
vi. The proportion of water conservancy projects investment in GDP[5]
vii. Water law adequacy and implementation [14]

viii. Role of politicians
ix. Consensus between administrative and watershed boundaries[25]
x. Change in basin's water resource management expenditures (in percentage)[27]
xi. Involvement of the state in undertaking a comprehensive national situational analysis[27]
xii. Adequacy of programs to support Integrated Water Resource Management[9]
xiii. Suitability of catchment management plan[9]
xiv. Smallest scale of administrative agencies[20]
xv. Involvement of project implementing agency[25]

5. Socio-Economic factor

The fifth dimension socio-economic factor is subdivided into four categories namely community characteristics, access & equity, health, knowledge and behaviour. In the category community characteristics fifteen indicators and for access & equity eleven indicators were identified respectively. Water-related disease incidence is the indicator identified in the category health. Six indicators were identified under knowledge and behaviour category.

5.1 Community characteristics

i. Demographics[10]
ii. Supply Source uses captured (distant) sources[7]
iii. Uses captured (distant) and local (near) sources[7]
iv. Availability of mechanisms for groundwater management and surface water management[27]
v. Drainage area encroachment[10]
vi. Urban surface growth rate versus river or water body health[11]
vii. Urban sewage treatment rate[6]
viii. Land use zoning, building codes, growth caps, hazard (e.g. floodplain) maps[11]
ix. Urbanization rate[5][6]
x. Water user associations (configuration, effectiveness)[10]
xi. Cascade (configuration, tank positioning)[27]
xii. Information regarding Networks, legal frameworks[27]
xiii. Adequacy of service[27]
xiv. Residency time[3]

5.2 Access and Equity

i. Women's participation[20]
ii. Equity in education index[9]
iii. Percentage households with piped supply [28]
iv. Distance from Household to water source (aerial and ground) (km, min)[13]
v. Domestic work disturbance related to potable water
vi. Total collection time (travel + queue)[30]
vii. Ability and willingness to pay[13]
viii. Percentage water carried by women[30]
ix. (percentage of non-durable dwellings with potable water access) ÷ (percentage of improved housings with potable water access)[13]
x. Presence/absence of conflict (community to trans boundary)[28]
xi. Water Distress[28]

5.3 Health

i. Water-related disease incidence[23]

5.4 Knowledge and Behaviour

i. Rainwater harvesting experience[26]
ii. Received operation and maintenance training for household systems[26]
iii. Home practices to improve water quality[13]
iv. Water transport and storage practices[29]
v. Water quality at home [29]
vi. Personal hygiene practices[29]

3. Results and Analysis

Comprehensive list of relevant indicators identified through the literature review were categorized into five dimensions (water resources, environment, water delivery system, governance, socio economic factors). Each of these dimensions was further sorted into number of categories and sub-categories. Comparison of various dimensions was carried out using Analytic Hierarchy Process (AHP) with the help of experts. The water resource and water distribution system were considered as dimension of prime importance by experts along with environmental, governance and socio-economic factors.

4. Discussion and Conclusion

While few multi-community index assessments suit the relative needs of individual communities, they were not specific for urban household. Moreover, indicator construction often relies heavily upon historical data records, thus limiting the utility of these indices for many communities especially in developing countries having scarce data. Qualitative and/or respondent-based evaluation can provide a solid starting point besides engaging all stakeholders in the process and ensuring that all voices are heard. This assessment of existing indicators across five identified dimensions of community provides water security, critical building blocks for a holistic, integrated, community-based assessment tool that is specifically designed for low resource settings. In reality, qualitative and quantitative data are required in order to assess all aspects of urban community water security status in order to enhance security. Clarity of indicators is critical, as it should be communicative and simple to understand.

This paper has assessed and compiled a comprehensive list of indicators for assessing urban household water security, particularly in Kerala context with flexibility. This model can be applied in coastal urban areas of Kerala state to ensure water security and to support overall urban infrastructure development. Potable water security Index with well-established Integrated Water Resource Management (IWRM) approach can support sustainable urban development schemes in any other low lying urban areas to fulfill the basic needs in future.

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