DEVELOPING SLUM WATER POVERTY INDEX

A Thesis Submitted

in the partial fulfilment of the requirements for the award of the degree of

Doctor of Philosophy

By:

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U N D E R T A K I N G

I, Mr Deen Maqbool Ahmed, the author of the thesis titled “Developing Slum Water Poverty Index”, hereby declare that this is an independent work of mine, carried out towards partial fulfilment of the requirements for the award of the Doctor of Philosophy at the Department of Planning, School of Planning and Architecture, Vijayawada. The work has not been submitted to any other organization / institution for the award of any Degree/Diploma.

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CERTIFICATE

This is to certify that the thesis titled "Developing Slum Water Poverty Index", has been submitted by Deen Maqbool Ahmed (Reg. No. 2140300005) at the Department of Planning, towards partial fulfilment of the requirements for the award of Doctor of Philosophy. This is a bonafide work of the student.

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ABSTRACT

It is estimated that by 2030 world's economic growth scenario of global water requirements would grow from 4500 billion cu.m today to 6900 billion cu.m i.e. 40% current accessible reliable water supply. By 2050, the world's urban population will increase to 6.25 billion, with 5.1 billion people i.e. 82% living in cities in the developing world. Of these, as many as 2 billion people (i.e. 39%) will live in slums. Realistic water assessments to determine the water situation plays a vital role in the development process of the city. For policy makers, it is essential to determine which geographic areas or groups are at risk of water scarcity. Distributional dimensions refers to groups within the population of a given geographic area are extremely important. In this context, water poverty assessments were reviewed and it is observed that assessments are done at various scales. However, in developing countries like India, water poverty assessments are must required considering the rapid population growth, infrastructure, and investment requirement. Water approached in developing countries like India, Sri Lanka, Bangladesh, Myanmar were reviewed to understand the water shortage issues across globe. In fact, empirical evidence shows that throughout the world, conflicts are already occurring as a result of dissatisfaction among large group of societies, especially the poor. Urban slums are most disadvantaged and more prone to access issues and remain as water poor. It is estimated that by 2025, one third of the developing population will live in basins where the water deficit is larger than 50%. It is because of lack of legal tenure status, norms in quality and quantity, spatial location, affordability, availability. In order, to provide policy makers with a pulse check of this performance, indicators needs to be established specific to the slums which measures the efficiency levels such as access to clean drinking water, duration, dependency on taps etc. The multi-deprivation level of poverty in India is still acute and needs more focused especially in water sector. There is an urgent need to look into the issues pertaining to the water access issues of different user groups especially in slums and their impact of water poverty at slum level. Developing water index at slum level of the settlement is an unexplored area which will prioritise the deprivation levels at community level.

In this research, primarily the review of terms and terminologies related water poverty has been done. Further, existing Water Poverty Index (WPI) model developed was studied to assess the water poverty situation of the settlement. Various research studies and WPI models to analyse the situation of water poverty at various scales is reviewed. Applicability of the models, indicators, parameters used to analyse the water poverty situation at country, regional, city, community levels in the developed countries is understood. The critiques of the WPI model is developed in terms of its applicability, weighting methods, selection of parameters, statistical methods applied to generate the results. Since the research focus is to develop Slum specific water poverty index (SWPI), the parameters were extracted from various studies and policies related to slum and water. Further, to develop a scientific rationale, Delphi method was applied to identify and prioritize the parameters that are specific to slums. Further, the weighting of indicators, detail calculations of each parameter is done. National water stress levels, percentage of slum population to urban population, slum population density were taken to identify the city for conducting the research. Within the city, ward level analysis was conducted by using Atal Mission for Rejuvenation and Urban Transformation (AMRUT) data of water supply to identify the critical wards with no service coverage, high percentage of slum population, ward wise water deficit(less than 135 lpcd), slum water deficit, Total dissolved solids (TDS) levels at ward level is analysed. The overlay of this maps helped in identifying the critical slums in the city.

The research was carried out based on a combination of quantitative and qualitative analysis. Semi-structured interviews and questionnaire along with focus group discussions were conducted within the slum settlements. Secondary data such as water supply status reports of AMRUT Vijayawada, Census abstracts were used to analyse the data. Quantitative analysis includes attribute data, preparation of ward level, slum level GIS maps, calculation of water poverty levels of identified settlements, statistical analysis of the parameters at slum levels. Cochran's formula was used to identify the number of samples to be surveyed across all the settlements. Stratified random sampling method was applied to conduct surveys within the settlement. Post completion of surveys, the data tabulation was done and the analysis was conducted at two levels i.e., at parameter level, at indicator level. In first level, graphical analysis was conducted at the initial level where all the parameters were mapped to understand the common parameters that affect across the settlement. the values of different parameters of water poverty were normalised on a scale of 0-100 where 0 represents the best condition i.e. least slum water poverty and 100 represents the worst condition i.e. indicator of maximum slum water poverty. Then taking average value of the parameters the values of different indicators were calculated. On the basis of the indicator values, SWPI was calculated using weighted composite index method. Secondly, indicator level analysis was conducted through spider web diagram to analyse and understand the criticality of the indicators that affects the settlement irrespective of the location. Further, to understand the cause and effect relationship, Pearson co-relation analysis is conducted and to understand the relationship between dependent and independent variables, multiple regression analysis was applied to identify the indicators/parameters on slum water poverty of settlements. The findings of the study helps in developing critiques in the usage and its applicability in the developing countries context and especially in the context of slums, developing a SWPI for a slum settlement, identifying uniform parameters/indicators that affects the settlement irrespective of the location. It helps to improve the resource management, accessibility, economic, usage and environmental aspects of water poverty. It also helps urban local bodies for identifying water stress levels in poor sections of the society. This will reap out the efficiency levels of water whether slums are better accessible to services or the better settlements are well accessible to services. It suggests measures for improving and minimizing the severity of the parameters in the city.

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ABBREVIATIONS

AMRUT-Atal Mission for Rejuvenation and Urban Transformation

APSRTC-Andhra Pradesh State Road Transport Corporation

BBMP-Bruhat Bengaluru Mahanagara Palike

BPL-Below Poverty Line

BSUP-Basic Services to the Urban Poor

CPHEEO-Central Public Health Environmental Engineering Organisation

DMC-Delhi Municipal Corporation

DPR-Development Project Report

ELSR-Elevated Level Service Reservoirs

GDP-Gross Domestic Product

GHMC-Greater Hyderabad Municipal Corporation

HB Colony-Housing Board Colony

HDI-Human Development Index

HH-House Hold

JNNURM-Jawaharlal Nehru National Urban Renewal Mission

MNRE-Ministry of Non-Renewable Energy

MoUD-Ministry of Urban Development

NCERT- National Council of Educational Research and Training

NCR-National Capital Region

NITI - National Institution for Transforming India

NGO-Non-Government Organisation

PMAY-Pradhan Mantri Awas Yojana

PVC-Poly Vinyl Chloride

RAY-Rajiv Awas Yojana

SDG-Sustainable Development Goal

SLB-Service Level Benchmark

SWPI-Slum Water Poverty Index

TDS-Total Dissolved Solids

UNDP-United Nations Development Programme

UNITAR-United Nations Institute for Training and Research

UN-United Nations

URDPFI-Urban and Regional Development Plans Formulation & Implementation

VGTM-Vijayawada–Guntur–Tenali–Mangalagiri

VMC-Vijayawada Municipal Corporation

VUA-Vijayawada Urban Agglomeration

VUDA-Vijayawada Urban Development Authority

WHO-World Health Organisation

WPI-Water Poverty Index

CHAPTER 1: INTRODUCTION

1.1 Background - Water Crisis Paradigm

According to the 2011 Census, the urban population in India grew to 377 million showing a growth rate of 2.76% per annum during 2001-2011. The present urban population (2018) of the country is 423 millions (World Population Review, 2019). The level of urbanization in the country as a whole increased from 27.7% in 2001 to 31.1% in 2011 – an increase of 3.3 percentage during 2001-2011 compared to an increase of 2.1 percentage during 1991-2001 (Bhagat 2011). Urbanization represents a challenge for water management in developed as well as in the developing countries. While cities in developed countries often struggle with high operation and maintenance costs 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). Sharp geographic, socio-cultural and economic inequalities persist, not only between rural and urban areas but also in towns and cities where people living in low-income, informal, or illegal settlements usually have less access to improved sources of drinking water than other residents. By 2025, half of the world's population will be living in water-stressed areas (United Nations 2018). As the global population expands and the planet warms, the demand for water is rising, while the quality and reliability of our water supply are declining. Six reasons people are deprived of access to water: Lack of finances and political priority, institutional capability to deliver and maintain the services, effective taxation and tariffs, Location and land tenure, Discrimination, Disaster & displacement. The consequences of these cause health impacts on safety and security, education drop outs, less per capita income etc.(UN World water development report, 2018)

Rapid industrialization and urbanization has created the demand on water at a time when the potential for augmenting supply is limited, water tables are falling and water quality issues have increasingly come to the fore. To overcome the challenges in water sector, a paradigm shift is needed in water management. Creation of transparent, accessible, accountable user-friendly data management system on water for the citizens can help to devise solutions for water problems (Mihir Shah, 2016). India ranks first in terms of lowest access to clean water to maximum people by population. Around one in seven of the world's population resides 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. (Satterthwaite 2015) 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 2 billion people will live in slums (Florida 2014). Population growth, along with rising incomes, changing dietary patterns, urbanization, and industrial development, will increase demand for a fixed supply of water as well as the increase in water conflicts. Water demand patterns of the future will be characterized by growing competition between primary, secondary and tertiary sectors, especially in developing countries, where population growth rates are high. Policymakers need to address systematic barriers that inhibit water access, such as poverty. Institutional reforms that enhance water access, like the expansion of infrastructure and investments in water management and distribution, are key policy interventions (Mogelgaard 2011). Various water assessment studies were carried out to understand the spatial and temporal inequalities in the distribution of population and water. This will enable to understand the inequity issues in different sections across the community in the city.

In developing country like India, the availability of water in the future will be different as compared to the present due to changes in the rainfall patterns. 40% of the residents in India will not have access to water. Climatic changes, associated with increasing population, urbanization and industrialization have extremely reduced the availability of water in India. Where the surface water is scarce and polluted, the ground water becomes the indispensable resource. Water table is high in the areas with high precipitation, areas with the presence of soft areas and vegetation, proximity to the water-bodies and lesser extraction (Jain Minakshi & Singh IP, 2017). It is estimated that the demand for water will rise by 20-40% in the next 20 years due to demographic changes, modernization and associated changes in lifestyle (NITI Aayog, 2018). It is projected that India's per capita availability of water will be as low as 1140 m3/year by 2050 (MOWR, 2008). Thus, on one hand, the demand for water in the country is likely to rise significantly but on the other hand, the water availability is rapidly declining, thus aggravating the problem. It is estimated that by 2030, world's economic growth scenario of global water requirements would grow from 4500 billion cu.m to 6900 billion cu.m i.e. 40% of current accessible reliable water supply (Miranda L 2011). It is noted that nearly 700 million people in Asia do not have access to safe drinking water and approximately two out of three lack access to water. (Seetharam 2009). India is currently facing a large number of water-related issues and challenges though 50% of the country's climate is dominated by tropical wet - dry and humid sub-tropical climate. Nearly three-fourth of India's population lives in water-stressed regions (where per capita availability is less than 2,000 cubic metres per year) of which one-third of the region is in water scarce areas (where per capita water availability is less than 1,000 cubic metres per year) (IDFC, 2011). The importance of current water research mainly focuses on rapid population growth, infrastructure and investment required in the developing country like India. A number of water conflicts arise due to its complexities in nature of water, the boundaries of conflicting parties in terms of class, caste, community, gender etc. For example; conflict between different users but within the same kind of use. Examples could be the conflict between middleclass localities and slums over drinking and domestic water. Allocation norms have evolved according to local situations, size and nature of the settlement, and historical socio-political relations. To tackle the conflicts over allocation and access there is a need to understand the concept of rights or entitlements to water (Suhas Paranjape and K.J. Joy, 2011). In fact, empirical evidence throughout the world shows that conflicts are already occurring as a result of dissatisfaction among a large group of societies, especially the poor. Urban slums are most disadvantaged and more prone to access issues and remain as water poor (Miranda L 2011). It is because of the lack of legal tenure, norms in quality and quantity, spatial location, affordability, acceptability. The state of urban service delivery in India's cities and towns is far poorer than is desirable for the country's current income levels. Cities with higher per capita income demand better water service infrastructure in terms of water availability, piped water coverage and hours of supply. However, the demand gets articulated in the supply of infrastructure in various ways thereby leading to improving the financial efficiency. (Tiwari P & Gulati M, 2011). Considering that the Indian economy has been one of the fastest growing economies in the world for some time, and aspirations and standards are rising, the present status of service delivery is intolerable. The magnitude of investment required (430 billion) for supplying water in urban areas (HPEC 2011). "As per the Census of India 2011, only 43.5% of the households in India have tap water." It represents slow improvement in access to safe drinking water. Urban slums are the most disadvantaged and more prone to access issues and remain as water poor. This is due to their poor housing conditions, non-availability of adequate water in terms of quantity & quality. It is also due to the geographical location of these places like unapproachable corners, peripheral areas, ditches, gutters, etc (Khosla 2013).

To define water poverty, it is important to understand the concept of poverty in general. An individual is defined to be 'poor on basis of qualitative measures, standard of living, low income, poor health, deprivation towards water access, sanitation, inability to exercise human and political rights. Internationally a person living on less than US$ 1.90 (INR 139.39) per day is termed to be living below the poverty line (BPL) (World bank, 2018). Poverty is affiliated with deprivation, inadequacy, lack of requirements for the human survival and welfare. A worldwide consensus on the basic needs of human survival and dignity which would help in identifying poverty does not exist and therefore the conception of water poverty will be an initiating point to explore the area of water poverty.

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. 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 (Franceys R. 2001). Poverty is usually associated with deprivation, deficiency, lack of needs for human survival and welfare. There is no unanimity on what constitutes basic needs. Some services are more 'basic' than others, as most often it is a matter of political decision (UNITAR & UN-Habitat, 2004). 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. It is observed that for defining water poverty, most frequently, context specific parameters were considered. In order to scale the water deprivation levels, there is lack of strong database system on indicators. Amongst the challenges that the water sector is confronted with, the first is that of the lack of credible "water information," that is, information about water storage, groundwater, water Access levels etc. Access to accurate water information could help one understand the risks and urgency of the situation and steer towards informed decisions. (Himanshu Thakkar, 2019). In view of this, the focus on water has become predominant area of research. The worrying condition on water scarcity describes the critical situation of water problem in the developing countries. According to Ahmed & Kranthi (2018), "the water scarcity in different countries highlighted the reasons such as unsafe drinking water leading to health hazards, ineffective institutional framework that regulates management of water." The issues such as inaccessibility, deficiency in water supply, service coverage and water scarcity conditions are majorly observed in developing countries. There is a need for refining the water assessment methods to reduce the water resource and management conflicts among cities in the developing countries. In order to address this, various national and international agencies have raised their standards to adopt safe drinking water techniques and indices for evaluating the performance levels of water. This is being done by improving the accessibility standards through the provision of individual taps within the premises, geographically extending the services thereby addressing the service coverage issues to reduce severe water scarcity in the cities.

Inequalities in access to public services are a major development challenge at present in the Indian cities (Zerah, 2008). Patrick Heller and Peter Evans have differentiated social inequalities at three levels (Heller & Evans, 2010). Primarily, residualist approach where policy decision makers, multilateral agencies, bilateral agencies considers that inequalities are caused by market failures, bad public policies, and could thus be resolved by a focus on 'good governance', public accountability and managerial efficiency (WB, 2004). This view of residualist is however criticized to depoliticize and adopt a techno-managerial approach to development programmes that does not allow to counter the root causes of poverty and inequalities (Leftwich, 2005). The second approach is "structuralist" view considers that inequalities are created by the neo-liberal capitalist model in the form of penalising the people with the capitalistic policies (Korten, 1995). This approach calls for a global reform of the neo-liberal political economy (Heller & Evans, 2010). In this context, basic services need to be provided by the institutions and when it comes to provisions, inequity issues persists between various income groups. These pave way for social exclusion approach where few get benefitted with the basic services and the remaining depends on alternative sources that leads to neo-liberal approach.

1.2 The Problem Statement

Water, the crucial element of all forms of life, varies spatially and temporally. Managing water resources requires spatially-explicit understandings of this complex system, which can be vulnerable to various factors. "Water scarcity is one of the current focus of research in relation to the growing concerns about the impacts of population growth, water supply, water conflicts, climate change etc." (Salmivaara, 2015). Understanding geographic inequalities in coverage of drinking-water supply will help track progress towards universal coverage of water by identifying marginalized populations, thus helping to control a large number of infectious diseases. Geographical heterogeneity and geographic inequalities, showed consistent findings for all the three indicators (water supply, improved sanitation, open defecation) that have important implications not only for the water supply sector, but also the international public health and development communities, policy makers, and donors etc. (Rachel L. Pullan 2014). With regards to the approaches to undertake realistic assessments, presently, water assessments were conducted focussing on various dimensions of water and its impact on social, economic, environmental dimension is very less. Further, the present assessment methods like service level benchmarks, water scarcity index cannot identify the spatial and temporal issues relates to population, water supply and distribution system. Lastly, conducting studies at macro/city level do not address the local water issues. Multiple dimensions of water scarcity issues have been introduced to identify and measure the various dimensions of water scarcity in recent times. Till now, the focus has been more towards water management rather than quantifying the water availability. An integrated approach that includes various dimensions like social, environmental, economic, political with 'physical measures of water scarcity' has been incorporated and derived water poverty index (WPI) for a community level (Caroline, 2002). WPI is used as an assessment tool across developed countries at country, region, city, and community level in developed countries context. But when it comes to developing countries, WPI is not been used and if it is used it cannot be contextualised at different levels especially when such kind of index needs to be applied at slum level. The WPI may not be useful because of its context specific application at that level. When it comes to India, various assessments and monitoring tools were developed in India to access water situations at city level. For example: Service level benchmarks (SLB) were developed by Ministry of

Urban Development (MoUD) to understand the performance level of the cities and to benchmark the service levels. However, the same indicators may not be scaled down to the section of the community i.e. slums. The same WPI if it is contextualised and modified as per the slums, then Slum specific water poverty index will be most useful. This will help to understand the ground realities of water access in slums. This will enable to identify the priority areas of investment for making positive decisions. The water poverty index as a tool which is recently developed doesn't able to address the issues of water scarcity at slum level and in developing countries context. A separate assessment tool at slum level is required to understand the underlying issues of water supply issues in slum settlements. The above discussion helps in formulation of the problem statement for this research.

> 'Despite the focused attention on water related issues in the past few decades through policy intervention at National and International levels, seemingly water scarcity continues to exist particularly in the context of slums. Hence there is a need to develop an index that will help improve the performance assessment and to address the problem of water scarcity in slum settlements'.

1.3 Need of the study

Water assessments help to understand the ground realities of the water situation of the settlements in developing countries. Considering the urban trends and the persisting water demand and supply gap within the cities, water scarcity issues, inequity issues among various groups in the developing countries will further increase. To address such kind of issues and considering the available resource constraints the water resource needs to be managed properly and the needy needs to be identified on the priority basis so as to provide access to basic services. To identify such issues, SWPI may be the solution that helps to understand and identify the water supply issues in the cities and towns. When it comes to slum settlements, at present, assessments are more unrealistic in understanding the ground realities in slums. Water Poverty Index has always been context specific at country, regional, city, and community levels. Present WPI models lack uniformity in parameters to be used at various scales. Especially when it comes to slum settlements i.e. at local scale which is the most important aspect of any urban settlement the WPI may not be useful. so, there is a need for deriving and modifying the existing WPI model to develop a SWPI model. The scale of the present studies has been concentrated at regional, city, community scales but not for slum level. Huge investments were made by the government authorities to provide better infrastructure for slums Pradhan Mantri Awas Yojana (PMAY), Rajiv Awas Yojana (RAY) are some of those central schemes where this kind of SWPI tool can be utilised to its fullest for catering to the needs of the slum population.

1.4 Research Questions

1. What are the shortcomings of the WPI model in practice that negates their applicability for effective water supply/demand assessments in Slums?
2. How can SWPI improve the performance assessment of water supply/demand in slums and aid in informed decision making?

1.5 Research Aim

To develop a conceptual model for Slum Water Poverty Index.

1.6 Research Objectives

The research aims to understand and analyse the outcomes related to water poverty especially at slum level by using SWPI through literature review, primary surveys, secondary data and focus group consultations to fulfil the following **objectives:**

1. To identify the slum water poverty specific parameters through review of Water Poverty Index models
    a. **Task 1:** Understanding the various existing Water Poverty Index (WPI) models that are being used for identifying the water specific issues.
2. To examine the relevance of water poverty indicators for slums
    a. **Task 1:** Identifying a desirable tool that evaluates water poverty issues at slum level.
3. To analyse the slum water poverty levels in the identified slum settlements.
    a. **Task 1:** To understand and analyse SWPI as a tool that helps in analysing the situation of the settlement
    b. **Task 2:** To analyse the impact of the SWPI for the identified settlements
    c. **Task 3:** To prioritise the critical parameters that affects the settlement
4. To develop a conceptual framework for slum water poverty index
    a. **Task 1:** To develop scenarios for addressing the water poverty problem.

1.7 Scope of the study

The selection criterion for study area is within municipal corporation limits of Vijayawada. All the 111 notified slums as identified by VMC are considered for identifying the critical slums within the municipal limits. The ownership of the slums would be under government. The slums are identified on basis of ward level assessment done at city level. Ward level assessment at city level includes the indicators like percentage of slum population, coverage of water supply network, percentage of household connections. The entire data is mapped on basis of the secondary data obtained from the Vijayawada Municipal Corporation (VMC). The data is restricted to Atal Mission for Rejuvenation and Urban Transformation (AMRUT) scheme a recent urban policy of the government to identify the water deprived areas within the city for infrastructure development. The slums falling within the different locations of the city after overlaying the water supply related data is considered for finalising the slums. The scope of the study includes reviewing the present WPI index models that are developed at different scales. The scope of the study is limited to the indicators like Resources, Access, Capacity, Use, and Environment. The parameters of the research are limited to Water Quantity availability, Sufficiency, Alternative sources, Reliability, Household with access to improved water access, Time spent for water collection, distance travelled to collect water, Expenditure on water, Domestic Water Consumption, Water Quality, HH level water treatment, Water related illness. These parameters are reclassified into five listed indicators. Developing/identifying parameters that are water poverty specific and applicable to slums are considered on basis of Delphi mechanism. To examine the parameters in the identified slums that are finalised as part of the ward wise water assessments. Identifying Slum Water Poverty Index (SWPI) for the slum settlements. The uniform parameters and the indicators/components affecting the SWPI is identified across all the slum settlements.

1.8 Study Utility

The findings would help to analyze the deprivation levels in water access and prioritise the slums for urban development. Management strategies and policy interventions comes as part of the scope of the study.

1.9 Limitations

In spite of the best of efforts to minimise all limitations that might creep in course of the research, there were certain constraints within which the research was completed. The constraints includes in the research was based on secondary as well as primary data. The past three years secondary data has been used while doing the research. The primary data required for research objective No. 3 was collected from the samples based in the identified slums in Vijayawada city. The samples selected from the slums are representative in nature. However, the objective of the survey was to check the water supply situation and the issues faced by the people. Thus, this may not create hindrance in achieving the desired objective.

1.10 Significance of the study

This study will provide an in-depth understanding of the water poverty assessments currently being carried out at various levels. It answers the validity, applicability and reliability of the index at various scales. It also contributes to the deliberations and discussions that are ongoing in relation to the water poverty across the globe to include social, economic, institutional, political dimensions that influence the water situation in the settlement. However, it will help to understand the context specific application of the slum specific WPI at settlement level. This will further help to make reliable water assessments and studies related to water in urban areas. It will further help researchers and academicians, administrators, bureaucrats through policy interventions and strategies and recommendations to take judicious decisions and prioritise investments in the slum settlements as per the need of the local people.

United Nation's, Sustainable Development Goals (SDG's) number six of clean water and sanitation also describes the global goals and national priorities on reliable energy, economic growth, resilient infrastructure, sustainable industrialisation, consumption and production, and food security, are all inextricably linked to a sustainable supply of clean water. It also signifies the importance of improving the water management at community level. Majority of the WPI studies has been carried out for developed nations not for developing nations such as India. The government of Andhra Pradesh in its state water policy focus on key areas of water management like effective use of modern technology, tools and approaches in water resource planning, deriving new tools to improve performance levels and reduce redundancies. A comprehensive policy to ensure judicious utilisation of water as per Jalasiriki Harathi programme of Andhra Pradesh (Government of Andhra Pradesh, 2018). The lack of thorough understanding of calculation methods to derive Water Poverty Index. This research will help to understand the community deprivation levels with respect to water supply and water security issues. It will also provide an interface and enhancing our knowledge on water, poverty, health, slums related issues to address the objectives of sustainable Development Goals (SDGs) at broader level in developing countries.

The expected outcome is conceptual framework/model for understanding the relation between water poverty situation and slums. This will help to contribute for development of a theoretical link between water poverty and slums. It is used to identify the variation in level of service and level of efficiency with respect to slums. It suggests measures for improving and minimizing the severity of the parameters across the settlements. It also supports in making probable policy interventions needed (if any) to improve the efficiency of existing system. The Conceptual model SWPI will also help in assessing the water poverty in slums.

1.11 Research Methodology

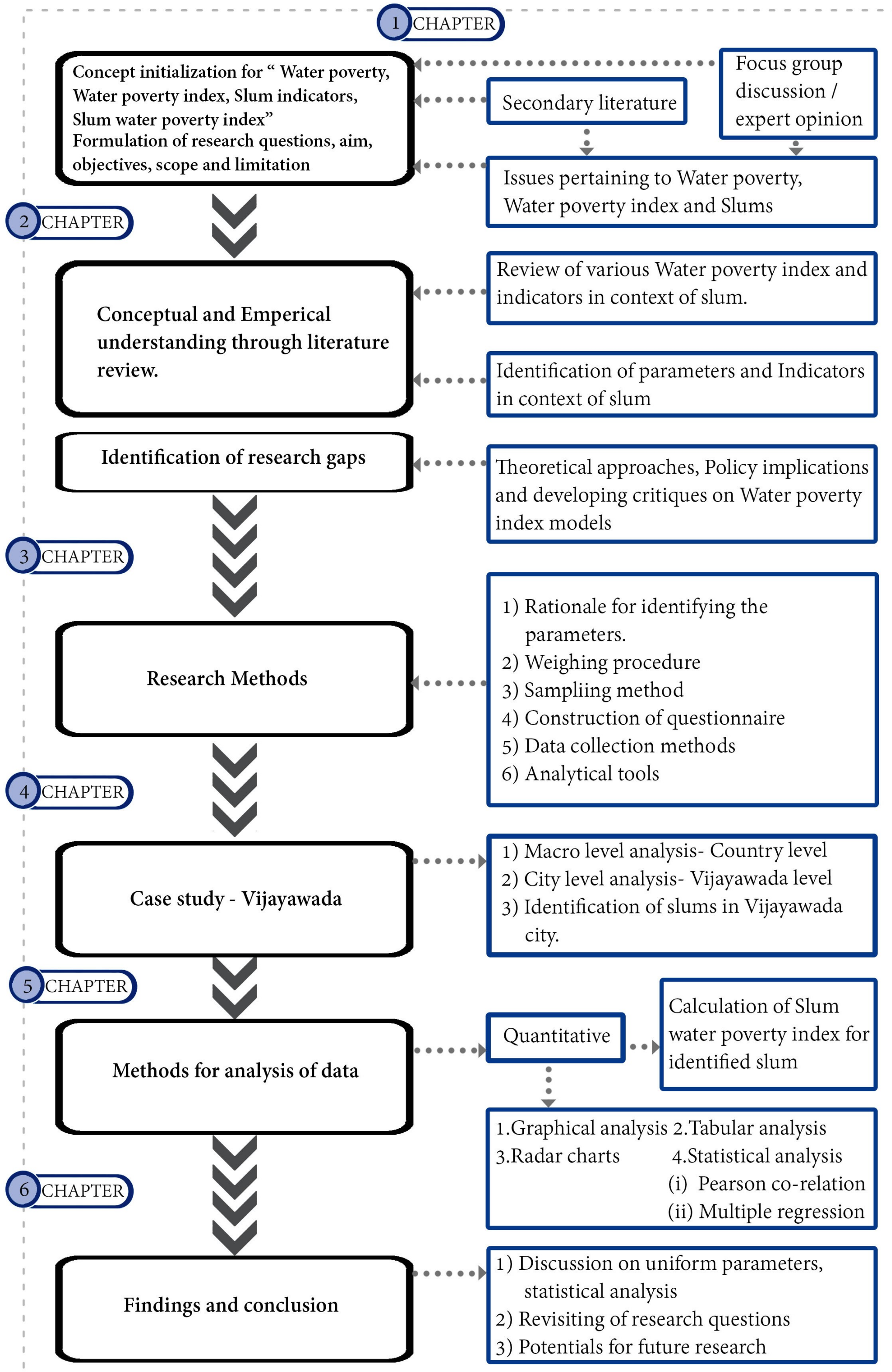
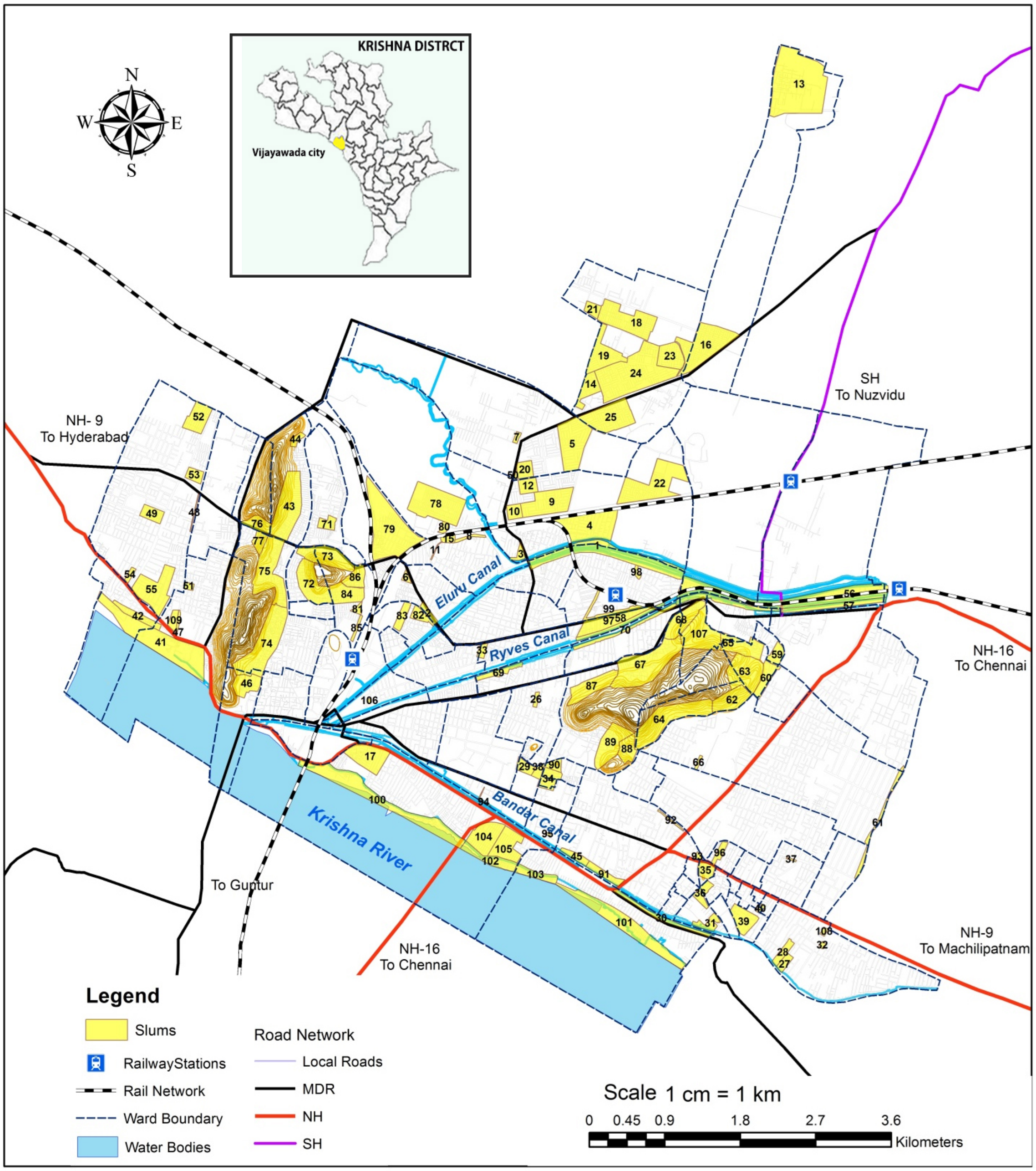


Figure 1.1 Research Methodology

1.12 Study area: Brief Profile

In Andhra Pradesh, Vijayawada is the second largest city located in the Krishna district. It is the commercial capital of Andhra Pradesh. The city is the third most densely populated in the urban population of built-up areas in the world with 31,200 persons per sq.km (Deccan Chronicle, 2016). “The Vijayawada Municipality was first constituted in the year 1888 and it was upgraded as a selection grade Municipality in the year 1960. In the year 1981 it was further upgraded to a Corporation. The city is divided into 59 political wards and an elected body headed by the mayor performs the administration of the corporation. It is a Mandal of Krishna District. The main economic activity of the City Vijayawada is agriculture and commercial. Vijayawada is located at Latitude of 16° 31' North and Longitude of 80° 37' east. It is a major railway junction connecting Northern and Southern India. It is, thirty fourth largest urban agglomerations in the country, consists of Vijayawada Municipal Corporation (VMC), Mangalagiri municipality, 4 panchayats and outgrowths. Vijayawada Municipal Corporation constitutes about 3.91 % of the total urban population of the state. The VMC population as per 2001 census is 8, 45,217 and as per 2011 census is 10,48,000. The present population of Vijayawada is 17,18,880 (India Population, 2019). The growth rate of population from 2011 to 2019 is 64%. The contributors to population growth are mainly the natural increase and the in migration from the surrounding villages and adjoining districts.” (VMC, 2013)



Map 1.1 Vijayawada City with location of slums

Source: Author, 2018

Vijayawada is located in Krishna District in the State of Andhra Pradesh which lies between 16° 31' North latitude and 80° 37' East longitude. It is situated on the northern banks of Krishna River being surrounded by the Indra Keeladri Hills on the west and the Budameru canal on the North. The city is placed as a very important trade and commerce centre especially agricultural production in the region, and it stands second in terms of population in Andhra Pradesh. The city is well connected to other parts of the country. There are two important National Highways (NH5 and NH9) which pass through the city connecting mega cities such as Chennai, Kolkata and Hyderabad. The Vijayawada railway station is one of the busiest railway junctions in the country, and has potential for future growth (RailNews, 2017).

1.13 Thesis Structure

The principle aim of this research is to review and develop the Slum Water Poverty index and its applicability to understand the water poverty issues at slum level. Slum WPI as a tool can be effectively used to conduct water assessment studies at settlement level.

Chapter 2 sets out the defining the terms and terminologies related to water supply scenario across the globe, issues related to water supply, water and poverty context, water poverty, spatial aspects of slum settlements, theoretical and empirical development of water poverty index framework, Usage of WPI to identify water scarcity issues in the settlement through development of water indicators. Relevant theories like residualist, social exclusion, neo-liberal theories were reviewed to understand and interlink the aspects of water poverty and slum settlements. As per first objective, a thorough review of water poverty index is developed understanding its merits and demerits contextualising it at various levels i.e. Country, Regional, City, Local/Community level. The applicability of the index in context to developing country was reviewed especially in the context of slum settlements. The critiques were developed and their inability to assess water supply issues at slum settlement level is reviewed. This establishes a gap for developing new parameters in specific slums. For the second objective, water assessment studies in India were reviewed by authorities, and parameters used under various schemes like RAY, AMRUT were reviewed. Slums and water interface were developed. Issues related to slums and various tools to measure water scarcity were reviewed. The Parameters were developed and was grouped into various components/indicators. These parameters were considered based on scoring method. The finalisation of parameters was done through stakeholder's consultation. Delphi method was used to arrive to context specific parameters within the indicators. The parameters were developed in relation to water and slums. An inclusive approach towards applied development research is considered in present research.

Chapter 3 highlights research methods framework of the study. This research encompasses the application of the Slum Water Poverty Index (SWPI) at the micro scales i.e. at settlement level. An elaboration of SWPI equation is explained followed by methodology, in terms of weights assigned and the components used across were elaborated in this chapter. It also includes collection of data from primary and secondary sources. The primary data includes sample surveys, visual observation of the slums. The secondary data includes data collected from various sources like Government officials, authorities, research reports, NGOs etc. Respondent interviews were also conducted during the primary surveys to understand the issues of the slum settlements. The data is described in detail through a brief discussion followed by practical applications of the tool to undertake water assessment studies. Cochran's formula for sampling method is used to arrive to the number of samples across the identified settlements. Stratified random sampling method is used within the settlements to select number of samples within the settlements.

Chapter 4 focuses this study at macro level; at city level i.e. Vijayawada, to understand the water supply statistics through spatial and temporal analysis. The Vijayawada as a case study was selected on basis of national water stress levels of the country, Census Slum Population abstract, density of population across ten municipal corporations of the country. AMRUT data of the city was taken as a base at a ward level to arrive to the water specific issues of the city at ward level. It includes water distribution network, water coverage, individual tap connections, Slum population at ward level. Post analysis at ward level analysis of slums, a rationale was developed to identify the slums at local level. Each of the core indicators of water poverty in relevance to slums were reviewed and identified, followed by the addition of the identified indicators in the present WPI and developing it to slum specific SWPI at the micro scale i.e. at settlement level. Slums were selected within the city that are spatially varied and are presented in detail in the chapter presenting details of water situation in the slum settlement. The basic profile of the slum settlement with the water situation of the slum is detailed out. The process of data collection carried out in the field within each slum settlement is discussed as part of third objective.

Chapter 5 indicates slum water poverty indicators in different settlements with the application of the SWPI formula for each settlement and presented results. The objective four of the research refers to the SWPI for each of the settlement that was tabulated and presented separately for each settlement. Graphical analysis, tabular analysis was done at slum settlement level. The comprehensive tabulated data for the all settlements is also tabulated to identify the uniform parameters across all the settlements. Indicator wise analysis was also conducted through radar chart analysis for identifying the uniform indicators across the identified settlements. Statistical analysis like Pearson co-relation and multiple regression analysis is conducted to understand the cause and effect, dependent variables for the identified settlements to identify the high coefficient variables that impacts the settlement in the form of discussions.

Lastly, Chapter 6 summarises the research findings and conclusion in the form of the outcomes of the analysis whilst presenting key recommendations and suggestions. A way forward for future potential areas of research is provided as final conclusions.

CHAPTER 2: THEORETICAL FRAMEWORK OF WATER POVERTY

This chapter reviews the terms and terminologies related to water scarcity levels across globe, country and water poverty situation in future ahead. It also gives an overall view of defining slum settlements across country and their definitions, spatial aspects of slums, geographical and territorial aspects of slums. It also outlines the theoretical and conceptual aspects of water and poverty, Water Poverty Index, review of water poverty index models. A critique of these models is developed to summarise the existing models of WPI and identify the gaps so as to make context specific parameters at slum settlement level so as to have its relevance in understanding the issues related to water supply. This chapter also sought to provide a precise and clear theoretical framework within which the present research is undertaken. It has demonstrated some of the failings of traditional measures of water scarcity paving the way for an alternative approach. Describing with the inception of concept of water poverty and the WPI through a historical lens and presenting evidence from case studies, which have sought to advance the WPI and in specific to slums moulding it to SWPI will provide the reader with the theoretical and practical knowledge of water poverty essential to understand this research.

2.1 Introduction

In the recent decades, urbanisation is proved as a significant reality in India. Presently, India with a population of 377.16 million (Census 2011), constitutes 7,933 cities and towns of different classes which makes India the second largest populated country in the world. 11 per cent of the World's urban population resides in India. The United Nations, Department of Economic and Social Affairs in 2015 has estimated that this will further increase to 13 per cent by 2030. Further, it has projected that the increase in the demographic trends will takes place in urban areas by adding 165 million to the present urban population. Currently, over fifty per cent of the world's population resides in urban areas and by the end of this century; seven out of ten people will migrate to urban areas. This process of urbanisation will add more and more population into cities and towns and at the same time there will be a drastic growth/proliferation in informal settlements generally known as slums. In India, approximately 13.7 million households i.e. 17.4% of the urban households live in slums that proportionate to over 200 million people. Out of this, 66.7 million of the India's slum population resides in 46 million-plus cities (Census of India 2011).

The urban population growth in the cities are posed to different challenge in terms of high densities, transient population, different institutional issues related to legislations, laws and legal status of slum dwellers, poor infrastructure (Water supply, sewers, roads, paving) poor quality housing. Public service provision in today's Indian cities suffers from a combination of discriminative administrative processes and political mediation. Through a rational 'inverse cross-category risk' (Jonathan Wolff; Avner De-Shalit 2007), the population of non-notified slums clearly and sensibly interferes with its political independence to assure its security and access to public services. The urban local bodies' inability to formally provide basic services to the non-notified population propagates the conditions for water trading and uneven power relations. (Swann Bommier 2014). In developing countries, urban population is growing rapidly and most of this added population is living in unplanned urban settlements often referred as shanty towns or slums.

2.2 Slums and Squatter Settlements

Census of India (2001) defines a slum as 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 a slum is not however universal. In 2001, about 23.5 per cent of the urban households were living in slums, which significantly reduced to 17 per cent in 2011. However, the absolute number of households living in slums has increased from 10.15 million in 2001 to 13.75 million in 2011. The mega cities of Greater Mumbai, Delhi NCR and Kolkata house about 42 to 55 per cent of their population in slums, whereas the proportion of slum dwellers and urban poor in the million-plus cities is around 35 per cent (India Habitat III 2016).

2.2.1 Understanding Slum

"Slum, in simple way is stated as a heavily populated urban area characterized by poor housing and squalor" (Amaral 1994). It summarizes the basic characteristics of the slums that includes sprawling densities and poor quality of infrastructure, and 'squalor'. The criteria include physical, spatial, social and behavioural aspects. The spatial nature of slums includes size, vulnerable condition, jurisdiction or spatial aggregation.

2.2.2 Territorial and spatial forms - Location of slums

Broadly, the slums are categorised based on their geographical location. It constitutes inner city slums, squatter, informal settlements and sub-divisions/layouts etc. Inner-city slums were formed when most of the central, prosperous residential areas of the cities underwent deteriorating conditions and there was a residential shift to the new residential areas. Government of India under Rajiv Awas Yojana (RAY) has developed Slum estates that refer to public housing which is constructed for specific use. For example Chawls in India, when the mills were closed, the people underwent social problems raised from pressured conditions by making them vulnerable to safety and security in terms of livelihood, access to basic services etc. Squatter settlements are formed without any legal permission from the owner of the land. However, most of these are found on vacant lands, across river banks, canals, railway lines etc. The spatial location, size, condition etc. not only decides the features of their residents, but also their social and political intervention. Illegal settlements denote, the unauthorised land developments or illegal sub-divisions in the plots within the city (Agnihotri 1994).

Scattered slum islands are 'islands of slums', bounded by formal housing on approved land uses. These are the parcels of land that are designated as open or green spaces in master plans, for its unsuitable nature, or spatial locations that are environmentally hazardous in nature. However, slums are often physically isolated from or within the urban areas through obstacles such as rivers, storm drains, railway tracks etc. However, the urban facilities and opportunities may not actually be able to benefit them. "Peripheral Slums on the city fringes are squatter settlements that occupy land that has been subdivided and for which they have paid or entered a rent purchase arrangement with the developer or landowner" (UN-Habitat 2003).

2.3 Geographical Assessment of Slum

Any urban area or region comprises of man-made and natural aspects. The interpretation of interrelationship between the natural and man-made factors depends on the analysis of different observations in the area. However, the factors like altitude (maximum and minimum height from mean sea level), slope (Birajdar R T 2015). Though human settlements occupy relatively a small portion of earth's surface area, their specific spatial location plays can still influence environmental and socio-economic consequences. This will lead to two kinds of issues: the decreasing density of cities and the significance of urban growth in different types of ecosystems (Martine 2011). Spatial objectives refer to the aspects of the geographic objectives that are explicitly spatial, implicitly spatial or non-spatial. An objective is explicitly spatial when it relates to how a settlement location scores in the evaluation process (Francesco Riccioli 2016).

Spatial location refers to a place on map physical located; using geospatial coordinates such as latitude and longitude and spatial coverage refers to data observations made that were the subject of experiments or observations (ANDS, 2008). Location of the slum is a variable that helps to analyse the development of slums. Various factors like city centre and availability of marginal land may be important factors for slum dwellers. Therefore, slum location represents both spatial pattern and process of physical change of slums over a period of time (Agnihotri 1994). Hence, slum area or informal settlement is defined as an area that embraces, to various levels that includes physical characteristics like diverse spatial features; dilapidated housing condition; high building density; irregular and poor circulation pattern; poor infrastructure; no open space; prone to hazardous locations (Niebergall, 2008).

Slums are categorised based on their geographical location In India and as per census 2011, the following is the breakup of different slum settlements spatially distributed across states and cities.

Table 2.1 Distribution of location wise settlements across different states

States/UTs	Along Nallah	Along Railway Line	River bank	River Bed	Others
Andhra Pradesh	13%	7%	19%	6%	54%
Delhi	21%	4%	0%	0%	75%
Gujarat	6%	0%	3%	0%	91%
Karnataka	44%	13%	0%	0%	43%
Madhya Pradesh	61%	1%	18%	0%	21%
Maharashtra	13%	12%	5%	1%	69%

Orissa	1%	18%	48%	0%	33%
Tamil Nadu	33%	0%	15%	1%	51%
Uttar Pradesh	90%	0%	1%	0%	10%
West Bengal	13%	18%	0%	0%	69%
INDIA	**22%**	**10%**	**8%**	**2%**	**59%**
Average of Cities	29%	7%	11%	1%	52%
Vijayawada	17%	11%	0%	8%	72% (Highways 45% & Hills 19%)

Source: Census of India, 2011

The above table represents that 48% of the slums lies across natural sources (Nallah, river bank, canal etc) and the remaining 52% lies across man made sources (railway line, National Highways etc). Hence it is inferred that the spatial location and physical aspects of slums plays a vital role in understanding the characteristics of the slum.

The research finds that it is the proximity that confirms the cohesion and harmony networks among the slum households (Restropo et.al. 2008). The area occupied by slum dwellers has a high commercial value that creates confusion state for the government to tackle them. These settlements often have a very high pitch population density because of the nearness to the centres of economic activities as well as employment opportunities, well-established urban infrastructure, which are often is located in the city centre. As the proximity increases from the centre limits, access to infrastructure, city-based facilities slow down the settling into the slums. In general, the spatial characteristics of certain slums may have particular similarities; however, it is impossible to identify two slums with the same physical and spatial layout. The spatial location of the settlement has an immediate reflection on the physical and spatial structure of the settlement and to certain extent on different risk situation (Rosa 2012). The spatial representation and changing aspects of slums acts as an innovative tool to understand the development and spatial growth, pattern within slums (Debraj R 2014).

Moreno research reveals that new techniques should be evolved to identify slums and associate them with specific geographic locations. However, urban and slum specific indicators together can help to understand the levels of deprivation and the dynamics of city growth and slum formation to make decisions for improving the quality of life of slum dwellers and make cities more inclusive (Moreno 2011).

Urban areas are spatially segregated. Therefore, spatial data is required to identify the future urban scenario. In general, it is difficult to understand the likely implication of growth of settlements at one particular location with respect to climate change, if one does not know the spatial location of urban settlements and what kind of spatial and demographic changes it has. Therefore, a spatial framework is required to address the effects of spatial changes of urban areas in environment context of the settlements (Balk 2011). Risk/vulnerability assessments needs to be undertaken specific to geographical location to identify disadvantaged people or settlements that are at risk and activities that may pose particular risks. The outcome of these will be in the form of spatial framework that will help to analyse the kind of impact in relevance to climate change. (Satterthwaite, 2011).

In recent times, gravity models have been proved effective to deal and solve location-based problems. In this spatial interaction between two urban areas is directly proportional to their socio-economic intensities and inversely proportional to the distance between them (Carrothers 2008). The factors that contribute for the development and expansion of slums are rapid rural-to-urban migration, regulatory framework, and inequality among the various user groups, population growth and globalisation. Most of the migrated population from rural to urban areas are forced to occupy illegitimate settlements on vacant/marginal lands at the peripheral areas of the city, along railways and riversides, or on other hazardous areas that is not suitable for human habitation which leads to proliferation of slums (UN Habitat 2003). Slums are the by-products of poverty and inequality. However, all urban poor do not accommodate in slums, nor are all residents of slum are always poor. They are formed due to lack strong institutional support, improper regulatory framework, poor governance, impassive financial systems and lack of political support. Human Settlement means cluster of dwellings of any type or size where human beings live. The process of settlement inherently involves grouping of people and apportion of territory as their resource base. There are various factors and conditions responsible for having different types of settlements in India. These include: (i) physical features – nature of terrain, altitude, climate and availability of water (ii) cultural and ethnic factors – social structure, caste and religion (iii) security factors – defence against thefts and robberies. Settlements in India can broadly be put into four types: Clustered, agglomerated or nucleated, Semi-clustered or fragmented, Hamleted, and Dispersed or isolated (NCERT, 2016)

2.4 Global Water Scenario

Water is considered as lifeline for planet and for the people. It is basic to the well-being of human kind and an extremely important need for the healthy functioning of all the world's communities (UNDP 2004). Approximately, 17% of the world's population i.e. over one billion people live in India. With a population of over a billion people, India is home to 17% of the world's population. This heterogeneity has made a huge division between rich and poor and one fourth of the total population of the country live in poverty (WaterAid, 2014). It is estimated that by 2030 our economic growth scenario of present global water requirements would grow from 4500 billion cu.m to 6900 billion cu.m i.e. 40% current accessible reliable water supply. (Miranda L 2011). It is noted that nearly 700 million people in Asia do not have access to safe drinking water and approximately 2 out of 3 lack access to water (Seetharam 2009). In fact, empirical evidence shows that throughout the world, conflicts are already occurring as a result of dissatisfaction among large group of societies, especially the poor. Over and above all, urban slums are most disadvantaged and more prone to access issues and remain as water poor. It is estimated that by 2025, one third of the developing population will live in basins where the water deficit is larger than 50%. (Liliana Miranda 2011). It is because of lack of legal tenure, norms in quality and quantity, spatial location, affordability. In order, to provide policy makers with a pulse check of this performance, indicators need to be established which measures the efficiency levels such as access to clean drinking water, duration, dependency on taps etc. The water foot print has also reduced by 50% from 1, 80,000 Cu.ft of water per person in 1947 has got down to 90,000 Cu.ft in 2001(Kishore Thapa, 2009).

2.4.1 Status of Water situation in India

The estimated world population living in chronic water shortage by 2025 is approximately 3.5 billion and 1.1 billion people will be prone to water scarcity in developing countries that does not have access to safe drinking water. Investment estimated by various reports for provision of water supply facility is $1/m^3 and for treatment $1.3/m^3 for waste water management. The water sector basically relies on state subsidies, capital grants supplemented by loans to develop new water sector infrastructure. The sector faces three challenges on water front namely water availability due to losses, access to all users, water quality (Kavita et.al, 2014).

2.5 Urban Poverty and Water Poverty Interface

To publicize the ability of the developing world's urban areas for growth, various challenges are hindering their economic potential and their capacity to provide a healthy living environment for their inhabitants must be logically understood and addressed. These include a huge demand for decent affordable housing, especially for the poor; the appalling housing conditions and the horrific physical environment in which many of the urban poor live, work, and raise their children; lack of a clean and adequate water supply; underinvestment in providing infrastructure for laying pipelines, addressing physical leakages; deteriorating natural environments; negative impacts of global climate change; and social instability — all of which reduce the efficiency with which developing cities function. (International Housing Coalition,2009).

2.5.1 Water and Poverty

Poverty at its most extreme threatens human survival. But for people living in poverty, it is a multi-dimensional experience that encompasses a range of factors including, but not limited to, survival. UNDP's Human Poverty Index is a composite of indicators of basic dimensions of deprivation: a short life (measured by the percentage of people expected to die before 40), lack of basic education (measured by literacy rates), and lack of access to public and private resources (measured by access to health services and clean water and percentage of malnourished children under five). These definitions generally encompass with people living under poverty generally lack: income, household and productive assets, entitlements, social connections and support networks, personal security (including increased exposure to violence), and empowerment to participate in the political process and in decisions that influence one's life. Environment is central to poor people's sense of well-being, empowerment and control over their own lives. When looking at the relationship between people living in poverty and water poverty, three dimensions of poverty stand out: health, livelihoods and vulnerability.

a. **Health:** The poor people disproportionately get affected by contaminated water and poor sanitation services, setting up a cycle of ill-health and further deteriorate severe financial and personal costs.
b. **Livelihood systems** are rooted in the natural world and depend upon ecosystem health. Lack of a safe, adequate water supply and contamination of common property resources like lakes, rivers and coastal areas directly translate into less food, income and time for the poor. Common property resources provide a significant share of food and household income for the poorest families.
c. **Vulnerability** is a critical dimension of poverty. Poor people are particularly at risk from environmental shocks and crises. The increasingly frequent and severe natural disasters brought on climate change (cyclones, hurricanes, foods, landslides, droughts) as well as changes in rainfall patterns, shifting agricultural zones, and rising sea level impacts in developing countries and the poor who live there disproportionately. They are also more vulnerable to market failures with regard to water pricing. Not only do they more often go without, but they also pay more for the little water they use. As most of the people purchase their water in small containers, the urban poor commonly pay four to ten times more per litre than the metered rates of their wealthier neighbours. (UNDP 2004)

2.5.2 Water Poverty

In the recent times, there is an increase in understanding that water is strongly related to poverty. It is assumed that water has a positive effect on socio-economic development (Jemmali H, M S Matoussi 2012). Feitelson and Chenoweth (2002) 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 about the accessibility to safe water. It also indicates that the water poverty is based on the availability, affordability, and quality of drinking water. As per the definition by Sullivan (2002), water poverty is described as a lack of adequate and efficient water supply that links physical estimates of water availability with socio-economic variables. This definition covers the quantitative aspects of resource availability and affordability of water. It however stresses on the sufficiency and efficiency levels but fails to understand the environmental aspects of the water poverty. Further, Lawrence, et al (2003), defined water poor in two different ways:(i) those who lack access to water or have insufficient water availability to meet their basic needs, and (ii) 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,J (2002) describes 'water poor' in terms of physical access, income and in 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. Water poverty is not only related to the specific user group but also involves the community, based on their socio-economic, physical/environmental and institutional/ political dimensions.

Most frequently, the access to water depends on the entitlement provided by the concerned authorities. Firstly, Urban water poverty is 'deficiency of entitlement' (A. Sen 1999). Urban water poverty is not related to technical or management capabilities but it also involves social and political aspects. According to Savenije (2000) water poverty is a new concept that provides a new dimension, to clarify the neglected connection between water availability and socio-economic dimensions. This definition highlights the intricate link between the water poverty and socio-economic dimensions. It highlights the income levels of the settlement only but not addresses other critical aspects such as water sufficiency, water efficiency, and quantity aspects.

Salameh (2000) defined water poverty as insufficiency of existing water resources for domestic use, food production, which 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. Also, it depends on the link between demand and availability. As per Allen A (2011), 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 (Chenoweth, 2008, p5). Besides, a number of other terms such as water crowding and water stress are also used to describe the water related issues. In 1989, 'water crowding' was first defined as a measure of how many people shared the same flow unit of water placing a clear emphasis on the social demands of water rather than physical stress (Falkenmark and Rockstrom, 2004). Crystal Fenwick (2010) defined 'water stress as the number of people sustaining on Unit flow of freshwater. 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). To sum up, water poverty embraces variety of situations. It is related to the poor population who cannot afford and access sufficient water to meet their basic needs. After a review of the multiple dimensions of water poverty, key parameters considered for defining water poverty and related words such as shortage, scarcity, deprivation, stress, etc. are listed in the table below:

Table 2.2 Water Poverty Definitions –Key Parameters

S.No.	Definition by	Year	Key parameters of the definition
1	Sen A	1999	Exclusion, Discrimination, Deficiency of entitlements
2	Savenije	2000	Neglected connection, Water availability, Socio-economic dimensions
3	Salameh	2000	Inefficiency of existing water resources, High Water demand, and water usage type (domestic, irrigation, etc.)
4	Caroline Sullivan	2002	Lack of adequate and efficient water supply
5	Meigh J	2002	Lack of physical access, Insufficiency of water, Non-affordability
6	Feitelson & Chenoweth	2002	Non-affordability for clean water, Non - availability for all people at all times
7	Lawrence	2003	Lack of access to water, Insufficient water availability

8	Chenoweth	2008	Number of people supported by each flow unit
9	Fenwick C	2010	Limited Technological capabilities, Limited Managerial capabilities
10	Allen A	2011	Resource availability, Concerned with political, social, economic and institutional dimensions

All the definitions review majorly focusing on issues related to water availability, water access, water affordability, social exclusion, etc. They include aspects related to resource availability or insufficient availability of water for basic purposes under water availability. Access is measured through distance travel to reach source of water and get it to its destination or time spend for the same. Affordability is discussed in specific to the income levels. Lastly, usage of the other parameters like water demand, technical capabilities, and management capabilities of water for various purposes is also discussed to define water poverty. From the above table, usage of more frequently used parameters, moderately used parameters, least used parameters to define water poverty. However, through this it is concluded that there is no a particular method to define or measure deprivation levels of water poverty.

2.6 Theoretical framework – From Development theory to practice

Shue's argument for the basic right to subsistence employs two central concepts, moral right and basic right. Any right that is fundamental to having all other rights is termed as basic right (Payne 2008). As per United Kingdom's Social Exclusion Unit, "The condition of social exclusion occurs when the people suffers from a combination of linked problems such as unemployment, poor skills, low income, poor housing, high crime environments, and bad health" (Blair A 1998). It refers to areas with different population groups from social exclusion that never have acceptable living conditions. Therefore, in developing nations, social exclusion has to be measured from the view point of considering what would be a basic standard of living (Camara 1990). There are two characteristic features of the concept. Firstly, it emphasizes multidimensional nature of inequality i.e., it includes different causes of inequality and incorporates the dimensions of society where exclusion arises; and secondly it is a multidimensional concept, which claims to provide a means of focusing on the active processes that give rise to inequality (Arthurson 2002). Power (2000) further argues that "Social exclusion is about the inability of our society to keep all groups and individuals within reach of what we expect as a society. It is about the tendency to push vulnerable and difficult individuals into the least popular places, furthest away from our common aspirations. It means that some people feel excluded from the mainstream, as though they do not belong" (Power A 2000).

Even though, the concepts of deprivation, social exclusion and poverty and are closely related, they are not synonyms. Poverty can be defined as a static and one-dimensional outcome, while social exclusion as a dynamic and multidimensional in nature (Robin P 2001). The concept of poverty primarily focuses upon distributional issues, the concept of social exclusion focuses primarily on relational issues, in the sense of inadequate social participation (Room 1995). According to Sen (1998) unlike poverty, *social exclusion is better defined in the space of capabilities rather than the space of commodities and is a state or process leading to deprivation*. In this, measurement of social exclusion moves the analysis in areas such as unemployment, lack of access to healthcare, lack of education opportunities, absence of social safety nets, credit market exclusion, lack of facilities for disabled persons, marketing limitations etc (A. Sen 1998).

As per Sen's (2002) Distributive Justice Theory, each society has its own socio-economic and political frameworks. These frameworks are in general instrumental in the distributions of different benefits and burdens across the society. The theory also emphasises on the fact that the above frameworks are a result of various political processes related to human society. Besides, they constantly determine the intra and inter society aspects over time. The frameworks are significant as the distributions of benefits and burdens resulting from them, primarily affect people's lives. (Julian L, 2017). As per William Stanley Jevons (2002), neoclassical economist believe that a consumer's primary concern is to maximize personal satisfaction, and that everyone makes decisions based on fully informed evaluations of utility. This theory coincides with the idea of Rational Behaviour theory, which states that people act rationally when making economic decisions.

The Neo Classical theory states that an organization is the combination of both the formal and informal forms of organization, which is ignored by the classical organizational theory. The informal structure of the organization formed due to the social interactions between the workers that affects and gets affected by the formal structure of the organization. Usually, the conflicts between the organizational and individual interest exist, thus the need to integrate these arises. The Neo Classical theory asserts that an individual is diversely motivated and wants to fulfil certain needs. The theory of Neoclassical economics is based on the premise that market forces of demand and supply are driven by customers, who intends to maximize his or her own satisfaction by choosing amongst the best available alternatives (E. Roy Weintraub, 2002).

As an assumption of neoclassical theory, In Rational Agents, An Individual selects product and services rationally, keeping in mind the usefulness thereof. To further this, human beings make choices that give them the best possible satisfaction, advantage, and outcome. When it comes to Market Equilibrium, it is achieved only when individuals and the company has achieved their respective goals. The competition within an economy leads to efficient allocation of resources, which in turn helps in achieving market equilibrium between supply and demand. (Valentini Laura, 2012) Capability approach concern itself with the distribution of resources alone, because resources have no value in themselves disconnected from their promotion of human functioning, i.e., what humans actually do and are. The capability approach asks social planners to inquire into the needs individuals have for resources and their diverse abilities to convert resources into functioning. The capabilities are classified based on Life, health, Senses, Emotions, Practical reason, Affiliation, Other species, Play, Control over one's environment. This ten forms the basis for the quality of life (Jan Garrett, 2008).

This research discusses critically the relevant aspects of Distributive justice, social exclusion, capability approach, human rights approach, neo-classical economic theoretical approach. The Sen's approach of Distributive Justice basically focuses on non-judicious, inequitable distribution of resources among the various sections of the community. The current research of water poverty deals with the dimensions of social, political and environmental aspect of the Water and the deprived communities. It also deals with the slum specific settlements wherein the certain sections of the community deprived of the resources irrespective of caste, creed, gender, income levels of the community. However, when it comes to identification of indicators in the research, the various indicators of water poverty like Resources, Access, Use, Capacity and

Environment falls under different categories of the above mentioned philosophies. It is evident that, water itself is considered as fundamental right as per the Constitution of India interpreted in Article 21 and is defined as social asset. Indicators like capacity is taken into consideration as the rights have thresholds limits and once it surpasses the demand/supply gap persists. This persistence can be seen as part of paying monetary benefits to the organization for the provision of goods and services. In context of SWPI, it is that the insufficiencies of water resources leads to increase in dependency of alternative sources like bottled water or tankers etc. wherein the expenditure gets reflected. However, within the literature, poverty is viewed as one of the most pervasive causes of social disadvantage. Poverty precludes people from having an acceptable standard of living, and denies them with access to essential goods and services (Madanipour A 1998). Social exclusion surfaces due to poverty. However, language and cultural barriers, locational disadvantage or discrimination arising out of disability of any kind can also play a part as well (UK Social Inclusion Unit 1997).

This research supports a multi-dimensional approach to the assessment of water poverty and using the SWPI as a tool contributing to the body of knowledge in the form of research that attempts to assess water poverty at slum level. Contrary to other desktop studies, that were concerned more towards WPI's ability to inform wider management policy, the research aims to address the reliability of results by testing the WPI at slum settlement level and analysing its robustness and assessing its ability to accurately reflect local perceptions of water poverty in slum settlement. The research comes under the domain of applied development research at local level, this study attempts to consider the disregarded needs of the people residing in the slums, who would not have benefit of doubt from a simple assessment tool designed to accurately define the water poor. This research therefore focuses solely on the determination of water poor communities or in the words of Gine & Perez Fouget (2008), the state of water poverty. However, this research does not significantly influence theories of development, but it is appropriate to briefly consider the specific notions of development theory that have informed the decision-making process of this work and the broader methodological framework arising from that theory.

There are two things to understand in the entire development research framework. One the approaching development through the lens of modernization following the residualistic approach, predominantly driven by western ideals that got failed and second the development theories are often too complicated and is difficult to communicate in a meaningful way. Considering the complexity of the theory, the following section attempts to describe a chronology of development theory, focusing on current trends in alternative development theory that aspire to shift the development discussion from theory to practice. Historically, conventional development theories, encircling traditional ideologies like neo-liberalism, have struggled to devise a universal approach to address the problems in third world countries often seek to impose a westernized solution on what we now recognize as unique, diverse and complex localized problems. The prominent failings of modernization theories remarks that they "have tended to ignore the irregularities of different countries and cultures seeking to find an existence within the international capitalist system of the world" (Nabudere 1997, p.203). These development theories, instead of meeting the needs of the people, they respond to the needs of policy makers and foreign interests.

As per Brohman (1996, p.325), there is a long history of "discipline centrism" in which "development process being artificially diluted and classified to fit the areas of specialization, research methods, and theoretical frameworks of individual disciplines."

This is observed especially in engineering disciplines, which historically, commonly required to alter western modernization without due consideration whether the local communities or local environments will able to cope up and sustain modern systems or not, both in terms of capacity and resources. Various approaches related to development were researched during 1980s and 1990s like beyond development, reflexive development, development alternatives which signifies that the alternative development theory has shifted its focus from economic centric approach to people centric approaches. The gap between theory and practice is commonly accepted as one of development's most historically difficult struggles. Theory is often too obscure and too complex for those on the ground, yet practice often fails to inform theory because of its localized context and initial lack of theoretical grounding. (Bebbington 2000). Brohman believes "that interdisciplinary approach to development have yet to gain much respectability in an intellectual environment which tends to favour more 'scientific' and 'rigorous' research in disciplinary specializations" (Brohman, 1996). This research also aims to adopt a reflexive and interdisciplinary approach to data collection at the settlement level (slum) that recognizes traditions of the natural and social sciences, their respective roles in development.

In an attempt to respond to all of these dimensions, this research necessarily adopted a reflexive and participatory approach to the assessment of water poverty at the slum scale in Vijayawada, while employing mainly empirical/quantitative methods to its assessment at the micro scale. It is important to have the understanding of alternative development theory and this chapter has sought to highlight the thrust for its development and the main theories supporting a new approach to development research. A sound argument for adopting a reflexive and participatory approach has also been presented as well as a discussion of some of the more common pitfalls associated with this genre of research.

2.7 Conceptual and Theoretical Understanding of Water Poverty

Predicting water poverty continues to be a challenging task, as it is often marred by subjectivity, scale and the magnitude of the problem. Most of the definitions indicate that in reality, there is an apparent imbalance between the availability of water and population. It may be noted that different parameters or dimensions were considered in different definitions for water poverty. Due to these varied parameters, understanding water poverty remains to be a complex task. All definitions are context specific focusing on issues related to water availability, water access, water affordability, social exclusion. It includes the aspects related to resource availability or insufficient availability of water for basic purposes under water availability. Access is measured through distance travel to get water and time spent to get water. Lastly, affordability is discussed in specific to the income levels. However, usage of the other parameters like water demand, technical capabilities, and management capabilities of water for various purposes is also discussed to define water poverty. Quantification and qualification of parameters to define water poverty becomes difficult as some parameters are measurable and some are not measurable. Existing definitions do not provide clarity on the intensity and nature of water poverty and cannot be used to measure the deprivation levels. There is no uniformity and consistency observed in defining the specific condition of water poverty. Therefore, it will be difficult to understand the gaps in the existing situation and measure the water poverty levels of the community**.** Another research suggested that the household water poverty is linked with quality, quantity, access, reliability, affordability, equity that helps in monitoring the water service delivery (Subbaraman R 2015).

With the above reviews, it is observed that the definition of water poverty covers only specific dimensions in water service delivery. The dimensions include social-economic, Physical-environmental, institutional-political. A context specific definition needs to evolve to understand and measure the water poverty levels at household, community, regional, national, international levels etc. However, it is mentioned that the 'water poor' are not only the poor people but may include people who can afford and still not have access to water. Spatial aspects of the water poverty are not included as most of the settlements are in the remote areas due their ecological fragility unsuitable locations. Therefore, a need is felt to develop a theoretical framework categorizing the parameters for a holistic understanding of water poverty. This framework can act as a base or a platform for coining new terms or new definitions on water poverty.

2.7.1 Theoretical understanding of Water Poverty

Water poverty refers to the varied conditions where individuals are not being 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. To define water poverty, it is required to understand the concept of poverty in general (Franceys R 2001). Poverty as a definition is associated with deprivation, deficiency, lack of the needs and requirements for the human survival and welfare. There is no unanimity on what exactly basic needs are. Therefore, the conception of water poverty will be an initiating point to explore the area of "water poverty". Most of the research conducted on water poverty is restricted to understand the basic norms and standards, coverage, access at household level i.e. minimum amount of water needed by a person to satisfy his day to day activities.

Technology as an indicator provides information about the improved water supply and available facilities. But the technology as an indicator is restricted to water coverage aspect. It does not provide information about the quantity supplied, the quality of water supplied or usage of water. These explain that the water poverty is strongly associated with deprivation, deficiency, lack of the needs and requirements for the human survival and welfare. Hence, they are dependent more on available local circumstances. So the concept of need is difficult to define and understand. Water demand and needs differs as per spatial location of the settlement.

These definitions provide incomplete and partial view of water poverty. Only comparisons can be made to scale up uniformity at different levels. But, conceptually the quality or standard of living of a person or household has different dimensions which involve different aspects of direct and indirect non-consumption activities and services (Sen A.K 1987). To sum up, water poverty embraces variety of situations. It is related to the poor population who cannot afford to get sufficient water in terms of acceptable quantity and quality or who cannot able to access the water supply to meet their basic needs. This segment of population is either uncovered with the municipal services due to their income or deprived of the access due to the spatial aspects of the settlement. However, this user group satisfies their needs from alternative operators and sources of water. This not only affects poor people, but also people with insufficient or unsafe access to water in terms of quality and quantity.

Overall, it is perceived that water poverty is not only related to qualitative and quantitative aspects but also depends on the satisfactory levels of the citizens with their water needs. As the level of dissatisfaction of the people increases, it is possible to measure the levels of water poverty in that settlement. The levels of water poverty vary depending on socio-economic structure of the households. According to local situations, the severity of water access from formal and informal water providers varies. The congregation of local circumstances in water access from water service providers exhibits different levels of water poverty. It is assumed that the people's behaviour towards availability of water varies according to geographical location (Angueletou 2007). It is evident that settlements are subjective to a large extent by water accessibility, topography, and transportation vicinity. Therefore, it is observed that the spatial locations of human settlements are unevenly distributed across various spatial scales. These spatial patterns can be analysed through an in-depth analysis of land use changes, ecological processes, cultures and lifestyles, etc. (Carrion-Flores and Irwin 2004). At a local level, site and situation specific geographical factors need to be understood to critically influence human settlement patterns (Jiyuan Liu 2005).

As per Weber R 2016, it is observed that socio-economics and spatial pattern plays a vital role in formulation of services and amenities. He has suggested that research should be carried out through incorporating socio-economic data and/or in-depth knowledge about geographical context (Ryan Weber 2016). Measures related to Place-based and people-based accessibility aspects to be considered on lines of social equity for provision of urban services in the physical, offline world. (Tijs Neutens, Tim Schwanen, Frank Witlox, Philippe De Maeyer 2010)

Theories of residential differentiation began with the Chicago School of the 1930s, which saw city growth as a colonization of different 'quarters' by different income and ethnic groups. Their successors, the neo-liberal urban economists, regarded slums as the natural response of the market in providing housing for poor people: the housing that they can afford. Poor people needed to live at high densities in poor quality dwellings in order to afford housing accessible to income earning opportunities. A number of other reasons have also been suggested as to why poor people are segregated in space: regulation; public spending; and separation of work places for the rich and poor. Post-modern theories of urban spaces are seen to be more appropriate to the multi-centred and fragmented cities of the 21st century. Many cities are now divided by different occupation groups: the very rich; the affluent professionals, the suburban middle class; the unskilled workers; the informal workers; and the residual or marginalized ‘underclasses. Each has a clear part of the city to them, supported by housing and distribution networks, but overlaying each other rather than necessarily confined to clear ‘quarters’.

Water as known to all is major source of growth or development. With time this abundant resource turned to be scarce for some unlucky men. Due to active involvement of industrial era and development along the globe, there has been huge misuse of water. This haphazard development led to climate change along the planet and also population growth in many countries. Apart from that this development made way for many other issues in the developing or as to state in “urban areas” i.e. slums. With the growing need of water, in developed and developing countries, the source and the quantity remains same. This leads to phenomena like water shortage, water scarcity etc. Water Poverty Index is a new holistic water management tool that is mainly relevant at local level. It can be used to determine priorities for action and to monitor progress towards targets. Sullivan, first proposed the Water Poverty Index (WPI) as an integrated approach to water poverty that "*link[s] physical estimates of water* *availability with socio-economic variables*." It states, "the intention of developing WPI is to help the process of identifying those areas and communities where water is most needed, enabling a more equitable distribution of water to be achieved".

2.8 Water Poverty Index

Indicators are usually presented in the form of an index derived from a range of available data. The resulting measure enables a judgement of performance relative to previous time periods, or to the performance of others. The purpose of the Water Poverty Index is to express an interdisciplinary measure which links household welfare with water availability and indicates the degree to which water scarcity impacts on human populations. The primary focus of the index is on poor people, who suffer most from inadequate access to water. It is combination of physical, social, economic and environmental information associated with water scarcity (Lawrence, et.al., 2003). The idea behind the development of the indices was to identify the outcomes by combining water availability with access and to identify the people's capacity or affordability to purchase water. Similar to human development index (education, life expectancy, GDP per capita at purchasing power parity) represents the socio-economic progress of a country or region, human poverty index represents the country's performance. It acts a mechanism to prioritize water needs; it acts as a tool for monitoring progress in water sector (Charlesvan 2010). Based on the HDI, WPI has been designed considering five principal components and by using max-min approach to calculate each indicator.

The approach has conducted to the definition of Water Poverty Index (WPI) by Sullivan (2002). The 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 is the water poverty index value for a particular location, X_i refers to component i of the WPI structure for that location, w_i is the weight applied to that component. Each component is made up of a number of subcomponents, and these are first combined using the same technique in order to obtain the components. For the components listed above, equation can be re-written as:

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

It is the weighted average of the five components Resources (R), Access (A), Capacity (C), Use (U), and Environment (E). 'w' is the weighting factor for each component. Each of the components is first standardised so that it falls in the range of 0 to 100; thus, the resulting WPI value is also 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.

Weighing of Components:

Some literature has been reviewed to determine the significance of weighting applied to indicators to provide a common baseline for comparative purposes. Furthermore, the appropriateness and indeed accuracy of representing qualitative data empirically may be questionable. Theoretically, WPI has the ability to compare performance across localities, but variables are very location specific. It is unclear how potential different variables are which consequently would affect the indicators. The authors have stated it would not be appropriate to determine one indicator of water scarcity as more important than another and all variables and indicators within the current model are weighted equally. However, the totalizing scoring system masks indicator scores essentially producing misleading results in terms of overall water poverty. Each indicator and the variables that comprise it are weighted equally. As each indicator is comprised of a different number of variables this may result in an unintentional imbalance. Furthermore, it could be argued that an equal weighting homogenizes problems of water poverty on a global scale that are unlikely to be balanced in reality. Criticising this aspect of the WPI, Feitelson & Chenoweth, (2002, p.268) write: "using a collective expert judgment to determine the weightings of a multi-dimensional index results in an index that is subject to the value judgments of cultural biases of those who created it, while arbitrarily adopting an equal weighting for all components of an index is a de facto weighting in itself that is no less problematic" (emphasis added). however, problems arise when one variable is highly correlated with a variable from another indicator. The problem of weighting has been raised numerous times. Although equal weightings already provide for a transparent process, transparency would be increased further enabling a more direct comparison of results, or at the very least, would render the decision of whether or not a particular variable is comparable possible. Developing weightings based on community perceptions of water poverty is a viable solution to both of these problems. However, community perception is relative and liable to be site specific thus its inclusion in any calculation might compromise the ability to compare (absolute) water poverty across sites with any scientific certainty.

In weighted composite indices, the choice of weights is aimed to reflect the relative importance given to the variables comprising the index. For example, in the WPI, greater weight would be placed beside the components which are considered to be more significant in the water poverty context. Different methods have been developed to determine weights that includes data-dependent statistical tools, judgment-based expert opinions etc. A conventional practice is the selection of weights through consultation with experts. However, this is a relatively subjective method of weighting, and it is often singled out for its arbitrariness (Booysen 2002). Alternatively, multivariate techniques like principal component analysis and factor analysis present an empirical and more objective option for weight assignment. This technique has the advantage to determine that set of weights which explain the largest variation in the original variables (Slottje 1991). In contrast, weighting only intervenes to correct and overlap information of two or more correlated indicators, and it is not a measure of theoretical importance of the associated indicator (Nardo et al. 2005). Therefore, statistical weights do not always reflect the priorities of decision makers (Esty et al. 2005) and since they are data specific, formulations have to be updated when more data become available (Lohani and Todino 1984). No weighting system is therefore above criticized. Furthermore, it is for this reason that equal weighting is often employed. Main argument for equal indicator weights is based on the premise that no objective mechanism exists to assess the relative importance of the different aspects included in the index structure. In any case, it has been noted that after experimenting with a variety of weighting systems, resulting indices remain fairly well correlated (Booysen 2002). In terms of index interpretation nonetheless, it is of primary importance to provide an adequate justification for the particular weighting system adopted.

Slums as defined by Census of India 2001 "residential areas where dwellings are unfit for human habitation by reasons of dilapidation, overcrowding, faulty arrangement, and design of such buildings, narrow or faulty arrangement of street, lack of ventilation. Light or sanitation facilities or combination of these factors which are detrimental to the safety and health". These places are more struck due to lack of resources or basic need for living. In world, one in eight people live in slums. In total, around a billion people live in slum conditions today (Slumalmanac 2016). This not only amounts to a rather unacceptable contemporary reality but to one whose numbers are continuously swelling. In spite of great progress in improving slums and preventing their formation– represented by a decrease from 39 per cent to 30 percent of urban population living in slums in developing countries between 2000 and 2014 – absolute numbers continue to grow and the slum challenge remains a critical factor for the persistence of poverty in the world, Approximately, 964 million people globally live in urban slums. Inadequate access to water is one characteristic that helps to define a "slum," based on the United Nations (UN) definition. Water Poverty Index (WPI) usually carried out at a macro level. And also, the indicator is limited to that scale and has to be contextualized for assessing the water poverty situation at different scales, hence not workable at a micro or slum level.

Slum Water Poverty Index deals with these indicators. With proper rationale, this index incorporates factors related to micro level, for better understanding and analysis at local level. Parameters being the same as taken from the readings (i.e. resource, use, capacity, access and environment), indicators here involved are relevant at micro level (slum for this case). This study is an attempt to form a conceptual framework for creating a Water Poverty Index for Slums or Slum Water Poverty Index.

Slums are (as stated above) majorly deprived of basic services- water being one of them- within an urban area. These settlements house majority of workmen (skilled and unskilled). Regarding water, slums lack any organised form of water distribution system. Slums come up in places which usually lack in basic infrastructure for settlements. Inhabitants are mostly depended on either public taps (in case of notified slums) or derive water from surface water resources in proximity. This in return affects their social as well as economic aspects. Women and men spent their major amount of time in collection of water, which bring down their working capacity (UN 2015). Untreated water from a source have its impact on the health and also expenditure for the same comes in parallel. Also, Water Poverty Index (WPI) has been done for macro level like city or state, its implications and indicators differ to that of micro level study like slums and neighbourhood. The indicators used for such a study has to be scale specific such as rainfall been one of the indicators to understand WPI is not useful when it comes to micro level study such as slums. Slums have mainly been study for the quality of water to examine the health criteria. Quantitative studies are not taken in account in most of the cases. The given study takes quality as well as quantity for slums to examine their WPI. By developing these indicators and structure for examining Slum Water Poverty Index will help in measurement or assessment of slums, hence, to priorities the development for the same.

In India, slums are notified, recognized or identified, by the government. Notified slums have the land tenure and they are entitled to have the basic services including water supply connections. But majority of the slum settlements in India are non-notified. People living in these non-notified slums suffer from issues like access to basic services like water supply and sanitation. (Subbaraman R 2015) Improper access to water supply services may lead to various other issues like conflict over water access, exploitation by private water suppliers, health diseases because of using bad quality water. Lack of access to clean water causes diarrhoeal illness in children (Subbaraman and Murthy 2015) it comes under the duties of the urban local bodies to provide the basic facilities also to the slum settlements, but it is not widely followed. Service delivery issues in the slum area is a major concern.

Extensive work has already been done on water poverty, but very few of them focus on the neighbourhood level that too on slum level. Based on our literature study, slum specific parameters of water poverty were evolved and the model used by sullivan was taken as a basis to understand the water poverty levels of the settlement. The indicators and parameters of the WPI model like resource, access, capacity, use and environment are used to understand the nature of issues of water in the slum settlement.

Table 2.3 Existing water poverty studies and their research gaps

S.no.	Research	Merits/Demerits	Learnings
1	Integrated assessment of water stress and scarcity linking physical estimates of water availability with socio-economic variables of poverty (Sullivan C 2002)	1. Developed at community level 2. Conventional composite indices approach using Water availability, Access to safe water, time taken to collect domestic water 3. Gap analysis approach by assessing community and ecosystem health 4. Two-dimensional matrix approach using availability & access and capacity & use.	1. Locally generated information about household welfare and water stress at the household / community level can form the core of WPI 2. No common and universal parameters for water poverty were defined and developed.
2	Development and uses of the Water Poverty Index to measure water stress at the household and community levels (Meigh, et.al, 2003)	1. Developed at city scale. 2. Parameters at city level were established in context to city level through household surveys 3. The parameters are realistic and can be measurable to city context. 4. It cannot be contextualised to the next scale of city. 5. Weighted composite index method is used. 6. Equal weights for all the components are given so as to ease the method of calculation. 7. Tried to link between the water poverty indicators and the five-capital theory.	1. Stakeholders consultation to prioritize the parameters. 2. Differential weights for the different indicators are not used. 3. Understanding the complexity of water issues, by integrating the physical, social, economic and environmental aspects and by linking water issues to poverty 4. Weightages of the indicators were not clarified, rather it was left on the basis of local data availability and the local conditions.
3	WPI proposes an appropriate holistic tool to both monitor sector progress and to prioritize resources allocation and can help to understand water and poverty linkages at regional scale (Garriga R & Augusti P 2009)	1. Developed at regional level. 2. The Indicators and parameters of water poverty proposed by Sullivan was considered that are very broad and cannot be contextualised at other scale. 3. Categorised under three basic parameters i.e. Pressure, State & Response.	1. Aspects related to sustainability of water schemes should be included in all five components of the index 2. There is a need to develop a holistic index which is non scale-dependent.
4	Finding out the most appropriate scale to understand the community vulnerability of water scarcity and water supply and improve knowledge about water-health-	1. Applicable at city and community level. 2. Mix of regional, city and community level parameters. 3. Applicable only for developed countries not for developing countries. 4. Statistical methods apart from radar analysis are used. Correlation was found between access and capacity is observed, at macro scale resource was considered as insignificant. 5. Used equal weights for all components	1. Correlation and regression analysis, Problem of weighting of components has been highlighted. 2. less number of parameters will give accurate results. 3. Method of weighting the components was not final. 4. Problem of scale of study was present and independent common parameters could be suggested.

S.no.	Research	Merits/Demerits	Learnings
	poverty issues (Crystal F 2010)		
5	Quantifying the difference in the water poverty index when calculated with the additive function compared to the multiplicative function (Charles van der Vyver, 2013)	1. Applicable at regional scale 2. Unrealistic parameters like seasonal variations, ability of managing water, amount of water used and extracted for domestic, agricultural and industrial use, Environmental impact of water management ensuring long term ecological sustainability were quantified.	1. Additive function (weighted composite index) method and multiplicative function (root index method) 2. Multiplicative function produced lower values of water poverty compared to the additive function. 3. No clear idea given about weighting the components 4. Problem of scale was persistent

Summary

The above existing water poverty models were reviewed in order to understand its applicability, merits and demerits for analysing the problems of water scarcity at various levels. All the existing models were scaled and contextualised at various levels. Understanding the complexity of water issues, by integrating the physical, social, economic and environmental aspects and by linking water issues to poverty. The existing WPI model is prepared at country level, regional level, city level, community level, neighbourhood level. Slum level studies is not been carried out in any of the study. Since, the WPI is context specific to the scale, slum specific water poverty index will help to analyse the water situation in the slums. All the models were universalised across five common indicators i.e. Resource, Access, Capacity, Use, and Environment. But the sub-parameters within the components were contextualised as per the scale.

No common parameters were found across the studies conducted at different levels. Stakeholders' consultations were conducted in each of the study to prioritise the parameters that are to be scaled down to that level. Household level information is being used as a basis to arrive to the situation of identifying the criticality of the water poverty situation of the settlement in the research studies. Weighting method is applied for the indicators used in the study. Critiques were also developed for using and applying equal weightages as well as the different weightages for the various research studies. Additive weighted composite method is applied in most of the research studies. Statistical methods are employed to understand the interrelation between various indicators. It is also suggested that less number of parameters will lead to more accurate results.

2.8.1 Review of Literature of Water Poverty Index (WPI)

The WPI is based on five components: resources, access, capacity, use and environment as argued (Lawrence et al., 2002). It can be used then through its individual figure or in the form of its components as an interdisciplinary and monitoring tool that expresses precisely the water situation in various areas. (Sullivan 2002), suggested that the WPI is applicable at a range of scales. It has since been applied at international scale (Lawrence et al., 2002) and community scale (Caroline 2006) and discussed in several papers about its applicability at various scales. According to Sullivan (Sullivan 2002) the WPI as described by its authors "was developed as a holistic tool to measure water stress at the household and community levels, designed to aid national decision makers, at community and central government level, as well as donor agencies, to determine priority needs for interventions in the water sector". To do this, the WPI "combines data on local water resources, access, use, social and economic capacity, and water-related environmental quality allowing agencies to monitor progress in water provision at the community level" (ibid.). The authors suggest these data could then be "aggregated to provide countries and international agencies with a much more accurate performance indicator to guide policy"

Charles van der Vyer "Water Poverty Index Calculation: Additive or Multiplicative Function?" (Charles 2013) in his research has defined each indicator of WPI. The indicator added for analysing the water poverty index are Resources that considers the availability of water, taking into account the variations in seasonal and inter-annual fluctuations and water quality. Access includes accessibility of water for human use taking into account the distance to a safe source and the time needed to collect the water for household and other needs including the irrigation of crops and for industrial use. The indicator Capacity includes the ability to effectively manage water. The indicators Use focus on the actual amount of water being used and extracted from the system. it also includes consumption of water for domestic, agricultural and industrial use. The environment aspect captures the environmental impact of water management with the intention to ensure long-term ecological integrity. "Environmental factors which are likely to impact on regulation will affect capacity".

A composite index approach is used to calculate the WPI (J. Cullis 2004). Each of the five components consists of a number of sub-components and a weighting can be applied to each component to indicate the component's importance. The components are standardised to fall in the range 0 to 100, resulting in a final WPI value between 0 and 100. The highest value, 100 is taken as the best situation with 0 being the worst. The purpose of the weightings is to emphasise a specific component of the WPI structure, and the importance of any component should not be predetermined by researchers as it is clearly a political decision.

However, likewise different authors have used different parameters to define water poverty for example, Richard and Augusti's Improved Method to calculate a Water Poverty Index at Local Scale discusses about the parameters in different way. Resource component measures availability of water resources using three different variables: water quantity sufficiency which considers if resource availability is enough to cover human or livestock demand; reliability of supply meaning period of time system is not operational and seasonal resource variability. Access component measures whether or not people have access to improved water and sanitation. Besides percentage of population accessing basic services, a set of related indicators were measured- (i) time spent in water collection that includes queuing time (II) cost of water (20 litres container) (III) operational status of the supply. Capacity index tries to capture those socio economic variables which can impact on abilities that communities should have to properly manage water resources. Indicators taken into account were thus related to the ability of water entities to oversee operation and management of the supply. Use component captures how the people make of water both in terms of hygienic practices and the treatment before the final consumption of the water. Environment component covers a number of indictors which not only cover water quality and stress, but also variables which are likely to impact on ecological integrity.

As per readings as mentioned above, there were some major issues that needs to be taken into consideration in order to develop a better understanding for Water Poverty Index (WPI). As the research limits itself to study Slum Water Poverty Index. The below discussed indicators describe about why they should be included in the research.

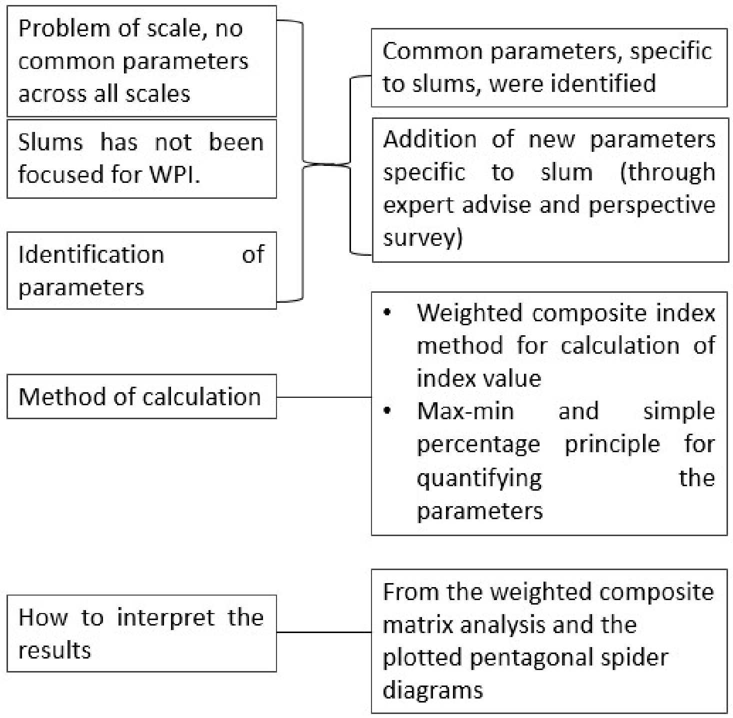


Figure 2.1 Key Learning from Literature Study

Comprehensive water management index is established by Government of India as a database decision making tool for water measurement, management and improvement at a state level. It seeks to enable data –backed water management in the country and promote 'competitive, cooperative federalism. It consists of broad indicators that are measured at state level. The indicators include Source augmentation and restoration of water bodies, ground water, Major and minor irrigation (Supply side management), Watershed development, Participatory irrigation practices, sustainable on-farm water use practice, Rural Drinking water, Urban water supply and sanitation, Policy and Governance(NITI Ayog, 2018). As per all the studies or readings carried out for the research, highlights the points, that very few of the studies were conducted at micro level i.e. community level or neighbourhood level. Major studies concerned were been undertaken at national, regional, state or district level. The indicators, thus differ when the study was conducted at a micro level instead of macro level. The scale of study has a major implication on the parameters focusing on the water poverty issues. For example, when studying about regions, Water Poverty Index for regional level indicators like rainfall, seasonal variation has a major impact on the Water resource availability. But, studying the same indicators for a smaller area such as a neighbourhood, rainfall does not play an important role in deciding the water resource availability. The below described indicators reflects their use and importance in deriving better understanding for the micro level studies.

After review of various research studies relevant to water poverty, the following observations were made:

Water Source has not been given preference as one of the major parameters to be considered as part of a resource component. Water source answers various questions related to quantity of water, availability of water, quality of water and others. Also, it helps to know the environmental condition of the area as such. For example, if the source of water for a community is ground water and that too in sufficient amount, it reflects that the ground water availability and quality of water for the area is in better condition for the settlement. In contrast to that, if the water is derived from Government connection (i.e. piped water system), then the quality is water is well treated by the authorities. Also, the issues of seasonal variability with respect to quantity and quality in many cases are resolved by this system. As urban local bodies will pump, filter and treat water before sending to the communities in the city.

Maintenance of the Source goes parallel with the source of water. Discussed in the readings are about the reliability of the water resources, but none concerned about the maintenance of the source. As maintenance of the source has its direct implications on the hygienic or qualitative aspect of water been used. For example, if a community receives water through piped water system, which is not well maintained i.e. any leakage in the pipe line, corroded water pipe etc. it affects the quality of water been supplied to the crowd depending on that particular source. In such cases, both the loss of water in case of quantity and also loss in health scenario of the community becomes a major concern. It also impacts the affordability and health related expenses related to water. The same scenario prevails for any surface water sources and ground water sources (Crystal F 2010).

Frequency of water supply or water collection is an indicator to judge the quantity of water when supplied through or fetched by. Maximum research been done on regional level hardly focuses on this indicator, discussed about the reliability of water source that involves time not operational during a day. But working on micro level such as slum, frequency of water collection i.e. how many times a week or months they get water describes the time and energy (expenditure) invested for the above mentioned. For example, If a house collects water three times a week, they have to collect water for the remaining four days of the week which means more expenditure on the assets to collect water (such as buckets, tanks etc.). Also, if the time duration of the water supply is less, then for the household it requires time investment by majority of the family member. That brings to the next indicator that deals with the social aspect of Water Poverty Index (Garigga 2009).

Loss of Working Hours, due to water collection, for the working population, the household investment of time in collecting water reflects their economic contributions. Loss of Working Hours, due to water collection decrease the dependency and working capacity of the people in community. Investing their working hours to collect water will reduce their income generation (labour class). Health being the important in social standards is not been a part of these study. Here, health aspects reflect the expenditure on health due to water illness for the livelihood (WHO 2006).

Alternative source: In the absence of piped water supply in slums, people are forced to improvise to meet their daily needs. Water in slums, in large part, comes from four sources: groundwater, local surface water, vendors, or illegal connections to nearby municipal water mains. Though vendors selling water from carts or water trucks in bottles and small tanks/drums are filling a critical gap in municipal service delivery, vended water is considered an unimproved source of water (UNDP 2006).

2.9 Spatial aspects of Slum

2.9.1 Altitude

Though human settlements occupy relatively small portion of earth's surface area, their specific spatial location can still influence environmental and socio-economic consequences. This will lead to two kinds of issues: the decreasing density of cities and the significance of urban growth in different types of ecosystems (Martine, 2011). Spatial objectives refer to the aspects of the geographic objectives that are explicitly spatial, implicitly spatial or non-spatial. An objective is explicitly spatial when it relates to how a particular settlement location scores in the evaluation process (Riccioli F, 2016).

2.9.2 Natural Water Source

It is estimated that more than 300 million people in developing countries are prone to the risk of disasters like floods, cyclones, landslides etc. and majority of them resides in slums. Because, most of these slum dwellers live in disaster-prone areas such as river banks, railway tracks, across hills, under bridges etc. This unplanned settlements and poor circulation pattern make people to rescue in the event of disasters (G L Ooi, 2009).

Slums can be categorised in specific to site and location. Typically, they are located in the areas such as along river banks, hill slopes, vacant lands, along railway tracks, near industrial areas, commercial areas, near canals etc. that are unfit for human habitation. Slums encroach on any vacant or marginal lands that include ecologically fragile and unsuitable areas. These settlements will be prone to various kinds of disasters like landslides, fire accidents, flash floods that cause environmental pollution and health risks (Garr, 1996).

The spatial location of slums in ecological sensitive areas i.e. hazardous or polluted locations, inadequate access to safe water and sanitation, the lack of land tenure, and poor housing conditions make people prone to health risks like diarrhoea, cholera, water borne diseases are the problems affecting slum dwellers (Amnesty International, 2009). Deprivation towards these amenities has direct impact on psychological and physical well-being of the poor population that leads to homelessness and social exclusion (Elliott D Sclar, 2005). Further, the monetary conditions of the slum residents condense them inept to access health facilities. According to UN Habitat, (2010b) 10 per cent of the slum dwellers in the world will be added and this continue to grow annually further increasing the problem. The problem of sprawling of slums further continues as the cities expand in forth coming years (UN Habitat, 2010b). Lack of basic amenities and facilities for slum dwellers exposed to various kinds of issues related to health (M Alberti, 2000). Although studies regarding the same indicators has been carried out in multidimensional measurement of household water poverty in a Mumbai Slum: Looking beyond water quality by Ramnath Subbaraman, Laura Nolan, Kiran Sawant, Shrutika Shitole, Tejal Shitole, Mahesh Nanarkar, Anita Patil-Deshmukh, David E. Bloom (L. N.-D. Ramnath Subbaraman 2015). But the statistical or methodological works are not clearly described. A comparative review of the existing water poverty studies has been given in

Table 2.3. Some of the parameters used in our study have been taken from the perception survey done on the existing water supply conditions in slums in Vijayawada. In most of the existing water poverty studies many parameters have been used whose quantification method was not clear. So, in some of the cases some methods of quantification method have been used by the author based on threshold values, variation etc, all of which have relevance to some well accepted indexing method. The highlighted parameters in the table 2.4 represent the uniform parameters that were used across various studies. The parameters that were not highlighted were been contextualised to that specific scale. The parameters taken from existing water poverty studies are identified by the researcher along with their quantification methods have been given in Table 2.5.

Table 2.4 Comparative literature study of the existing Water Poverty Index models

Components	C.A. Sullivan, J.R. Meigh,P. Lawrence etc. (2003)	Crystal Fenwick (2010)	Charles Van Der Vyver (2013)	Ricard Gine Garriga & Agusti Perez Foguet (2009)
Resource	1. **Surface & ground water availability** 2. **Reliability** 3. **Water quality**	I. **Water availability**, 2. **Reliability** 3. Rainfall variability	1. **Water availability** 2. Seasonal variability 3. **Water quality**	1. **Water quantity sufficiency** 2. **Reliability** 3. Seasonal variation.
Access	1. **Percentage of HH having piped water supply** 2. Report of conflict over water 3. Percentage of water carried by women	1. **Piped water access** 2. **Time required to collect water** 3. Conflict over water sources	1. Distance to the source 2. Time needed to collect water	1. **Access to safe water** 2. **One-way distance to water source** 3. **Waiting time** 4. **Cost of water** 5. Operational status of

	4. **Time spend for water collection.**			water source
Capacity	1. **Wealth proxied by ownership** 2. **Income** 3. Under-five mortality rate 4.Educational Level	1.Primary school completion rate 2.Ratio of female to male primary school completion rate **3. Income** **4.Water related illness**	Ability to effectively manage water	1.Management system 2.Ownership over water source 3.Facilities managed by legal registered associations 4. Water entities with financial control & water entities whose funds are regularly audited
Use	1.**Domestic water consumption rate** 2.Agricultural, livestock and industrial water use	**Domestic consumption** and livestock consumption	**Domestic**, agricultural & industrial water use	1.**Domestic water consumption** 2.**Local level (HH level) treatment of water**
Environment	1.People's use of natural resources 2.Crop loss 3.Soil erosion	1. Quantitative and qualitative measure of **water quality** 2. Change in soil fertility 3. Change in tree cover	Environmental impact of water management to ensure long term ecological integrity	1.Water quality 2 Protection of water sources 3.Number of pollution sources around the water point 4.Number of environmental impacts around water point

Table 2.5 Parameter Identification in relevance of Slums

S.no.	Indicator	Parameter	Method of Quantification
1	**Resource**	Water quantity availability	Adopted from Candi T. Hosein research on WPI
		Sufficiency	Standard water demand of 135 lpcd as per Indian standard conditions; Minimum water requirement of 135 lpcd as per **IS 1172: 1993**
		Alternative Sources	Rajiv Awas Yojana (Identified by author)
		Reliability	Adopted from WPI study done by Garriga & Perez.
2	**Access**	Households with access to improved water access	Adopted from Fenwick (2010)
		Time spent for water collection	30 minutes round trip as per World Health Organisation, 2016
		Distance travelled to collect water	1000 m to & fro distance specified by WHO; but 500 m has been taken as per the concept of walkability. Adopted from Charles van der Vyver (2013)
3	**Capacity**	Expenditure spent on water	5% specified in UN-Water Decade Programme on Advocacy and Communication and Water

			Supply and Sanitation Collaborative Council Adopted from Candi T. Hosein research on WPI (2015)
4	**Use**	Domestic Water Consumption	Consideration by the author (variability in water consumption) Adopted from Sullivan (2003)
5	**Environment**	Water Quality	Acceptable TDS limit of 300 mg/lit has been taken as per the Indian Standards
		HH level water treatment	% of sample households surveyed giving response that HH level water treatment is practised w.r.t the total sample surveyed households
		Water related illness	% of sample households surveyed that they suffer from water related diseases with respect to the total sample surveyed households

2.10 Chapter Conclusion

All of the aforementioned problems were particularly evident in this research. This chapter has sought to provide a clear and concise theoretical framework within which this research is situated. It has demonstrated some of the failings of the traditional measures of water scarcity paving the way for an alternative approach. Describing the inception of water poverty and the WPI through a historical lens and presenting evidence from case studies, which have sought to advance the WPI should provide the reader with the theoretical and practical knowledge of water poverty essential for understanding this research. Apart from understanding the concept of Water poverty indicators, a brief review of existing water poverty models is studied, critiques were developed to identify the issues in terms of scale, context, parameters used. Comprehensive list of water specific parameters in relevance to the slums are identified. The next chapter focuses on quantification of each parameter within the component, identification of parameters based on Delphi method to prioritize component wise parameters for further study. It also discusses about the sampling method, details of each component/Indicator and parameters, calculation and evaluation mechanism, weights assigned for each component. The chapter gets concluded with deriving the formula for SWPI.

CHAPTER 3: RESEARCH METHODS

This chapter's methodology is about how the parameters are developed from the identified literature. The questionnaire construction, sampling method, planning tools and techniques, analytical tools and techniques used in the research process are discussed in the present chapter. It also elaborates on the Delphi approach used to prioritise various parameters out of the total list of parameters identified in the research. A brief description of the method used and scoring applied to prioritise the parameters is detailed out. It also gives the brief description of the calculation method of each parameter used in the various components/indicators for SWPI. The rationale behind each parameter is listed out to have clarity on the parameters. It also discusses about the application of weights for each component so as to apply and calculate the final values of SWPI for each settlement. It also elaborates on the construction of questionnaire, sampling method, planning tools, analytical tools and techniques. The chapter is concluded with the formula that enables to identify the Slum water situation of the settlement.

Water as known to all is a major source of growth or development. With time this abundant resource has become scarce resource across the world. Due to active involvement of industrial era and development along the globe, there has been huge misuse of water. This haphazard development led to climatic changes along the planet and also population growth in many countries. Apart from that, this development made way for many other issues in the developing or as to state in "urban areas" i.e. **slums.** With the growing need of water, in developed and developing countries, the source and the quantity remains same. This leads to phenomena like water shortage, water scarcity etc. To relook on these aspects, the various approaches followed in developing countries are reviewed for understanding the prevailing water scarce issues across globe. The countries like India, Bangladesh, Sri Lanka, Myanmar were chosen for reviewing the water supply system.

India: This scenario of water shortage is no different in a country like India, which is one of the fastest growing economies of the world. The current state of urban service delivery in India is simply unacceptable. As per the Census of India 2011, only 43.5% households in India have tap water connection. However, the problem is more acute in slums. In Indian cities, there is seemingly a huge gap between demand and supply of potable water. In order to reduce this, performance indicators of water supply need to be established. This in turn can help in measuring the efficiency levels for providing access to safe drinking water (Biswas, 2009).

Bangladesh: The rate of urbanization in Bangladesh is one of the highest in Asia with more than one third (35.6%) of the country's total population (164.8 million) already living in urbanized areas. Of 58.6million people living in urban areas, seven million live in slums which lack access to sources of clean drinking water, thus making it a challenge in urban areas (UNICEF Bangladesh, 2017). The WHO estimates that a staggering 60% of the population has to endure unsafe drinking water (Hedrick S, 2017). In Dhaka, only 18% of the daily water requirements are sourced from sources of water on the surface, while the remaining is abstracted from ground water which has resulted in the water table sinking by more than 50 meters since independence. Increasing levels of arsenic in the water along with wastes from industrial development polluting surface water, is further reducing the available amount of water for human consumption. Water shortages have reached such dire levels that the government had to deploy troops to guard water pumps following angry protests in 2010 (Wadud M, 2017). Improving the situation would thus require the management of the excess water in the rainy season along with higher investment, improved revenue collection, structural reforms and the establishment of a regulatory body to oversee the same (Haq A K, 2006).

Sri Lanka: Around 1.3% of land area is under water. Ground water a major resource used the by country's 21.27 million inhabitants to fulfill their water needs. Fewer than 40% of the country's populations have organized water supply facilities and about 60% of the population. This includes the 10% that depend on unprotected sources of water use wells, tube wells, streams and rivers etc., as their primary source of water. Although the country should be 90% self-sufficient in its water requirements, 47% face scarcity of water. The main reason for this water shortage in the country is the trade in Virtual water (Gunatilaka, 2008). Increasing salinity levels in water bodies close to the coast, contamination of the surface sources due to improper disposal of waste and excessive extraction of ground water are some of the threats to water security in Sri Lanka (Herath, 2011). Water management methods that aim at artificially recharging ground water such as rainfall harvesting needs to be explored to face sever water shortages in the future (Gunatilaka, 2008).

Myanmar: In Myanmar, 82.3% of the total population and 93.2% of the population living in urban areas have access to an improved source of drinking water (UNICEF Myanmar, 2011). It exemplifies how water security underpins all security. Poverty and lack of access to resources are particularly critical issues for the civilian population of Myanmar. According to the United Nations Development Program, almost a one-third of Myanmar's population lives below the poverty level, primarily in rural areas. These same communities suffer from unsafe drinking water. Responsible water management and overall resilience to vulnerabilities are required to meet the processes of urbanization, economic growth and progress with prudence (Mai Mizuno, 2016).

It is at a crucial juncture where its increasing population and developing economy are looking progressively towards water resources in order to support growth. After reviewing the water scenarios of developing countries, it is understood that water availability, sufficiency levels, access issues are uniform across the globe. To have a judicious distribution of water resources, a quantitative mechanism needs to be developed for having a check on the water resources.

Water Poverty Index is a new holistic water management tool that is mainly relevant at community level. It can be used to determine priorities for action and to monitor progress towards targets. Sullivan, first proposed the WPI as an integrated approach to water poverty (where water poverty is defined as a lack of adequate and efficient water supplies) that "*link[s] physical estimates of water availability with socioeconomic variables*." She states, "the development of a Water Poverty Index is intended to help the process of identifying those areas and communities where water is most needed, enabling a more equitable distribution of water to be achieved". Slum Water Poverty Index, deals with these indicators. With this index incorporates factors related to micro level for better understanding and analysis. Parameters being the same as taken from the readings (i.e. resource, use, capacity, access and environment), indicators here involved are relevant at micro level (slum for this case). This study is an attempt to form a conceptual framework for creating a Water Poverty Index for Slums or Slum Water Poverty Index.

Slums are majorly deprived of basic services in which water is being one of them- within an urban area. These settlements include skilled and unskilled people. Slums basically don't have an organised form of water distribution system. Slum residents mostly depend on either public tap (in case of notified slums) or derive water from surface water resources in nearby proximity areas. This in turn affects their social as well as economic aspects. Women and men spent their major amount of time in collection of water, which bring down their working capacity. Untreated water from a source have its impact on the health and also expenditure for the same comes in parallel (UN, 2006). Also, Water Poverty Index (WPI) has been done for macro level like city or state, its implications and indicators differ to that of micro level study like slums and neighbourhood.

The indicators used for such a study has to be scale specific such as rainfall been one of the indicators to understand WPI is not useful when it comes to micro level study such as slums. Slums have mainly been study for the quality of water to examine the health criteria. Quantitative studies are not taken in account in mostly all the cases. The given study takes quality as well as quantity for slums to examine their WPI. By developing these indicators and structure for examining Slum Water Poverty Index will help in measurement or assessment of slums, hence, to priorities the development for the same.

The following chapter provides an overall perspective of methodology used for the formulation of Slum Water Poverty Index at Micro level. To begin with the research slums were selected through a perspective survey throughout the city of Vijayawada. This survey provided with a preliminary scenario to judge the problems across the slums. Major or repetitive factors leading to water scarcity or any other water issues were taken as a base to categories slums.

The major issues identified by the preliminary survey were found to be in Resources and Access. In Resource the major share is been taken by quantity and quality of water available, while in access it is distance travelled to fetch water and time spent in collecting water. Access also varies if the individual has community tap then the issues arises as mentioned above.

3.1 Methodology (Parameters and Calculation Procedure)

The basic indicators for assessing water poverty have been taken same as that given by Sullivan et al. in 2003. The indicators relevant to each parameter have been justified with slum specific parameters which can be defined quantitatively. The list of indicators and parameters used for calculating the Slum Water Poverty Index has been given below. The indicators were given weightages based on expert opinion survey (keeping in mind the prevailing conditions in the case area).

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.

The Delphi technique is a powerful approach that can be used (a) to gather data and opinions from experts (such as identifying primary performance constraints) or (b) to lead to a group decision (such as making recommendations about what to do). The Delphi technique is also referred to as the Delphi method, Delphi approach, Delphi activity, or Delphi study. The Delphi technique is a data collection tool that one can use to solicit insight from a group of experts in a structured way. In a needs assessment, the Delphi technique is typically used to gain expert input for defining needs, to identify desired results, to prioritize causes, or to recommend solutions. The intention with the Delphi technique is for the iterative process not only to solicit insight from experts, but also to ultimately reveal the areas where experts have consensus in their views. This consensus expert insight can be an invaluable source of information to support decision making about things such as needs, goals, and anticipated outcomes. The information that is generated through this technique typically (a) provides insight about a variety of different alternatives, (b) seeks to correlate expert insight on a specific subject, (c) provides the background information necessary for decision making, or (d) reveals consensus in expert opinions about a particular subject or theme.

3.1.1 Weighing of Components

In the present research, each indicator and the variables that comprise it are weighted equally. Each indicator consists of a set of different variables that result in an unintentional imbalance. As discussed in chapter 2, an equal weighting homogenizes problems of water poverty at various scales. This highlights an important problem of using equal weightings in a composite index where an uneven number of variables are used to calculate each indicator. Theoretically this is resolved by the classification of variables into indicators where each indicator is given a weight of 0.2, This study continues the tradition of weighting indicators equally but acknowledges the need to investigate this aspect further. The problem of weighting has been highlighted as a major problem by many researchers and although this study opted to replicate the original model by using equal weighting. However, it is recognized as an outstanding problem that needs to be addressed in future research.

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 income, **expenditure spent on water,** education, employment, expenditure on health due to water illness, **domestic water consumption**, **consumption deficit, water quality, household level water treatment,** type of water borne diseases **water related illness**. The identified parameters were sent to a panel of 10 subject experts from academics, research and industry for prioritisation of parameters. These experts were chosen who are basically specialized in water sector and currently doing research in water across the globe. Three subject experts from academic background who has sectoral knowledge on water and basic services were chosen. Three researches who are currently pursuing and has domain expertise knowledge on water and slums was chosen. Four experts from industry who are basically involved in executing water supply projects in slums under different central/state schemes were chosen.

I. 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, 14 parameters were prioritised.
II. First 14 high scoring parameters were selected. Among them, 'water quantity' scored the highest and 'employment' the least.
III. The details of indicators, key parameters, scores, ranks and identified parameters (green colour) are shown in the Table-3.1.1.

Table 3.1 Process of identification of SWPI parameters

S. No.	Indicators	Key Parameters	Overall Score	Overall Rank	Identified Parameters
1		Source of Water	52	26	
2		Water quantity	89	1	
3		Water sufficiency	77	7	
4		Alternative Sources	74	10	
5		Altitude	56	23	
6		Reliability	72	11	
7	Resource	Ground Water level	66	15	
8		Potable water access	86	2	
9		Frequency of water supply	64	16	
10		Time spent for water collection	78	6	
11		Distance travelled to collect water	75	9	
12		Queuing time	63	17	
13		Women engaged in collecting water	62	18	
14		Children engaged in collecting water	60	19	
15	Access	Distance from surface water source	68	14	
16		Maintenance of water supply	59	20	
17		Maintenance of water source	57	22	
18		Household Income	58	21	
19		Expenditure spent on water	85	5	
20		Education	55	24	
21		Employment	50	27	
22	Capacity	Expenditure on water related illness	54	25	
23		Domestic water consumption	84	4	
24	Use	Consumption deficit	71	12	
25		Water Quality	82	5	
26		Household level water treatment	76	8	
27	Environment	Water related illness	70	13	

The details of each indicator are discussed below:

(i) **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, and reliability that are most important at slum level were not considered.

(ii) **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 etc. It is inferred that slum specific parameters were often not considered.

(iii) **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 (2011) 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 affects on their earning. Investing their working hours to collect water often reduces income generation.

(iv) **Usage** –For measuring WPI, water consumption has been usually referred in the context of consumption of water for agricultural, industrial, domestic, livestock, purposes etc.,. However, domestic water consumption, Consumption deficit at slum level has not being considered.

(v) **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 3.1 above

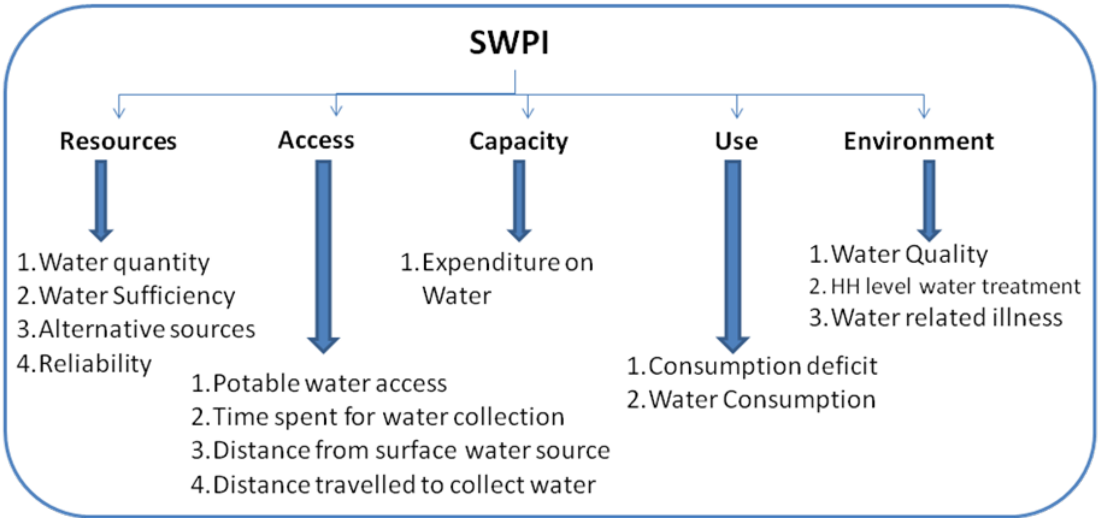


Figure 3.1 Key Parameters identified for Slum Water Poverty Index

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 over the world, misuse of water became rampant. As a result, repercussions led to haphazard development, which in turn had impact on 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 (slumalmanac, 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) became relevant, as it can be used to address community related issues. SWPI is developed with the same indicators and formulae 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-3.2

$$\sum_{i=1}^{N} WiXi = W_R{*}R+W_A{*}A+W_C{*}C+W_U{*}U+W_E{*}E\ ;$$

$$\sum_{i=1}^{N} Wi = W_R+W_A+W_C+W_U+W_E$$

$$\mathbf{SWPI} = \frac{\sum_{i=1}^{N} \mathbf{w_i X_i}}{\sum_{i=1}^{N} \mathbf{w_i}}$$

SWPI thus develop enables a better understanding and analysis of the slums. SWPI is vital in this indicator which includes source of water, water quantity, water quantity sufficiency and reliability of water supply.

Water quantity is measured in *litre per capita per day (lpcd)* and intricately linked to the living standards of people. The quality perceiving various ground realities associated with slums. The utility and the context specific usage of each of the parameters are elaborated below:

3.1.2 Resource

(i) *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 directly impacted by the water quantity.

(ii) *Water sufficiency* is measured in lpcd and compared with the required standard so as to ascertain the sufficiency.

(iii) *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.

(iv) *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.

3.1.3 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.

(i) *Potable water* refers to the percentage of households having access to potable water within the premises. Individual piped water connections may enable to reduce the water related issues.

(ii) *Time spent for water collection* involves travel and queuing time. This usually refers to the number of trips that the individuals make during the operational hours of water supply.

(iii) *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 minutes.

3.1.4 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.

3.1.5 Use

This indicator includes domestic water consumption.

(i) Domestic water consumption- As per the URDPFI guidelines (2015), the minimum norm against which the gap assessment done is 135 lpcd and for the slums as per the recent study it is observed to be 75-80 lpcd.

(i) Consumption Deficit: The number of households that doesn't meet the minimum consumption standards.

3.1.6 Environment

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

(i) *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.

(ii) *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.

(iii) *Water related illness:* Consumption of untreated water most often can result in the water borne diseases, such as cholera, diarrheic, malaria, etc.

Table 3.2 Parameters considered for calculations

Sl No.	Indicators	Weightages		Parameters	Scoring Logic
1	Resource	0.2	R1	Water Quantity (lpcd)	% Variation in water quantity availability
2			R2	Water sufficiency	% deficit in water availability with 80 lpcd
3			R3	Alternative Sources	% of HH dependent on alternative sources
4			R4	Reliability	% of time water supply is not operational
5	Access	0.2	A1	Potable water access	% of HH not having IHH water supply connections
6			A2	Time spent for water collection	% of HH spending more than 30 minutes for water collection
7			A3	Distance from surface water resource	% of HH travelling more than 500 metres to and fro for getting water from surface resource
8			A4	Distance travelled to collect water	% of HH travelling more than 500 metres to and fro for getting water access
9	Capacity	0.2	C1	Expenditure spent on water	% of respondents spending more than 5% of their income on the account of water related illness
10	Use	0.2	U1	consumption deficit	% Water consumption per household with respect to 80 lpcd
11			U2	Water consumption	% variation in per capita water consumption

12	Environment	0.2	E1	Water Quality	% of water sample having TDS> 500 mg/lit
13			E2	HH level water treatment	% of HH reporting water treatment
14			E3	Water related illness	% of HH reporting water related illness

Water availability from the main source of water has only been calculated. Water availability for households depending on community tap has been calculated using supply time, water pressure (i.e. time to fill water) and the dependency ratio over that water source. The formula used for this purpose is

$$\text{water availability (lpcd)} = \frac{\text{daily supply time (in hrs)} * 3600}{\text{time to fill 1 litre water} * \text{dependecy ratio over the water source}}$$

But in slums where people have individual household water supply connections, they have their water storage structures either in the form of PVC drums of different capacities (mostly having 200 litre drums) or roof top PVC tanks (500 litre or 1000 litre capacity storage tanks). In that case, it is inferred by discussing with them that ones they fill the tank in the morning and use it until the water gets finished. Generally, they use 0.5 HP or 1 HP pump, which enable them to fill the tanks in almost 45 minutes to 1 hour on an average. Throughout the whole day they use this water, which makes them to run the pump for half an hour on an average to fill the empty tank. Thus, in those cases, total water quantity has been taken equal to the capacity of water storage available in each household, because water if at all also available for the entire supply period, but some portion of that time is left unused. So, household connection,

$$\text{Quantity of water availability (lpcd)} = \frac{\text{Total water storage volume}}{\text{Household Size}}$$

Then for the purpose of quantification, water quantity availability has been converted into insufficiency in water availability by calculating percentage deficit in water availability with respect to a standard of 80 lpcd.

From the sample survey results, it was identified that the households are mostly water deficient, especially when it is about the availability from the main or primary water source. That's why they have to depend on alternative water sources like groundwater (borewell), natural surface sources of water, municipal tankers or water bottles. That has not been investigated into much detail as the study is on the water aspects in slums and as slum is an integral part of an exclusively urban character, so the root cause for not meeting the requirements of slum population leads to the failure in service delivery by the urban local body. As they are not being able to supply sufficient amount of water to the slum people to fulfil their basic requirements, so in order to do so, they are becoming dependent on some alternate sources whatever be type of that alternate source. Dependency on some alternate source signifies slum water poverty. Household surveys were conducted rather than individuals and these surveys were assumed to be representative of the entire community.

3.2 Rationale behind the parameters identified

Under Resource indicator, parameters such as source of water, water quantity, water quantity sufficiency and reliability of water supply are considered. Source of water is directly linked to the quality of the water. If it is a piped water supply, then the water is generally treated by the water works of the urban local bodies, that's why the quality of it does not vary too much with the seasonal variations. This parameter is basically taken to measure the per capita water deficit with respect to the service level benchmarks. Water quantity affects the living standards of people. Reliability of water supply is basically applicable in case of piped water supply. This factor is considered in order to take into account the frequency of the piped water supply. Basically, slums don't have household water supply connections, they have community water taps. In some cases, it is usually seen that there is a tap, but that is non-functional or the frequency of the supply is very less. These issues make the situation more critical because in community taps, the dependency ratio on a single tap is already high. Once these parameters are applied as the component of resource, the issues related to water availability is understood at a greater depth.

Under Access, parameters such as percentage of households with potable water access, frequency of water supply, time travelled to collect water, distance travelled to collect water, time spent in water collection (including queuing time), percentage of water carried by women, percentage of water carried by 9-14 children. Percentage of households with potable water access is directly related to the water quality issues. If they have access to piped water supply, then issues regarding water quality will be less. Slums majorly have community water taps, the distance of the water point from the individual household also matters. According to the Sustainable Development Goals 2017, the water point should be within to and fro walking distance of 30 minutes. Percentage of water carried by women has been taken into account because of the water justice and gender issues. Subsequently, if women percentage is less than the job of fetching water will be done by the male members of the family or the children. So, either it may have an impact on the attendance rate of the school-going children or on the working men. This will enable to understand the access level issues in detail at a settlement level.

Under Capacity, parameters such as maintenance of water sources, household income, expenditure on water, education, employment, expenditure on health due to water illness etc. Maintenance of the water source has a direct impact on the water quality. If sufficient quantity of water is not available for meeting the daily demands, then the slum dwellers are forced to buy water from the private tankers by paying extra money. Sometimes people suffer from various water related illnesses if they access water from nearby surface sources like bore well, river, canals etc.

Under Use, parameters such as domestic water consumption rate and consumption deficit. Water consumption rate is an important aspect deciding the quality of life. In this we shall be estimating the gap in the per capita availability from 80 lpcd as per the Indian Standards.

Under Environment, parameters such as water quality, any household level treatment (if needed) and types of water borne diseases affecting the population. Water quality is basically related with the source of water. It is also linked with the seasonal variation if the source is other than piped water supply. Usage of improper quality of water directly impacts on health. To avoid these, people sometimes locally use some household level treatments like boiling or bleaching etc.

3.3 Method of evaluation of the parameters

Table 3.3 Indicators and Parameters for SWPI

Sl. No	**Indicators**		**Parameters**	**Scoring Logic**	**Source**
1		R1	Water Quantity (lpcd)	% Variation in water quantity availability	Improved Method to Calculate Water Poverty Index at a Local Scale *by Ricard Gine Garriga & Agusti Perez Foguet* (1943)

Sl. No	Indicators		Parameters	Scoring Logic	Source
2	Resource	R2	Water Sufficiency	% of HH getting less than 80 lpcd	Improved Method to Calculate Water Poverty Index at a Local Scale *by Ricard Gine Garriga & Agusti Perez Foguet* (1943).
3		R3	Alternative Sources	% of HH dependent on alternative sources	
4		R4	Reliability	% of time water supply is not operational	Improved Method to Calculate Water Poverty Index at a Local Scale *by Ricard Gine Garriga & Agusti Perez Foguet* (1943)
5	Access	A1	Potable water access	% of HH not having IHH water supply connections	*Lawrence et al (2003), Fenwick (2010)* Water Poverty Mapping and its Managament Apllications by *Charles van der Vyver, Dawid B Jordaan* (2010)
6		A2	Time spent for water collection	% of HH spending more than 30 minutes for water collection.	The Water Poverty Index: Development at Community Scale by *C.A.Sullivan, J.R.Meigh, P.Lawrence* (2003) Using the Water Poverty Index to monitor progress in the water sector by *Centre for Ecology & Hydrology, Wallingford* Core questions on drinking-water and sanitation for household surveys by *WHO & UNICEF* (2006)
7		A3	Distance travelled to collect water	% of HH travelling more than 500 metres to and for getting water access	The Water Poverty Index: Development at Community Scale by *C.A.Sullivan, J.R.Meigh, P.Lawrence* (2003) Concept of Walkability
8	Capacity	C1	Expenditure spent on water	% of respondents spending more than 5% of their income on the account	UN-Water Decade Programme on Advocacy and Communication and Water Supply and Sanitation Collaborative Council

Sl. No	Indicators		Parameters	Scoring Logic	Source
				of water related illness	
9	Use	U1	Water consumption	% variation in per capita water consumption	Ricard Gine Garriga & Agusti Perez Foguet (1943) Lawrence et al (2003)
		U2	consumption deficit	% Water consumption per household with respect to 80 lpcd	
10	Environment	E1	Water Quality	% of water sample having TDS> 300 mg/lit	Lawrence et al (2003)
11		E2	HH level water treatment	% of HH reporting water treatment	Ricard Gine Garriga & Agusti Perez Foguet (1943)
12		E3	Water related illness	% of HH reporting water related illness	C.A.Sullivan, J.R.Meigh, P. Lawrence (2003)

Data collected through field surveys is analysed using the weighted composite index method to find the final SWPI for different slums. SWPI values will be grouped against various conditions like high, moderate and low describing the status of the slum. The pentagonal radar plotted against each slum will give us an overall idea of the most affected parameter, which should be focused for that slum.

3.4 Method of Calculation of SWPI

Five households were selected randomly from each of the settlements. The procedure of scoring each parameter is described below:

For Resources; R1 denotes Quantity (lpcd), Quantity is defined on basis of percentage of variation in water quantity availability. This will help us to understand the availability of water resource at a settlement level. R2 denotes Sufficiency as per the service level benchmark of 135 lpcd the results of primary survey have been crosschecked with the Service level benchmark value to come out with the deficiency in percentage; R3 denotes alternative sources if any source other than piped water supply is used by the slums or households, then the percentage value of households are taken in consideration with different source of water and R4 denotes Reliability of water supply.

$$R1 = [(Q_a - Q_{min}) / (Qmax - Q_{min})] \times 100$$

Qa = Average water quantity available in lpcd, Qmin = Minimum water quantity availability in lpcd, Qmax = Maximum water quantity availability in lpcd

$$R2 = (X_2/X) \times 100$$

X_2 = Number of sample households (HH) getting less than 135 lpcd

X = Total number of sample Households

$$R3 = (X_3/X) \times 100$$

X3 = Number of sample HH depending on alternative water sources

$$R4 = (X\text{-}X4/X) \times 100$$

X4 = Total number of supply hours

X= Total number of hours in a day

For Access; A1 denotes Potable water access i.e. the percentage of household having access to potable water; A2 denotes time spent for water collection, in this parameter total time spent in water collection in a period of 24 hours is calculated in percentage and A3 denotes distance travelled to collect water from household, where the threshold for the above mentioned is 500 meters or less. This will help us to understand the access related situation in the settlement and this as component will be an important in calculation of Index. It also helps to understand the

$$A1 = (X_4/X) \times 100$$

X_4 = Number of HH having individual HH water supply connections

$$A2 = (X_5/X) \times 100$$

X_5 = Number of Sample HH spending more than 30 minutes for water collection

$$A3 = (X_6/X) \times 100$$

X_6 = Number of Sample HH travelling more than 500 metres for water collection

$$A4 = (X_7/X) \times 100$$

X_7=Number of sample HH travelling to collect water from the nearest surface source

For Capacity; C1 denotes economic capacity of the household, expenditure spent on water. This will help to understand the economic and social aspect of water in slums at a broader level. This will help us to understand the access related situation in the settlement and this as component will be an important in calculation of Index.

$$C1 = (X_7/X) \times 100$$

X_7 = Number of Sample HH spending more than 5% of their income because of water related illness

$$U1 = [(C_a - C_{min})/ (C_{max} - C_{min})] \times 100$$

C_a = Average water consumption in lpcd, C_{min} = Minimum water consumption in lpcd, C_{max} = Maximum water consumption in lpcd

$$U2 = (C_b/C)$$

C_b = Total Per capita consumption deficit of sample HH; C= Total number of samples

$$E1 = (X_8/X) \times 100$$

X_8 = Number of water sample having TDS more than 300 mg/lit

$$E2 = (X_9/X) \times 100$$

X_9 = Number of sample HHs reporting HH level water treatment

$$E3 = (X_{10}/X) \times 100$$

X_{10} = Number of sample HHs reporting water related illness

The cumulative of all the values has to be aggregated and multiplied to arrive to slum specific water poverty index at a settlement level.

In order to come with a common value for all the parameters, average value of the sub parameters is taken as follows

For Resources; R = (R1+ R2+ R3+R4)/4

For Access; A = (A1+ A2+ A3)/3

For Capacity; C = C1

For Use = (U1+U2)/2

For Environment = (E1+ E2+E3)/3

All these individual values of parameters are then multiplied by their respective weightages obtained through Delphi method.

Table 3.4 Parameters and their weightages

Parameter	Weightage (Wi)
Resource (W_R)	0.2
Access (W_A)	0.2
Capacity (W_C)	0.2
Use (W_U)	0.2
Environment (W_E)	0.2

Final formula to calculate Slum Water Poverty Index is as follows;

$$SWPI = \frac{W_R*R+W_A*A+W_C*C+W_U*U+W_E*E}{W_R+W_A+W_C+W_U+W_E}$$

$$SWPI = \frac{0.2 \times R + 0.2 \times A + 0.2 \times C + 0.2 \times U + 0.2 \times E}{0.2+0.2+0.2+0.2+0.2}$$

Construction of Questionnaire

The objective of the questionnaire survey was to test the water poverty issues in the slum settlement. It also attempted to capture an overview of the current service levels of water issues in the identified settlements. A survey provides a fast and efficient means of gathering information with regards to the respondents' perception about the water supply situation in this aspect. The questionnaire was designed for purpose of identifying the issues related to slum water poverty. Close ended questions were asked as part of survey format. Guttmann scaling method is applied to prioritize the parameters within the indicators especially while using Delphi method. To understand the vocabulary of target population(slum settlement) the questions were kept simple and easily answerable. An initial collection of variables selected from the literature review were selected and used during the pilot study. Pre-coded questions were used to minimise the cost of data management. Pilot survey questionnaire as a structured survey format was formulated in the initial level to understand and test the questionnaire.

The entire questionnaire is divided into three sections. In the first section, the general information of the slum is collected in terms of name of the slum, ward number and the house number of the respondent. Second section requires the respondent to provide household (HH) information about themselves in terms of the number of households living in the house, head of the HH, caste, religion, income, gender, number of employees in the household. In the third section, the respondent has to provide the information related to sources of water for drinking and HH chores, time spend in collecting water, who will be collecting water, treat water before drinking, what treatment method, storage facilities available, reasons for storing water, quantity of water used for drinking and cooking, amount household pay as water connection bill, water quality, water pressure, satisfaction level of municipal water supply, ground water details, usage of bore water, taste of water, color of water, water borne diseases, location of community tap, how far is the distance to the community tap, how many households depends on one community tap, availability of water tanker facility, dependency on water bottles as drinking water, how many bottles per day, how much money spent every month are the questions that were asked during the pilot study. Post conduction of survey, it was felt that some questions may be avoided and some were not useful for analysis. However, when the final questionnaire was prepared, the format was divided into two sections. first was related to general information of the household and the second was related to water supply information in terms of source of water, water sufficiency, water availability, operational hours, potable access to water in terms of individual taps and community taps, frequency of water supply, time spent to collect water, distance travelled to collect water, women engaged in collecting water, child engaged in collecting water, Maintenance of water sources, Household Income, Expenditure spent on water, Expenditure on health due to water illness, Employment, Domestic water consumption per head per day, Potable water consumption per head per day, Insufficiency in consumption, Water quality (TDS), Household level water treatment, Type of water borne diseases affecting the population.

3.5 Sampling Design

Sampling design refers to the process of selecting samples from a population. There are two types of sampling designs namely (i). Probability sampling design and Non-Probability sampling design. Probability sampling design has been chosen for the present research and the stratified random sampling technique has been employed.

3.5.1 Selection of Sample Households

In this present research, the stratified random sampling technique has been used for the selection of sample households in the identified slums. There are two reasons for using stratified random sampling technique, primarily, it helps the researcher in obtaining data about the different components of the case area and secondly this sampling technique is more efficient, as it increases the representativeness of the sample households to reflect the overall population. The entire population is stratified in such a way that the elements are uniform within the different slum settlements. Since the researcher interest is to identify the slum specific water poverty parameters that are more critical across all the settlements, the appropriate criteria for stratification would be accessing slum water poverty among the listed indicators so that the parameters that are more specific to that indicators will be highly correlated. As part of the household survey in the identified slum settlements, 77 samples were collected by covering the entire seven slums in the research. The Cochran's formula is applied to identify the final number of samples that are elaborated in the fourth chapter.

3.6 Data Collection Methods

Two types of data have been collected pertaining to this research that was carried out and employed in this investigation. They are primary and secondary sources of data.

3.6.1 Primary Sources of Data

Sample survey at the household level was carried out for collecting the required amount of data at the slum level.

3.6.2 Secondary Sources of Data

Required data from the published and unpublished literature, unpublished documents, newspapers and reports from various sources at different levels were collected pertaining to this research.

3.7 Planning Tools and Techniques

3.7.1 Survey Research Tools

Appropriate survey tools, such as, pilot study/pretested schedule were conducted in this present research. They are discussed as below:

3.7.2 Pilot Study/Pre-tested survey

Pilot study/Pretested household survey was conducted at the slum settlement level. It covered the aspects related to water supply issues related to accessibility, availability, affordability and usage of water at the households' level. Besides this, semi-structured interviews were also conducted among the residents to understand the water supply issues in the settlement.

3.7.3 Methods of conducting the Surveys

The household survey was conducted in the year 2017. To conduct the household survey, the researcher approached the households directly, had a detailed discussion with the members of the households, obtain prior appointments from the respondents for conducting survey at the household level. Thereafter, the researcher conducted the survey at the household level based on the availability of the respondent. Since the researcher himself has conducted both the surveys, a lot of insight/observation about the overall function of the water supply system was understood.

3.7.4 Analysis

The collected primary and secondary data were cross checked for completeness and correctness, and errors or bias in the data was also eliminated by crosschecking. Subsequently, after due consideration, the data have been transferred into excel sheets to avoid errors and then to SPSS-V20 software for further analysis.

3.8 Analytical Tools and Techniques

3.8.1 Analytical Tools

After the analysis of various analytical tools, such as, computer software (MS Excel, SPSS-20, AutoCAD, ArcView Mapping) were used for data processing, and analysis.

3.8.2 Analytical Techniques

Relevant statistical techniques, like data tabulation methods, Pearson correlation; multiple regression; were employed based on the requirement of this investigation.

3.8.3 Framework Matrices:

The framework method encourages to organise and manage the research through the process of summarisation, resulting in a robust, flexible and unique matrix output which allows researcher to analyse the data both by case and theme. This helps in managing and interpreting of data. A matrix of all the parameters across all the slums will be tabulated so as to understand the uniform parameters affecting the slum settlement

3.8.4 Derived Results and Discussions

Results of all types of analysis, which include review of literature, primary household survey, statistical analysis etc., have been discussed in detail to arrive at findings and conclusions

3.8.5 Inferences

The probable findings were drawn for evolving a set of guidelines and development strategies to address the issues of slum water poverty.

3.8.6 Strategies and Recommendations

A set of strategic solutions would be prepared and recommended based on the results, discussions and inferences of the proposed research for addressing the problems of water scarcity in the slum areas.

3.9 Chapter Conclusion

The chapter focus on the parameters of the slum water poverty derived through secondary literature. It also gives the calculation procedure for all the parameters. The weighing procedure used to calculate SWPI on lines of WPI is also discussed. The process of Delphi mechanism is described where the stakeholders consultation from academic, consultancy, water domain experts views were recorded to score and rank the parameters in order of its priority specific to slums context. The details and rationale behind each parameter are elaborated in the form of flow chart and scoring logic applied is explained. Finally, the slum water index formula is summarised by elaborating the weights of each indicator and its parameters, aggregation method to derive SWPI of a settlement. The next chapter focuses on elaborating the rationale for identifying the case areas at macro, meso and micro levels. Meso level discusses about the country level issues that help to prioritise state and as well as city. The meso level helps in conducting city level analysis and identify suitable slums at city level. The micro level helps in detailing out the case areas in terms of slum profiling, detailing out the water scenario of the slum settlements.

CHAPTER 4: CASE STUDY - VIJAYAWADA

This chapter outlines about the rationale for identifying the slums at city level through a detailed analysis. Rationale for the study was developed at three levels i.e. macro level, meso level, and micro level. Macro level helps in identifying the case study at country level there by identifying the critical zones through established criteria for identifying the state and city. At meso level i.e. at city level, ward level assessment is done through identified criteria. The data for conducting the ward level assessment is done through secondary data obtained from ongoing programmes in the country. This enables to identify the critical wards with slums across the city. The micro level analysis focuses on profiling of slums and detailing out the water scenario of the identified slum settlement.

4.1 Case Study Selection Criteria

Rapid urbanization and increase in slum population has induced problems related to water scarcity and accessibility to drinking water. The impression of water scarcity on the slum population of India is continuously deteriorating and it further deteriorates which will reflect the quality of life and thereby standard of living. The basis or the criteria for selecting the pilot study for the research is based upon the city having highest slum population and density, people severely affected by the water scarcity, accessibility to water supply. The research study is delineated and evaluated at three levels for identification of case area.

4.2 Macro Level Analysis at Country level

The topography will define the spatial location of the settlement and this would further help to study the impact of geographical location of the settlements in urban context. Here, the settlements refer to slums located at varied locations in city. It was also further identified that the settlements with varied spatial locations would be more apt to address water scarcity in the slums with varying topography. The favourable topography helped to study impact of geographical locations on slums. Accordingly, the other three important criteria which helped to identify the city are as follows;

Criteria 1: Cities with high percentage of slum population to the total urban population.

Criteria 2: Density of Slum population in the city.

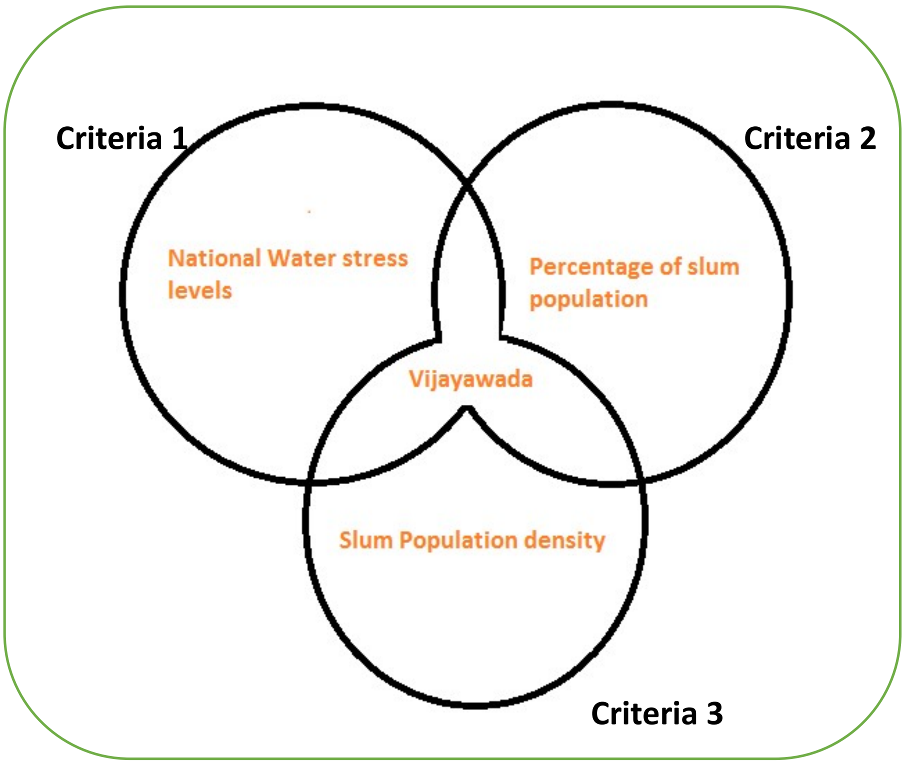


Figure 4.1 Macro level criteria for Vijayawada

Criteria 3:

a) National Water stress levels

b) Percentage of slum population to the urban population

Criteria 1:

In the first stage of analysis, Cities with population more than 10 lakh were selected because they are more urbanized in nature, have established infrastructure, parastatal agencies to operate them, and which experience higher levels of migration, scope for employment opportunities. It is also observed that, the more the urbanization, the more the quantum of slums population residing in these urban areas. In this, the cities having higher percentage of the population living in the slums are analysed with the total population of the respective cities. It is found that according to the census 2011, the cities with their percentage of slum population where Vijayawada ranked the maximum percentage of slum population with about 44% of the total population living in the slums. This is followed by cities like Mumbai and Visakhapatnam with 42 % each. The following table represents the statistical figures as per census 2011.

Table 4.1 The statistical figures of slums as per census 2011

Sl. No	City Name	No of HH	Slum Population 2011	Total Population 2011	% of Slum Population
1	Greater Mumbai (M Corp.) (Part)	1135514	5206473	12442373	41.8%
2	G Vishakhapatnam MC (Part)	194959	720971	1728128	41.7%
3	Vijayawada (M Corp.) (Part)	123228	451231	1034232	43.6%
4	Nagpur (M Corp.)	179952	859487	2405665	35.7%
5	G. Hyderabad MC (M Corp. + OG) (Part)	507396	2287014	6993262	32.7%
6	Kolkata (M Corp.)	300755	1409721	4496694	31.4%
7	Chennai (M Corp.)	329827	1342337	4646732	28.9%
8	Pune (M Corp.)	151278	690545	3124458	22.1%
9	Delhi MC (U) (Part)	332022	1617239	11034555	14.7%
10	BBMP (M Corp. + OG) (Part)	165341	712801	8495492	8.4%

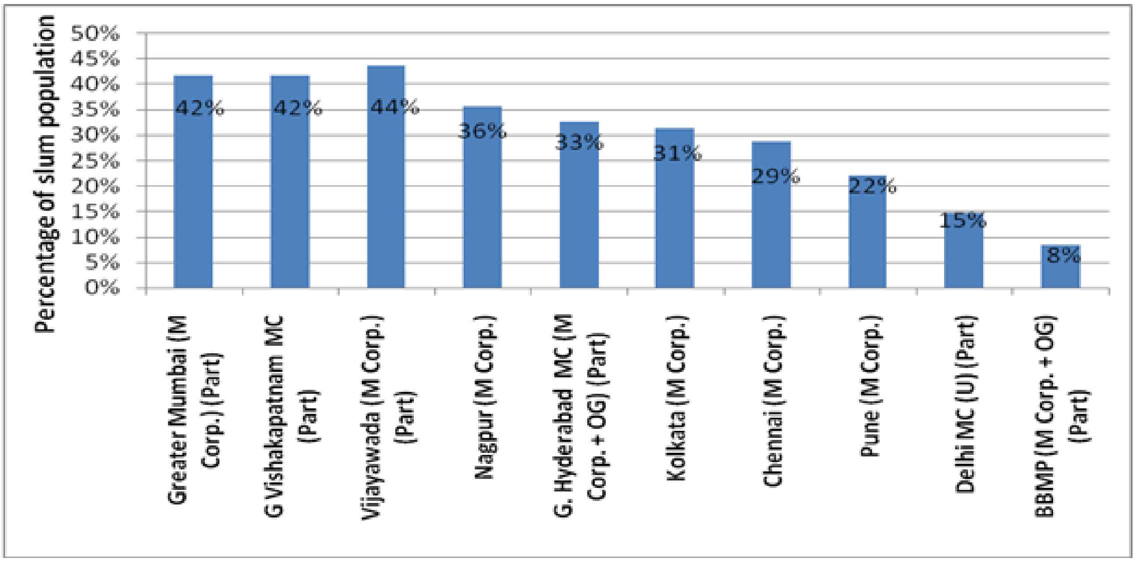


Figure 4.2 Slums in different cities in India

In the second stage of analysis, the density of the slum population is calculated, which indicates the pressure on the service provisions and simultaneously on their living condition. To calculate density, the slum population living in the limits of Municipal Corporation is divided by its total area. In the analysis, it is observed that the density of Vijayawada is 7292 Persons/Sq.km, which is next to Mumbai with 10842 Persons/Sq.km. The below table represents the density wise slum population in the city.

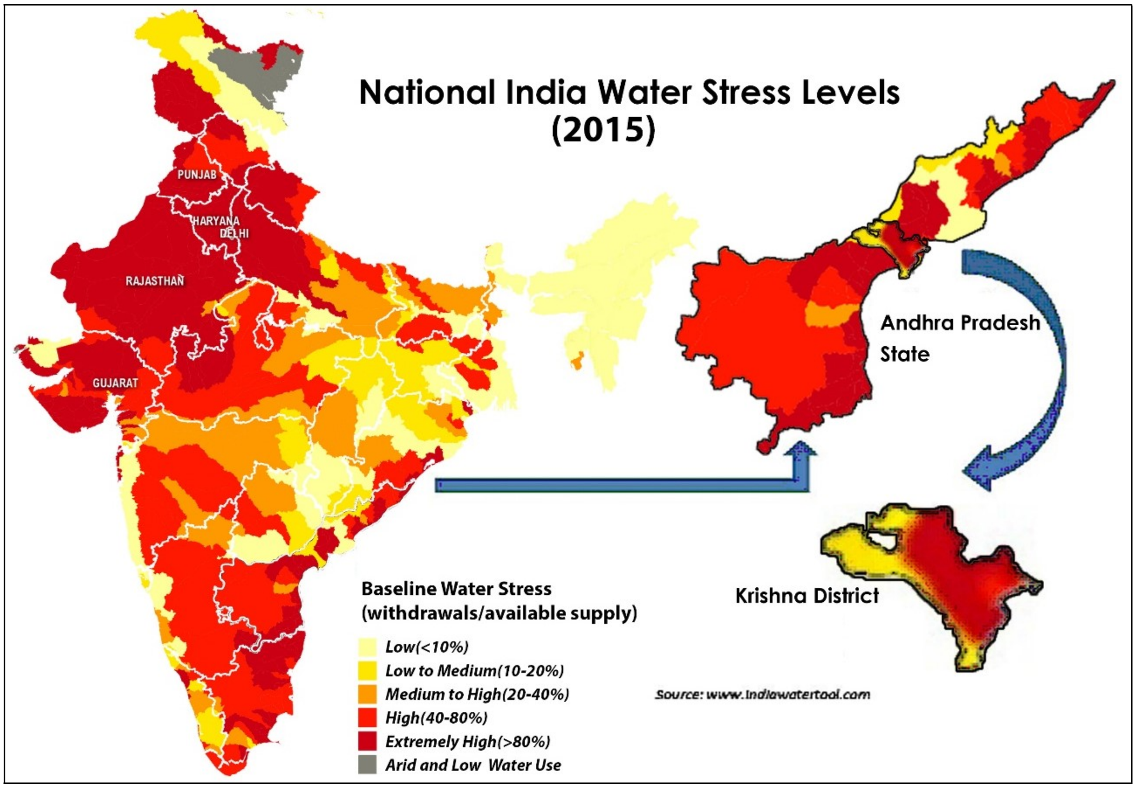
Table 4.2 Slums in different cities of India

Criteria 2: Sl. No	Name of the City	No HH	Total slum Population	Area (sq. kms)	Density of Slum Population
1	Greater Mumbai (M Corp.) (Part)	1135514	5206473	480.24	10841.40
2	G Vishakhapatnam MC (Part)	194959	720971	111.6	6908.34

3	Vijayawada (M Corp.) (Part)	123228	451231	61.88	7292.03
4	Nagpur (M Corp.)	179952	859487	227.37	3780.12
5	G. Hyderabad MC (M Corp. + OG) (Part)	507396	2287014	650	3518.48
6	Kolkata (M Corp.)	300755	1409721	205	6876.69
7	Chennai (M Corp.)	329827	1342337	426	3151.03
8	Pune (M Corp.)	151278	690545	552	1250.99
9	Delhi MC (U) (Part)	332022	1617239	1397.3	1157.40
10	BBMP (M Corp. + OG) (Part)	165341	712801	741	961.94

Source: Census of India, 2011

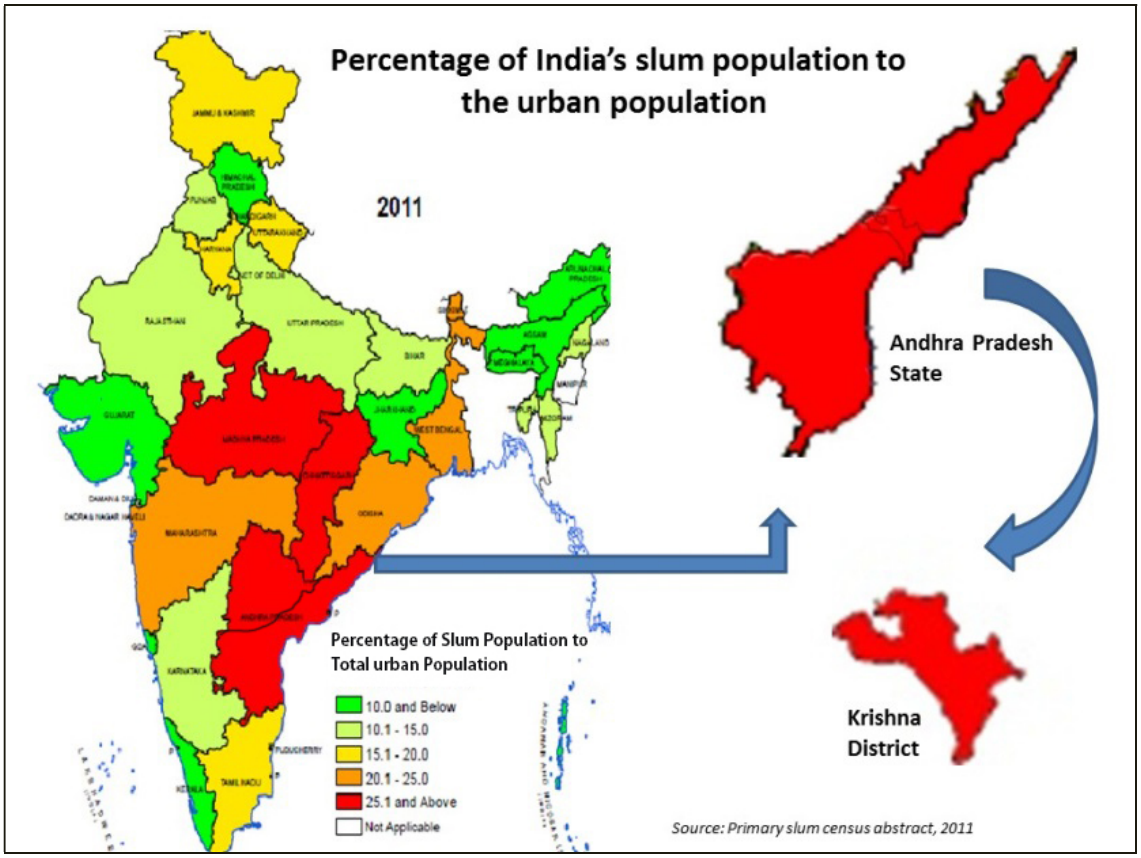
Criteria 3: This map defines the national water stress levels in 2013, which represents the range starting from less than 10% to extremely high of more than 80%, across country. Water stress occurs when the demand for water exceeds the available amount during a certain period or when poor quality of water restricts its use. Water stress causes deterioration of fresh water resources in terms of quantity (aquifer over-exploitation, dry rivers, etc.) and quality (eutrophication, organic matter pollution, saline intrusion, etc.)



Map 4.1 National Water Stress levels

Source: National Water Stress levels

From the above water stress map, it is observed that, the North Western States like Rajasthan, Gujarat, Punjab, Delhi, Haryana, etc. are facing extremely high stress compared to Central and Eastern states like Madhya Pradesh, Chhattisgarh and seven states in East India are facing low to medium water stress. If we observe Andhra Pradesh, it falls mostly in high zone and also more than half part of Krishna District is in High zone which is of great concern to urban planners and policy makers to intervene and understand the problem of water issues. This fact shifts our focus to Vijayawada with relevance to the previous added criteria. This map is from census 2011 abstract data, shows state wise percentage of slum population to urban population. Madhya Pradesh, Chhattisgarh and Andhra Pradesh have high percentages of slum population to their urban population with more than 25.1 %.



Map 4.2 Percentage of slum Population in India to urban area population

Source: Primary Slum Census Abstract, 2011

It depicts that major urban areas consist of slum population in Andhra Pradesh. This implies that Vijayawada is a relevant case area to carry out the research. Further narrowing the urbanization process, slum reflects the failure of government to guide and facilitate the growth of low-income housing and providing basic services for incoming migrants in urban areas. It is also observed that the State of Andhra Pradesh stands first in proportion of slum households to the urban households among all the states i.e. 35.7%.

4.3 Meso Level Study – Vijayawada (City Level)

4.3.1 Introduction

Vijayawada is the 30th largest metropolis in India (Census of India, 2011b). It is an important transit node connecting south to North India. Historically, this city has been the religious center (of Hinduism, Buddhism and Jainism). Currently, Vijayawada has positioned itself as one of the potential capital for new Indian state – Seemandhra (The Hindu, 2013). Vijayawada has multiple challenges in spatial development front for socially inclusive and physically integrated outcomes. The components of spatial planning vary on inclusiveness and integration aspects. For example, water poverty (in our case) has been considered as a major area of research, whereas slums have been considered in social inclusion context but with respect to location of the settlement. However, provision of water can be inclusive in nature, but based on the context of Vijayawada our focus has been limited to water poverty issues with respect to the location of the settlement.

4.3.2 Vijayawada - History

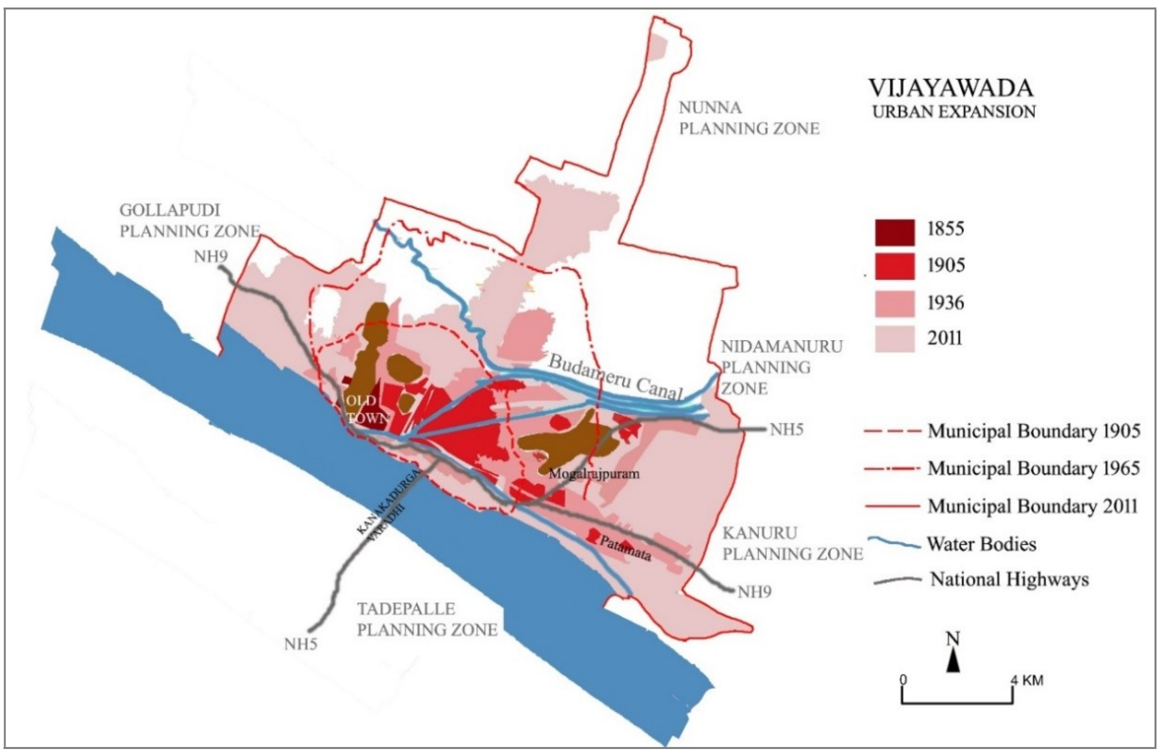
Vijayawada is a flourishing city of great historic importance. Archaeological evidence reveals existence of Vijayawada settlement over two thousand years ago, during the Satavahanas rule. During 5th and 6th century, the entire Eastern Krishna valley was an important centre for Buddhist culture with Amaravati as capital which was 18 miles away from Vijayawada on the southern banks of river Krishna. Existence of early trading during this period is evident from the number of ships from various foreign countries like China, Indonesia, Cambodia, Ceylon and Persia. Formerly known as Bezwada, Vijayawada was an important centre of the Vishnukundin rulers. Later the city was taken by the early Chalukya (later known as Eastern Chalukya) of Badami and became the headquarters of their eastern domains. The strategic position of the town commanding the coastal trading routes of the Bay of Bengal determined its economic importance through the centuries. During the medieval period, 10th - 12th century, the city became the centre for Hinduism, when famous Kanak Durga temple was constructed under the patronization of the Komatis.

During the rule of Qutub Shah of Golconda, 17th century, Vijayawada became the seat of governance, since two of the ministers were from this area, though for a brief period (Parthasarathy, 1995). The growth of the town picked up momentum, which was already in the form of a small settlement on the east of the Indrakiladri Hills, by 1855 A.D. after the construction of Krishna barrage and three irrigation canals namely Eluru, Ryves and Bandar canals; and the rail bridge over the river Krishna in 1892 during British rule in that area. By 1850 the town had become the transit point for travel on the Grand trunk route to Madras, from the north. Travellers used to cross the river at Vijayawada and resume the journey by road. The city provided ferries for the travellers and few rest houses. Huge potential for the city growth was provided during 1850 with the construction of anicut across river Krishna. This increased area under irrigation and the famine prone parts also became prosperous. Hence number of Vaisya traders migrated to the city to participate in grain trade between 1850 and 1900. The construction of Railway Bridge across Krishna in 1890 connecting Hyderabad, Madras and Calcutta, gave further fillip to growth. Later a larger barrage was erected in 1950 to replace the old anicut, which further increased are under irrigation, and decade later it became part of the Nagarjuna Sagar irrigation system. During this time the implementation of the programme of green revolution, made the Krishna Delta one of the most prosperous regions in India.

Though during the pre-independence era, the city experienced only a modest growth; however, after the independence the construction of road bridge over the river Krishna, establishment of South-Central Railway terminal, setting up of divisional headquarters, major government offices including district court, major institutions for higher education, major commercial and distributive trading activities, wholesale establishments, agricultural marketing centre and Jawahar Auto-Nagar industrial estate have brought a substantial effect on the city's growth. Vijayawada has many locational advantages with dominant trade-transport function. It borders the Telengana region and is close to the Rayalaseema region of Andhra Pradesh. The city emerged as an important transport hub that enhanced its export for agricultural production hence forming a base for rich agricultural farmers of coastal Andhra especially Krishna Delta. (Vijayawada Urban Development Authority, 1971).

4.3.3 Growth of Vijayawada City

In early 1950s, the city was confined in the area between the Indrakiladri hills where Kanaka Durga temple is located on the east, the railway station on the west and Prakasam Barrage in the south. Later the city started to grow eastward along the Bandar Road (former NH5) and Eluru road. The "One Town" market is located in the old city area and has a thriving economy with a huge garment market. Situated in the fertile Krishna delta, the city has historically been the agricultural market centre of the region. In 1960s the Auto Nagar Industrial estate was setup. Some residential development, like Vidydharapuram, Bhavanipuram, and HB colony, has taken place towards the east of the Indrakiladri Hills in the 1980s. During 1999-2000, Lanco set up a thermal power plant and a residential township on the west along the NH-9 which goes towards Hyderabad. Residential areas like Ajith Singh Nagar, Payakapuram, and Vambay have been developed by Vijayawada Municipal Corporation (VMC) in the past 2 decades to house the urban poor. The city has grown along the eastern and western corridor, along the Bandar canal in the south. Recent growth areas in the north include the large Vambay Colony is the site of the Basic Services to The Urban Poor (BSUP) supported Ground+3 flats projects for slum relocation under the Jawaharlal Nehru National Urban Renewal Mission (JNNURM). Even though the River Krishna flowing through the southern part of the city has historically served hindered growth towards the south, however, in the new VGTM Master Plan, outer ring roads and bypasses have been planned which can stimulate growth towards the north and south (Fig.3). It is anticipated that with more connectivity across the River Krishna in the future, there will be more development towards the Mangalgiri area, which lies across the river to the south (Vijayawada Municipal Corporation, 2006b).



Map 4.3 Vijayawada expansion, 1855 – 2011

Source: Map prepared based on VGTM-UDA (2006)

Historically, certain period showed pick rise in population. In 1880s, population grew due to labour migration for laying railway lines, whereas in 1940s large scale rich and poor peasants migrated due to emergence of city as an important commercial and political centre (Parthasarathy, 1995). Majority of the rich farmers that migrated in the city occupied the outlying rural areas like Patamata and Gundala, which later became urban areas with extension of city limit. Migration of rich peasants into the city was one of the strong factors of city growth in the past. Whereas the poor migrants settled mostly along the river, canals and hill slopes, forming the present slum areas (Parthasarathy, 1995).

Table 4.3 Historical events that influenced planning in Vijayawada, 1855 – 2013

Year	Event
1855	Construction of a barrage and three irrigation canals Eluru, Ryves and Bandar
1888	Constituted as municipality with an area of 30sqkm
1951	First grade municipality
1961	11 slums with 10,600 households and cover about 3.8 sq.km
1961	80 lpcd water used to be supplied
1965	400 persons depending on one public tap for water supply
1969	First Master Plan was approved
2001	26% of slum population reside in city i.e. 2000151 with 109 slums
2010	111 slums were notified by VMC
2012	RAY scheme got implemented for provision of infrastructure and land tenure

Source: Authors' compilation from various sources

4.3.4 Demography

Vijayawada Urban Agglomeration (VUA), with 1.49 million populations, is the 30th largest city in India and the second largest city in the state of Andhra Pradesh after Visakhapatnam (Census of India, 2011). VUA spreads over two districts, namely Krishna and Guntur that consists of Vijayawada Municipal Corporation, 14 Outgrowths, 2 municipalities, 6 census towns[1].

According to 2011 census, 1.84 million persons lives in Krishna district (urban) out of 4.51 million persons (total population of Krishna district), which means urbanization level in Krishna district was 40.81% much ahead than India (31.2%). Moreover, the urban population growth rate in Krishna district (2001-2011) was 37.23%, whereas the rural population growth rate declined by 6% conveying the fact that Krishna district is rapidly urbanizing. Comparison to urban Andhra Pradesh (AP) (35.6%), the population growth of urban Krishna (37.2%) was a little higher in the last decade, however, rural Krishna experienced 6% decline in population while rural AP still experienced 1.73% growth. Vijayawada has a major share of urban Krishna (56.9%) and VUA (70.3%) by population. Therefore, data from urban Krishna/VUA will fairly represent Vijayawada. The population growth rate of VUA (44.28%) was significantly higher than the VMC (24%) as well as urban AP (35.6%). It is inferred that the development sprawl is spread beyond the municipal limits. Over time, Vijayawada experienced densification, merely

[1] Statutory Towns: All places with a municipality, corporation, and cantonment board, notified town area committee, etc.
Census Towns: All villages with a minimum population of 5,000 persons in the preceding Census, at least 75% of male main working population engaged in non-agricultural activities and a population density of at least 400 persons per sq km.
Urban Agglomerations (UAs): A continuous urban spread comprising one or more towns and their adjoining out growth(s)
Out Growths (OGs): Areas around a core city or town, such well recognized places, like, Railway colony, university campus, port area, etc., lying outside the limit of town.

from 9,544 persons/km2 in 1961 to 16,940 persons per km2 (Table 4.3). As expected, density for VUA (13,502 persons/km2) was less than the VMC in 2011 (Vijayawada Municipal Corporation, 2006b).

Table 4.4 Population, area and density of VMC and VUA, 1961-2011,

Year	**Vijayawada (M.Corp.)**				**Vijayawada Urban Agglomeration**	
	Population	**Population decadal growth (%)**	**Area (Km2)**	**Density (Person/Km2)**	**Population**	**Population decadal growth (%)**
1961	230397	42.93	24.14	9544	269536	44.61
1971	317258	37.7	29.4	10791	395084	46.58
1981	461772	45.55	29.4	15707	613756	55.35
1991	701827	51.99	55.56	12632	845756	37.80
2001	845217	20.43	61.88	13659	1033562	22.21
2011	1034232	24.02	61.88	7292.03	1718880	44.28

Source: Adapted from (Census of India, 2011b; VGTM-UDA, 2011)

The population growth in the city was predominantly due to natural growth and in-migration from neighbouring villages. For example, during 1991-2001, VMC population accounted to natural growth was 53% and remaining 47% was due to in-migration (Vijayawada Municipal Corporation, 2006b). The present urban population of VMC is 1718880 (India Population, 2019)

4.3.5 Slums in Vijayawada

Vijayawada Municipal Corporation has 111 slums, out of which 20 falls under hazardous slums and the remaining 91 falls under non-hazardous category. The total area of the city is 61.88 sq.km and the slum area is estimated to be 9.27 sq.km. The slum population has grown from 1, 69,043 in 2001 to the present value of 4,51,231. Out of 111 slums, 58 slums are on state government land, 22 on private land, 27 on local body land and 4 are on railway land. It is observed that 81 slums are in residential area, 22 in commercial areas and eight are in institutional areas.

Table 4.5 Slums in Vijayawada

Sl. No.	Legal Status of slums	No. of slums	Population in slum		Area of slums		No. of households in slums	
			No. of person	Slum population in % terms of total population of slums	Area covered by slums in the city (Sq. km)	Slum area in % terms of Total area	No. of households in slums	Slum households in % terms of total number of households in slums
1	Notified Slums	111	4,51,231	100	9.27	14.98	82,115	100
2	Non-Notified Slums	0	0	0	0	0	0	0
	Total	111	4,51,231	100	9.27	14.98	82,115	100

Source: Rajiv Awas Yojana, 2014

For the detail study, ward level analysis is conducted through AMRUT data for water supply. This includes slum population, service coverage, per capita consumption of water for slums and urban households. On basis of this, slums located at different geographical locations of the city are selected in the meso-level analysis.

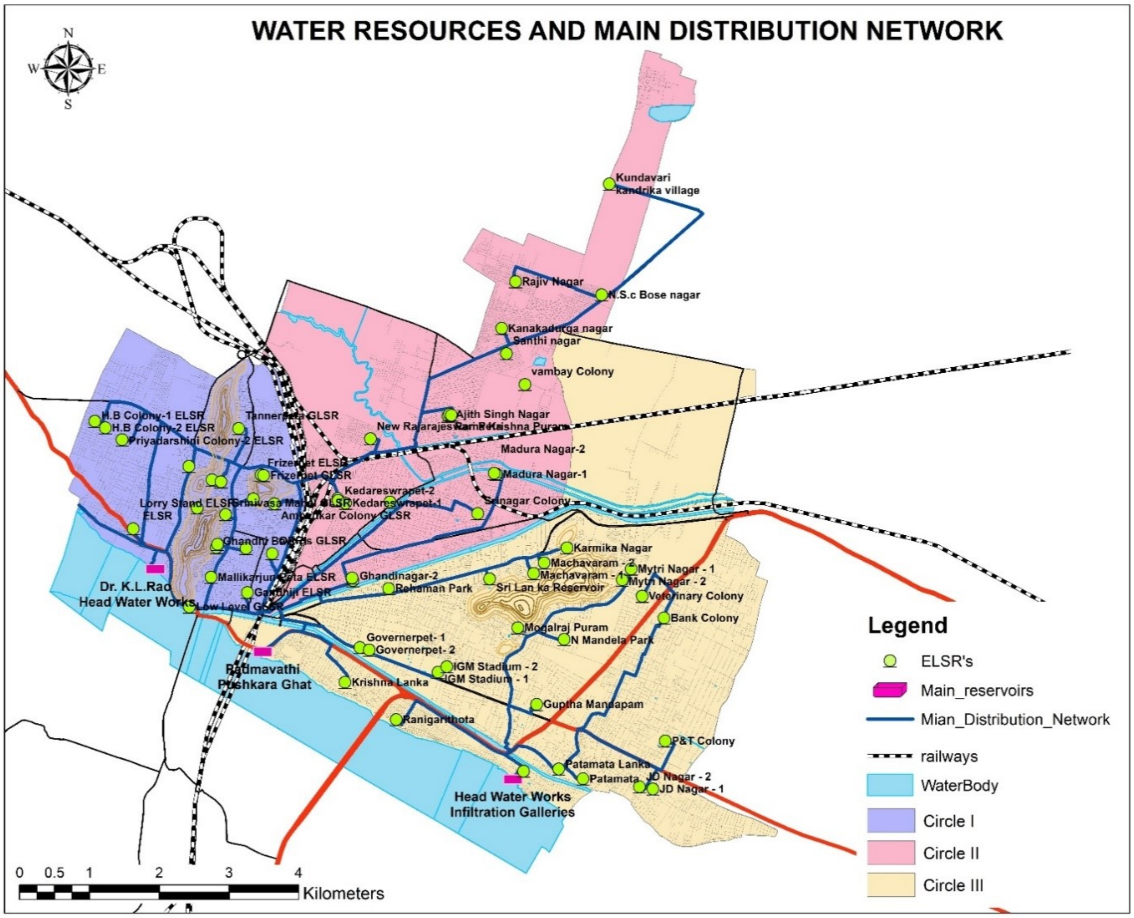
4.3.6 Water Supply Scenario in Vijayawada

Vijayawada is another city in India which is getting added to the metropolitan league in near future. The rapid urban sprawl and the ever-increasing population will demand for more resources. One of the major reasons is due to its proximity to the new capital city which is now an opportunity for the city to witness urban growth. The city is witnessing an inflow of people from all over the state and adjoining states through immigration. This in turn results in the ascending demand for the supply of water in the city. The city resides on the banks of river Krishna which add a great advantage to the city's water supply system. It has a huge availability of raw water to be treated and supplied to its whole population. With such a huge potential, the vision of the Vijayawada Municipal Corporation (VMC) in terms of water supply sector is to implement 24x7 supplies in the near future.

The main source of water supply to the city is the Krishna River from where the water is stored in three reservoirs namely Dr. K.L Rao Head Water Works, Padmavathi Puskar Ghat and Head Water Works Infiltration Galleries and supplied to the residents of the city. There is a total of 68 Elevated Level Service Reservoirs (ELSRs) located in different wards of the city's jurisdiction. The city has a storage capacity of 227.30 MLD. The total installed capacity of water supply system is 212.75 MLD out of which 206.00 MLD is working capacity. The net present supply is about 171.84 MLD. The total length of the pumping main is 224 Km and that of the distribution network is 2051 Km. It is projected that by 2021 another 5 lakh people will be added to the city and this will pressurize the present water infrastructure requirement in terms of distribution network, supply in percapita lpcd and coverage aspects. The total number of house service connections are estimated to be 1,25,707 out of which 75,231 are general and 41,938 are for the BPL families. This will further deprive not only urban HHs but also HHs residing in Slums.

The total numbers of public stand posts are 2892 and there about 2421 hand bores in the city. Even there are 56 power bores, 27 boosters and 52 booster pumping stations available in the city. Sixteen water tankers provide mobile water service around the city making 120 trips per day. Out of the total 125707 House service connections, only 8538 are metered connections. The Vijayawada Municipal Corporation area is divided into three water supply circles namely Circle I, Circle II and Circle III. Each circle comprises of combination of number of election wards. In circle I, the total number of assessments was 47568 and the total number of water connections is 31777 out of which 25923 are for general and 5854 are for BPL families. There is total of 2000 metered water connections in circle I out of which 1282 are residential, 621 are commercial and 97 are apartment connections. In circle II, the total number of assessments is 61788 and the total number of water connections are 47991 out of which 18213 are for general and 29778 are for BPL families. There is total of 1789 metered water connections in circle II out of which 973 are residential, 549 are commercial and 267 are apartment connections. In circle III, the total numbers of assessments are 79935 and the total numbers of water connections are 37401 out of which 31095 are for general and 6306 are for BPL families. There is total of 4749 metered water connections in circle II out of which 1874 are residential, 1793 are commercial and 1083 are apartment connections.

Distribution system is a network of pipelines that distribute water to the consumers. They are designed to adequately satisfy the water requirement for a combination of Domestic, Commercial, industrial and Fire fighting purposes. The distribution system should be capable of delivering adequate quantity of water under prescribed pressure to all the consumers to be serviced within the network system.In Circle I, the available length in the distribution network is 347.15 Km out of which 152.25 Km is damaged or deficient length. In Circle II, the available length in the distribution network is 269 Km out of which 65 Km is damaged or deficient length. In Circle III, the available length in the distribution network is 384.31 Km out and has no damaged or deficient length.



Map 4.4 Water resource and main distribution network

Source: Vijayawada Municipal Corporation, 2018

Some of the key issues identified in the water supply sector is water loss due to leakages & unauthorized connections was indicated on the higher side compared to the 15% limit as per bench mark. Only 50 per cent of the households are connected to the water supply system indicating a sizeable gap between the total number of properties and the number of house service connections. No initiative has been taken for reuse of wastewater and rain water harvesting.

VMC has 111 slums, out of which 20 falls under hazardous category and the remaining 91 falls under non-hazardous category. Presently, there are 111 notified slums in the city and the percentage of slum area covered in ULB is 14.98%. The Actual daily water supply in slums is 26.30 MLD. The number of House Service Connections in slum area is 33268. There are 2056 public stand posts, 19 power borewells and 1108 hand bores in the slums of the city. The length of water distribution network is 253 Km in the slums due to which 9% of the slum population remains unserved. 74% of the total slum households have individual water connection. It is observed that 100% of the population have water supply at a distance less than 0.5 km. 100% of the population have daily water supply.

Table 4.6 Water distribution source wise in Vijayawada

Source	No. of Household	Percentage
Own Tap	60,765	74.00
Public Tap	13,138	16.00
Outside Premises: Tube well/Bore well/Hand Pump	2,636	3.21
Inside Premises: Tube well/Bore well/Hand Pump	4,910	5.98
Open well	189	0.23
Water tanker	477	0.58

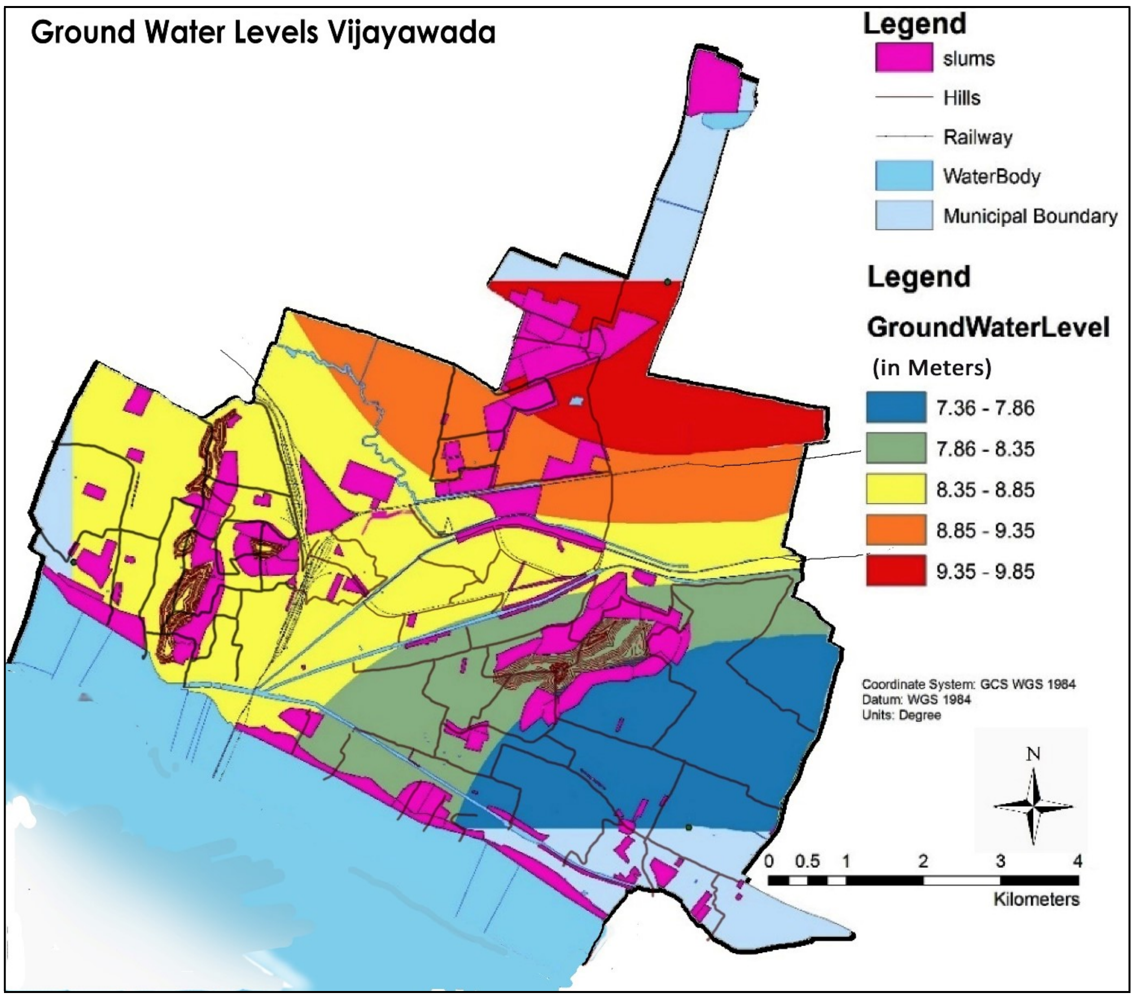
Source: Water Supply DPR, AMRUT, 2017

4.4 City Level Analysis

City level analysis is performed using AMRUT files of Vijayawada city. Refer annexure 2

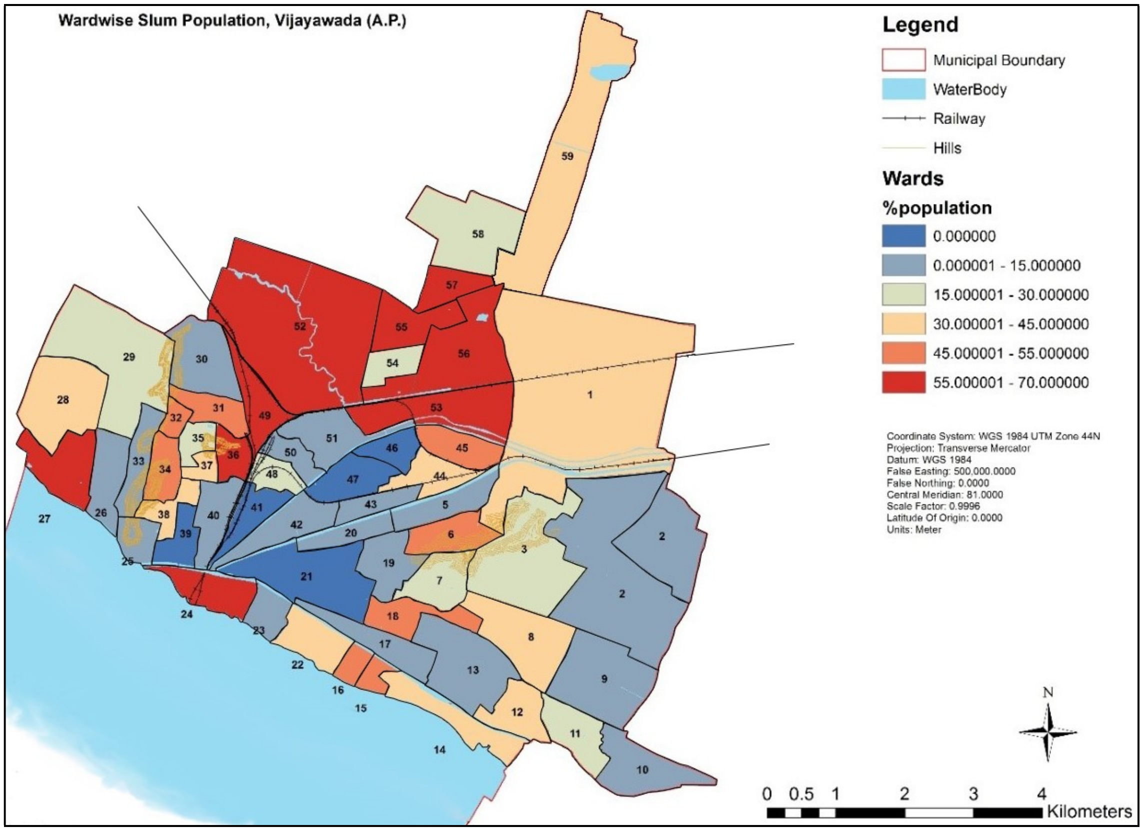
Groundwater levels of a city is an important characteristic to study the water scenario of the city. The city of Vijayawada has groundwater levels varying from 7.36 meters to 9.85 meters. Areas near the river bank (Krishna river) has a level of 7.36 meters. While the area far from the river such as Pyakapuram has a level as high as 9.36 meters.

It is evident that there is no exploitation of major ground water resources as the level of extraction seems to be normal in metro cities. but this may get further exploited considering the future urban growth scenario of the capital city. In order to generate the map average value of groundwater i.e. pre-monsoon and post monsoon has been considered. The secondary data collected from the department is used to extract the levels. Rani GariThota has a least depth of 7.36 meters. Slums falling in circle 3 of the city (as per water supply system) has an average value of between 8.35 to 8.85 meters.



Map 4.5 Ground Water Map Vijayawada city

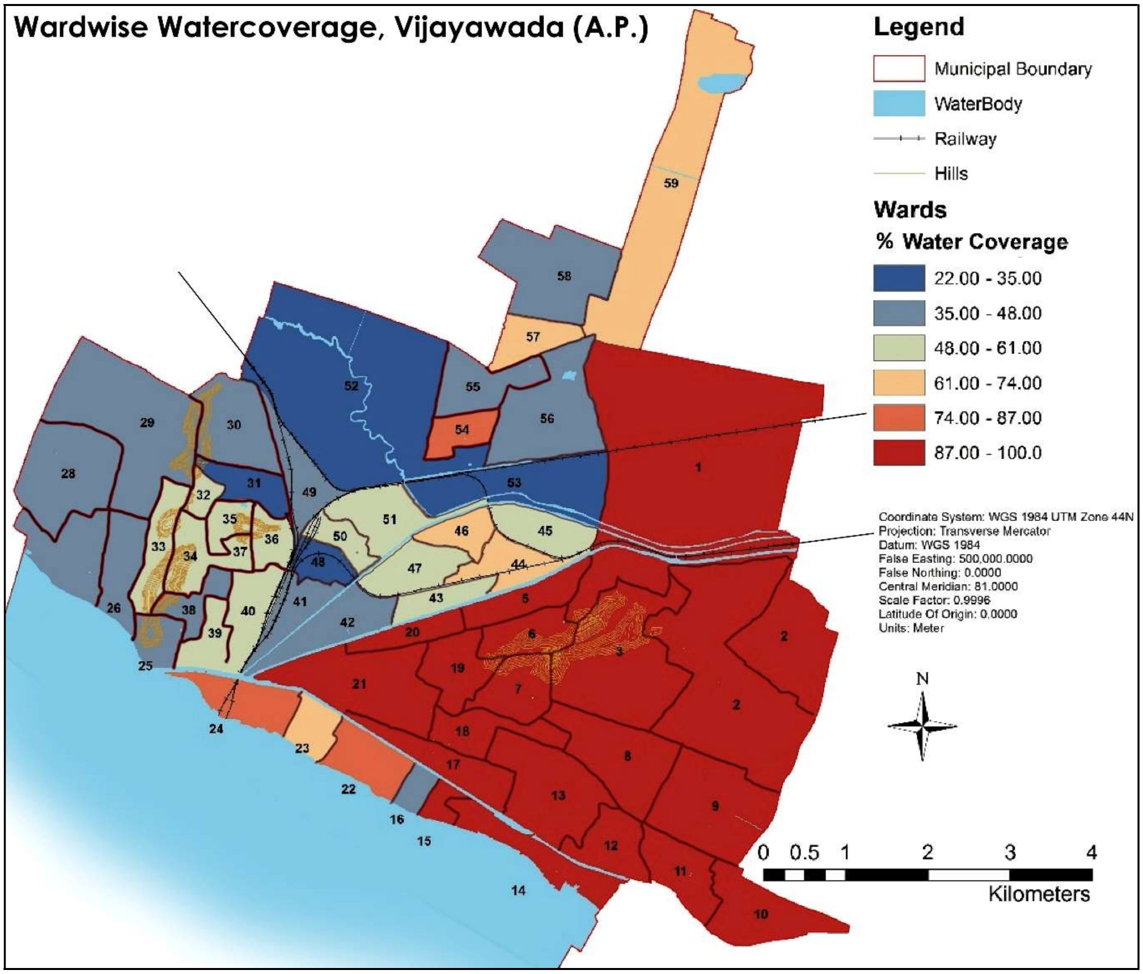
Source: AMRUT, 2018



Map 4.6 Ward wise Slum Population Map, Vijayawada

Source: AMRUT,2018

Vijayawada city has one among the highest slum population in India. The city has a total of 59 wards. Each ward has some amount of population residing in slums. The above given map was prepared by using the data from AMRUT file of Vijayawada city, which describes the slum population in the wards. The rationale for the slum population is taken as deprivation levels of slum population will be higher than urban population. The dependency on the alternative sources is always linked with the affordability of the household. This will help to analyse the issues faced due to lack of basic services by the people in those areas.

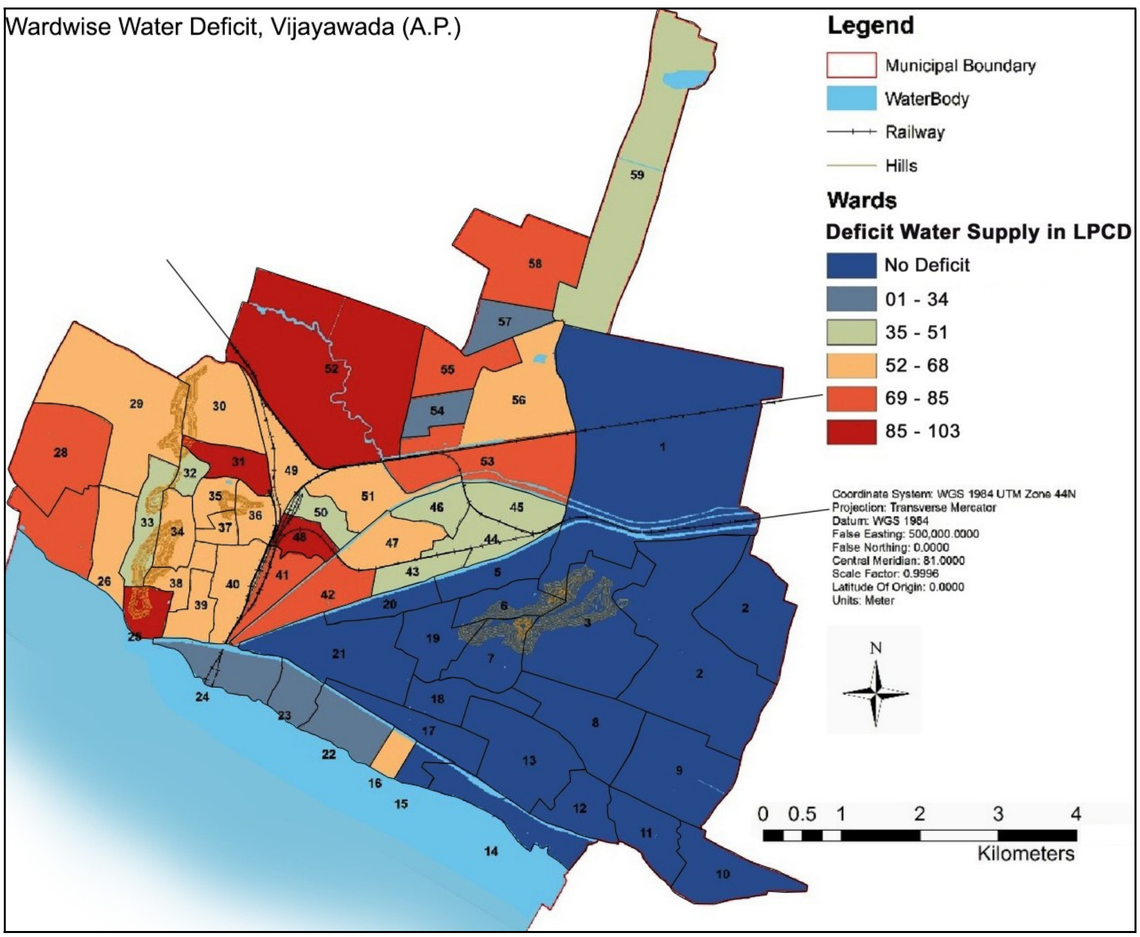


Map 4.7 Ward Wise water coverage Map, Vijayawada

Source: AMRUT, 2018

It was found that ward no. 57, 55, 52, 56, 53, 27, 36, 24 has the highest percentage of slum population, ranging from 55% to 70% of the total population residing in that wards. These wards may be considered to access the water situation in the respective settlements. Also, ward no. 31, 32, 34, 16, 15, 18, 06, 45 had a percentage of 45% - 55 % of total population residing in that wards. Ward no. 47, 46, 41, 23 and 39 had zero percentage of slum population.

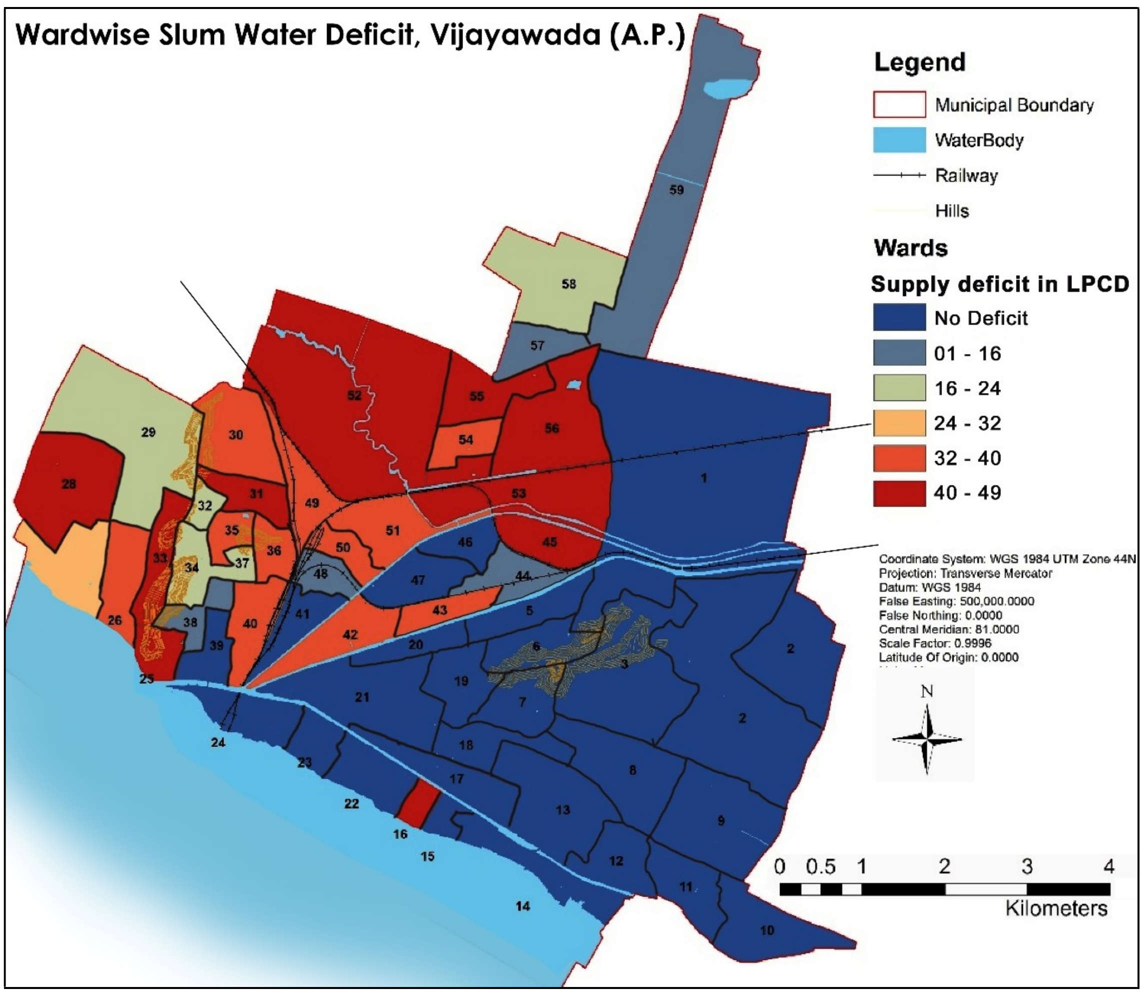
Water coverage is an important criterion to understand the water supply scenario of an area. Water coverage here is calculated by dividing water pipeline length of that area by the total road length of that area. It was found that ward no. 52, 53, 48 and 31 had least percentage of water coverage falling between the range of 22- 35 i.e. at maximum 35% of the area is covered with water supply connection. Falling on the range of 35-48% of water coverage are ward no. 58, 56, 55, 29, 30, 28, 27, 26, 25, 30, 38, 41, 42 and 16. It was also observed that circle 3 had maximum coverage of water supply ranging from 88- 100%, while the wards falling near the river has low water coverage in Circle 3.



Map 4.8 Ward wise water deficit map

Source: AMRUT, 2018

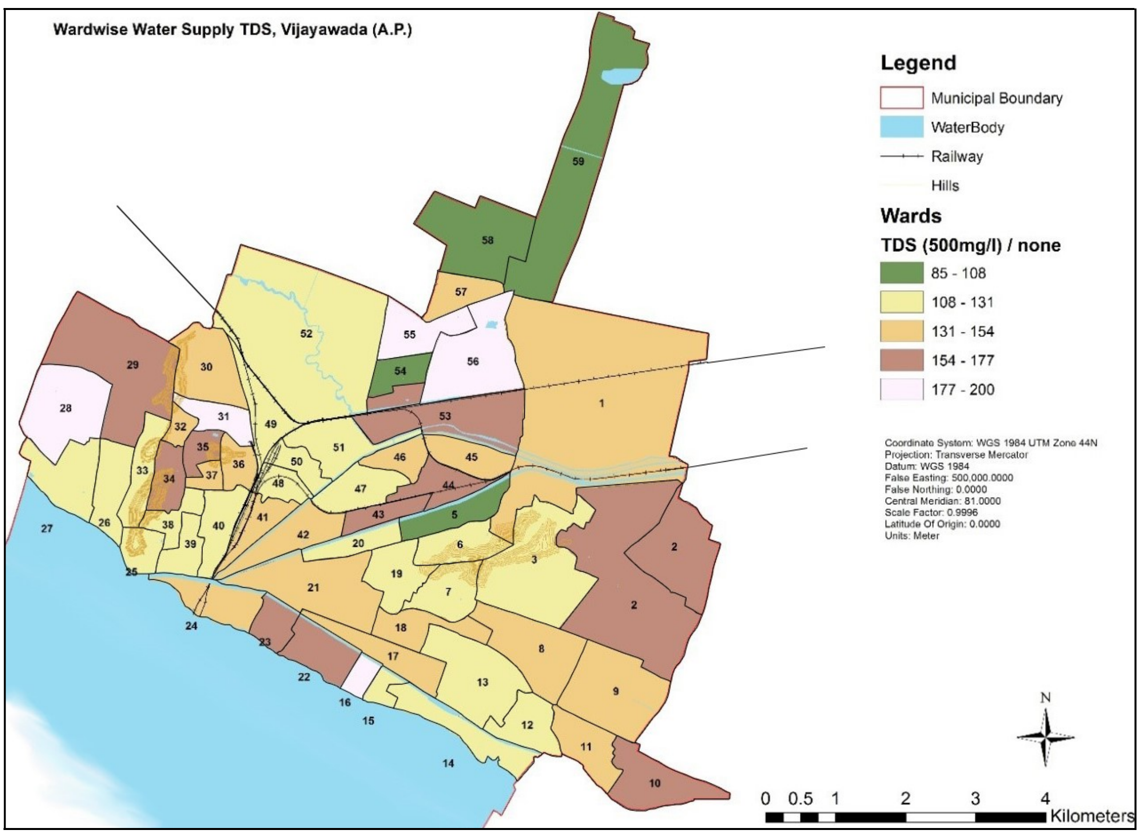
Water deficit of an area is directly proportional to water consumption. As per Indian standards a city should provide 145 lpcd of water to its citizen for their daily household chores. Water deficit here is calculated by subtracting water supplied by the corporation to the service level benchmark of 145 lpcd. It was found that ward no. 52, 31, 48, and 25 had a deficit ranging from 85-103 lpcd. Almost all the wards in circle 3 of the city had zero water deficit, except ward no. 16 ranging water deficit from 51-68 lpcd. Other wards falling in this range are as follows 56, 29, 30, 26, 34, 35, 37, 38, 39, 40, 36, 49, 51 and 47. Wards falling in the range 68-85 lpcd water deficit are 58, 55, 53, 41, 42, 28 and 27.



Map 4.9 Ward wise Slum water deficit, Vijayawada

Source: AMRUT, 2018

In order to calculate water deficit at slum level, a service level benchmark of 80 lpcd has been considered. For this calculation wards with zero slum population has been neglected. Ward no. 52, 55, 56, 53, 45, 31, 28, 25, 33 and 16 has the maximum deficit of 40-49 lpcd. While ward no. 54, 30, 26, 35, 36, 40, 42, 43, 50 and 51 falls in the range of 32-40 lpcd water deficit. This deficit areas will help to understand the poverty levels of the settlement as majority of the households will not able to meet the standards of water requirement. the resource availability, access, capacity, use and environments as components of water poverty directly gets reflected in this context. However, the degree of the severity of such components needs to be identified through proper assessment. Therefore, the slum water poverty index as a tool will be used to analyse the degree of severity of such components to conduct water assessments.



Map 4.10 Ward wise water TDS level, Vijayawada

Source: AMRUT, 2018

The above map represents the water quality levels across the city. This data is taken and mapped from the secondary sources. TDS level for the city was found to be well below the limit i.e. 500 mg/l throughout the cities. The water quality levels are within the acceptable ranges and it is inferred that most of the water supplied by the urban local body properly filters, maintains the water quality standards. But at the household levels, the quality needs to be assessed. As the city level data may not be contextualised to household level. The distribution network and the location of community taps may also influence the quality of water in the slum settlement. This will have impact on the components of water poverty.

Summary of Issues

The given maps help to highlight the most water affected wards in the city of Vijayawada. In order to calculate water poverty indicators used were Resource, Access, Capacity, Use and Environment. The data represented in maps above have used parameters within the given indicators to select the area to study within the city.

The above ward level analysis for the city level is conducted in the context of the five components so as to have the uniformity for identification of settlements at slum level. The analysis includes water coverage that includes the resource component, water deficit at ward level, ward wise slum water deficit, ground water availability that includes the access component, total dissolved solids (TDS) that includes the environment component. Since, the entire data was mapped on basis of secondary data available from the AMRUT scheme i.e. a centralised scheme of Government of India (GoI). The additional parameter Capacity and Usage was not included due to non-availability of data at ward level.

Parameters used are as follows

4.4.1 RESOURCE

- **Water coverage**

Water coverage has been calculated by diving the length of water supply pipeline in the wards to the length of the road in the given wards. The calculated value i.e. the shortage in water coverage has been converted in percentage of the coverage and the map has been generated using Arc GIS. (map no. 4.6)

It was found that ward no. 52, 53, 48 and 31 had least percentage of water coverage falling between the range of 22- 35 i.e. 35% of the area is covered with water supply connection. Falling on the range of 35-48% of water coverage are ward no. 58, 56, 55, 29, 30, 28, 27, 26, 25, 30, 38, 41, 42 and 16. It was also observed that circle 3 had maximum coverage of water supply ranging from 88- 100%, while the wards falling near the river has low water coverage in Circle 3.

4.4.2 ACCESS

- **Water Deficit at ward level:**

Water deficit is an important criterion to understand the deficit of water within the wards when compared with the service level Benchmark of 145 lpcd. The given data of water availability has been taken from AMRUT files of water supply system in Vijayawada. Water deficit is calculated by Subtracting the service level benchmark of 145 lpcd with the water availability per capita of the ward.

It was found that ward no. 52, 31, 48, and 25 had a deficit ranging from 85-103 lpcd. Almost all the wards in circle 3 of the city had zero water deficit, except ward no. 16 ranging water deficit from 51-68 lpcd. Other wards falling in this range are as follows

56, 29, 30, 26, 34, 35, 37, 38, 39, 40, 36, 49, 51 and 47. Wards falling in the range 68-85 lpcd water deficit are 58, 55, 53, 41, 42, 28 and 27.

- **Slum Water Deficit:**

Service level benchmark for minimum water requirement of slum has been taken as 80 lpcd. Water Availability in slums has been than subtracted by service level benchmark of 80 lpcd.

For this calculation wards with zero slum population has been neglected. Ward no. 52, 55, 56, 53, 45, 31, 28, 25, 33 and 16 has the maximum deficit of 40-49 lpcd. While ward no. 54, 30, 26, 35, 36, 40, 42, 43, 50 and 51 falls in the range of 32-40 lpcd water deficit.

- **Groundwater Availability:**

Groundwater is an important clean water, alternative source of water supply for an area and can be harnessed using borewell, Open well or hand pumps. Other alternative sources being surface water resources such as river, ponds, canals, etc. Average groundwater level for the city of Vijayawada is 8.6 metres (depth of groundwater). Majorly wards near to the river Krishna have least depth of 7 meters. Wards being 14, 15, 16 22, 23, 24 falls in the vicinity to river Krishna. While the wards at farther distance from the river have a maximum ground water depth of more than 9 meters, wards being 55, 54, 56, 57 etc.

4.4.3 ENVIRONMENT

- **TDS of water:**

Environment cover the chemical and physical characteristics of water used by the people. Also, it has a parameter that identifies the water treatment at household level to use water especially for drinking purposes. In order to understand the environmental aspect of the water TDS levels of the water supplied to the wards were analysed with the service level benchmark of <500 mg/l.

TDS level for the city was found to be well below the limit i.e. 500 mg/l throughout the cities. The water supplied by the corporation was only taken in consideration to understand the TDS levels. Alternative source was not seen for the same.

Other parameters used were:

- **Slum population:**

Percentage of slum population in the wards helps to understand the importance of the slum. The demographic data of the slum population was collected from Municipal Corporation for the year 2011 (Census 2011). The available slum population has been represented in the form of percentage to that of the total population residing in the ward.

It was found that ward no. 57, 55, 52, 56, 53, 27, 36, 24 has the highest percentage of slum population, ranging from 55 to 70% of the total population residing in that wards. Also, ward no. 31, 32, 34, 16, 15, 18, 06, 45 had a percentage of 45-55 % of total population residing in that wards. Ward no. 47, 46, 41, 23 and 39 had zero percentage of slum population. Use and Capacity were not involved in the above analysis as they are to be studied at the slum settlement level.

4.5 Rational for Case Area Selection

Wards with Zero slum population were neglected for consideration to study. These wards were: 47, 46, 41, 21, 39. While wards with slum population more than 50% of the total population residing in the wards has been given prime importance. For all the parameters selected to conduct city level analysis, **Wards with 50% or >50%** of the value has been considered for selection. Ward no. 52 was the most affected **ward in terms of water deficit** at ward and slum level. Also, it has maximum percentage of slum population and minimum amount of water coverage among all the wards.

Following this ward. Ward no. 31 had slum population more than 50% of the total population residing in that ward. Also, it has a water deficit (ward and slum level) and water coverage equals to that of ward 52.

Ward no. 53 falls in the same category of slum population as that of ward 52. **Water coverage** for the ward is same as that of ward 52 and 31. Although the ward does not have ward level water deficit value more than 50%. But, the slum water deficit value of the ward occurred in the range that of ward 52 and 31.

Other wards selected are as follows:

55, 56 (Slum water deficit and slum population in range similar to the ward 52, while water coverage and ward water deficit is more than 50%)

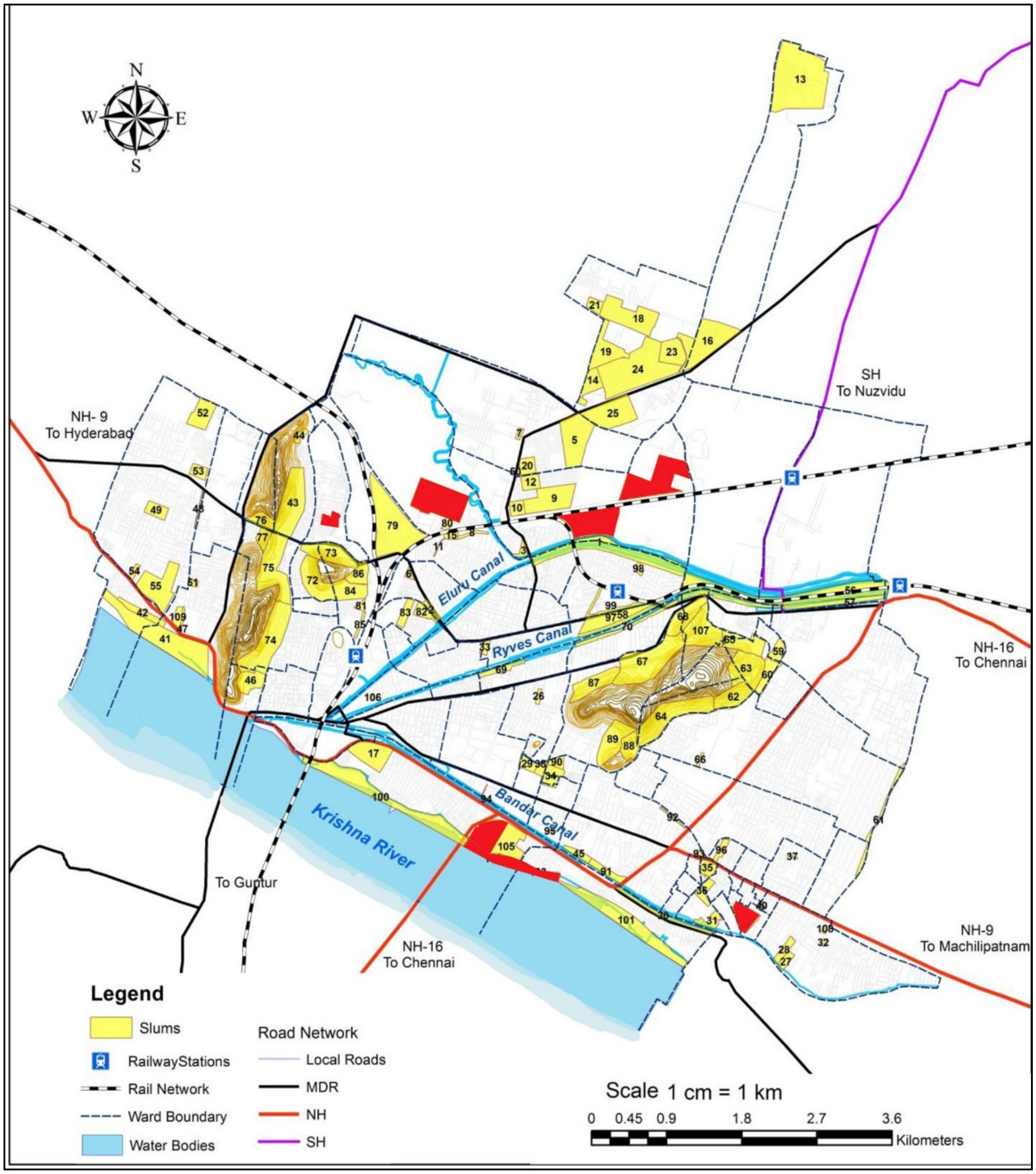
16, 28 (ward wise water deficit is similar to ward 52, 55, 56 and 31. Have a slum population more than 50% of the total population, water coverage falling in the range of 31, 55 ward).

The identified slums from the city level analysis were, 52, 31, 55, 56, 16 and 28.

After the identification of wards with major issues in water supply (more slum population, less coverage, less consumption) etc. A perspective survey was carried out in the slums of the selected wards. The survey took place with a set of question regarding resource, access, Use, capacity and environment. After carrying out the survey and analysing the data from the perspective survey slums were identified. Refer Annexure 2

Selected slums are as follows:

1. Ranigari Tota, Chalasani nagar Ward no. 16
2. Ranigari Tota, North river bund Ward no. 16
3. Devinagar Slum Ward no. 53
4. K.L. Rao nagar Slum Ward no. 31
5. Vambay Colony Ward no. 56
6. New Raja Rajeshwari Ward no. 52
7. Santhinagar, Payakapuram Ward no. 55



Map 4.11 Selected Slums, Vijayawada

Source: Author, 2018

4.6 Introduction to Slums

4.6.1 Socio-Economic profile of the identified slums

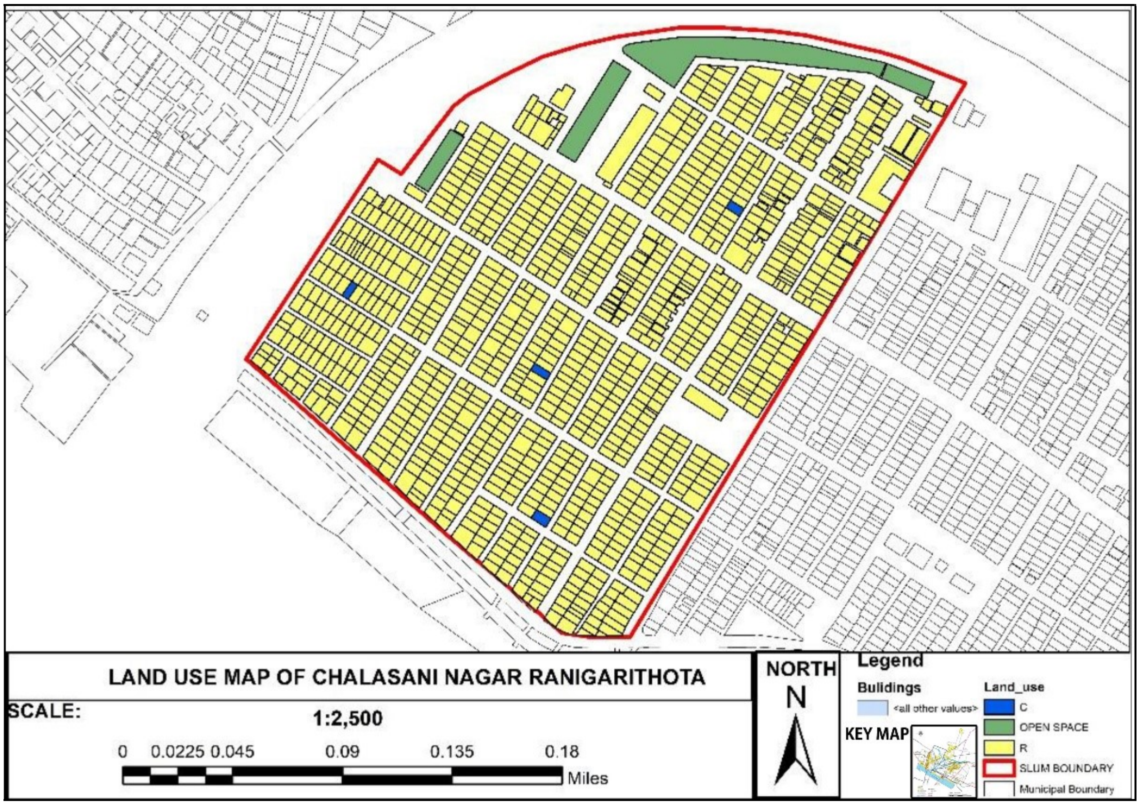
Table 4.7 Socio-economic profile of identified slums in Vijayawada

Name of the Slum	*Chalasani Nagar RaniGari Tota*	*Rani GariThota River Bund low level North*	*Devinagar*	*K.L.Rao*	*Vambay Colony*	*New Raja Rajeshwari peth*	*Santhinagar Payakapuram*
Location	Krishnalanka	Bapanayyanagar	Devinagar	Chittinagar	Vambay colony	Raja Rajeshwari peta	Payakapuam
Spatial location	Near River	Near River	Near Industry	Near Railway station	Near Railway Track	Near Railway Station	Near hill
Type	Notified	Notified	Notified	Notified	Notified	Notified	Notified
Tenability	Non-hazardous slum	Non-hazardous slum	Non-hazardous slum	Non-hazardous slum	Non-hazardous slum	Non-hazardous slum	Non-hazardous slum
Area(ha)	10.76	10.76	16.64	3.56	27.09	27.09	16.56
Population	6733	1582	3693	2232	10165	9691	6484
No of HH	1840	448	1101	628	2314	2794	1919
HH size	4	4	4	4	5	4.5	4
Dominate Class	BC	ST, SC	ST, SC	ST, SC	ST, SC	ST, SC	ST, SC
Owned houses	1147 (63%)	93 (21%)	542 (49%)	396 (63%),	1057 (36%)	1378 (49%)	1225 (64%)
Tenant Houses	693 (37%)	349 (79%)	559 (51%)	232 (37%).	1875 (64%)	1407 (51%)	694 (36%)
Predominant land use	Residential	Residential	Residential	Residential	Residential	Residential	Residential
Sanitation facilities	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Type of Drainage	Open	Open	Open	Open	Open	Open	Open

Source: Slum free city, Vijaywada, 2015

4.7 Water scenario of Slums

4.7.1 Chalasani nagar Ranigarithota



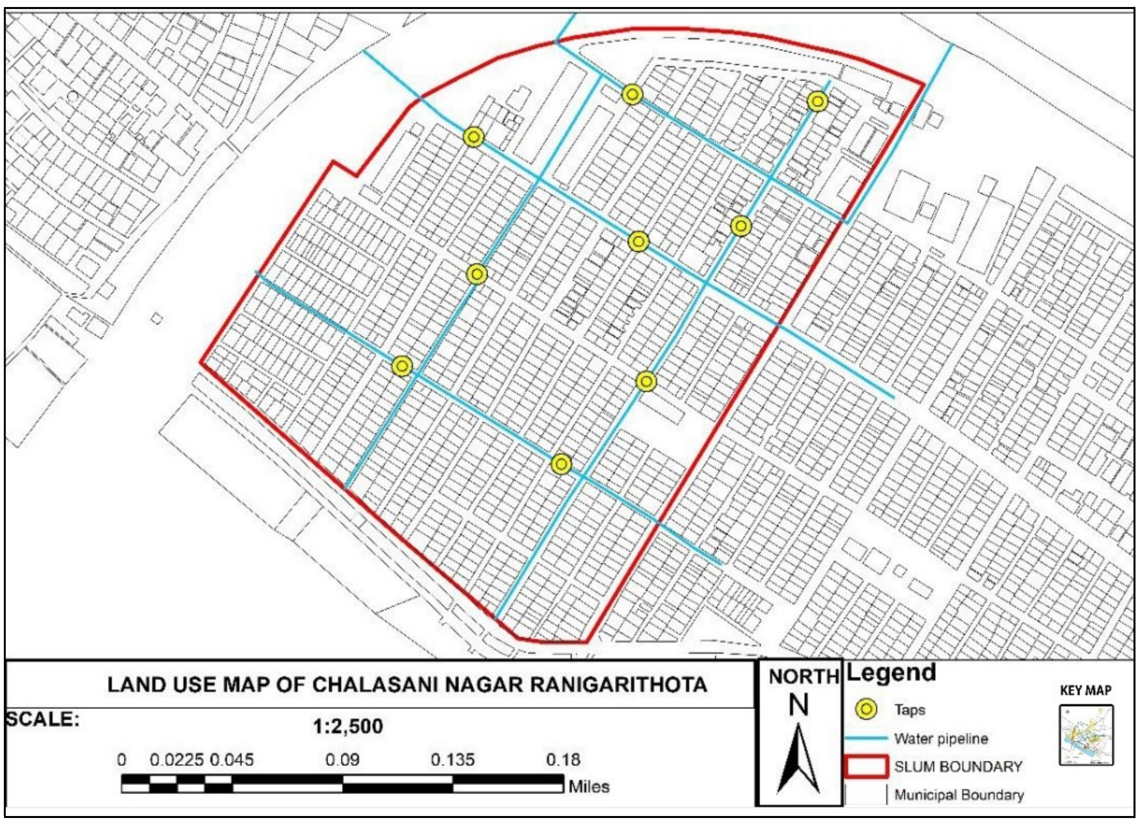
Map 4.12 Land Use map Ranigari Thota Chalasani Nagar

Source: Author, 2018

On the basis of the rational, slums were prioritised to conduct final surveys for identifying SWPI of the settlement. The slum had problems in Quality of water, Quantity of water and accessibility. Lacking in all the factors and in reaching their threshold, the slums is one of the prime locations to conduct detailed survey. Out of all the household, 324 i.e. 17% does not have access to tap water in approachable distance.

Figure 4.3 Performing water quality test and discussion with Slum HHs

4.7.1.1 Water Scenario



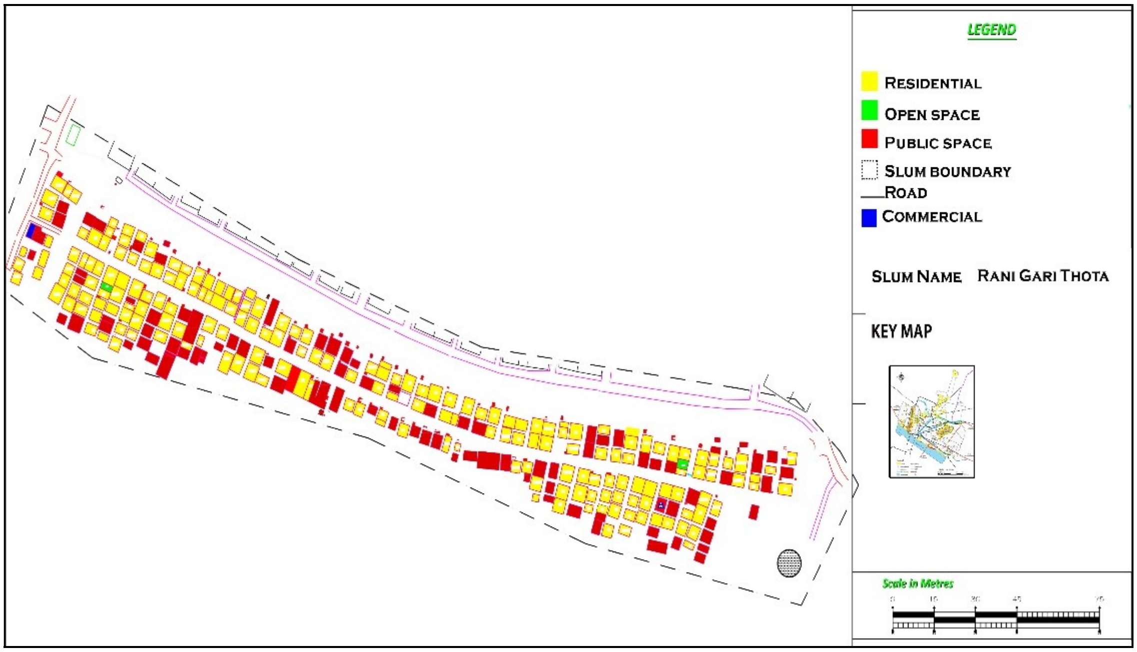
Map 4.13 Water supply map Ranigari thota Chalasani Nagar

Source: Author, 2018

Water infrastructure is a major problem identified in the slum both by primary and secondary data collection and analysis. Major source of water for the slum is through piped water system. A total of 969 i.e. 52% households have own tap, while 309 i.e. 48% depends on public taps. 101 houses get water once in two days, while 38 houses get water once in a week. Also, 52% of the household receive muddy water once or twice a week. While almost all the houses receive muddy water during monsoon season, which increases their vulnerability to health-related issues especially in monsoon seasons. This impacts the household income as the expenses will be more towards health expenditure. Household rely on household level treatment for purifying water such as filtration, boiling water for drinking purpose and also adding alum to water in order to clean the water.

Figure 4.4 Community tap connections

4.7.2 Ranigarithota river bund low level north



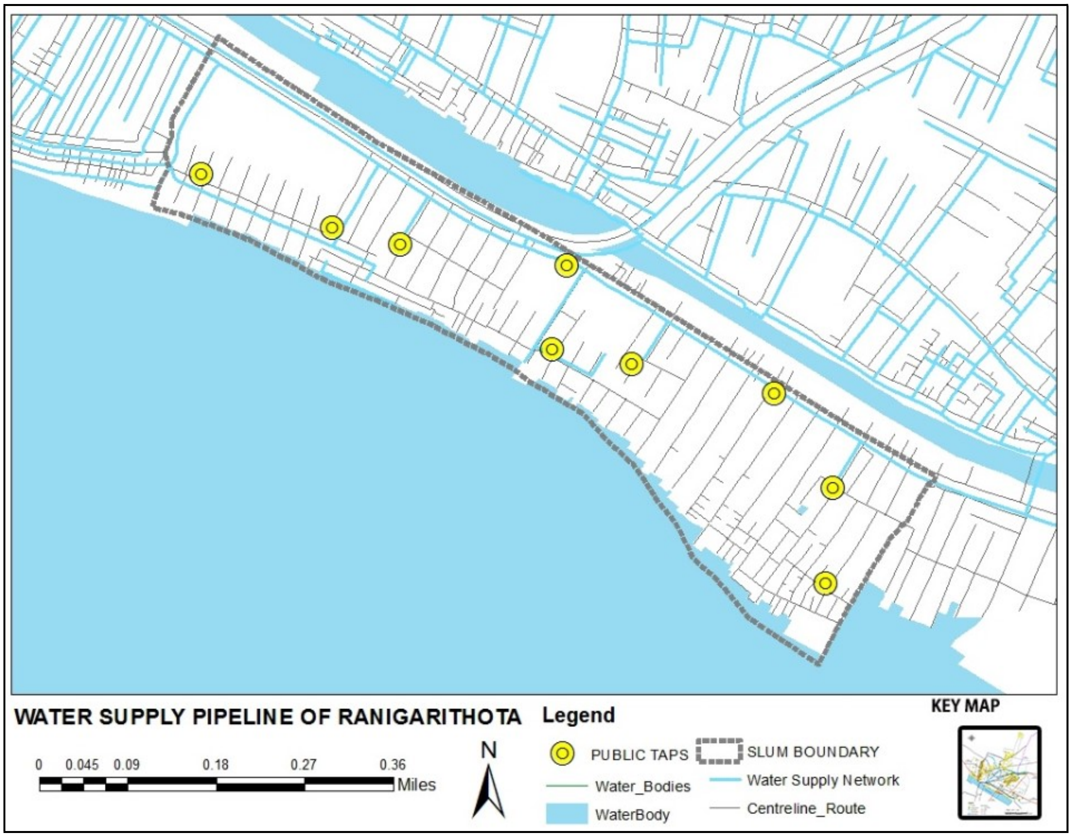
Map 4.14 Land use of RanigariThota,

Source: Author, 2018

4.7.2.1 Water Scenario:

Water infrastructure is a major problem identified in the slum both by primary and secondary data collection and analysis. A total of 35 i.e. 8% households have own tap, while 321 i.e. 72% depends on public taps and 92 i.e. 20% households depend on bore water. 15 houses get water once in two days, while 04 get once in a week. Also, 40% of the household receive muddy water once or twice a week.

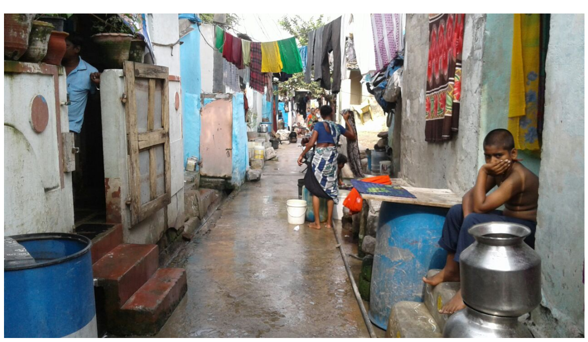
Figure 4.5 Women standing in queue to access water



Map 4.15 Water supply pipeline of RanigariThota.

Source: Author, 2018

While almost all the houses receive muddy water during monsoon season, which increases their vulnerability to health-related issues especially in monsoon seasons. Household rely on household level treatment for purifying water such as filtration, boiling water for drinking purpose and also adding alum to water in order to clean the water.



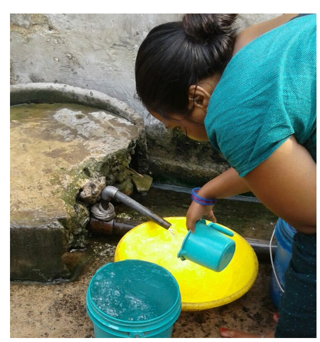
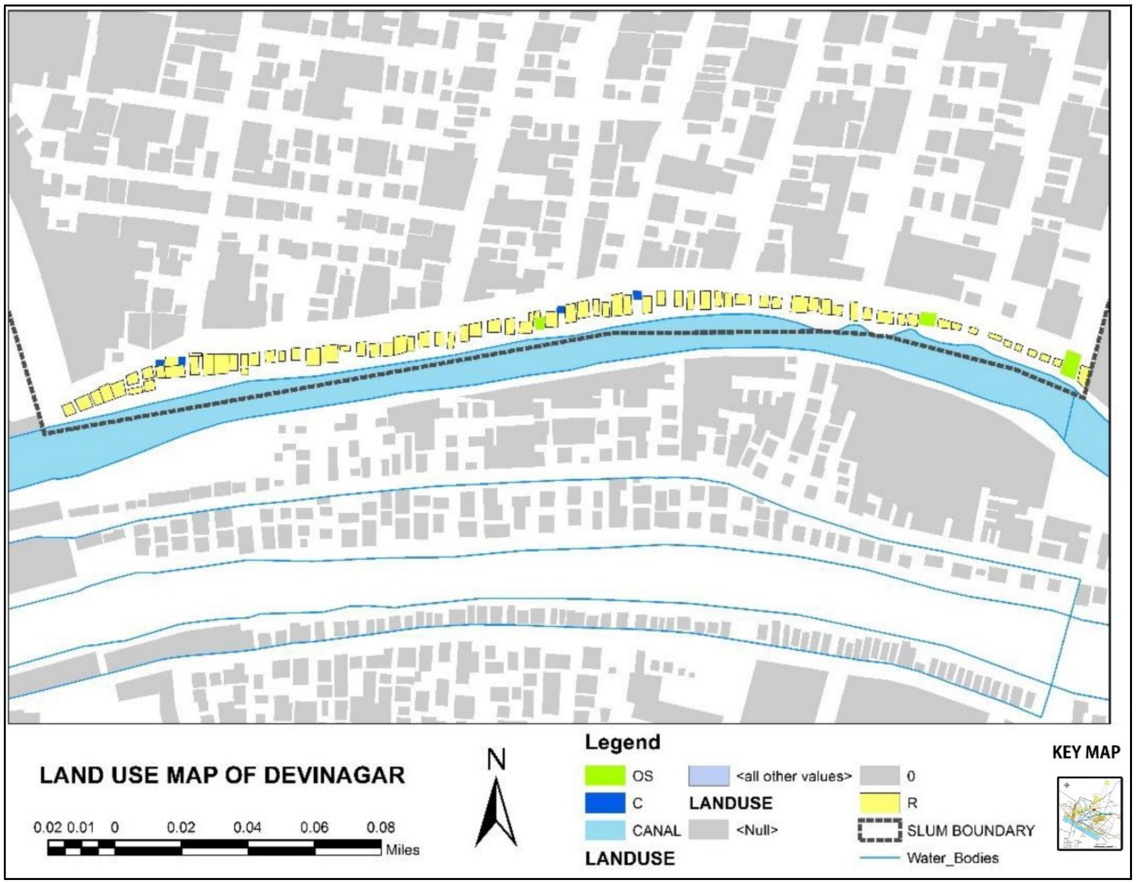


Figure 4.6 No Proper community taps & Figure 4.7 Location of storage tanks along the street

4.7.3 Devinagar



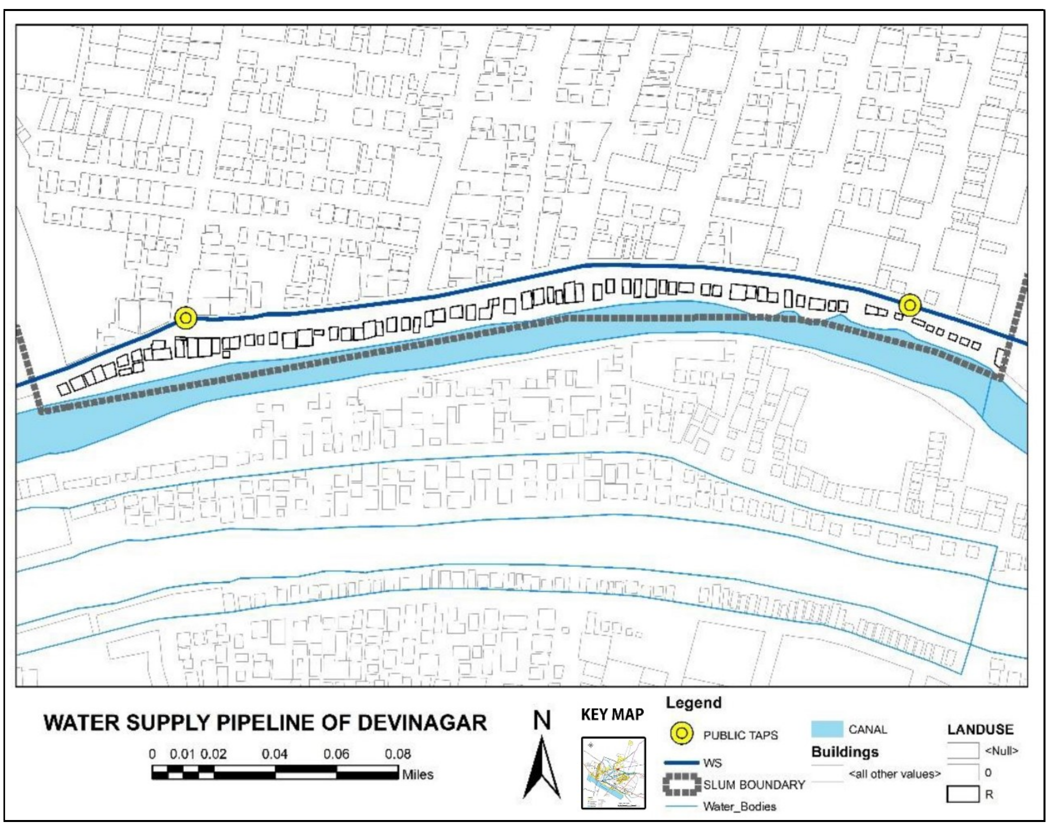
Map 4.16 Devinagar Land Use Map

Source: Author, 2018.

Figure 4.8 Interaction with the group & Figure 4.9 Use of hand pump as Alternative source

4.7.4 Water Scenario

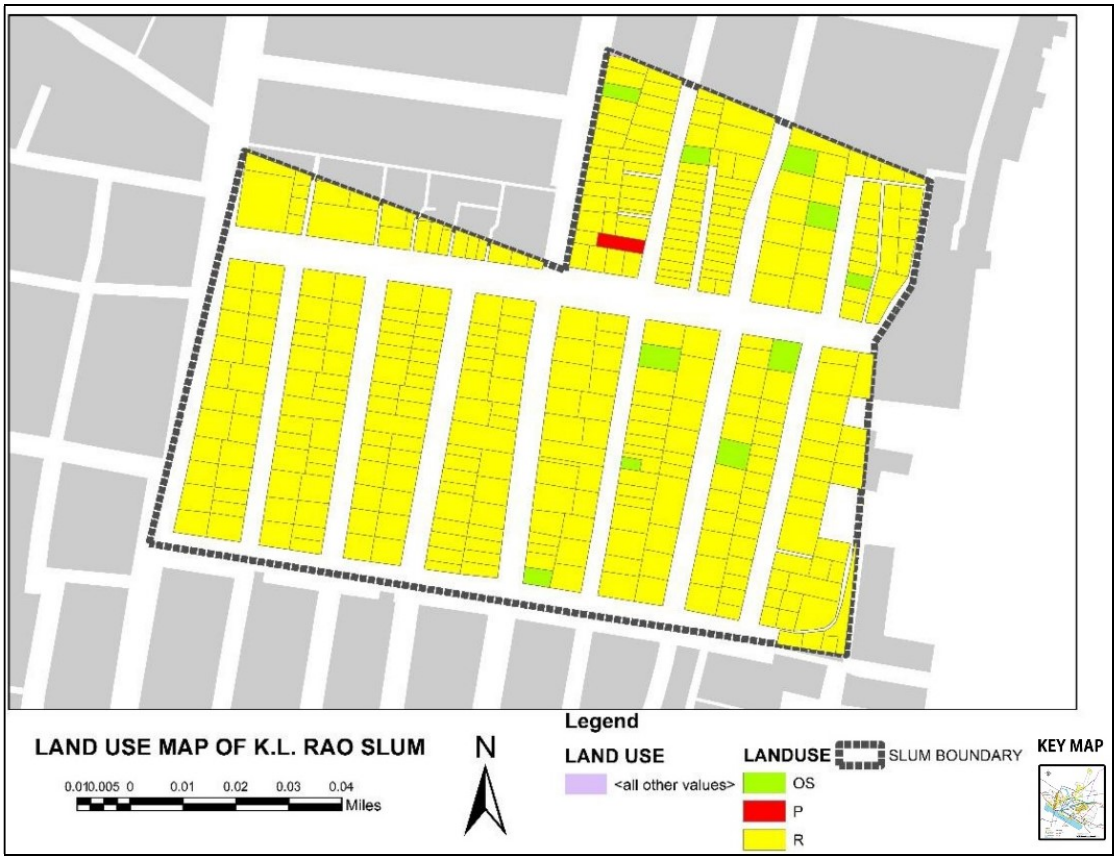
Water infrastructure is a major problem identified in the slum both by primary and secondary data collection and analysis. Out of all the household, 95 does not have access to tap water in approachable distance. Major source of water for the slum is through piped water system. A total of 683 i.e. 62% households have own tap, while 418 i.e. 38% depends on public taps. 07 houses get water once in two days, while 54 get once in a week. 35% of the household receive muddy water once or twice a week. While almost all the houses receive muddy water during monsoon season, which increases their vulnerability to health-related issues especially in monsoon seasons. Household rely on household level treatment for purifying water such as filtration, boiling water for drinking purpose and also adding alum to water in order to clean the water.



Map 4.17 Devinagar Water supply map

Source: Author, 2018

4.7.5 K.L.Rao

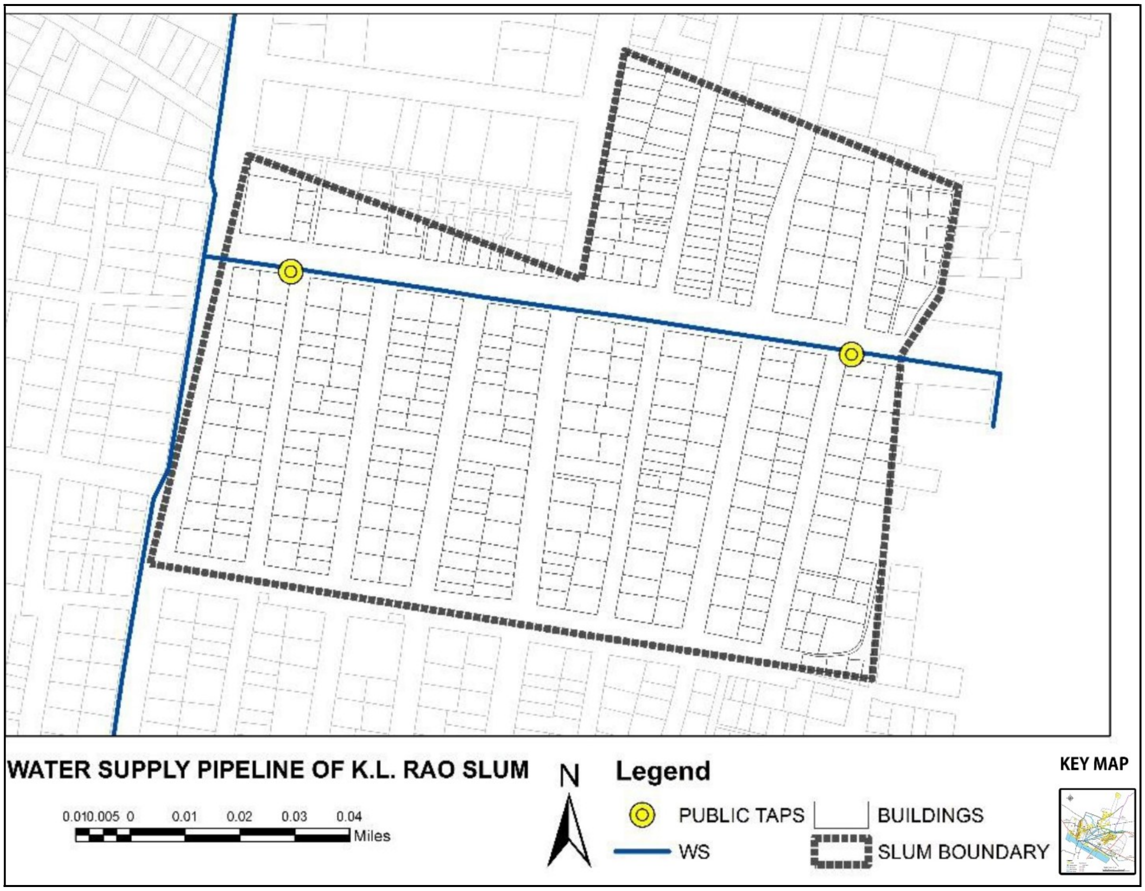


Map 4.18 KL Rao Slum Land use map

Source: Author, 2018

4.7.5.1 Water Scenario

Water infrastructure is a major problem identified in the slum both by primary and secondary data collection and analysis. Major source of water for the slum is through piped water system. A total of 423 i.e. 67% households have own tap, while 205 i.e. 33% depends on public taps. 01 houses get water once in two days, while 03 get once in a week. 45% of the household receive muddy water once or twice a week. While almost all the houses receive muddy water during monsoon season, which increases their vulnerability to health-related issues especially in monsoon seasons. Household rely on household level treatment for purifying water such as filtration, boiling water for drinking purpose and also adding alum to water in order to clean the water.



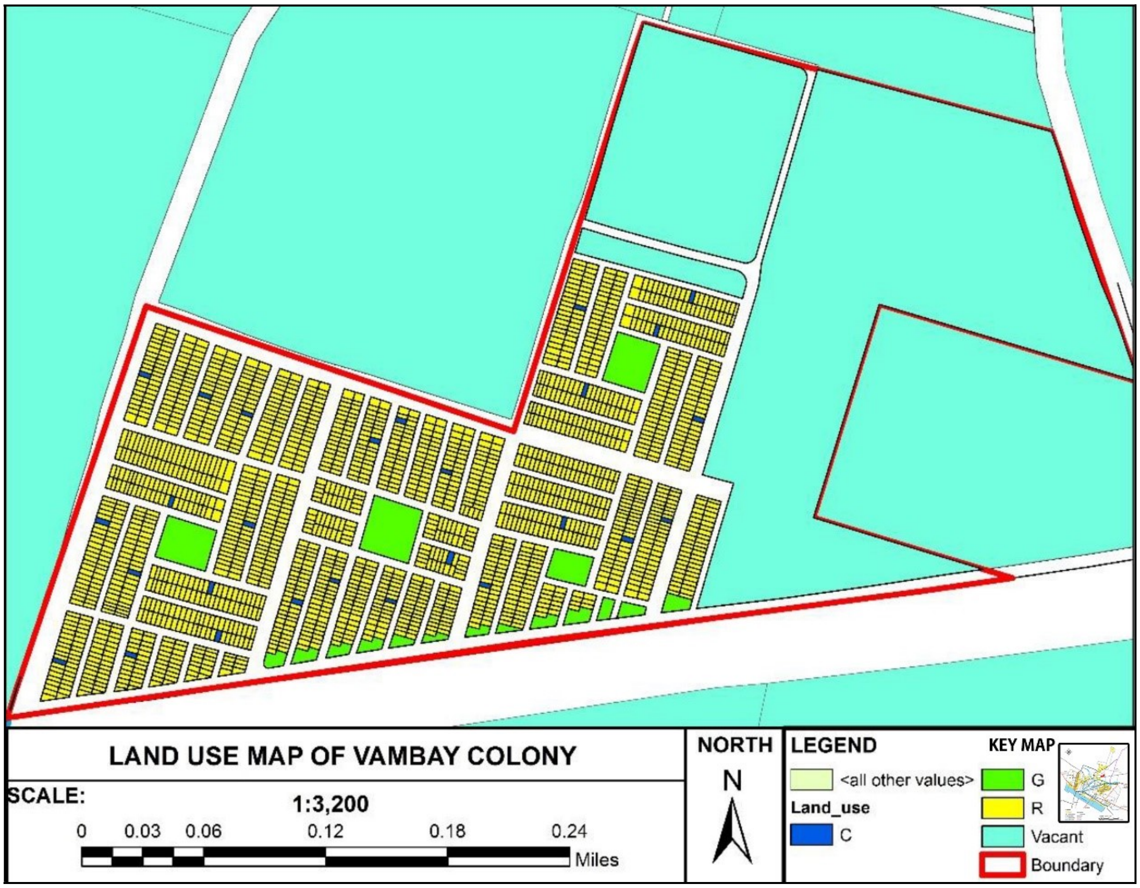
Map 4.19 Water Supply network of K.L Rao Nagar

Source: Author, 2018

Figure 4.10 Focus group discussion with slum HHs

Figure 4.11 Performing Water Quality Test

4.7.6 Vambay Colony



Map 4.20 Vambay Colony Land use map

Source: Author, 2018

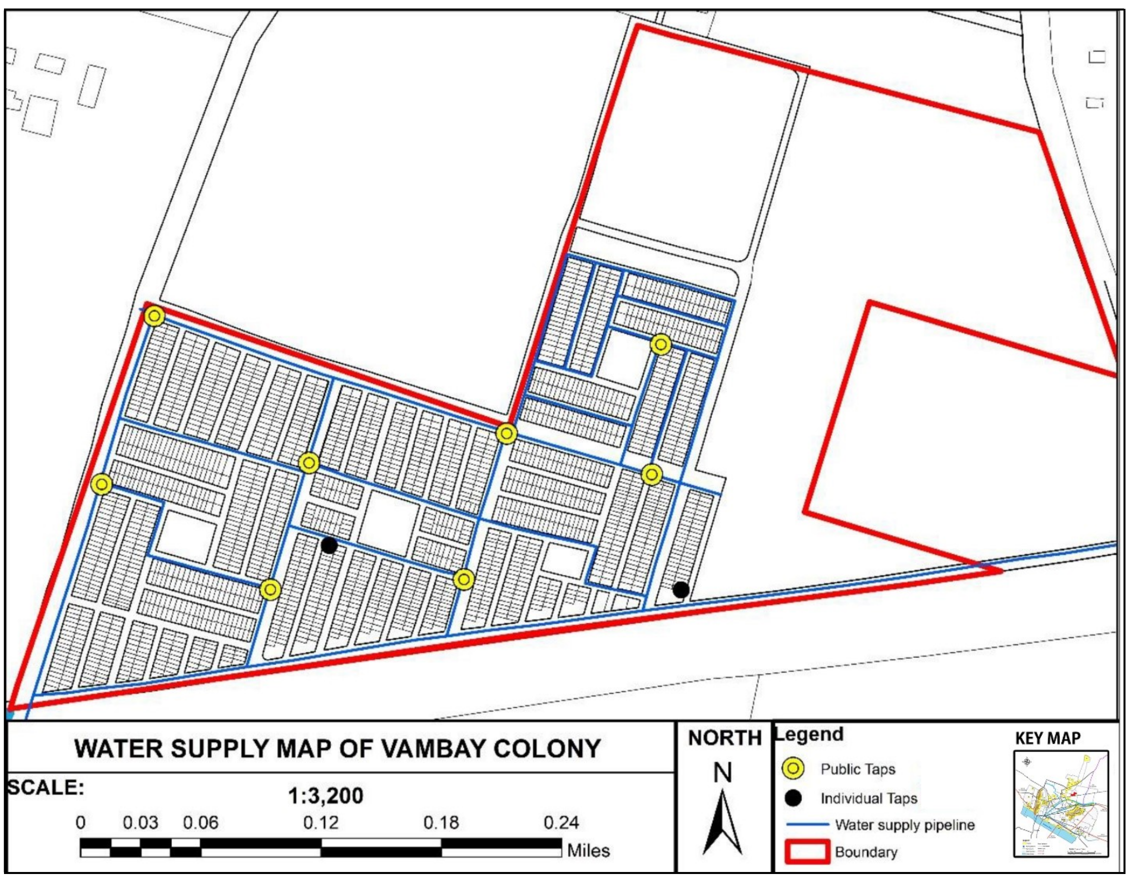
The household size of the slum is 5. The slum is majorly dominated by backward class population followed by Other backward castes, schedule caste and schedule tribe.

4.7.6.1 Water Scenario

Water infrastructure is a major problem identified in the slum both by primary and secondary data collection and analysis. Major source of water for the slum is through piped water system. A total of 1857 i.e. 80% household have own tap, while 457 i.e. 20% depends on public taps. 06 houses get water once in two days, while 30 get once in a week.

Figure 4.12 Water quality test conducted in slum

Figure 4.13 Location of storage tanks

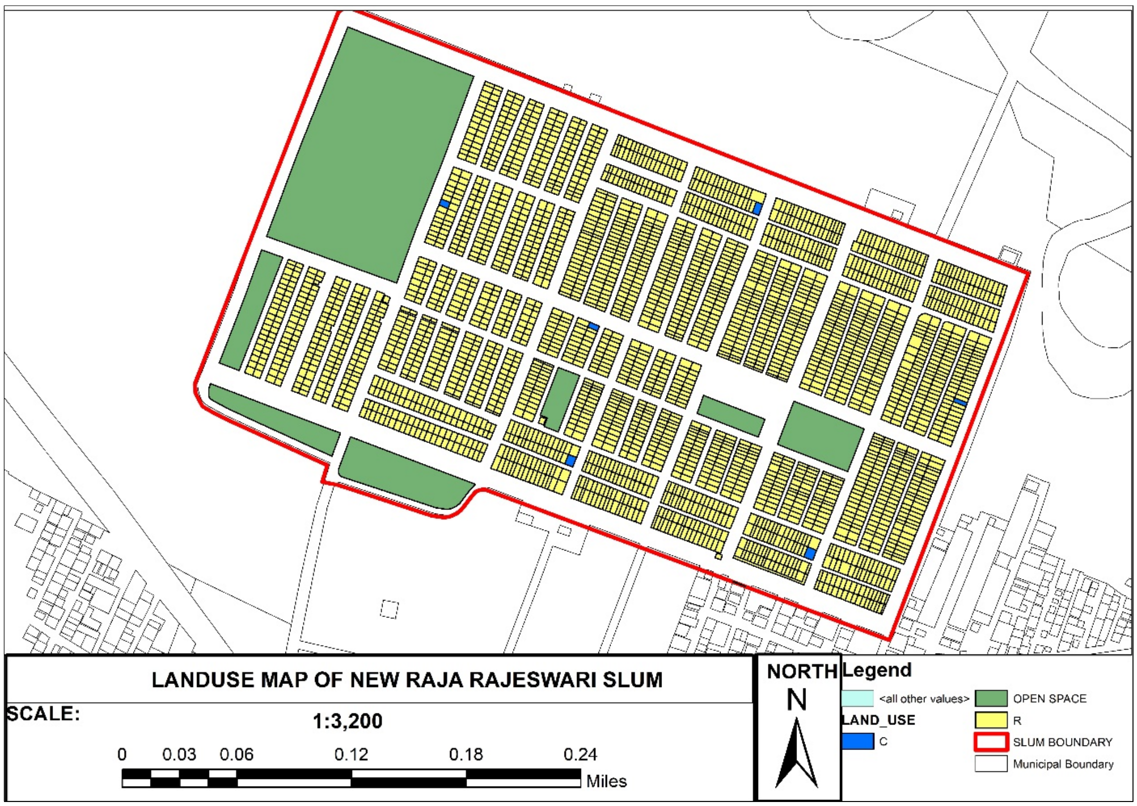


Map 4.21 Vambay Colony Water supply map

Source: Author, 2018

Also, 43% of the household receive muddy water once or twice a week. While almost all the houses receive muddy water during monsoon season, which increases their vulnerability to health-related issues especially in monsoon seasons. Household rely on household level treatment for purifying water such as filtration, boiling water for drinking purpose and also adding alum to water in order to clean the water.

4.7.7 New Raja Rajeshwari peth



Map 4.22 Land use Map New Raja Rajeshwari Peth

Source: Author, 2018

Figure 4.14 Collection of water

Figure 4.15 Quality test of water cans

4.7.7.1 Water Scenario

Water infrastructure is a major problem identified in the slum both by primary and secondary data collection and analysis. Major source of water for the slum is through piped water system.

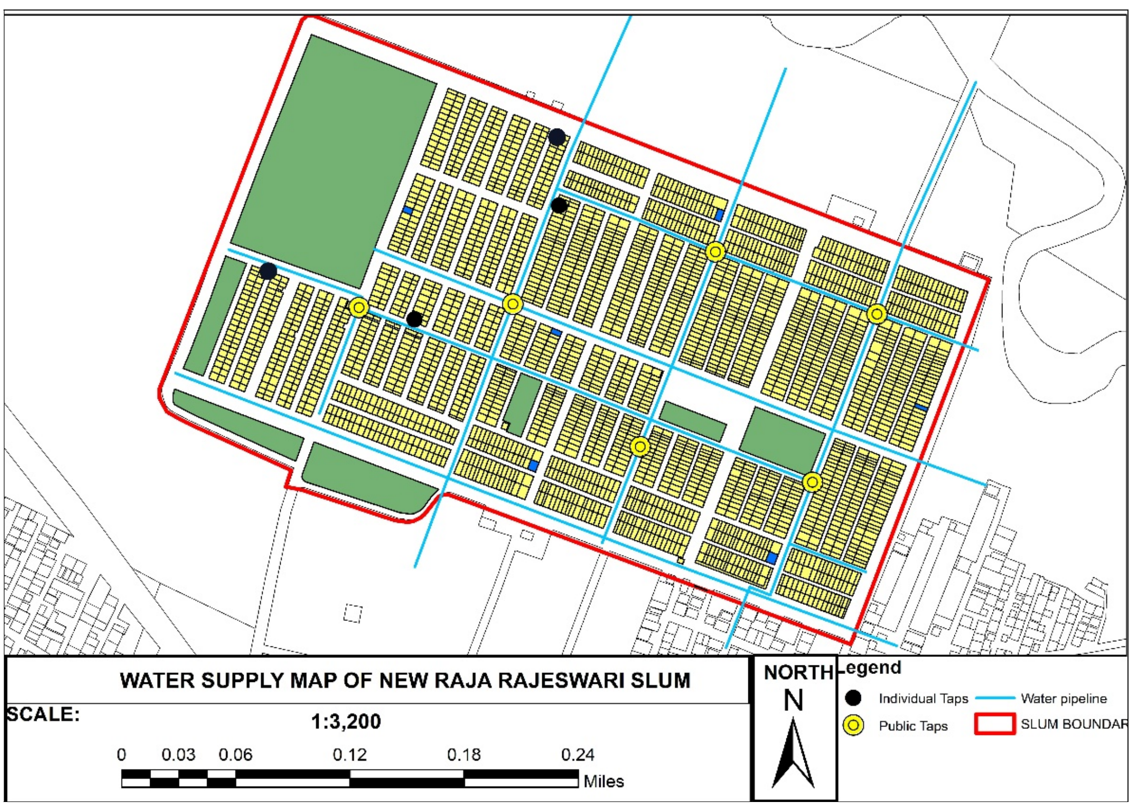
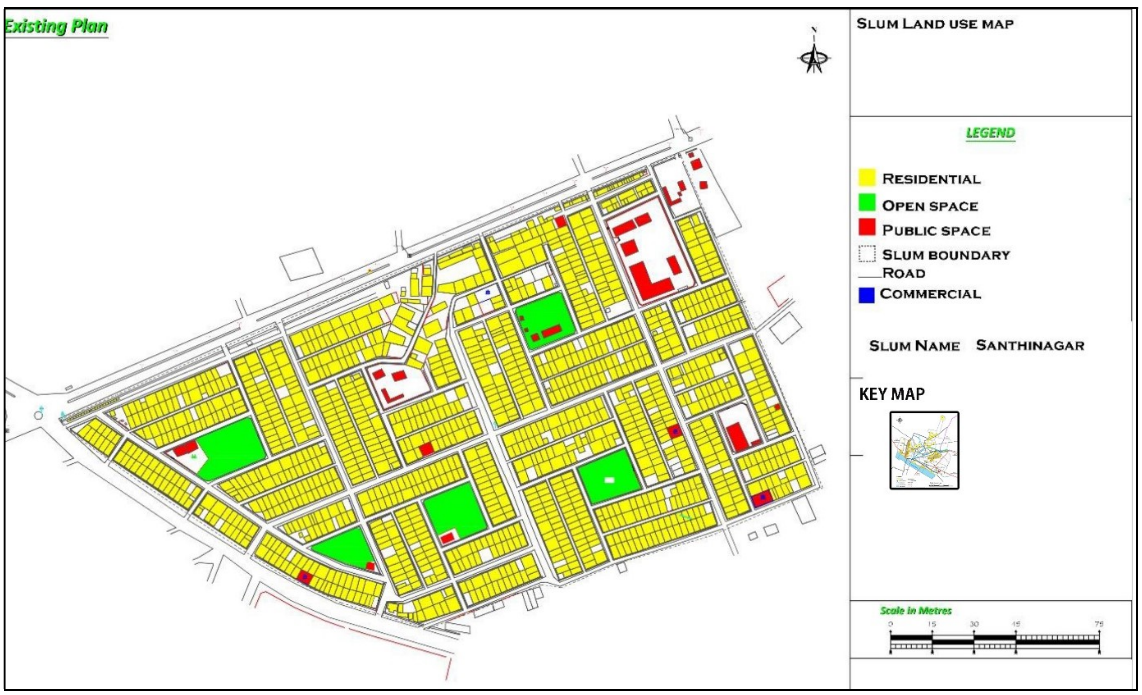


Figure 4.16 Water Supply Line New Raja Rajeshwari Peth

Source: Author, 2018

A total of 2457 i.e. 88% household have own tap, while 337 i.e. 12% depends on public taps. 17 houses get water once in two days, while 03 get once in a week. Also, 32% of the household receive muddy water once or twice a week. While almost all the houses receive muddy water during monsoon season, which increases their vulnerability to health-related issues especially in monsoon seasons. Household rely on household level treatment for purifying water such as filtration, boiling water for drinking purpose and also adding alum to water in order to clean the water.

4.7.8 Santhinagar Payakapuram



Map 4.23 Santhinagar Land use map

Source: Author 2018

Sanitation condition in the slum is weak with only 0 shared dry latrines and 11 community septic flush. Out of all the household, 25 does not have access to tap water in approachable distance. The slum has a major land use of residential area (1881 houses) followed by commercial (06) and mixed (31).

4.7.8.1 Water Scenario

Water infrastructure is a major problem identified in the slum both by primary and secondary data collection and analysis. Major source of water for the slum is through piped water system. A total of 1406 i.e. 73% household have own tap, while 513 i.e. 27% depends on public taps. 0 houses get water once in two days, while 0 get once in a week. 27% majority of the household receive muddy water once or twice a week. While almost all the houses receive muddy water during monsoon season, which increases their vulnerability to health-related issues especially in monsoon seasons. Household rely on household level treatment for purifying water such as filtration, boiling water for drinking purpose and also adding alum to water in order to clean the water.

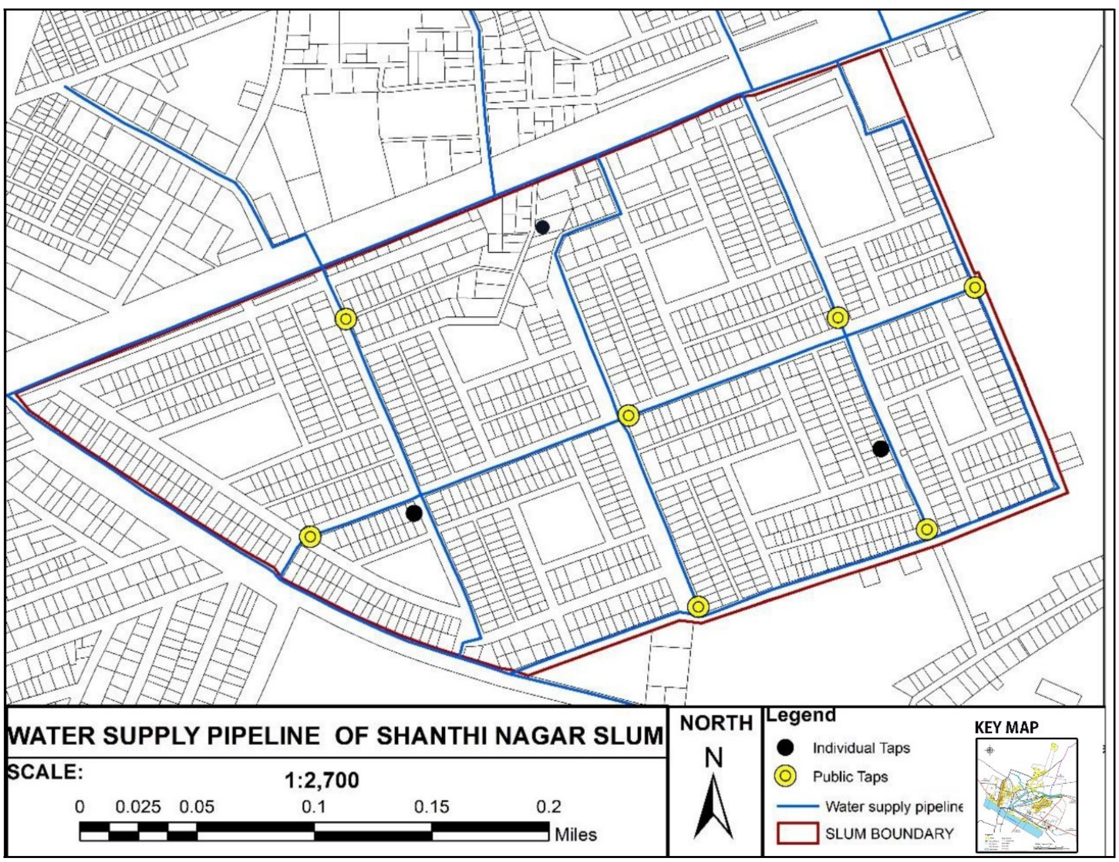


Figure 4.17 Santinagar water supply map

Source: Author, 2018

Figure 4.18 Running of Pipeline in slum

Figure 4.19 Community Taps

It is inferred from the above slum settlements that; all the slums are located across different spatial locations in the city. Different socio-economic groups dominate the settlements in terms of castes. The average household size of the slum settlement is 4. It is observed that 75% of slum residents have own house and the remaining are tenants. It is observed that housing typology of the slum settlements stays in thatched roof houses, metal sheets, concrete roofed houses and mud huts. All the slums have the common issues related to connectivity of water supply, hours of water collection, dependency on community taps, distance travelled to access water, quality of water, frequency of water supply and other health related issues.

Figure 4.20 Collection of water from borewells

4.8 Chapter Conclusion

This chapter focus on prioritising the slums at city level through a detailed analysis. Primarily, macro level analysis was conducted to identify the criticality of water stress levels, slum poverty levels at state level, highest density of population, highest percentage of slum population to the total urban population in the million plus cities. At meso level i.e. at city level, ward level assessment for identifying the critical wards that has high percentage of slum population, ground water levels, no service coverage, water deficit wards, and slum water deficit wards as per the standard requirement, Total dissolved solids (TDS) levels. This enables to identify the critical wards with slums across the city. Further profiling of the identified slums in terms of social economic aspects, infrastructure aspects is detailed out. The next chapter focus on identifying the slum water poverty index (SWPI) of each slum settlement. The parameters that were prioritised in the chapter 3 and the case areas that were identified in the chapter 4 is taken forward to identify the criticality of water poverty levels in slum settlements. This will enable to understand the component wise water supply issues at slum level. The analysis of parameters, indicators is done to identify the issues at parameter level as well as indicator level.

CHAPTER 5: SLUM WATER POVERTY INDEX

This chapter outlines the calculation of SWPI for the identified slum settlements across the city. Sampling method and sampling technique (Cochnran's Formula) was used to finalise the number of samples across all the settlements. The graphical analysis is conducted to understand the issues related to the parameters in the slum settlement. Likewise, the SWPI is calculated for all slums. Indicator analysis is also conducted to to analyse the uniformity of indicators across all the settlements. Statistical analysis is conducted further to analyse the cause and effect relationship among the parameters that affect the slums in the research.

The below table represents the list of indicators, parameters for calculating SWPI.

Table 5.1 Parameters for slum water poverty index

Parameters	Sub-Parameters	Explanation
Resource	Source of water	Individual Tap connection, Community Tap, Bore-well, Well etc. to decide the quality of water
	Water Quantity	Measured in litres per capita per day (lpcd), this indicator will be used to know the amount of water received by the user
	Water Sufficiency	Measured in litres per capita per day (lpcd), this indicator will enable us to know the amount of water received as per population with respect to the Service Level Benchmarks (SLB).
	Reliability	No. of hours in a day - Operational hours in Water supply
Access	Household with Potable water access	Percentage of households that receives potable water
	Frequency of water supply	No. of days within a week consumer receive water
	Time spent to collect water (house to source)	Measured in minutes
	Distance travelled to collect water	Measured in meters
	Time spent in water collection at source (queuing time)	Measured in minutes

	Women engaged in water collection	Percentage of women engaged in water collection
	Children engaged in water collection	Percentage of children within the age group of 9-14 years
Capacity	Expenditure on water (INR)	Measured on the basis of total percentage of income spent on water
Use	Domestic water consumption per head per day	Measured in lpcd
	Potable water consumption per head per day	Measured in lpcd
Environment	Water Quality (TDS)	Measured in ppm
	Household level water treatment	Boiling water. Bleaching etc.
	Type of water borne disease affecting population	Such as Cholera, fluoride, dysentery etc.

The above-mentioned parameters were taken. These parameters were derived that was elaborated in chapter 2 and chapter 3. Based on expert's parameters were identified and selected to make them significant and reasonable. The details are listed in annexure 1

5.1 Sampling Technique

Basically, stratified random sampling approach has been adopted for conducting the household survey at slum level. Stratified random sampling to obtain a sample population that best represents the entire population being studied. Stratified random sampling involves first dividing a population into subpopulations and then applying random sampling methods to each subpopulation to form a test group. Stratified random sampling divides the population into smaller groups, or strata, based on shared characteristics. A random sample is taken from each stratum in direct proportion to the size of the stratum compared to the population. Stratified random sampling accurately reflects the population being studied because researchers are stratifying the entire population before applying random sampling methods. In short, it ensures each subgroup within the population receives proper representation within the sample. As a result, stratified random sampling provides better coverage of the population since the researchers have control over the subgroups to ensure all of them are represented in the sampling.

5.1.1 Sample Size

Cochran pointed out that if the population is finite, then the sample size can be reduced slightly. This is due to the fact that a very large population provides proportionally more information than that of a smaller population. The formula to calculate the final sample size in this case which is given below

$$n = \frac{pq\,z^2}{e^2}$$

Where 'n0' is the sample size, 'z' is the selected critical value of the desired confidence level, 'p' is the estimated proportion of an attribute that is present in the population, 'q= 1-p' and 'e' is the desired level of precision. The total population of the 111 slums is 4,51,231. As the degree of variability of such a large population is not known, it is taken as 50% (i.e. p= 0.5) taking 95% confidence level with ±5% precision; q=1-p = 0.5. z= 1.96 for 95% confidence level and e = 0.05. So, the required sample size $n_0 = (1.96^2 \times 0.5 \times 0.5)/ (0.05^2) = 384$.

Taking the average HH size as 5; Number of HH to be surveyed = 384/5 ≈ 77; Taking 5 samples from each slum, No, of slums to be surveyed = 77/7 ≈ 11. As the whole process of surveying has mostly been guided by the number of water sources available at that particular slum. Because, the source of water is the most important aspect. 11 samples have been taken from each slum, depending on the number of water sources available.

Source of water and its other characteristics (time of water availability i.e. reliability, dependency over that water source, filling time i.e. discharge etc.) only decide how much quantity of water each family or each individual is getting. Insufficient water availability is the main reason behind water poverty, which itself is guided by so many other factors.

The slums which are dependent exclusively on community water taps, there 11 sample HH has been surveyed, overall 77 samples from all the slums has been surveyed. All slums were divided into grids and equal representation of samples from all the slums is considered to have a water scenario of the settlement. A household with individual tap has been assessed considering the fact that the characteristics of water availability dependent on the main source of water is same for one household and for the households depending on a community tap will have almost similar characteristics of water availability. Dependency of the households over community taps has been confirmed by discussing with the slum dwellers. The proportionate number of households depending on each community tap is taken into consideration by deducting the individual tap connected households in each identified slum.

40% of the households have access to individual water supply connections in Slums. But in the remaining slums, there are a mix of individual taps and community taps where only some portion of the slum, especially the peripheral part has individual HH water taps, as a little extension of the city water supply line. But the major part of the slums especially the core areas does not have individual connections. They are still dependent on community taps. From the city level pilot survey it is observed that in most of the slums, where there are mix of both individual and community taps, i.e. some households have individual taps and some have community taps, the ratio of households having individual connections to the households depending on community taps are in ratio varying between 60:40 to 80:20. In those cases 10 sample households have been surveyed, where the number of households depending on community taps and individual taps, out of 10 samples have been taken in a similar ratio.

After conducting the preliminary survey across the city's slums, some of the parameters. It was clear that all the parameters do not fall under the usage for slums in Vijayawada. So, parameters relevant to the case area were selected on the basis of preliminary survey. Refer annexure 3

Out of all the parameters 52% of the sub-parameters were chosen. The sub-parameters used were considered in order to make the values quantifiable. So, that empirically SWPI can be generated. Following table provides the sub-parameters used.

Table 5.2 Final parameters identification for SWPI

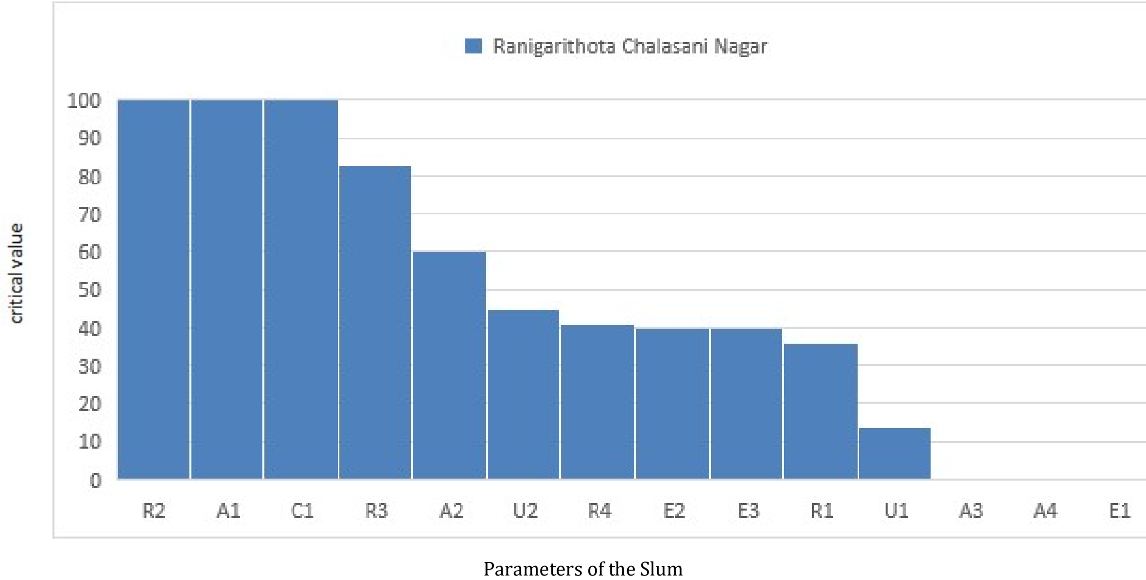
Sl No.	**Indicators**	**Weightage**		**Parameters**	**Scoring Logic**
1	Resource	0.2	R1	Water Quantity (lpcd)	% Variation in water quantity availability
2			R2	Water sufficiency	% deficit in water availability with 80 lpcd
3			R3	Alternative Sources	% of HH dependent on alternative sources
4			R4	Reliability	% of time water supply is not operational
5	Access	0.2	A1	Potable water access	% of HH not having IHH water supply connections
6			A2	Time spent for water collection	% of HH spending more than 30 minutes for water collection
7			A3	Distance from surface water source	% of HH travelling more than 500 metres to and fro for getting water from surface resource
8			A4	Distance travelled to collect water	% of HH travelling more than 500 metres to and fro for getting water access

9	Capacity	0.2	C1	Expenditure spent on water	% of respondents spending more than 5% of their income on the account of water expenditure
10	Use	0.2	U1	consumption deficit	% Water consumption per household with respect to 80 lpcd
11			U2	Water consumption	% variation in per capita water consumption
12	Environment	0.2	E1	Water Quality	% of water sample having TDS> 500 mg/lit
13			E2	HH level water treatment	% of HH reporting doing HH level water treatment
14			E3	Water related illness	% of HH reporting water related illness

Calculation methods as discussed in the previous chapters have been used to calculate the Slum Water Poverty Index of selected slums.

5.2 Calculation of SWPI - Rani Gari Thota Chalasani Nagar

The slum is located in Circle 3 of Vijayawada water works division, in the vicinity of Krishna River. To conduct primary survey the slum data was collected through household and perspective survey. The finalisation of the samples was done based on the identified sampling method. The collected data was then analysed on the basis of indicators -discussed in the previous section. The thresholds or service level benchmarks as decided by organisations/authorities described in the literature review. Slum was then studied using the individual indicators of the parameters in order to find out the major reason or cause of the water poverty in the slum and also the degree of water poverty in the slum was calculated. This will help us to understand which component of the indicators is highly getting affected and the reasons behind that parameter.

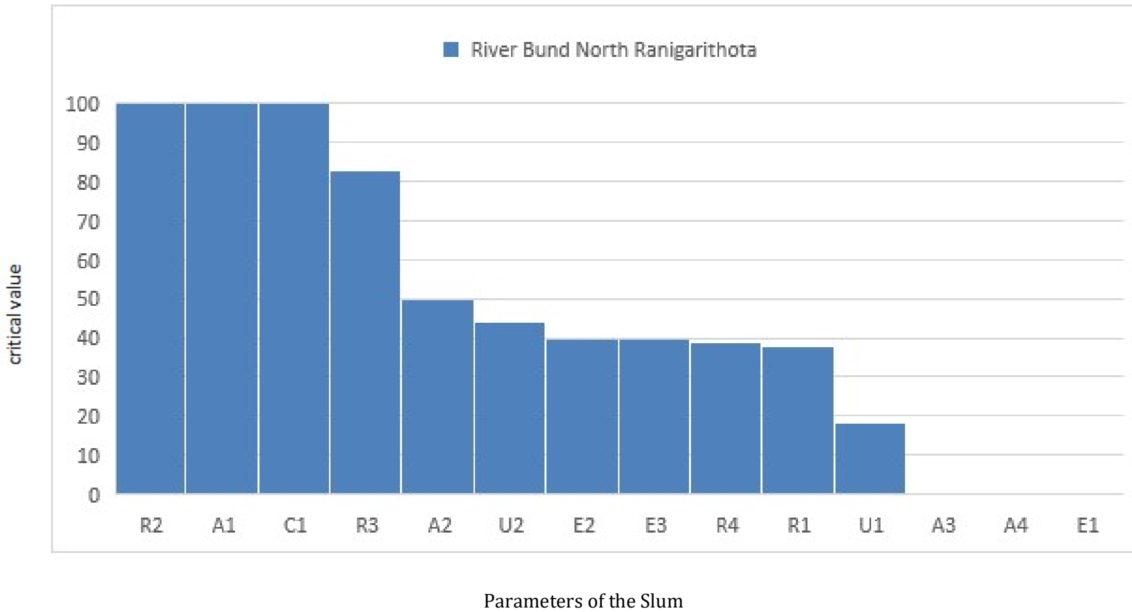


Graph 5.1 Comparative analysis Ranigarithota Chalasani Nagar

The above histogram shows that indicators R2, A1, C1 i.e. Alternative source dependency, not having pipe water access and spending more than 5% of the income are the most affected parameters for the slum or are the major reasons, increasing water poverty in the slum. While A3, A4 and E1 i.e. distance travelled to collect water (more than 500 m), Distance from natural resource (water resource) TDS of water respectively are least affected in the slum.

5.3 Calculation of SWPI - River Bund North RaniGari Thota

The slum is located in Circle 3 of Vijayawada water works division, in the vicinity of Krishna River. To conduct primary survey the slum data was collected through household and perspective survey. The finalisation of the samples was done based on the identified sampling method. The collected data was then analysed on the basis of indicators -discussed in the previous section- and their thresholds or service level benchmarks as decided by organisations/ authorities described in the literature review. Slum was then studied using the individual indicators of the parameters in order to find out the major reason or cause of the water poverty in the slum and also the degree of water poverty in the slum was calculated.

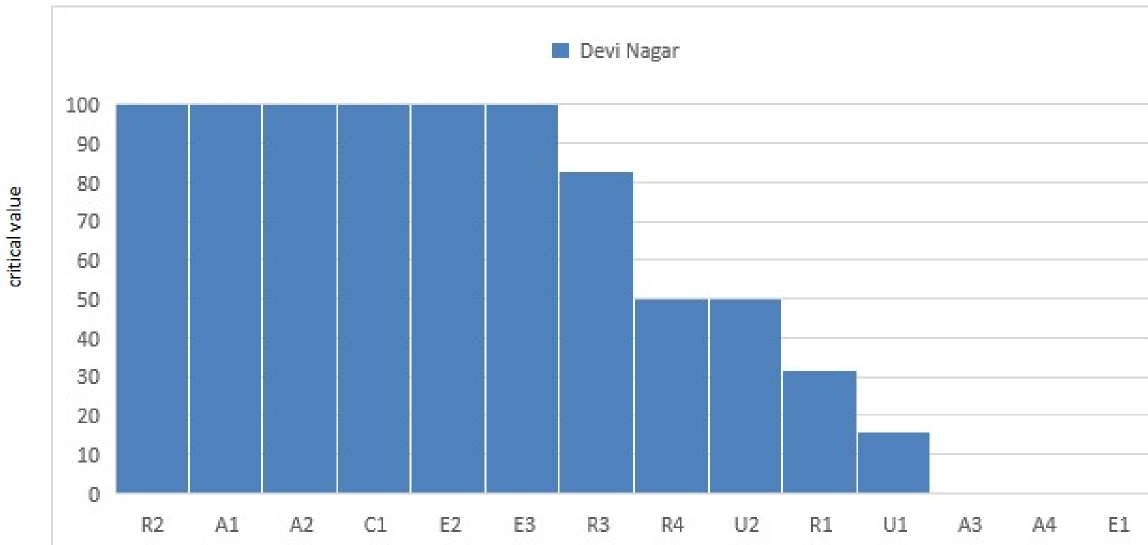


Graph 5.2 Comparative analysis River Bund Ranigarithota

The above histogram shows that indicators R2, A1, C1 i.e. Alternative source dependency, not having pipe water access and Spending more than 5% of the income are the most affected parameters for the slum or are the major reasons, increasing water poverty in the slum. While A3, A4 and E1 i.e. distance travelled to collect water (more than 500 m), Distance from natural resource (water resource) TDS of water respectively are least affected in the slum.

5.4 Calculation of SWPI - Devinagar slum

The slum is located in Circle 2 of Vijayawada water works division, in the vicinity of Krishna river canal. To conduct primary survey the slum data was collected through household and perspective survey. The finalisation of the samples was done based on the identified sampling method. The collected data was then analysed on the basis of indicators -discussed in the previous section- and their thresholds or service level benchmarks as decided by organisations/ authorities described in the literature review. Slum was then studied using the individual indicators of the parameters in order to find out the major reason or cause of the water poverty in the slum and also the degree of water poverty in the slum was calculated.

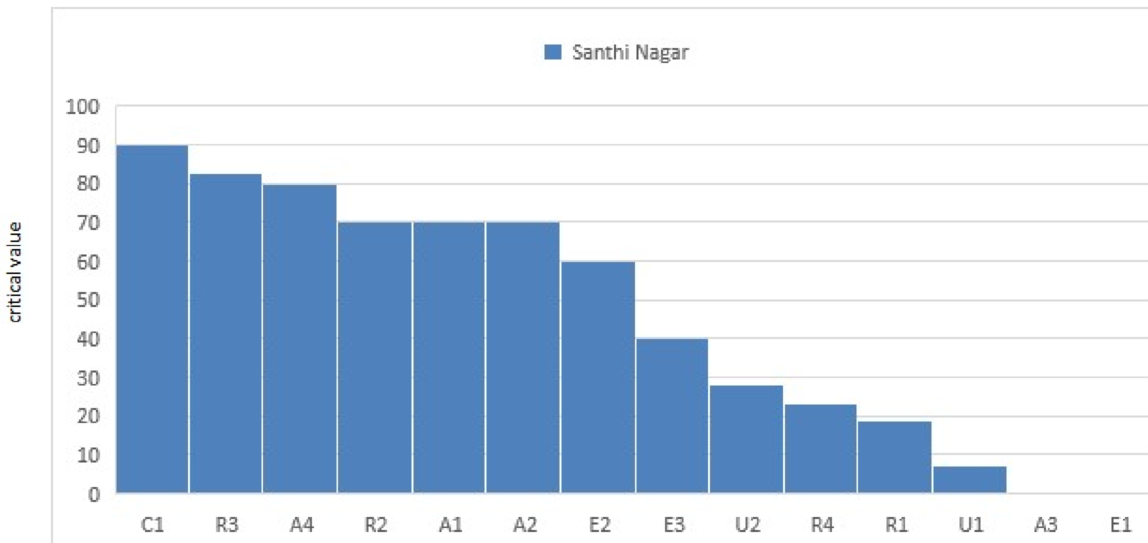


Graph 5.3 Comparative analysis Devi Nagar

The above histogram shows that indicators R2, A1, A2, C1, E2, E3 i.e. dependency on alternative source of water, household not having piped, Household traveling more than 30 minutes for water collection, households spending more than 5% of the income for water, households treating water at domestic level for consumption and most of the people get affected by water illness in this slum. While A3, A4, E1 i.e. distance travelled to collect water (500 m), Distance from Natural water resource and TDS of water respectively are least affected in the slum.

5.5 Calculation of SWPI - Santhinagar slum

The slum is located in Circle 2 of Vijayawada water works division. To conduct primary survey the slum data was collected through household and perspective survey. The finalisation of the samples was done based on the identified sampling method. The collected data was then analysed on the basis of indicators -discussed in the previous section- and their thresholds or service level benchmarks as decided by organisations/ authorities described in the literature review. Slum was then studied using the individual indicators of the parameters in order to find out the major reason or cause of the water poverty in the slum and also the degree of water poverty in the slum was calculated.

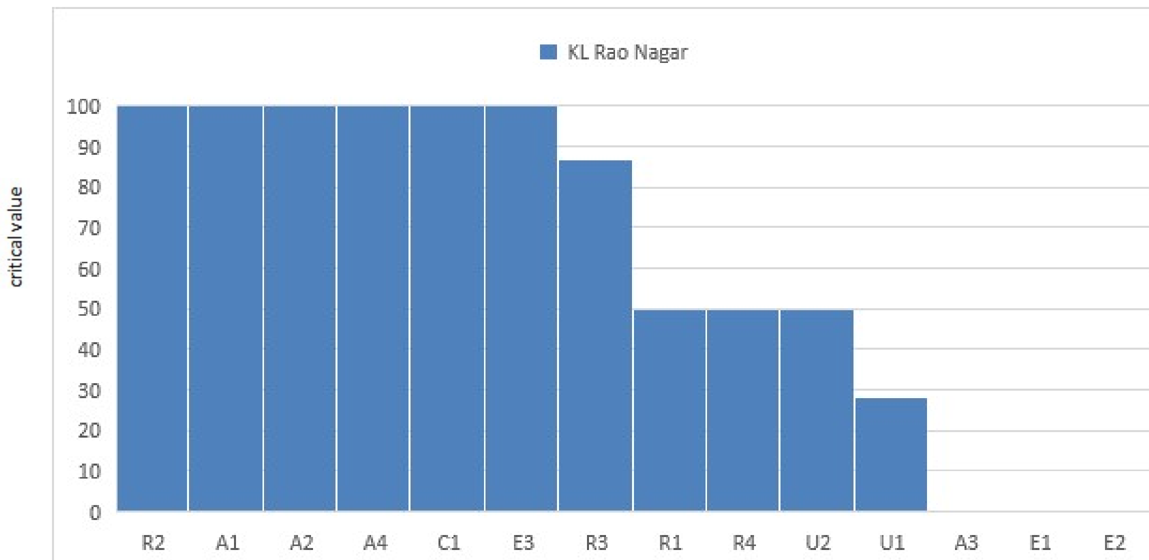


Graph 5.4 Comparative analysis Santhi Nagar

The above histogram shows that the indicator C1 is most affected i.e. households spending more than 5% of their income for water. However, the values indicate that the situations in the previously discussed slums were worst when compared to this slum. While A3, E1 i.e. distance travelled to collect water, TDS of water respectively are least affected in the slum.

5.6 Calculation of SWPI - K.L. Rao Nagar

The slum is located in Circle 1 of Vijayawada water works division. To conduct primary survey the slum data was collected through household and perspective survey. The finalisation of the samples was done based on the identified sampling method. The collected data was then analysed on the basis of indicators - discussed in the previous section - and their thresholds or service level benchmarks as decided by organisations/ authorities described in the literature review. Slum was then studied using the individual indicators of the parameters in order to find out the major reason or cause of the water poverty in the slum and also the degree of water poverty in the slum was calculated.

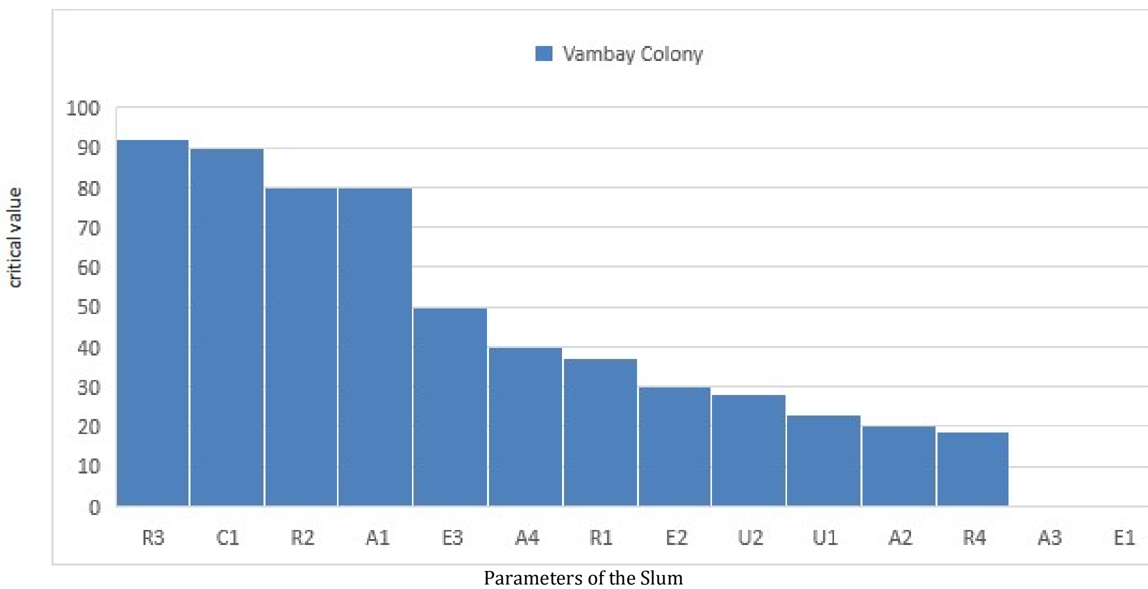


Graph 5.5 Comparative analysis KL Rao Nagar

The above histogram shows that indicators R2, A1, A2, A4, C1 and E3 dependency on alternative source of water, household not having piped, Household traveling more than 30 minutes for water collection, distance from natural water resources, households spending more than 5% of the income for water and people affected by water illness are most affected in this slum. While A3, E1 and E2 i.e. distance travelled to collect water, TDS of water and water treatment at domestic level for consumption respectively are least affected in the slum.

5.7 Calculation of SWPI - Vambay Colony

The slum is located in Circle 2 of Vijayawada water works division, in the vicinity of Krishna river canal. To conduct primary survey the slum data was collected through household and perspective survey. The finalisation of the samples was done based on the identified sampling method. The collected data was then analysed on the basis of indicators -discussed in the previous section- and their thresholds or service level benchmarks as decided by organisations/ authorities described in the literature review. Slum was then studied using the individual indicators of the parameters in order to find out the major reason or cause of the water poverty in the slum and also the degree of water poverty in the slum was calculated.

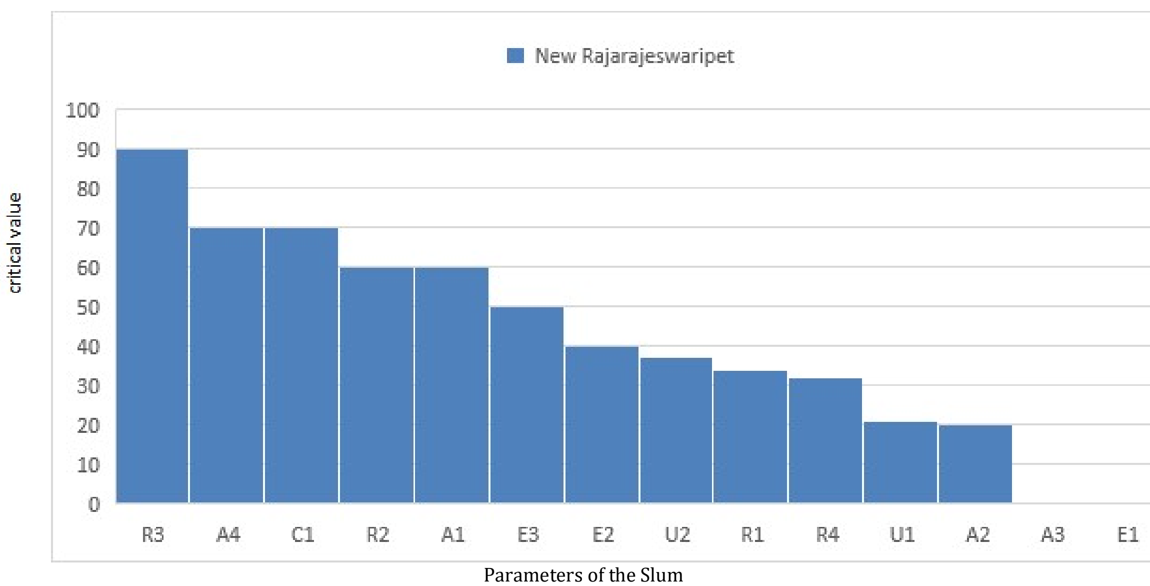


Graph 5.6 Comparative analysis Vambay Colony

The above histogram shows that none pf the parameters are affected 100 %. But parameter R3 is most affected in the slum i.e. Reliability on water resource, followed by C1, where household spent more than 5% of income for water. While A3, E1 i.e. distance travelled to collect water, TDS of water respectively are least affected in the slum.

5.8 Calculation of SWPI - New Rajarajeshwari Pet

The slum is located in Circle 1 of Vijayawada water works division. To conduct primary survey the slum data was collected through household and perspective survey. The finalisation of the samples was done based on the identified sampling method. The collected data was then analysed on the basis of indicators - discussed in the previous section - and their thresholds or service level benchmarks as decided by organisations/ authorities described in the literature review. Slum was then studied using the individual indicators of the parameters in order to find out the major reason or cause of the water poverty in the slum and also the degree of water poverty in the slum was calculated. Refer to Annexure 6.



Graph 5.7 Comparative analysis New Rajarajeshwari Pet

The above histogram shows that none pf the parameters are affected 100 %. But parameter R3 is most affected in the slum i.e. Reliability on water resource, followed by C1 and A4. While A3, E1 i.e. distance travelled to collect water, TDS of water respectively are least affected in the slum.

5.9 Calculation and comparison of SWPI for different slums

On the basis of the results of the sample survey done for the seven slums, the values of different parameters of water poverty were normalised on a scale of 0-100 where 0 represents the best condition i.e. least slum water poverty and 100 represents the worst condition i.e. indicator of maximum slum water poverty. Then taking average value of the parameters the values of different indicators were calculated. On the basis of the indicator values, SWPI was calculated using weighted composite index method.

Table 5.3 Normalised weightages of different parameters of SWPI

		Slum Profiles						
Parameters	Parameters2	Rani Gari Thota Chalasani Nagar	River Bund North RaniGari Thota	Devinagar slum	Santhinagar slum	K.L. Rao Nagar	Vambay Colony	New Rajarajeshwari Pet
Water Quantity (lpcd)	R1	4	4	4	5	3	4	4
Alternative Sources	R2	5	5	5	4	5	4	3
Reliability	R3	5	5	5	5	5	5	5
Water sufficiency	R4	5	4	5	3	5	2	4
Potable water access	A1	5	5	5	4	5	4	3
Time spent for water collection	A2	3	3	5	4	5	1	1
Distance from surface water resource	A3	1	1	1	1	1	1	1
Distance travelled to collect water	A4	1	1	1	4	5	2	4
Expenditure on water related illness	C1	5	5	5	5	5	5	4
consumption deficit	U1	1	1	1	1	2	2	2
Water consumption	U2	3	3	3	2	3	2	2
Water Quality	E1	1	1	1	1	1	1	1
HH level water treatment	E2	3	3	5	4	1	2	3
Water related illness	E3	3	3	5	3	5	3	3

Table 5.4 Scoring of different parameters

No	Parameters	Ranges	Scoring	No	Parameters	Ranges	Scoring
1	R1	0-20	5	8	C1	0-20	1
		21-40	4			21-40	2
		41-60	3			41-60	3
		61-80	2			61-80	4
		>80	1			81-100	5
2	R2	0-20	1	9	U1	0-20	1
		21-40	2			21-40	2
		41-60	3			41-60	3
		61-80	4			61-80	4
		81-100	5			81-100	5
3	R3	0-20	1	10	U2	0-20	1
		21-40	2			21-40	2

		41-60	3			41-60	3
		61-80	4			61-80	4
		81-100	5			81-100	5
4	R4	0-10	1	11	E1	0-20	1
		11-2O	2			21-40	2
		21-30	3			41-60	3
		31-40	4			61-80	4
		41-50	5			81-100	5
5	A1	0-20	5	12	E2	0-20	1
		21-40	4			21-40	2
		41-60	3			41-60	3
		61-80	2			61-80	4
		>80	1			81-100	5
6	A2	0-20	1	13	E3	0-20	1
		21-40	2			21-40	2
		41-60	3			41-60	3
		61-80	4			61-80	4
		81-100	5			81-100	5
7	A4	0-20	1				
		21-40	2				
		41-60	3				
		61-80	4				
		81-100	5				

Where, 5 being 'Highly Problematic' and 1 being 'No Problem'.

Table 5.5 Identified parameters of SWPI

RaniGari Thota Chalasani Nagar	River Bund North Rani Gari Thota	Devi Nagar slum	Santhi Nagar slum	K.L. Rao Nagar	Vambay Colony	New Rajarajeshwari Pet
R1	R1	R1	R1	R1	R1	R1
R2	R2	R2	R2	R2	R2	
R3	R3	R3	R3	R3	R3	R3
R4	R4	R4		R4		R4
A1	A1	A1	A1	A1	A1	
		A2	A2	A2		
			A4	A4		A4
C1	C1	C1	C1	C1	C1	C1
		E2	E2			
		E3		E3		

The detailed calculation of SWPI for each slum settlement calculated is attached as an Annexure 7.

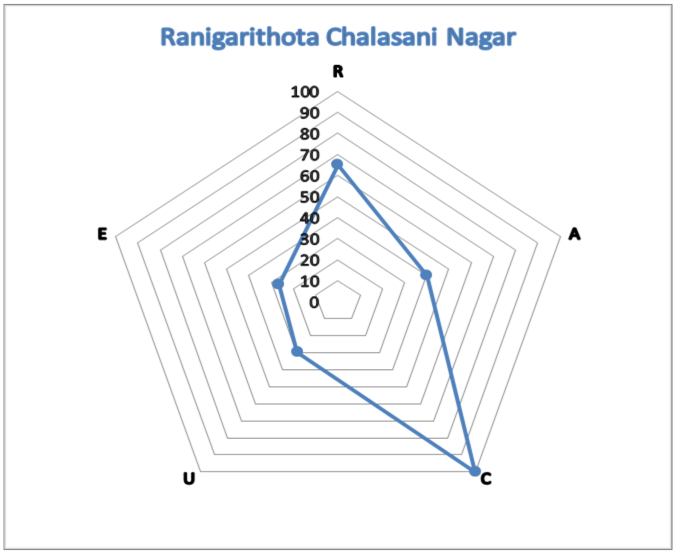
Table 5.6 Calculation of SWPI for different slums

Slum	R	A	C	U	E	SWPI
Ranigarithota Chalasani Nagar	65	40	100	30	27	52
River Bund North Ranigarithota	65	38	100	31	27	52
Devi Nagar	66	50	100	33	67	63
Santhi Nagar	49	55	90	18	33	49
Vambay Colony	57	35	90	26	27	47
Rajarajeswaripet	54	38	70	29	30	44
KL Rao Nagar	72	75	100	39	33	64

	High critical slums		Moderate critical slums		Low critical slums

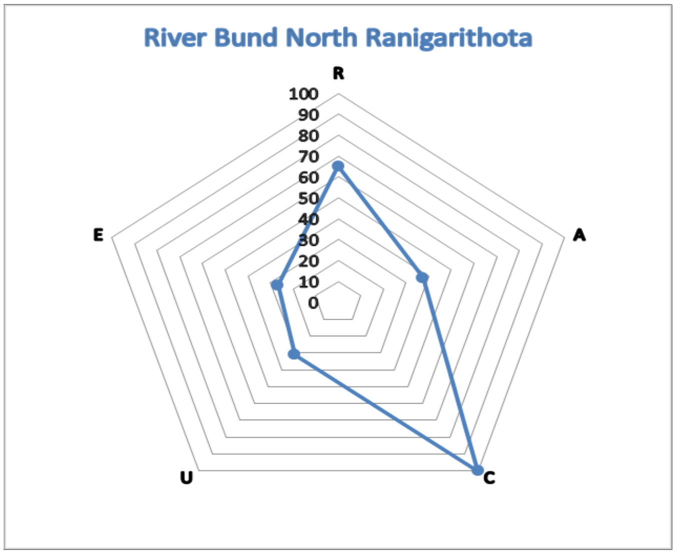
It is inferred that, the slums of Devi nagar and K L Rao nagar falls under high critical areas as the SWPI calculation. The slums River Bund North Ranigarithota and Ranigari Thota Chalasaninagar fall under moderate critical areas. The slums Santinagar, vambay colony and Rajarajeshwari peta fall under low critical areas. As per the analysis within each slum and across all slums, many parameters have been in common that are majorly responsible for increasing or decreasing water poverty for all the slums. In order to come out with these common indicators, parameters of all the slums studied for the research are compared and judged using the similar parameters.

The comparative study is conducted in order to understand the dependency of each parameters among themselves and to examine the major parameter leading to slum water poverty index for the selected slums. In order to conduct the study slums are scrutinised on the basis of Resource, Access, Use, Capacity and Environment. The values thus obtained were compared using spider web diagram. This helps to understand the most affected dimensions of water poverty in each slum. It also helps to examine if any of the five dimensions of slum water poverty are getting affected in common irrespective of the location of the slum. Results are as follows:



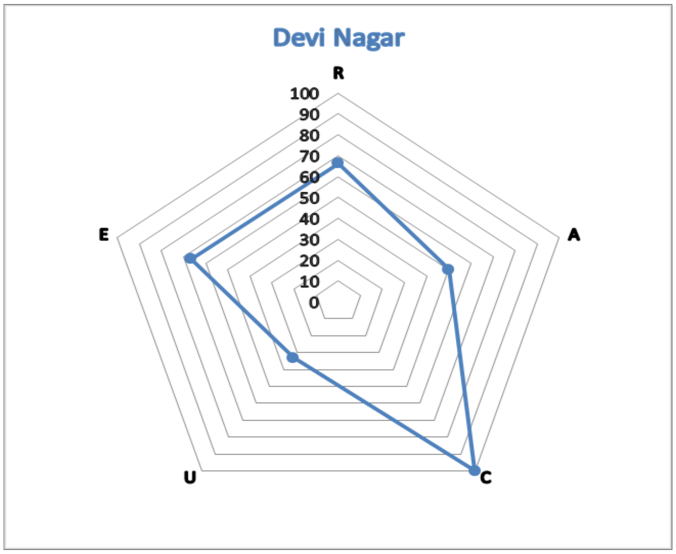
Graph 5.8 Spider Web SWPI Ranigarithota Chalasani Nagar

The above web diagram represents the slum water specific components of Ranigari thota. In this, resource and capacity are the major components that are more affected in the slum settlement. The remaining components are not extremely affected. It is inferred that majority of the parameters within the components of resource like quantity, reliability (time operational- number of hours) are severely gets affected and due to this the parameter of capacity like spending capacity to depend on alternative sources gets affected in terms of getting water bottles, using bore water or extracting water from ground through usage of water motors, directly impact the spending capacity of the household. The parameters of Access, usage and environment also contribute to SWPI but the severity will be less than the resource and capacity components.



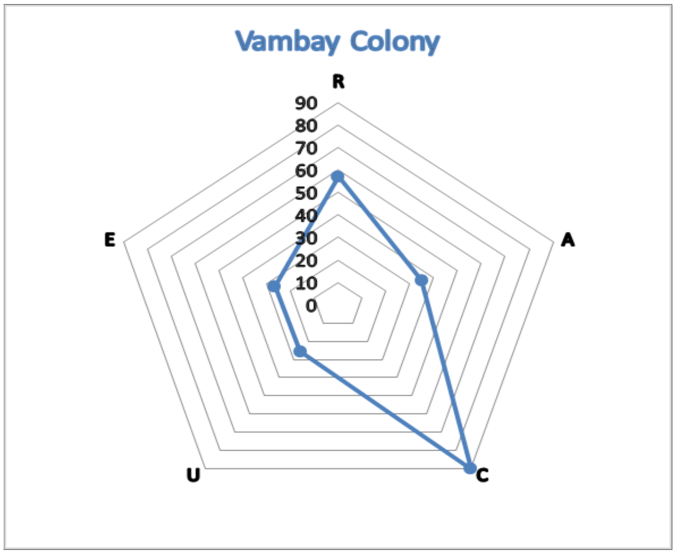
Graph 5.9 Spider Web SWPI River Bund North Ranogarithota

In the above-mentioned web chart, it is inferred that the capacity and the resource components are majorly affected because of which the SWPI of the slum settlement is getting in worst mode. It is observed that parameters related to resource like quantity, availability, reliability are contributing to the overall scenario of the indicator. Further, in the capacity component, expenditure spent on water is more than 3% - 5% as per UN water decade programme on collaborative council on water and sanitation. The parameters of access, usage and environment also contribute to SWPI but the severity will be less than the resource and capacity components. All the parameters are interrelated and contributes to the water poverty situation in the community. Addressing a parameter or group of parameters within a component or indicator will reduce the severity of the settlement.



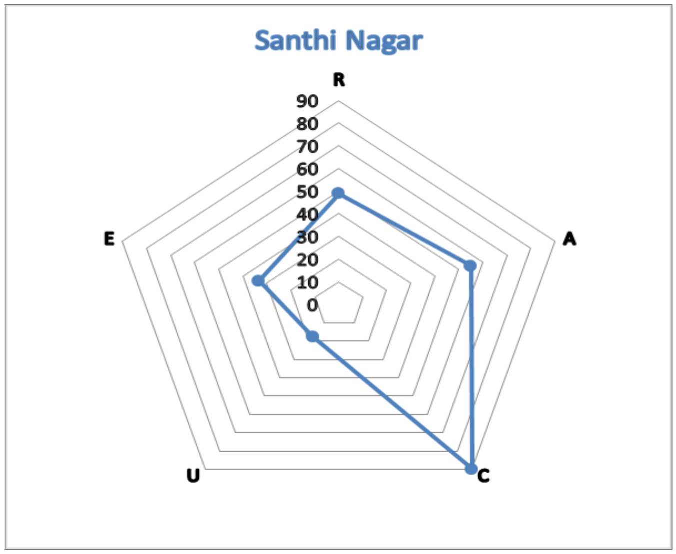
Graph 5.10 Spider Web SWPI Devi Nagar

The above web diagram represents the slum water specific components of Devinagar. In this, environment, access, and capacity are the major components that are more affected in the slum settlement. The remaining components like usage and resource are not extremely affected. It is inferred that majority of the parameters within the components of access like non availability of water source within reasonable distance, non-availability of individual tap connections, high dependency on community taps makes people to depend on alternative resources because of which the economic productivity of the people gets severely affected and due to this the component of capacity like spending capacity to depend on alternative sources gets affected in terms of getting water bottles, using bore water or extracting water from ground through usage of water motors directly impacts the spending capacity of the household. It is not only because of non-availability of water, even though water availability is sufficient the quality of water may not be within the acceptable limits of TDS. The parameters of usage and resource also contribute to SWPI, but the severity will be less than the rest of the components.



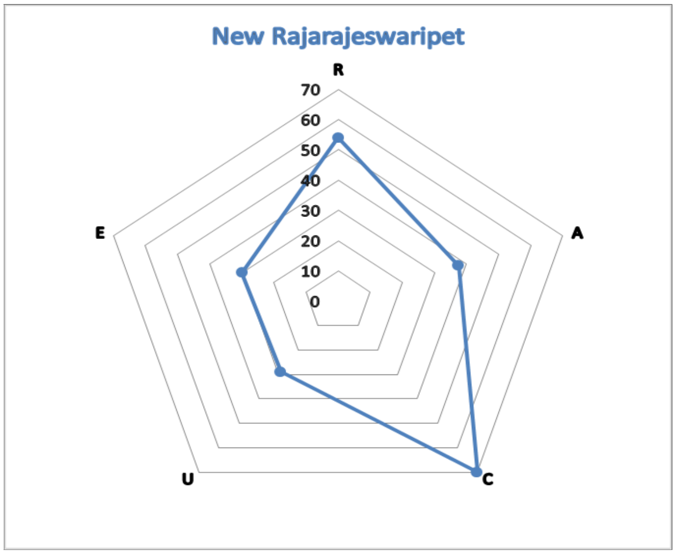
Graph 5.11 Spider Web SWPI Vambay Colony

The above web diagram represents the slum water specific components of Vambay Colony. In this, Resource, access, capacity are the major components that are more affected in the slum settlement. The remaining components like usage and environment are not extremely affected. It is logically inferred that due to non-availability of sufficient quantity of water, non-availability of individual tap connections, the resource component gets affected and it impact the access in terms of the people where they have to go longer distances and have to stand in queues to get water. However, because of the reliability (time operational hours) the people may not get actual quantity of water to the households. Further, the same households depend on alternative sources that gets reflected in their working hours that effects the component of capacity like spending capacity to depend on alternative sources gets affected in terms of getting water bottles, using bore water or extracting water from ground through usage of water motors directly impacts the spending capacity of the household.



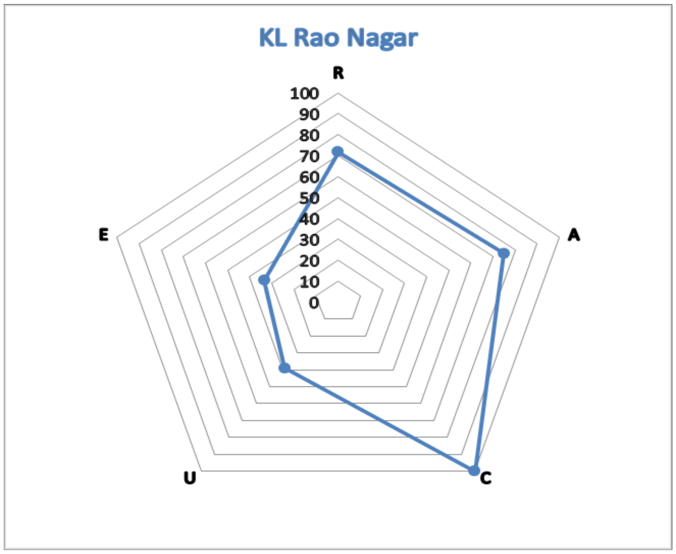
Graph 5.12 Spider Web SWPI SanthiNagar

The above web diagram represents the slum water specific components of Santhinagar. In this, resource and capacity are the major components that are more affected in the slum settlement. The remaining components are not extremely affected. It is inferred that majority of the parameters within the components of resource like quantity, reliability (time operational- number of hours) are severely gets affected and due to this the parameter of capacity like spending capacity to depend on alternative sources gets affected in terms of getting water bottles, using bore water or extracting water from ground through usage of water motors directly impacts the spending capacity of the household. The parameters of Access, usage and environment also contribute to SWPI but the severity will be less than the resource and capacity components.



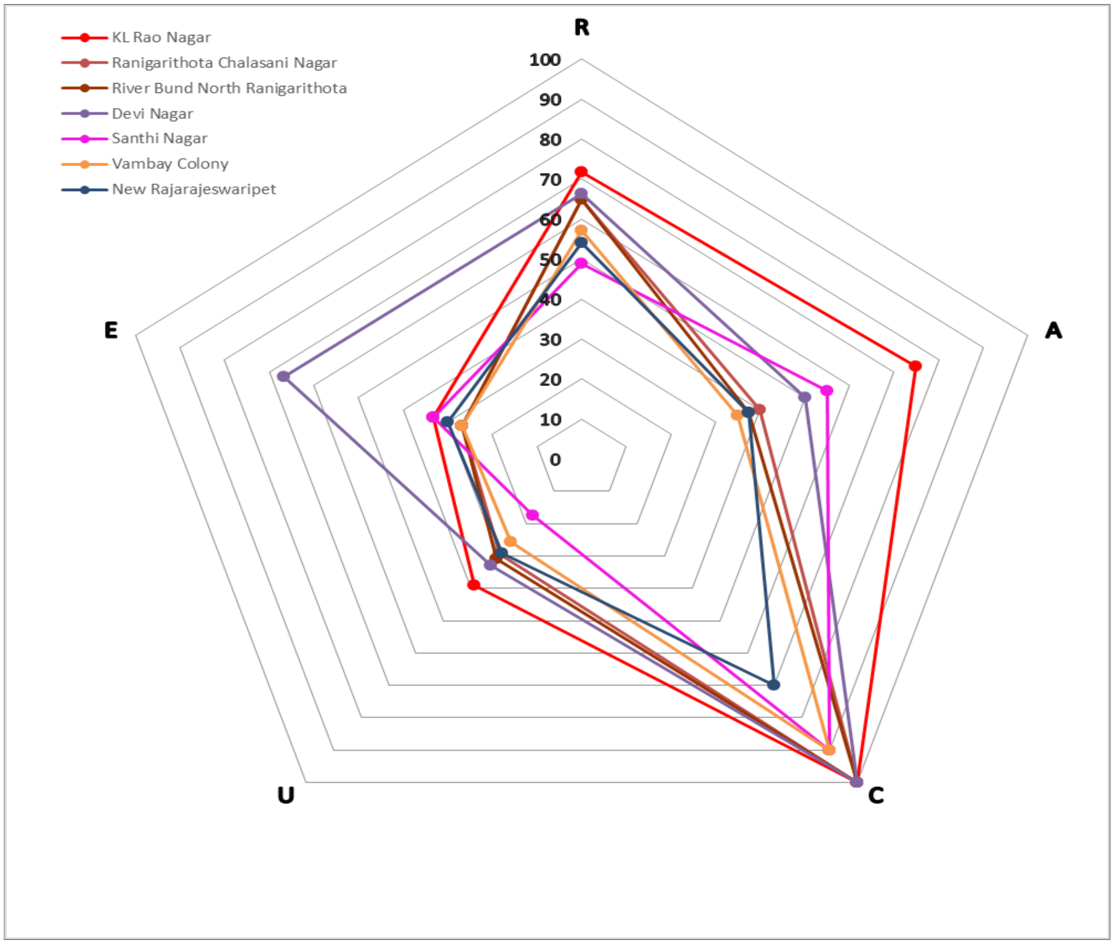
Graph 5.13 Spider Web SWPI NewRajarajeshwari pet

The above web diagram represents the slum water specific components of New Rajarajeshwaripet. In this, Resource, access, capacity are the major components that are more affected in the slum settlement. The remaining components like usage and environment are not extremely affected. It is logically inferred that due to non-availability of sufficient quantity of water, non-availability of individual tap connections, the resource component gets affected and it impact the access in terms of the people where they have to go longer distances and have to stand in queues to get water. However, because of the reliability (time operational hours) the people may not get actual quantity of water to the households. Further, the same households depend on alternative sources that gets reflected in their working hours that effects the component of capacity like spending capacity to depend on alternative sources gets affected in terms of getting water bottles, using bore water or extracting water from ground through usage of water motors directly impacts the spending capacity of the household.



Graph 5.14 Spider Web SWPI KL Rao Nagar

The above web diagram represents the slum water specific components of K L Rao Nagar. In this, resource and capacity are the major components that are more affected in the slum settlement. The remaining components are not extremely affected. It is inferred that majority of the parameters within the components of resource like quantity, reliability (time operational- number of hours) are severely get affected and due to this the parameter of capacity like spending capacity to depend on alternative sources gets affected in terms of getting water bottles, using bore water or extracting water from ground through usage of water motors directly impacts the spending capacity of the household. The parameters of Access, usage and environment also contribute to SWPI but the severity will be less than the resource and capacity components.



Graph 5.15 SWPI Comparative analysis of selected slums

Components of Resources, Access, Capacity, Environment and Usage are the major aspects that decide the slum water poverty situation of the settlement. There are multiple parameters in each of the component that directly or indirectly impacts the basic services in the slum. The SWPI of all the slums is cumulated and mapped on the single web chart to analyse the uniformity of the components that are common in all the slums. All the seven slum settlements that were prioritised through city level analysis were analysed to understand the slum water poverty index for each settlement. However, all the slums were combined and analysed on the common platform. This will help to analyse the common indicators that influence of each parameter on that indicator. Comparative analysis of the indicators was done for each slum, it was done in order to understand which particular component or indicator is causing the water poverty for the slum or slums. On analysing the slums, it was found that Capacity was the major reason causing slum water poverty among the slums. Capacity here reflects that majority or almost all the household spent more than 5% of their income for water. This also reflects usage of alternative sources of water such as water cans for drinking water or dependency on water tanks, ground water, bore wells etc. This indicates that factor among the resource and Access lead to increasing expenditure of the slum dwellers. Also, a part of environment plays an important role in increasing expenditure but as surveyed very less households' treats the water before use so the expenditure on treating water is negligible. Due to less accessibility to potable water and also less operating time of the community tap is another reason found, which coerce the households to spend for water and because of which the economic productivity of the household gets reduced. The quality of water, domestic consumption issues are not in the severe mode as the people are less dependent on consuming water and the ground water, bore water are basically used for domestic chores at residences. In the entire analysis of this, except the resource, access and capacity other components may not be of critical nature.

To understand the better dependency of parameters, and to ascertain the reason for water poverty at slum level, statistical analysis need to be carried out to understand the dependency, cause and effect relationship between the indicators at slum level. Co-rrelation and multiple regression analysis as a statistical tool. Till now the graphical analysis has been conducted to ascertain the results. To conduct in-depth analysis and to extract logical results, statistical analysis is required so as to come out with realistic results. This will help to address the issues related to water supply in the identified slums.

5.10 Correlation Analysis

Correlation is a method to identify dependency or relation between two parameters. It will help us to understand the cause and effect relationship between different variables in the given context. Correlation in this scenario is conducted to identify the relation or dependency of individual parameters i.e. Resource, Access, Use, Capacity and Environment with Slum Water Poverty Index. The parameters extracted from primary survey data and the literature review is used to perform correlation. The values used for this correlation were derived through the data collection and calculation used to develop SWPI for individual selected slums. By doing so, parameters which enhances the Slum Water Poverty Index or parameters which are leading to increase SWPI are identified.

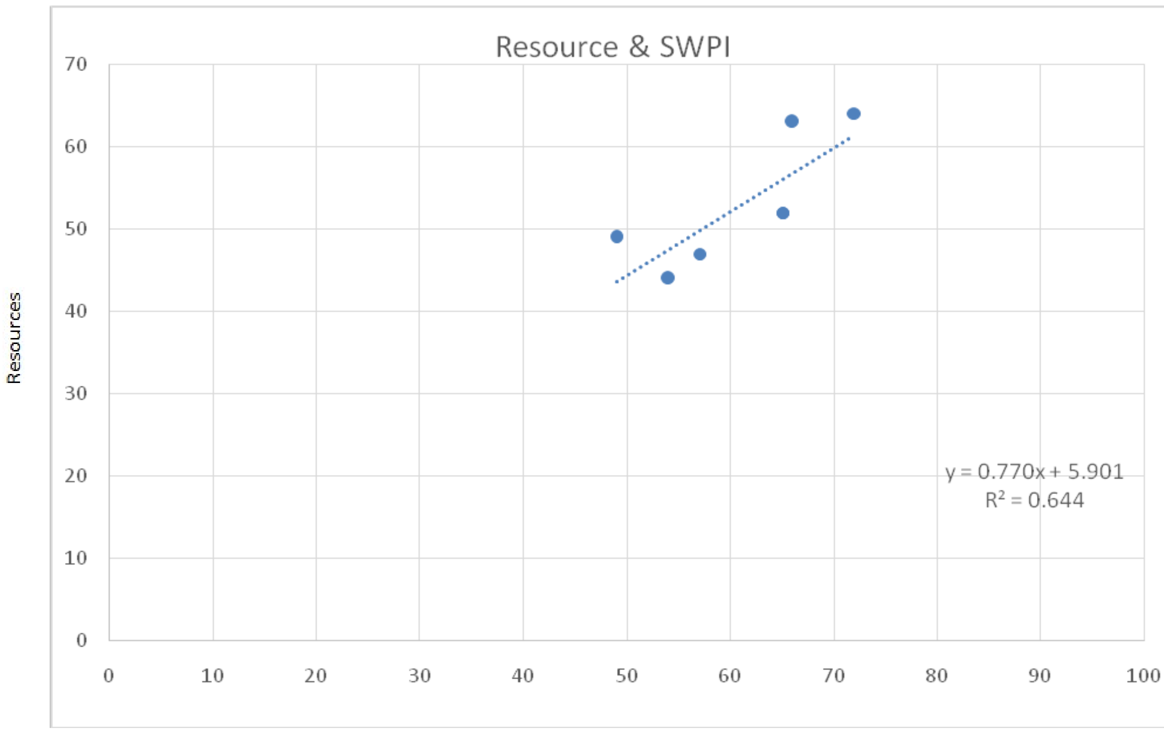
Correlation matrix is as follows:

Table 5.7 Correlation matrix for different slum water poverty indicators of Slum Water Poverty Index

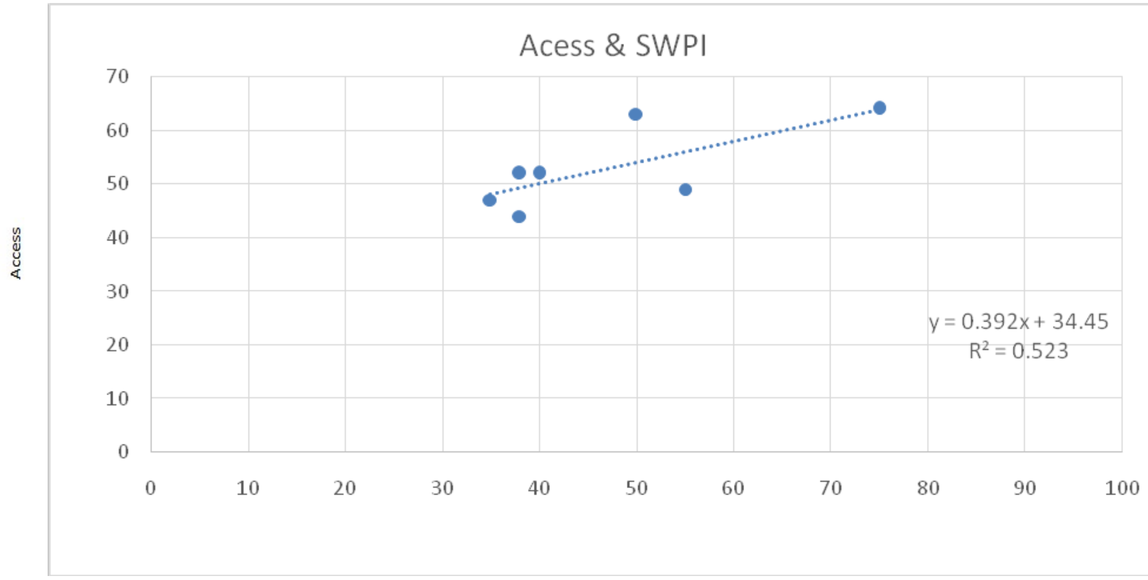
	Resource	***Access***	***Capacity***	***Use***	***Environment***	***SWPI***
Resource	1.000					
Access	0.386	1.000				
Capacity	0.702	0.347	1.000			
Use	0.913	0.384	0.363	1.000		
Environment	0.245	0.259	0.248	0.241	1.000	
SWPI	**0.804**	**0.716**	**0.720**	**0.701**	**0.634**	**1.000**

After the correlation analysis, it was encountered that resource was major parameter affecting the water poverty index in the slums. Since majority of the households are dependent on community taps for their day to day chores. These taps have low pressure and less operational time. People thus are haled to depend on alternative sources of water. These sources cost them in monetary values. Hence, impacting their capacity to afford the water. This collides with Capacity parameter making it second most affected parameter among all others. Refer annexure 5

The above developed correlation matrix defines the dependency of individual parameters among themselves and SWPI. Correlation among the individual parameters and SWPI are described as follows.

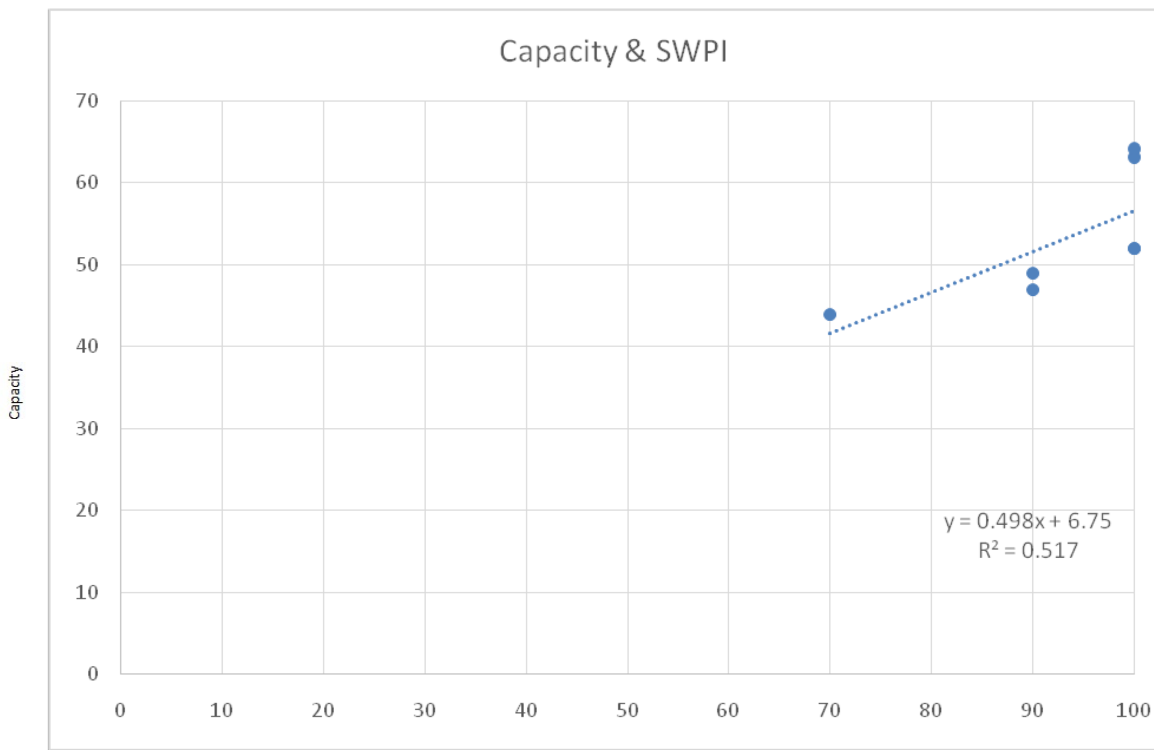


SWPI
Graph 5.16 Correlation plot resource and SWPI



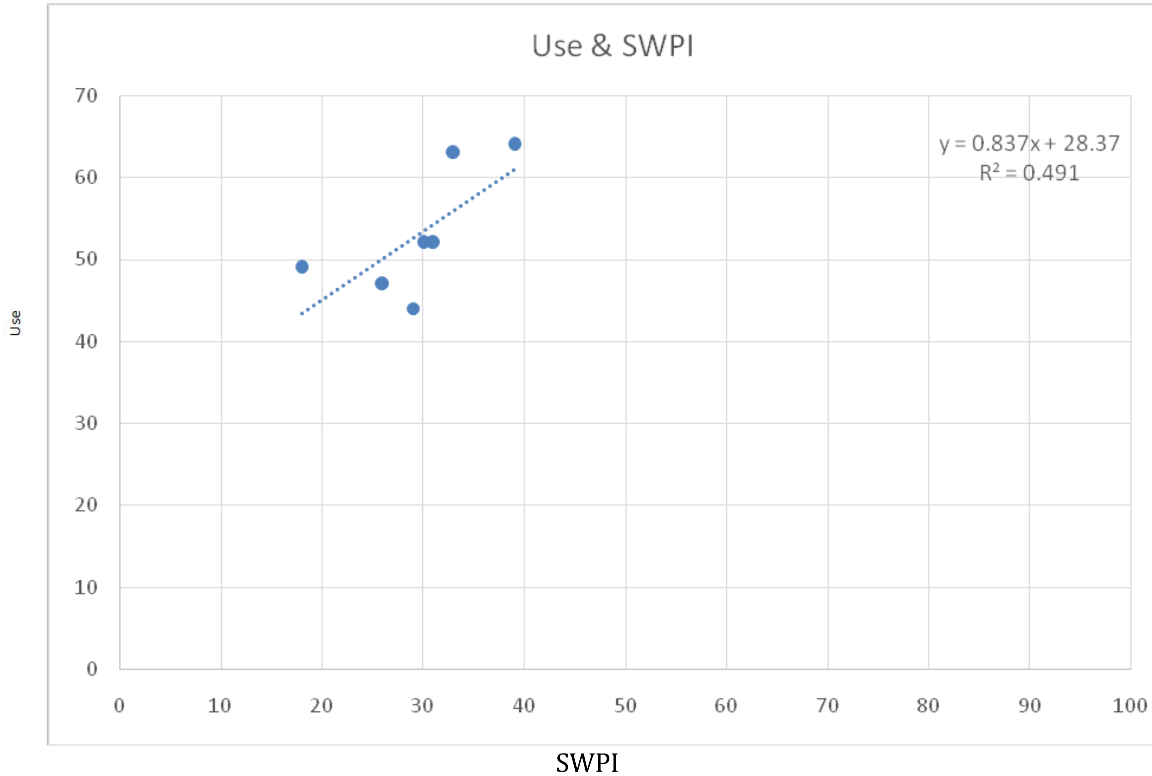
SWPI

Graph 5.17 Correlation Plot Access and SWPI

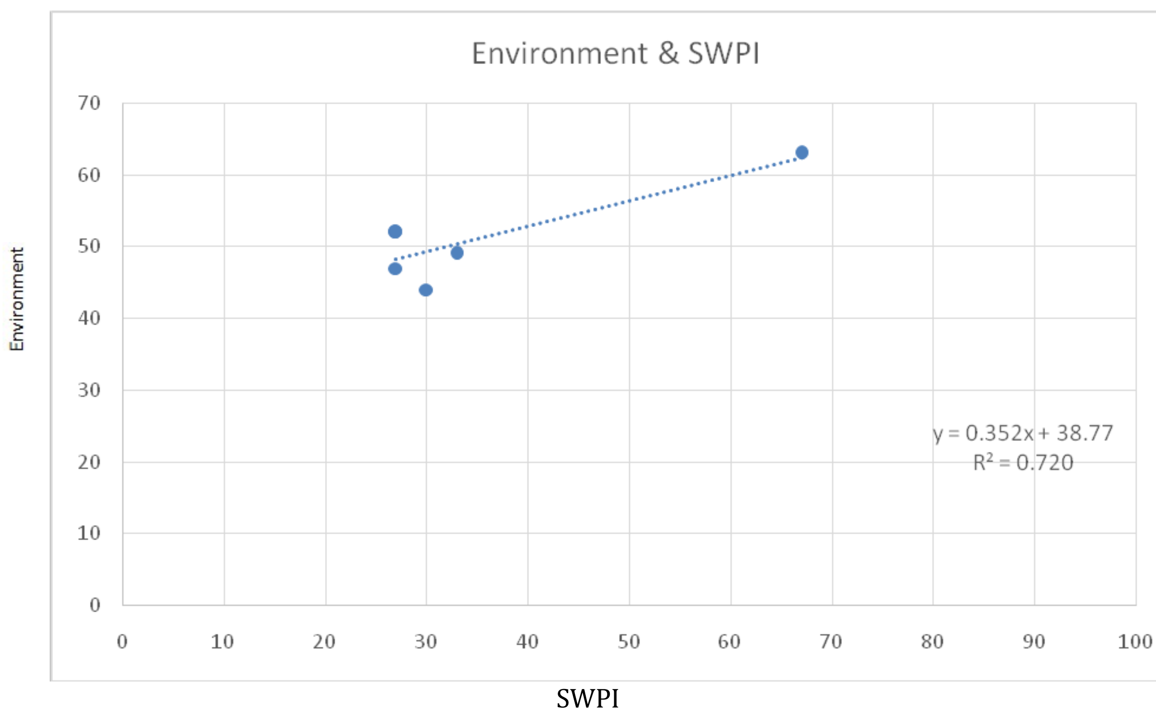


SWPI

Graph 5.18 Correlation Plot Capacity and SWPI



Graph 5.19 Correlation Plot Use and SWPI



Graph 5.20 Correlation Plot Environment and SWPI

5.11 Regression Analysis

Correlation analysis of the indicators reduced the dependency of the parameters among each other. But the extent of dependency has to be calculated in order to derive a linear equation. This equation is derived using regression analysis where these indicators- Resource, Access, Capacity, Use and Environment- are used to calculate regression equation for selected variables among each parameters described above.

Correlation and multiple regression analysis were performed to examine the relationship between water quantity availability and its various predictors. Multiple linear regression analysis was performed to examine the dependency of the predictor variables on the dependent variables. This help to understand the interdependence between the parameters of slum water poverty and helps in generating scenarios by altering in one or more parameters.

Variable 1: Quantity or Availability of water (y) = dependent variable

Table 5.8 Estimation of variance for water quantity availability

Model	R	R Square	Adjusted R Square
1	0.949	0.901	**0.894**

The three independent variables (filling time, supply time & dependent HH) explain 89.4% of the variance in the dependent variable (availability of water quantity) as shown in Table 5.11.1.

Table 5.9 Descriptive statistics of multiple regression for water quantity availability and its predictors

Model parameters (Water availability_lpcd):

Source	Value	Standard error	T	Pr > |t|	Lower bound (95%)	Upper bound (95%)
Intercept	81.614	4.371	18.672	**< 0.0001**	72.787	90.441
Time_secs	-7.454	0.575	-12.972	**< 0.0001**	-8.615	-6.294
Supply time (secs)	0.004	0.000	17.218	**< 0.0001**	0.003	0.004
Dependent People	-0.819	0.058	-13.999	**< 0.0001**	-0.937	-0.701

Table 5.11.2 summarises the descriptive statistics and analysis results. Water quantity availability is significantly negatively correlated with filling time and dependent HH and it is positively varied with the supply time.

From this,

Equation derived

$$\mathbf{Y = 81.614 + (-7.454 * X_1) + (3.86E\text{-}03 * X_2) + (-0.819 * X_3)}$$

Where;

Response (Y) = Water availability,

Potential Predictor (X1) = filling time i.e. time taken to fill water in seconds,

Potential Predictor (X2) = Supply time or reliability factor has been considered (in seconds)

Potential Predictor (X3) = Dependency ratio or dependent population on the tap

Ex. for supply time of 4 hrs i.e. 14400 secs, filling time 8 secs per litre and a dependency of 10 HH i.e. 40 people, the average water quantity availability will be

Water quantity availability (lpcd) = 81.614 +(-7.454*8) +(3.86E-03*14400) +(-0.819*40)

$$= 44.926 \approx 45 \text{ lpcd}$$

This regression analysis helps us suggesting improvements in the water supply condition to increase the per capita water availability. Increasing the water supply timings (reliability), improving the pressure levels and reducing the dependency ratio on the community taps by providing individual HH water supply connections or increasing the number of community taps will increase the overall per capita water availability (lpcd).

Variable 2: Capacity (y) = dependent variable

Model Summary

Table 5.10 Estimation of variance for Capacity

Model	R	R Square	Adjusted R Square
1	0.714[a]	0.510	0.501

a. Predictors: (Constant), Alternative source
b. Dependent Variable: Money_Spent_More_than_5 Percent

Dependency on alternative source as independent variable explains 50% of the variance in the dependent variable Capacity (money spent on water i.e. percentage of income spent on water) as shown in Table 5.11.3.

Table 5.11 Descriptive statistics of multiple regression for Capacity and its predictors

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.889	.141		6.294	.000
	Alternative source	.556	.075	.714	7.360	.000

a. Dependent Variable: Money_Spent_More_than_5Percent

Table 5.10 summarises the descriptive statistics and analysis results. Capacity i.e. money spent on water is positively correlated with dependency on alternative source. Coefficient of 0.556 for alternative source increases the money spent or capacity by one unit. Dependency on alternative sources of water in the form of water cans etc will cause them to spend extra expenditure on water.

Equation Derived

$$\mathbf{Y = 0.556 * X_1 + 0.889}$$

Where;

Response (Y) = Capacity, more than 5% of income spent for water,

Potential Predictor (X1) = Alternative source of water

Ex. for dependency on alternative source of water X1 = 2

Capacity Y = (0.556*2) + 0.889

= 2.001 ≈ 2, which signifies spending more than 5% of income on water.

Though expenditure on water includes literally the actual cost of water along with the other necessary arrangements and also indirectly to the treatment costs due to water related illnesses, but it was noticed during the survey that cost of treatment for water related illness was not so much significant to the percentage of HH income. So, the main cost is due to the actual cost of water. So, insufficient water availability and the subsequent dependence on alternate sources of water is the main reason behind the money spent on water. So, the similar kind of interventions lie providing individual connections or increasing the supply time etc as discussed in the previous case will help to reduce the expenditure on water.

Variable 3: Water treatment (y) = dependent variable

Table 5.12 Estimation of variance for Water Treatment

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.769[a]	.591	.583	.324	.591	75.221	1	52	.000
2	.801[b]	.642	.627	.306	.050	7.147	1	51	.010

a. Predictors: (Constant), Quan_Deficit

b. Predictors: (Constant), Quan_Deficit, Alternative_source

c. Dependent Variable: Treatment

Water treatment is dependent on deficit in water quantity availability and dependency on alternative source. These variables explain 63% variance in percentage of HH reporting of doing HH level water treatment as shown in Table 5.11.5.

Table 5.13 Descriptive statistics of multiple regression for treatment and its predictors

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.143	.092		23.339	.000
	Quan_Deficit	-.026	.003	-.769	-8.673	.000
2	(Constant)	1.481	.263		5.636	.000
	Quan_Deficit	-.037	.005	-1.088	-7.463	.000
	Alternative_source	.519	.194	.390	2.673	.010

a. Dependent Variable: Treatment

Table 5.11.6 summarises the descriptive statistics and analysis results. Treatment is negatively correlated with quantity deficit and positively correlated with dependency on alternative source. If people are facing deficit in water quantity availability from the municipal source, then definitely they will be dependent on alternative sources of water in the form of mainly water cans and water tankers, which will make treated water available to them, which will reduce their effort to treat the water.

Equation Derived

Y= (-0.037 * X1) + (0.519 * X2) + 1.481

Where;

Response (Y) = Water treatment at domestic level, reflects environment

Potential Predictor (X1) = Deficit in quantity,

Potential Predictor (X2) = Alternative source of water

Ex. for a water quantity deficit X1= 36 lpcd and dependency on alternative sources X2= 2, HH reporting doing treatment = (-0.337*36) + (0.519*2) +1.481

= 1.181 ≈ 1, which represents HH not doing any HH water treatment.

Variable 4: Dependency on alternative source(y) = dependent variable

Table 5.14 Estimation of variance for dependency on alternative source

Model Summary[e]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.839[a]	.705	.699	.206	.705	124.087	1	52	.000
2	.915[b]	.836	.830	.155	.132	41.079	1	51	.000
3	.933[c]	.871	.863	.139	.034	13.187	1	50	.001
4	.958[d]	.917	.910	.113	.047	27.549	1	49	.000

a. Predictors: (Constant), Dependent_HH

b. Predictors: (Constant), Dependent_HH, Filling_Time_secs

c. Predictors: (Constant), Dependent_HH, Filling_Time_secs, Reliability

d. Predictors: (Constant), Dependent_HH, Filling_Time_secs, Reliability, Time_Spent_more_than30Min

e. Dependent Variable: Alternative_source

Dependency on alternative source is determined by number of HH dependent on a tap, pressure level of water (water filling time in seconds), reliability (water supply time), time spent for water collection more than 30 minutes. These variables determine 91% variance over the dependency on alternate sources of water.

Table 5.15 Descriptive statistics of alternative source and its predictors

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.179	.065		18.110	.000
	Dependent_HH	.067	.006	.839	11.139	.000
2	(Constant)	.636	.098		6.505	.000
	Dependent_HH	.069	.005	.860	15.165	.000
	Filling_Time_secs	.094	.015	.364	6.409	.000
3	(Constant)	.200	.149		1.340	.186
	Dependent_HH	.072	.004	.901	17.265	.000
	Filling_Time_secs	.138	.018	.538	7.682	.000
	Reliability	.077	.021	.256	3.631	.001
4	(Constant)	-.121	.135		-.894	.376
	Dependent_HH	.068	.003	.851	19.669	.000
	Filling_Time_secs	.144	.015	.559	9.853	.000
	Reliability	.109	.018	.359	5.960	.000
	Time_Spent_more_than30Min	.181	.034	.242	5.249	.000

a. Dependent Variable: Alternative_source

Table 5.11.8 summarises the descriptive statistics and analysis results. Dependency on alternative source is positively correlated with dependent HH, water pressure (filling time for 1 litre of water), reliability (supply time of water), time spent for water collection.

Equation Derived

$$Y = (0.068 * X1) + (0.144 * X2) + (0.109 * X3) + (0.181 * X4) + (-0.121)$$

Where;

Response (Y) = Dependency on alternative source
Potential Predictor (X1) = Dependent HH
Potential Predictor (X2) = Filling time for 1 litre water in secs; equivalent to water pressure level
Potential Predictor (X3) = Supply time i.e. Reliability

Potential Predictor (X4) = HH spending more than 30 min for water collection

Ex. for X1 = 15 dependent HH, 1 litre water filling time X2 = 5.5 secs, X3 = 1 for 4 hours supply time, X4 = 1 for not spending more than 30 minutes for water collection, dependency on alternative source Y = (0.068*15) + (0.144*5.5) + (0.109*1) + (0.181*1) + (-0.121) = 1.981 ≈ 2, which signifies dependency on alternative sources. Refer annexure 6

To summarise the statistical analysis in context of regression analysis, the parameters like quantity of water availability, supply timings, dependency ratio, water sufficiency, dependency on alternative sources, supply timings, water treatment aspects were tested. The regression value R^2 signifies the criticality of the parameter i.e. on the scale of 0 and 1. Wherein '0' represents the least critical and nearer to '1' represents more critical. In this research, it is observed that the value of water availability in the slum settlement is 0.8 that represents the slum lacks water availability that leads to insufficiency and other water related parameters. In another case, it is observed that more than 55% of the HHs i.e. O.56 R^2 Value is depending on alternative sources and their expenditure is getting affected. In third case, it is observed that because of less quantity of water, and dependency on alternative sources like bore water, canals etc i.e. 0.6 R^2 value. The quality of water availability has high impurities that affect the health aspects. In the fourth case, the dependency on alternative source of water is affected because of reliability in supply timings and less filling time. Hence, in this case, the R^2 value 0.9 that is highly critical within the settlement. Addressing the parameters like quantity availability, supply timings, reliability will improve the performance levels of the water supply system in the slum settlement which answers the research question.

5.12 Chapter conclusion

The above chapter helped in understanding the SWPI of all the settlements and issues of SWPI at local level. It also gave us the understanding of sampling technique, methods applied, calculation of SWPI, uniform parameters, and indicators through different analysis. Further, the research focus on identifying the detailed findings of the research towards parameters, indicators used and the methods applied i.e. co-relation and regression. The research is concluded with the shortcomings in the present research and to identify the potential areas of research.

CHAPTER 6: FINDINGS AND CONCLUSION

Water poverty is a phenomenon that reflects the importance and finite nature of water resource on the planet. Many researches were conducted to understand the reasons, parameters behind this phenomenon. The research varies in their approach, scale and even in their techniques statistically and theoretically. This research attempts to mark a distinction with the existing water poverty studies by focusing particularly on “slums”. Slums being its target area, it signifies the scale at a local level. The most significant characteristic of this research is that, it concentrates on slums which are the marginalised parts of an urban area, so the parameters selected for the study reflect their suitability to be used at a slum scale.

From the graphical analysis represented in chapter 5, it is inferred that out of all the parameters used to measure water poverty, the parameters related to resource, access and capacity are predominant that effects the settlement. Parameters like water sufficiency, potable water access, Time spent in collection of water, expenditure spent for water are the major parameters that are affecting the settlement. It is inferred that due to less availability of water as per the need and requirement of the household, people depend on alternative source of water i.e. either they purchase or they depend on bore water, ground water. In all the slums, bore water, bottled water is used as alternative source and most of the expenditure is spent on water purchase. In the analysis, it was also found that the slum households are not using traditional treatment methods like adding alum, boiling for drinking water. Hence water quality directly impacts the health standards of the slum settlement that is inferred from the correlation analysis where environment indicator is showing the high significance level. The another finding of the research is 70% of the slum households in the study areas are dependent on community taps. The supply time for collecting water was is limited to four hours every alternate day. Moreover, the dependency on community taps is higher as number of households dependent on community taps for water collection is more. It is observed that more than ten households in a lane are dependent on community taps. Further, the number of trips made to collect water from the source becomes difficult. This is also one of the reasons for insufficiency of water supply in the settlements. From the indicator level analysis, it was inferred that out of all the five indicators, resources, access and capacity affects the most across all the settlements. It is observed that because of poor access and non-availability of resource, the capacity of the household is getting affected. However, the interdependence of one indicator on another indicator is analysed through statistical analysis. The Pearson co-relation analysis was conducted to analyse the cause and effect of one indicator on another indicator. In this, it was observed from Table 5.5 that out of all the slums, resource, access and capacity components are highly co-related in terms of its significance levels, but when they were graphically represented it is observed that R square value for resource and environment are highly co-related. It also infers that due to less availability of water and the source of availability is from the community taps, the quality of the water becomes questionable. This was observed in the R square value as per the graphs mentioned in the chapter 5. Further, regression analysis is conducted for understanding the dependency of various variables on the individual independent variables. The resource, capacity, and environment parameters were considered to understand the major parameters that effect the settlement. Each of these parameters helps in identifying the major parameters that effects the slum settlement.

In response to issues arising around spatial and temporal variability of data and their applicability at different scales, the first objective of the research was to determine the existing WPI models that were being used for water poverty assessments at various scales. The present indicators used across the studies includes the social, economic, and physical dimensions of the water poverty, the water poverty index (WPI) as an tool helps in understanding the water poverty situation of any scale that was elaborated in the chapter 2. Nevertheless, this research has sought to demonstrate its complex nature, its application in practice quite difficult. Its inability to accommodate and contextualise local variations in the dimensions of water poverty easily reveals its failure to accurately reflect ground realities of water poverty and importantly its ineffectiveness to compare water poverty at different levels. It has enabled to debate on the usage, applicability, calculation and scales of water poverty at its best to calculate the appropriateness of defining water poverty. The issue of scale continues to be problematic and response to the first objective is the review of various scales, indicators used context specific and the parameters used to define the scale were reviewed so as to understand the applicability of WPI. Since, the existing WPI is not contextualized and cannot be used at slum level, the parameters were identified that were basically used to define water situation in the slum. Some of these problems may be mitigated by incorporating questions designed to elicit information about the various dimensions of water poverty in future household censuses, although reliability of data will continue to be problematic.

In response to the research, the second objective sought to examine the relevance of water poverty indicators for slums by developing SWPI tool at settlement level that helps to evaluate water poverty issues at slum level that was elaborated in chapter 2. The question of desirability that evaluates water poverty issues at slum settlement level is analysed by developing a tool that consists of both indicator and parameter within the model. In response to questions about its ability to accurately represent local realities, the third objective aimed to assess the ability of the WPI to reflect slum level perceptions of water poverty by analysing and contrasting the results with locally defined variables determined through extensive field work and people consultations. The testing of SWPI as a tool and its applicability, its robustness and validating its accuracy to successfully predict community water poverty by undertaking rigorous analyses of the SWPI at the slum scale is done in chapter 5. It gave an understanding of the slum settlements in what way the indicators, parameters are affecting the settlements.

Parameters were reviewed in the present study in order to select the ones which will be suitably executed in order to accomplish the task. Although a common approach of indicators has been selected to carry forward the studies while the parameters within the indicators has been used in such a way that it rectifies and contextualize its use at slum level. These indicators are namely - Resource, Access, Capacity, Use and Environment. This research has taken into account some additional parameters like ground water, surface water availability, service coverage, per capita deficit at city level, per capita deficit at slum level to identify deprived slums which are not been considered at this scale by other authors. Other parameters have been taken from the existing literature studies and as well as from domain experts examined.

Resource (water quantity availability) and Use (water consumption), besides considering water sufficiency, with respect to the standard water demand of 80 lpcd for slums, variations in these parameters within a slum has also been considered as measure of water poverty. One assumption that has been considered behind this is that more the variations in water availability and consumption within a particular slum, more the water poverty in that slum.

The main source of water is municipal water supply, water access has been defined in terms of individual household water supply connections. If slum households are not having access to individual tap connections, then they are depending on community water taps as their main source of water. In that water poverty has been analysed on the basis of dependency over the water source and the intermittency of water supply. It was seen in the current research that in slums where both these cases had been existing (intermittent water supply through community taps with a higher dependency), for obvious reasons this made the people in those slums to be water poor.

This research seeks to address, the problems of assessing water poverty at local level and taking slum as its targeted local area, gives a generalised framework with parameters relevant for slums and an appropriate and exonerate methodology that can help analysing the water poverty situations in slums and help in comparing the uniqueness of different parameters across the slums. This comparative analysis of the different parameters of water poverty can help urban planners' and policy makers identifying the unfocused and underrated dimensions regarding water supply in slums. Slum Water Poverty has been determined in the light of 'household water poverty' which not only focuses on the absolute scarcity of water but also incorporates aspects of deficiencies in one or more key water service delivery indicators related to economic capacity, infrastructural deficiencies, health aspects etc. This multidimensional definition of water poverty is analogous to some extent to the concept of poverty given by Amartya Sen, which says that the issue of poverty is due to multiple factors.

One of the major drawbacks in the earlier water poverty studies (Garriga & Perez Foguet) (Vyver, 2013) was regarding the weightages taken for different indicators for a composite index-based study. But there was difference in those views also. Sullivan et al

(2003) describes the process of differential weighting as political rather than statistical. However, in this research application of equal weights has been used for all the indicators. This allows the statistical analysis of correlation to identify the most important indicators behind slum water poverty.

From the correlation analysis it is understood that Resource is the main problem behind any type of water poverty. In further analyse, it is proved that sub-indicators or components shows that insufficient water availability and the subsequent dependency of slum dwellers on alternative water sources are the major reasons causing water poverty issues. Now the major difference of this research with the earlier ones is that Resource is always the major problem because water scarcity will obviously lead to water poverty. But beyond that what comes out to be an important issue in this study is reflect Resource, Capacity are another important reason behind slum water poverty and this fact is something which makes this study somewhat different form the earlier water poverty studies. Because slum water poverty is purely part of an urban water issue and in urban areas where municipal water supply is the main or primary source of water, there if people get insufficient quantity of water from the primary water source then for meeting their demand, they will have to dependent on alternative sources of water for meeting their water deficit. Another important fact is that the domestic water demand will be more in urban areas compared to rural areas. In urban areas, due to the high population density, ground water and surface water availability are generally less. Because of that, here alternative sources of water are mainly water cans or municipal water tankers etc which cause them to pay extra amount of money which stimulates Capacity to be one of the most affected dimensions. This implies that a substantial amount of the household income is spent behind water (for water access and also due to the treatment cost because of the treatment cost due to water related diseases). The prioritization matrix is developed on the basis of the results obtained from the regression analysis so as to identify the major parameters affecting the slum. This will help to arrive the strategies to be developed so as to address the critical parameters in the study. With these strategies, a conceptual model is developed that helps to understand the parameters that directly influence the settlement and the parameters that indirectly affect the settlement. It also signifies the indicators that affect the slum water poverty of the settlement.

As discussed in second chapter, the existing WPI cannot be contextualised to local level. The available WPI may not address the problem of the country/region/community as a whole. The data set is to be categorised very specific to that level. In the process of data extraction, the index can address the problem specific to that level rather than addressing the problems at each level. Till date, the discussions and deliberations were done how to universalise the index that can be applied to that level. In general, when it about the slums, the existing WPI may not be applied to the slums. Slums are specific in nature that has different set of population group, socio-economic aspects and the infrastructure conditions. Water specific issues varies as per scales of the settlement. The country level issues or regional level strategies may not be applied or may not be assessed to understand the generic problems of water poverty of the settlement. At the slum level, water affordability, water quantity availability and reliability are clearly observed as an outcome. But when the WPI is discussed at regional/country level the ground water depletion, fresh water withdrawals, soil erosion, run off levels are discussed. This demarks the clear differences between at regional and slum settlement level. hence the first research question is proved that the existing WPI cannot be applied for the slums.

With regards to the second research question, there is a dire need to understand the slum water poverty issues. Most of the investments in developing countries is invested in the development of infrastructure and provision of basic services for the urban poor. However, there is no realistic assessment tool that will help to understand the priority areas among the slum settlements that are chronic and prone to severe water deprivation levels. To analyse the ground realities of the slum settlement, Slum water Poverty Index (SWPI) needs to be developed at a local level is detailed out in the chapter one. However, the development and need of such index is also discussed in the same chapter. The review of various existing WPI studies, identification of indicators, parameters, critiques of WPI is contributed as a part of the research in chapter 2. Slum specific parameters were developed from the slum-based water studies. The calculation procedure, the details of qualitative and quantitative parameters, sampling procedure, planning tools and analytical tools, construction of questionnaire is also detailed out for developing a comprehensive Slum water poverty index as a contribution for the research in the chapter 3. Development of conceptual model after calculation of SWPI, its validation in form of scenarios, its applicability for the policy makers and the urban local bodies is contributed in the chapter 6. This description proves the need to develop a slum water poverty index.

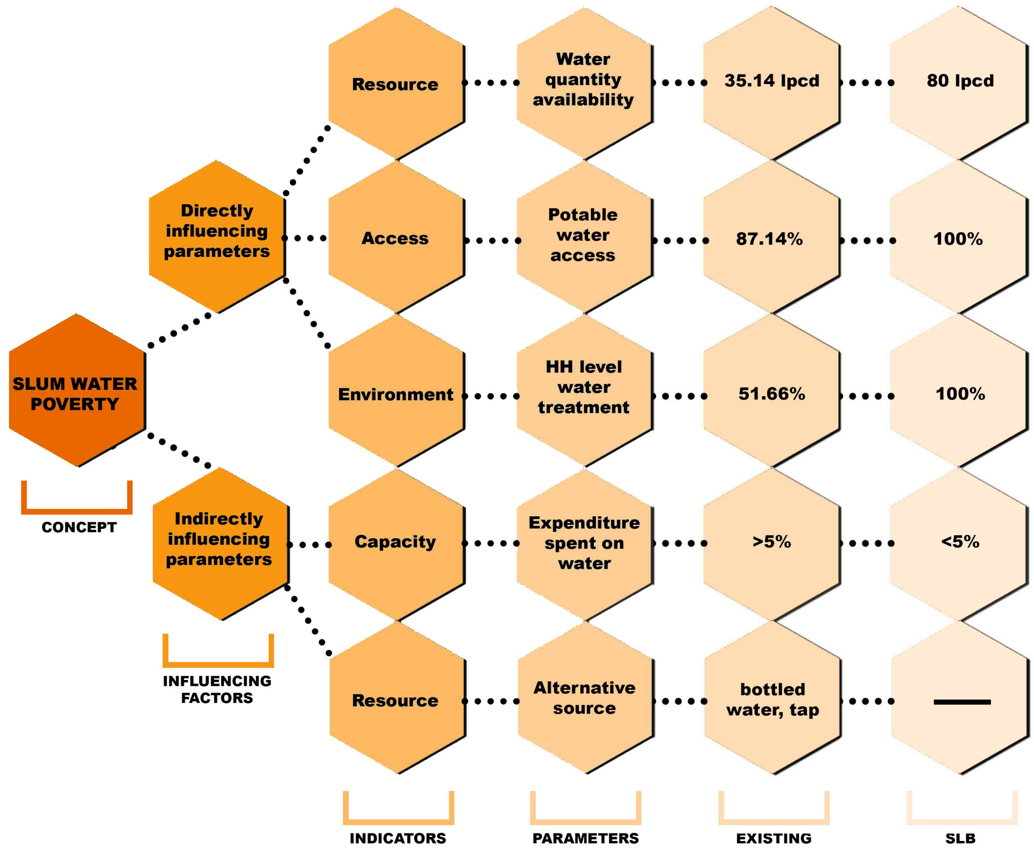


Figure 6.1 Conceptual model of SWPI

6.1 Model Validation:

The above conceptual model is developed on the basis of the results obtained from the statistical analysis. From the above conceptual model it is understood that resource, access, capacity and environment parameters are affecting the settlement in terms of quantity, reliability, expenditure. By identifying the status of the service levels in the settlement, benchmarking of services for the slum settlement can be done in the future studies. For the present study, the scenarios are developed so as to address the present problem of water poverty in the Vijayawada city. Three scenarios were developed where individual tap connections, reliability levels, quantity levels were taken as a basis to address the issue. The above model may be applicable for identifying the criticality of water issues in the slum settlement.

6.2 Scenario Building

Scenario building exercise is done statistically to find out ways to improve the water poverty situation in the slums:

Scenario 1: 100% Individual piped water access to all the households.

When all the households will be provided with access to piped water supply, a total supply time of 1 to 2 hours a day will be required. This will not change the pressure of the Water supply but will provide or will meet the bare minimum requirement of 80 lpcd service level benchmark.

Scenario 2: 100% community taps

When all the households are provided access through community. Taking a dependency ratio of 20 households per community tap. And supplying water for 12 to 14 hours a day, water poverty will reduce meeting the service level benchmark of 80 lpcd to the slum dwellers, without affecting their capacity.

Scenario 3: Individual taps for 50% households and community taps for remaining 50% households

By providing individual taps to 50% of the households in the slums and a water supply time of 1 to 2 hours a day will reduce the water poverty. Also, keeping the dependency ratio of 20 Households per community remaining households can get water through community taps for a time period of 12 to 14 hours a day. These interventions will help meeting the service level benchmark of 80 lpcd to slum dwellers. Refer annexure 7

6.3 Slum Water Poverty Index (SWPI) Model

The developed SWPI model (fig 6.1) is useful to understand the water specific issues at household level in the slums that are spread across the city. The developed SWPI helps in identifying the parameters that are more predominant affecting the settlement. It also helps to understand to what extent the problem is critical. It also helps in understanding the parameters that are directly and indirectly influencing the settlement. The directly and the indirectly influencing parameters were extracted based on the multiple regression analysis. The parameters like water quantity, reliability, expenditure spent on water, HH water treatment, alternative sources, portable water access are the major parameters that are affecting the settlement in the city. When these parameters were categorised on basis of its priority, it is observed that there are parameters that are directly and indirectly impacting the settlement. It is inferred that direct influencing parameters of the settlement has to address on the priority basis rather than indirectly influencing parameters. In the present case, time is the major factor, Piped water connections (dependency on community taps) is the major factors that are affecting the quantity of water availability. In turn, it is also affecting the expenditure of the household that is major component and the observation found out from the research. A conceptual model is developed on the basis of the common parameters that were identified throughout the study through statistical approach. The scenarios were developed to address the problem of water scarcity issues in the slum through SWPI. The scenarios may be altered depending on the identified parameters from the study. It has its limitation in terms of scale, applicability, calculation, benchmarking. It cannot address the problems beyond the scale of slum settlements. However, it will resolve the issues related to water in the slum settlements.

Potential for future research

This research points out to a basic fact that due to the water poverty issue the poor and those deprived of access to basic services are getting more marginalised. In some slums, the municipal service is in the form of household water supply connection (individual connections) has been extended to some extent to some of the slums, most of the slum dwellers have not been able to take the connections due to the high amount of one-time investment required. But unfortunately, the people depending on community taps, are paying more than those households having individual water connections due to their water insufficiency and the subsequent dependency on the alternative sources of water. This is creating a serious issue of spatial inequity, which needs to be addressed.

Correlation and regression analysis helped to understand the dominance of the parameters on the overall water poverty situation in the particular slum and it also helps to understand the interdependence of the parameters. Regression equations formed on the basis of the observations help to build scenarios that if conditions are altered regarding one or more parameter, how that can affect the other parameters and can alter the overall water supply scenario. This particular phenomenon can help the policy makers and city planners to estimate the benefits of upgrading the community water supply characteristics through quasi-experimental or randomised trials. These randomised trials finally help generating scenarios which will provide options for the city planners and policy makers for making interventions which can solve the issue of slum water poverty or the spatial disparity in water availability and access in urban areas. From the available options strategic interventions can be made through implementing the cost-effective strategies. As per the United Nations, inadequate water access is one of the criteria defining a slum, so improved water metrics may additionally move forward the precision for the estimation of the slum population in India and also globally.

The problem of inter-correlation between indicators is acknowledged and further work is needed to be done in this regard. The research helps in understanding the existing WPI developed at different scales and issues related to its application. These responses to the first research question. The application of differential or equal weighing for the indicators and for each variable may be a possible extension of the research study. The subject of weighting is highly complex, far more complex than anticipated at the outset of this research and could easily justify an entirely separate thesis. Furthermore, there is no end to the different weighting methodologies in use. The calculation mode, statistical approaches needs refinement that can be undertaken as a separate study. Moreover, although their research position within management science implies a certain level of objectivity this is presumably at the expense of in-depth knowledge of the social problems specific to water poverty. Nevertheless, future research into this specific problem is considered essential for the future of the WPI.

This research can be carried forward looking into the social, political and economic aspects of water poverty. More importantly there is always a scope of improving the parameters to suit the study for the defining water poverty at slum level. Even the method of application of weightages to the components of water poverty is still a debatable issue. Studies can be undertaken to look into that aspect. Development of SWPI at settlement level helps in assessing the performance levels of the settlement. In context to Philosophical aspect, it is also evident that the distributive justice thresholds lead to residualist approach that is oblivious perceived through the present research. However, to maintain the threshold and for equitable distribution of resources, the strategies and policy interventions need to be relooked. The SWPI helps to access the performance levels demand and supply status of the slum settlement. However, the further research may also focus on benchmarking of such parameters and analysing the data to identify the deprivation levels. Further, the primary data related to parameters like expenditure on water, treatment methods used at HH level, TDS levels, water related illness may be collected as part of National Sample Survey Organisation.

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Annexure

Annexure 1

Expert Opinion Survey - Slum specific Water Poverty parameters

Dear Madam / Sir

I am Deen Maqbool Ahmed and I am pursuing my doctoral research at School of Planning and Architecture, Vijayawada. The topic of my dissertation is 'Developing Water Poverty Index for Slums'.

Many research studies in water focus on assessment of water service levels at City/Urban level. Government and funding agencies are involved for provision and funding water services for urban poor in developing countries through various development schemes. However, till date we don't have any realistic tools to assess water situations in slums apart from service level benchmarking for urban areas. Because of this, cities are unable to prioritise investments in urban slums. Countries like USA, UK and various development institutions have already evolved Water Poverty Parameters that are context specific to Country, Regional, Community level. Since the parameters are context specific in nature the established WPI needs to be remodified for developing countries and specific to the slums at micro level.

One of my research objectives is identification and developing of water poverty parameters for slums. For the same, I have studied and compiled various Water Poverty parameters. In order to finalise the list of parameters from each indicator that needs to be retained or added in the study, I intend to obtain expert opinion on the same.

Given your expertise and knowledge in the area, I invite you to kindly fill in the survey form. The survey form will require approximately ten minutes to fill in. You can suggest any new parameter(s) if need be added in each indicator.

Thank you for taking the time to assist me in my research endeavours.
With warm regards.

Yours Sincerely,
Dean Maqbool Ahmed
Contact number: 09032604094, 9949142031
E-mail id: maqbool@spav.ac.in

* Required

Survey Format

1. Resource

1. Source of water
Individual Tap connection, Community Tap, Bore-well, well etc. to decide the quality of water *Mark only one oval.*

- ◯ Yes

No

Other:

Water Quantity

Measured in liters per capita per day (lpcd), this indicator will be used to know the amount of water received by the user
Mark only one oval.

Yes

No

Other:

3. Water sufficiency

Measured in liters per capita per day (lpcd), this indicator will enable us to know the amount of water received as per population with respect to the Service Level Benchmarks (SLB).
Mark only one oval.

Yes

No

Other:

4. Operational hours in Water supply

No.of hours in a day
Mark only one oval.

Yes

No

Other:

2. Access

5. Households with potable water access Percentage of households that receives potable water *Mark only one oval.*

Yes

No

Other:

6. Frequency of water supply

No. of days within a week consumers receive water *Mark only one oval.*

Yes

No

Other:

7. Time spent to collect water (House to water source)
   Measured in minutes
   Mark only one oval.

   - Yes
   - No
   - Other: ____________

8. Distance travelled to collect water
   Measured in meters
   Mark only one oval.

   - Yes
   - No
   - Other: ____________

9. Time spent in water collection at source (queuing time)
   Measured in minutes
   Mark only one oval.

   - Yes
   - No
   - Other: ____________

10. Distance from Natural surface water source *
    HH travelling to and fro more than 500 m to get access to natural surface water source *Mark only one oval.*

    - Yes
    - No
    - Other: ____________

11. Women engaged in collecting water Percentage of women engaged in water collection *Mark only one oval.*

    - Yes
    - No
    - Other: ____________

12. Children engaged in water collection
    Percentage of children within the age group of 9-14 years *Mark only one oval.*

    - Yes
    - No
    - Other: ____________

3.Capacity

13. Maintenance of water sources
    Water source maintained by Govt., Public themselves, Private personnel *Mark only one oval.*

    - Yes
    - No
    - Other: ______________________

14. Maintenance of water sources
    Frequency of maintenance of water source by responsible authority *Mark only one oval.*

    - Yes
    - No
    - Other: ______________________

15. Household Income (₹)
    Mark only one oval.

    - Yes
    - No
    - Other: ______________________

16. Expenditure spent on water (₹)
    Mark only one oval.

    - Yes
    - No
    - Other: ______________________

17. Education
    No of days Absents from schools monthly due to water related problems such as water scarcity /water borne diseases.
    Mark only one oval.

    - Yes
    - No
    - Other: ______________________

18. Employment
    Working hours loss due to due to water related problems such as water scarcity /water borne diseases.
    Mark only one oval.

    - Yes
    - No

Other: ____________

19. Expenditure on health due to water illness (₹)

Mark only one oval.

Yes

No

Other: ____________

4. Use

Domestic water consumption per head per day

Measured in lpcd

Mark only one oval.

Yes

No

Other: ____________

21. Potable water consumption per head per day

Measured in lpcd

Mark only one oval.

Option 1

22. Insufficiency in consumption

Percentage consumption deficit with respect to standard demand of 80 LPCD *Mark only one oval.*

Yes

No

Other: ____________

5. Environment

23. Water quality (TDS)

Measured in parts per million (ppm) *Mark only one oval.*

Yes

No

Other: ____________

24. Household level water treatment

Boiling water, bleaching water, adding alum etc. *Mark only one oval.*

- Yes
- No
- Other: ______________________

25. Type of water borne diseases affecting the population
    Such as Cholera, fluoride, dysentery etc
    Mark only one oval.

- Yes
- No
- Other: ______________________

Annexure 2

RAY Data of Slums

S.No	Slum Code	Slum Name	Tenability	Area in ha	House Holds	Population
1	204	Devi Nagar	Non-Hazardous	16.64	1101.00	3693.00
2	205	East K.L.Rao Road in 23rd Dvn.	Non-Hazardous	19.33	1233.00	4321.00
3	206	Kuddushnagar_ Kadareswaripet	Non-Hazardous	1.07	104.00	361.00
4	207	Nandamuri Basavathraka Nagar	Non-Hazardous	1.29	87.00	320.00
5	208	New Ayodhyanagar Donka	Non-Hazardous	2.14	57.00	194.00
6	209	Yerukala area near UP School	Non-Hazardous	17.78	1149.00	4121.00
7	210	Area near 1 _ 2 Blocks A.S.Nagar	Non-Hazardous	3.69	468.00	1616.00
8	211	Cement factory hutting	Non-Hazardous	0.87	64.00	250.00
9	212	Area near Block No.37 _ 40 A.S.Nagar	Non-Hazardous	4.65	242.00	851.00
10	213	Kundavari Kandrika Rural	Non-Hazardous	21.21	435.00	1443.00
11	214	L.B.S.Nagar_Payakapuram	Non-Hazardous	6.32	800.00	2783.00
12	215	Nandamuri Taraka Rama Nagar	Non-Hazardous	1.67	244.00	808.00
13	216	N.S.C.Bose Nagar Kandrika	Non-Hazardous	22.58	2887.00	10165.00
14	218	Rajiv Nagar Colony	Non-Hazardous	19.79	2314.00	8209.00
15	219	Sundaraiah Nagar	Non-Hazardous	11.06	1323.00	4621.00
16	220	Vaddera Colony 23rd Dvn	Non-Hazardous	4.32	275.00	993.00
17	221	Vaddera Colony, Rajiv Nagar Extn	Non-Hazardous	2.89	445.00	1669.00
18	222	Vambey Colony	Non-Hazardous	27.09	2968.00	10838.00
19	223	P.S.Nagar behind Burma Colony	Non-Hazardous	8.29	232.00	832.00
20	224	Prakash Nagar	Non-Hazardous	35.94	2248.00	7742.00
21	225	Santhi Nagar_ Payakapuram	Non-Hazardous	16.55	1919.00	6484.00
22	226	Seetharama Puram	Non-Hazardous	1.48	52.00	170.00
23	227	Interior parts of RTC Colony Patamata	Non-Hazardous	2.56	96.00	333.00
24	228	J.D.Nagar	Non-Hazardous	3.59	114.00	408.00
25	229	New Giripuram	Non-Hazardous	3.89	835.00	2960.00
26	231	Malapalli canal hutting (Patamata Ambedkar Nagar)	Non-Hazardous	3.55	582.00	2082.00
27	232	Sanjay Gandhi nagar_ Patamata	Non-Hazardous	0.60	90.00	304.00

28	234	Badava _ Woodpet	Non-Hazardous	5.42	208.00	745.00

Sl.No	Slum code	slum name	Population	No. of Households	water tap	
					yes	yes
			1	2	3	4
39	239	Santhinagar_ Patamata	279	1045	183	183
40	240	Thotavari street_ Patamata	217	773	203	203
41	241	Karakatta Down South	2107	6902	1300	1300
42	242	Karakatta Down North	742	2674	551	551
43	243	Lambadipet_ Chittinagar Hill area	1897	7083	1556	1556
44	244	Slum behind SAS college	120	436	109	109
45	245	Canal Hutting Greenlands Hotal	200	721	45	45
46	246	Mallikharjunapet	85	299	80	80
47	247	RTC Work shop_ Gorila Doddi	149	492	116	116
48	248	RTC work shop Rama Nagar	280	939	123	123
49	249	Priyadarsini Colony	507	1781	489	489
50	250	Singhnagar Road Side Hutting	26	94	6	6
51	251	Sanjay Gandhi Labour Colony	206	716	206	206
52	252	Urmila Subba Rao Nagar	1365	4747	1329	1329
53	253	Joji Nagar Colony	176	651	152	152
54	254	K.R.Dall Mil Area (Ware house Godown)	78	275	0	0
55	255	Nulakapet_ Bhavanipuram	435	1627	429	429
56	256	Ryves canal Hutting North &South from Dal Mill	840	2746	823	823
57	257	Eluru road hutting (Ring road East Exten)	582	1991	444	444
58	258	Canal hutting up to Cabin end	276	923	22	22
59	259	Harizanawada (Gunadala)	100	336	95	95
60	260	Christianpet (Gunadala)	230	853	184	184
61	261	Autonagar area	117	367	103	103
62	262	Arul Nagar (Gunadala)	463	1599	380	380
63	263	Ayyappa Nagar Quarry (Vijay and Uma Nagar)	583	1910	552	552
64	264	Christurajapuram	1276	4458	1066	1066
65	265	Lurd Nagar	619	2068	574	574
66	266	Varalakshmi Nagar	92	347	80	80
67	267	Machavaram Down, Karmika Nagar	976	3338	973	973
68	268	Machavaram upto Quarry Hill area	463	1527	433	433
69	269	KothavanthenaCanal hutting west side	383	1290	148	148
70	270	Maruthinagar Canal Hutting	461	1484	208	208
71	271	K.L.Rao Nagar	628	2232	609	609
72	272	Tailorpet Hill area	1495	5596	1370	1370
73	273	Frizerpet Hill area	1059	3821	794	794
74	274	Kothapet hill area upto Srinivasa mahal	3018	10678	2801	2801
75	275	Kothapet hill area from Srinivasa mahal to Tunnel South	3599	12647	3348	3348
76	276	Turnel North hill area	203	735	184	184

Sl.No	Slum code	slum name	Population	No. of Households	water tap	
					yes	yes
			1	2	3	4
77	277	Turnel South hill area	682	2445	671	671
78	278	New Raj Rajeawari Pet	2794	9691	2649	2649
79	279	Raj Rajeaswari Pet	1987	7064	1638	1638
80	280	T.Subbaraju Nagar	191	625	186	186
81	281	Abbothu Appanna Pakalu	183	706	116	116
82	282	Dhall mill area	209	715	38	38
83	283	Heart pet	90	302	3	3
84	284	Wynchipet Hill Area	1902	6666	1476	1476
85	285	Wynchipet Ry.station	102	378	51	51
86	286	Chinthalamala palli	700	2753	576	576
87	287	Machavaram Hill slope down Harijana wada	1153	3970	1096	1096
88	288	Mogalrajupuram Hill Area East	208	757	206	206
89	289	Mogalrajupuram Hill Area West	869	3060	826	826
90	290	Mogalrajupuram Prajashakti nagar	503	1809	466	466
91	291	Pakeer gudeam	604	2042	277	277
92	292	Pettingul pet	105	383	94	94
93	293	Workment pet	38	150	36	36
94	294	Slum South & West of Montissori College	58	206	4	4
95	295	Slum Kapu Kalyan mandapam	84	348	78	78
96	296	Atchamma Bazar	167	557	166	166
97	297	Gulabhi Thota area	166	619	165	165
98	298	Madhura nagar Revenue Layout	551	1933	454	454
99	299	Madhura Nagar Donka Road and Track	626	2238	462	462
100	300	Bramarambapuram River Bund Burial Ground	637	1968	169	169
101	301	River Bank Rpakalu_ Bramarambapuram	1933	6386	624	624
102	302	River Bund low level north Ranigarithota	448	1582	184	184
103	303	River Bund Ranigarithota _ Nehru Nagar	1291	4460	1019	1019
104	304	Chalasani Nagar Ranigarithota	1840	6733	1516	1516
105	305	Ranigarithota Bhaskara Raopet	2102	7642	1673	1673
106	306	NamburiGopal Rao street	32	104	22	22
107	307	Bethlaham Nagar	670	2334	533	533
108	308	Ambedkar Nagar (Krishana Nagar)	100	348	88	88
109	309	By the Side Of Lorry Stand,Vidyadharapuram	67	240	61	61

Sl.No	Slum code	slum name	source name										water supply frequency			
			own tap	public tap	outside the premises	inside premises	open well	tank/pnd	river/canal/lake/spring	water tanker	no supply	others	daily	once in two days	once in week	once in 15 days
			5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	201	Ambedkar Nagar canal hutting upto Madhura nagar	297	170	10	1297	0	0	0	0	0	1	1775	0	0	0
2	202	Warehouse Road	55	20	0	1	0	0	0	0	0	0	75	1	0	0
3	203	Budameru flood bank Ramakrishnapuram	327	29	0	92	0	0	0	0	0	0	448	0	0	0
4	204	Devi Nagar	683	123	86	199	2	0	0	0	3	5	1040	7	54	0
5	205	East K.L.Rao Road in 23rd Dvn.	424	805	3	0	1	0	0	0	0	0	1192	40	1	0
6	206	Kuddushnagar_ Kadareswaripet	67	37	0	0	0	0	0	0	0	0	104	0	0	0
7	207	Nandamuri Basavathraka Nagar	41	45	1	0	0	0	0	0	0	0	86	1	0	0
8	208	New Ayodhyanagar Donka	56	1	0	0	0	0	0	0	0	0	56	1	0	0
9	209	Yerukala area near UP School	902	189	28	3	0	0	0	1	0	26	1124	20	5	0
10	210	Area near 1 _ 2 Blocks A.S.Nagar	429	35	0	1	2	0	0	0	0	1	466	2	0	0
11	211	Cement factory hutting	59	5	0	0	0	0	0	0	0	0	63	1	0	0
12	212	Area near Block No.37 _ 40 A.S.Nagar	242	0	0	0	0	0	0	0	0	0	241	1	0	0
13	213	Kundavari Kandrika Rural	428	7	0	0	0	0	0	0	0	0	433	2	0	0
14	214	L.B.S.Nagar_Payakapuram	788	8	0	0	0	0	0	0	0	4	799	1	0	0
15	215	Nandamuri Taraka Rama Nagar	68	123	8	1	44	0	0	0	0	0	214	20	10	0
16	216	N.S.C.Bose Nagar Kandrika	2598	282	3	2	0	0	0	0	0	2	2885	2	0	0
17	217	Saw Mill Hutting	1040	332	378	1177	73	1	0	0	3	8	2992	18	2	0
18	218	Rajiv Nagar Colony	1841	14	6	187	2	0	0	258	2	4	2305	9	0	0
19	219	Sundaraiah Nagar	1194	18	0	3	0	0	0	104	0	4	1323	0	0	0
20	220	Vaddera Colony 23rd Dvn	266	9	0	0	0	0	0	0	0	0	272	3	0	0
21	221	Vaddera Colony, Rajiv Nagar Extn	335	107	1	0	0	0	0	0	1	1	444	1	0	0
22	222	Vambey Colony	2833	42	20	0	2	1	1	1	7	61	2932	6	30	0
23	223	P.S.Nagar behind Burma Colony	190	23	1	0	0	0	0	0	0	18	228	3	1	0
24	224	Prakash Nagar	2119	68	2	0	0	1	0	48	0	10	2233	14	1	0
25	225	Santhi Nagar_ Payakapuram	1906	6	1	0	0	0	0	0	1	5	1919	0	0	0
26	226	Seetharama Puram	52	0	0	0	0	0	0	0	0	0	52	0	0	0
27	227	Interior parts of RTC Colony Patamata	67	7	16	5	0	0	0	0	1	0	96	0	0	0

28	228	J.D.Nagar	104	2	5	0	3	0	0	0	0	0	89	0	25	0
29	229	New Giripuram	589	1	1	242	0	0	0	0	0	2	832	3	0	0
30	230	Ramalingeswara nagar canal hutting	86	182	27	519	1	0	0	1	0	2	817	1	0	0
31	231	Malapalli canal hutting (Patamata Ambedkar Nagar)	557	18	3	2	0	0	0	0	0	2	579	1	2	0
32	232	Sanjay Gandhi nagar_ Patamata	86	4	0	0	0	0	0	0	0	0	90	0	0	0
33	233	Venkateswara Manyam Hutting	173	162	14	26	0	0	0	0	0	3	377	1	0	0
34	234	Badava _ Woodpet	175	31	0	2	0	0	0	0	0	0	208	0	0	0
35	235	DarsipetI	629	0	1	0	0	0	0	0	0	3	632	1	0	0
36	236	DarsipetII	227	2	0	0	0	2	0	0	0	2	233	0	0	0
37	237	High School Road_ Patamata Scavengers Colony	173	4	1	0	0	0	0	0	0	0	177	1	0	0
38	238	Nehru Nagar (Giripuram)	455	34	0	0	0	0	0	0	0	0	489	0	0	0

Sl.No	Slum code	slum name	source name										water supply frequency			
			own tap	public tap	outside the premises	inside premises	open well	tank/pnd	river/canal/lake/spring	water tanker	no supply	others	daily	once in two days	once in week	once in 15 days
			5	6	7	8	9	10	11	12	13	14	15	16	17	18
39	239	Santhinagar_ Patamata	172	62	3	33	1	1	3	1	3	0	277	2	0	0
40	240	Thotavari street_ Patamata	205	1	0	11	0	0	0	0	0	0	217	0	0	0
41	241	Karakatta Down South	834	1245	28	0	0	0	0	0	0	0	2068	36	3	0
42	242	Karakatta Down North	467	273	1	1	0	0	0	0	0	0	716	25	1	0
43	243	Lambadipet_ Chittinagar Hill area	1594	292	1	2	0	0	0	0	1	7	1896	0	1	0
44	244	Slum behind SAS college	109	9	0	1	0	0	0	0	0	1	120	0	0	0
45	245	Canal Hutting Greenlands Hotal	7	168	25	0	0	0	0	0	0	0	199	1	0	0
46	246	Mallikharjunapet	36	46	2	0	0	0	0	0	0	1	85	0	0	0
47	247	RTC Work shop_ Gorila Doddi	62	81	6	0	0	0	0	0	0	0	148	1	0	0
48	248	RTC work shop Rama Nagar	124	156	0	0	0	0	0	0	0	0	280	0	0	0
49	249	Priyadarsini Colony	498	9	0	0	0	0	0	0	0	0	505	0	2	0
50	250	Singhnagar Road Side Hutting	6	0	0	0	0	0	0	0	0	0	6	0	0	0
51	251	Sanjay Gandhi Labour Colony	205	1	0	0	0	0	0	0	0	0	206	0	0	0
52	252	Urmila Subba Rao Nagar	1335	21	4	0	1	0	0	0	1	3	1351	10	4	0

53	253	Joji Nagar Colony	153	23	0	0	0	0	0	0	0	0	176	0	0	0
54	254	K.R.Dall Mil Area (Ware house Godown)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55	255	Nulakapet_ Bhavanipuram	432	2	0	1	0	0	0	0	0	0	430	1	4	0
56	256	Ryves canal Hutting North &South from Dal Mill	739	85	4	10	2	0	0	0	0	0	799	40	1	0
57	257	Eluru road hutting (Ring road East Exten)	458	55	53	12	2	0	0	1	1	0	576	6	0	0
58	258	Canal hutting up to Cabin end	10	265	0	1	0	0	0	0	0	0	275	1	0	0
59	259	Harizanawada (Gunadala)	57	42	1	0	0	0	0	0	0	0	100	0	0	0
60	260	Christianpet (Gunadala)	138	90	2	0	0	0	0	0	0	0	221	7	2	0
61	261	Autonagar area	108	6	3	0	0	0	0	0	0	0	117	0	0	0
62	262	Arul Nagar (Gunadala)	362	65	17	0	3	0	0	0	2	14	285	173	5	0
63	263	Ayyappa Nagar Quarry (Vijay and Uma Nagar)	555	21	0	0	0	0	0	0	3	4	570	13	0	0
64	264	Christurajapuram	1153	107	3	2	0	1	0	1	3	6	1256	19	1	0
65	265	Lurd Nagar	574	44	1	0	0	0	0	0	0	0	619	0	0	0
66	266	Varalakshmi Nagar	80	10	0	2	0	0	0	0	0	0	92	0	0	0
67	267	Machavaram Down, Karmika Nagar	970	2	0	1	2	0	0	0	0	1	971	3	2	0
68	268	Machavaram upto Quarry Hill area	436	25	0	1	0	0	0	0	0	1	459	4	0	0
69	269	KothavanthenaCanal hutting west side	151	231	0	0	0	0	0	0	0	1	383	0	0	0
70	270	Maruthinagar Canal Hutting	39	150	272	0	0	0	0	0	0	0	455	6	0	0
71	271	K.L.Rao Nagar	623	2	1	2	0	0	0	0	0	0	624	1	3	0
72	272	Tailorpet Hill area	885	604	5	0	0	0	0	0	0	1	1484	10	1	0
73	273	Frizerpet Hill area	787	260	2	0	0	0	0	0	0	10	1041	18	0	0
74	274	Kothapet hill area upto Srinivasa mahal	2905	109	1	0	0	0	0	0	1	2	2957	60	1	0
75	275	Kothapet hill area from Srinivasa mahal to Tunnel South	3390	198	6	0	0	0	0	1	0	4	3571	23	5	0
76	276	Turnel North hill area	187	8	1	4	0	0	0	0	1	2	199	4	0	0

Sl.No	Slum code	slum name	source name										water supply frequency			
			own tap	public tap	outside the premises	inside premises	open well	tank/pnd	river/canal/lake/spring	water tanker	no supply	others	daily	once in two days	once in week	once in 15 days
			5	6	7	8	9	10	11	12	13	14	15	16	17	18
77	277	Turnel South hill area	523	133	24	0	0	0	0	0	0	2	680	2	0	0
78	278	New Raj Rajeawari Pet	2713	45	19	6	1	0	0	0	1	9	2774	17	3	0
79	279	Raj Rajeaswari Pet	1578	200	50	131	2	0	4	3	4	15	1914	49	24	0
80	280	T.Subbaraju Nagar	190	0	0	0	0	0	0	0	0	1	190	1	0	0
81	281	Abbothu Appanna Pakalu	56	127	0	0	0	0	0	0	0	0	183	0	0	0
82	282	Dhall mill area	28	177	0	0	0	0	0	0	0	4	209	0	0	0
83	283	Heart pet	7	83	0	0	0	0	0	0	0	0	90	0	0	0
84	284	Wynchipet Hill Area	370	1515	11	3	0	0	1	0	2	0	1900	2	0	0
85	285	Wynchipet Ry.station	61	41	0	0	0	0	0	0	0	0	87	15	0	0
86	286	Chinthalamala palli	644	48	0	3	1	0	0	0	0	4	691	8	1	0
87	287	Machavaram Hill slope down Harijana wada	1085	40	5	12	2	0	0	0	7	2	1150	3	0	0
88	288	Mogalrajupuram Hill Area East	196	11	0	0	0	0	0	0	0	1	207	1	0	0
89	289	Mogalrajupuram Hill Area West	777	78	7	0	2	0	0	0	0	5	846	17	6	0
90	290	Mogalrajupuram Prajashakti nagar	477	18	2	0	0	1	0	0	1	4	491	12	0	0
91	291	Pakeer gudeam	233	338	1	32	0	0	0	0	0	0	546	5	53	0
92	292	Pettingul pet	96	4	5	0	0	0	0	0	0	0	102	2	1	0
93	293	Workment pet	36	2	0	0	0	0	0	0	0	0	38	0	0	0
94	294	Slum South & West of Montissori College	0	55	3	0	0	0	0	0	0	0	56	1	1	0
95	295	Slum Kapu Kalyan mandapam	60	22	1	0	0	0	0	0	0	1	83	1	0	0
96	296	Atchamma Bazar	167	0	0	0	0	0	0	0	0	0	167	0	0	0
97	297	Gulabhi Thota area	166	0	0	0	0	0	0	0	0	0	164	2	0	0
98	298	Madhura nagar Revenue Layout	125	415	3	5	0	0	0	0	0	3	546	5	0	0
99	299	Madhura Nagar Donka Road and Track	409	216	0	0	0	0	0	0	0	1	624	1	1	0
100	300	Bramarambapuram River Bund Burial Ground	57	258	113	202	1	1	0	0	0	5	634	2	1	0

101	301	River Bank Rpakalu_ Bramarambapuram	51	46	1153	589	89	2	0	0	0	3	1628	3	302	0
102	302	River Bund low level north Ranigarithota	35	321	26	58	0	0	0	0	6	2	429	15	4	0
103	303	River Bund Ranigarithota _ Nehru Nagar	727	35	154	364	10	0	0	0	0	1	1286	1	4	0
104	304	Chalasani Nagar Ranigarithota	969	309	194	345	0	0	0	7	4	12	1701	101	38	0
105	305	Ranigarithota Bhaskara Raopet	2005	65	16	8	0	1	0	3	0	4	2048	33	21	0
106	306	NamburiGopal Rao street	24	8	0	0	0	0	0	0	0	0	32	0	0	0
107	307	Bethlaham Nagar	569	69	4	23	0	0	1	0	0	4	630	35	5	0
108	308	Ambedkar Nagar (Krishana Nagar)	71	25	3	1	0	0	0	0	0	0	100	0	0	0
109	309	By the Side of Lorry Stand,Vidyadharapuram	62	10	0	0	0	0	0	0	0	0	72	0	0	0

Annexure 3

Perspective Survey Result:

Slum	Quantity problem	Quality problem	Accessibility problem
Raniarithota Chalasani Nagar	Yes	Yes	Yes
River Bund North Ranigarithota	Yes	Yes	Yes
Devi Nagar	Yes	Yes	Yes
Santhi Nagar	Yes	Yes	Yes
Vambay Colony	Yes	Yes	Yes
Rajarajeswaripet	Yes	Yes	Yes
KL Rao Nagar	Yes	Yes	Yes

Annexure 4

Onsite survey Questionnaire:

Sl No.	Parameters	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
1	Main source of water (individual or community tap)					
2	HH size					
3	Dependency ratio over the tap					
4	Distance travelled to fetch water					
5	Time spent in water collection including queuing time					
6	Time of water availability (hours/day)					
7	Quantity of water (litres)					
8	Frequency of water (days/week)					
9	Monthly HH income					
10	Monthly expenditure on water related health issues					
11	Water related disease (if facing any)					
12	Potable/drinking water availability					
13	Water consumption for drinking					
14	Water consumption for bathing					
15	Water consumption for cooking					
16	Water consumption for washing					
17	If any physical water quality					

	issues					
18	If any kind of water treatment is done at HH level					
19	Cost of water (monthly charges)					
20	Cost of water (monthly expenditure if water cans/ tankers are used)					
21	Water quality (TDS)					
22	Distance from natural surface water source					

Annexure 5

Correlation Matrix of SWPI parameters

Correlations

		Quantity	Quan_Deficit	Consumption_Deficit	Alternative_source	Reliability	Dependent_HH	Piped_water_access	Time_Spent_more_than30Min	Dist_NSWS	Filling_Time_secs	Money_Spent_More_than_5Percent	Treatment	Illness
Quantity	Pearson Correlation	1	-.687**	-.532**	-.779**	.184	-.674**	-.779**	-.282*	.161	-.269*	-.816**	.444**	.407**
	Sig. (2-tailed)		.000	.000	.000	.183	.000	.000	.039	.246	.050	.000	.001	.002
	N	54	54	54	54	54	54	54	54	54	54	54	54	54
Quan_Deficit	Pearson Correlation	-.687**	1	.932**	.818**	.127	.820**	.818**	-.003	-.143	.125	.584**	-.769**	-.681**
	Sig. (2-tailed)	.000		.000	.000	.362	.000	.000	.984	.303	.367	.000	.000	.000
	N	54	54	54	54	54	54	54	54	54	54	54	54	54
Consumption_Deficit	Pearson Correlation	-.532**	.932**	1	.597**	.330*	.681**	.597**	-.243	-.037	-.036	.427**	-.808**	-.683**
	Sig. (2-tailed)	.000	.000		.000	.015	.000	.000	.076	.791	.799	.001	.000	.000
	N	54	54	54	54	54	54	54	54	54	54	54	54	54

Alternative_source	Pearson Correlation	-.779**	.818**	.597**	1	-.215	.839**	1.000**	.431**	-.230	.314*	.714**	-.500**	-.464**
	Sig. (2-tailed)	.000	.000	.000		.118	.000	0.000	.001	.095	.021	.000	.000	.000
	N	54	54	54	54	54	54	54	54	54	54	54	54	54
Reliability	Pearson Correlation	.184	.127	.330*	-.215	1	-.121	-.215	-.392**	.150	-.673**	-.217	-.185	-.001
	Sig. (2-tailed)	.183	.362	.015	.118		.384	.118	.003	.280	.000	.115	.181	.994
	N	54	54	54	54	54	54	54	54	54	54	54	54	54
Dependent_HH	Pearson Correlation	-.674**	.820**	.681**	.839**	-.121	1	.839**	.264	-.176	-.057	.600**	-.569**	-.538**
	Sig. (2-tailed)	.000	.000	.000	.000	.384		.000	.054	.204	.682	.000	.000	.000
	N	54	54	54	54	54	54	54	54	54	54	54	54	54
Piped_water_access	Pearson Correlation	-.779**	.818**	.597**	1.000**	-.215	.839**	1	.431**	-.230	.314*	.714**	-.500**	-.464**
	Sig. (2-tailed)	.000	.000	.000	0.000	.118	.000		.001	.095	.021	.000	.000	.000
	N	54	54	54	54	54	54	54	54	54	54	54	54	54
Time_Spent_more_than30Min	Pearson Correlation	-.282*	-.003	-.243	.431**	-.392**	.264	.431**	1	-.060	.188	.308*	.257	.258

	Sig. (2-tailed)	.039	.984	.076	.001	.003	.054	.001		.667	.174	.024	.061	.059
	N	54	54	54	54	54	54	54	54	54	54	54	54	54
Dist_NSWS	Pearson Correlation	.161	-.143	-.037	-.230	.150	-.176	-.230	-.060	1	-.196	-.234	-.062	-.049
	Sig. (2-tailed)	.246	.303	.791	.095	.280	.204	.095	.667		.156	.088	.654	.726
	N	54	54	54	54	54	54	54	54	54	54	54	54	54
Filling_Time_secs	Pearson Correlation	-.269*	.125	-.036	.314*	-.673**	-.057	.314*	.188	-.196	1	.271*	-.036	-.171
	Sig. (2-tailed)	.050	.367	.799	.021	.000	.682	.021	.174	.156		.047	.794	.217
	N	54	54	54	54	54	54	54	54	54	54	54	54	54
Money_Spent_More_than_5Percent	Pearson Correlation	-.816**	.584**	.427**	.714**	-.217	.600**	.714**	.308*	-.234	.271*	1	-.357**	-.331*
	Sig. (2-tailed)	.000	.000	.001	.000	.115	.000	.000	.024	.088	.047		.008	.014
	N	54	54	54	54	54	54	54	54	54	54	54	54	54
Treatment	Pearson Correlation	.444**	-.769**	-.808**	-.500**	-.185	-.569**	-.500**	.257	-.062	-.036	-.357**	1	.779**
	Sig. (2-tailed)	.001	.000	.000	.000	.181	.000	.000	.061	.654	.794	.008		.000

	N	54	54	54	54	54	54	54	54	54	54	54	54	54
Illness	Pearson Correlation	.407**	-.681**	-.683**	-.464**	-.001	-.538**	-.464**	.258	-.049	-.171	-.331*	.779**	1
	Sig. (2-tailed)	.002	.000	.000	.000	.994	.000	.000	.059	.726	.217	.014	.000	
	N	54	54	54	54	54	54	54	54	54	54	54	54	54

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

c. Cannot be computed because at least one of the variables is constant.

Annexure 6

Regression Analysis Table

Observation	Weight	Avalibility_lpcd	Pred(Avalibility_lpcd)	Residual	Std. residual	Std. dev. on pred. (Mean)	Lower bound 95% (Mean)	Upper bound 95% (Mean)	Std. dev. on pred. (Observation)	Lower bound 95% (Observation)	Upper bound 95% (Observation)	Adjusted Pred.
Obs1	1	43.636	47.190	-3.554	-1.164	0.847	45.479	48.901	3.168	40.792	53.588	47.486
Obs2	1	54.545	57.013	-2.468	-0.808	0.741	55.517	58.510	3.141	50.669	63.358	57.168
Obs3	1	41.379	44.954	-3.574	-1.171	0.870	43.196	46.711	3.174	38.543	51.364	45.270
Obs4	1	50.000	53.286	-3.286	-1.076	0.604	52.067	54.505	3.112	47.002	59.571	53.420
Obs5	1	55.385	56.108	-0.723	-0.237	0.633	54.829	57.387	3.118	49.812	62.404	56.141
Obs6	1	67.164	61.166	5.998	1.965	0.884	59.380	62.952	3.178	54.747	67.585	60.617
Obs7	1	57.143	55.655	1.488	0.487	0.675	54.293	57.018	3.126	49.341	61.969	55.579
Obs8	1	53.333	51.928	1.405	0.460	0.694	50.526	53.330	3.131	45.606	58.251	51.851
Obs9	1	40.000	42.105	-2.105	-0.689	0.895	40.297	43.912	3.181	35.680	48.529	42.303
Obs10	1	49.315	50.145	-0.829	-0.272	0.641	48.851	51.438	3.119	43.845	56.444	50.183
Obs11	1	40.000	43.463	-3.463	-1.134	0.904	41.638	45.288	3.184	37.033	49.893	43.795
Obs12	1	44.000	43.436	0.564	0.185	0.962	41.492	45.379	3.201	36.971	49.900	43.373

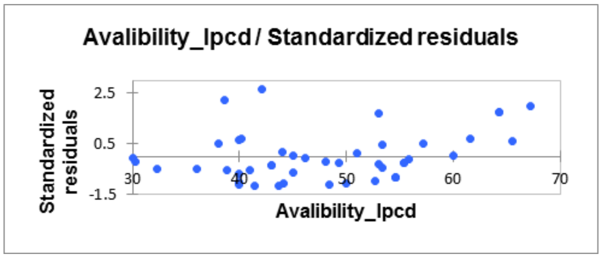
Obs13	1	45.000	44.926	0.074	0.024	0.875	43.160	46.693	3.176	38.513	51.340	44.920
Obs14	1	44.118	47.323	-3.205	-1.050	0.642	46.026	48.620	3.120	41.023	53.623	47.471
Obs15	1	46.154	46.417	-0.263	-0.086	0.794	44.813	48.022	3.154	40.047	52.788	46.436
Obs16	1	48.000	48.654	-0.654	-0.214	0.692	47.256	50.051	3.130	42.332	54.975	48.689
Obs17	1	48.331	51.795	-3.464	-1.135	0.580	50.624	52.967	3.107	45.520	58.071	51.925
Obs18	1	52.941	47.748	5.193	1.701	0.977	45.776	49.721	3.205	41.275	54.221	47.156
Obs19	1	61.538	59.382	2.156	0.706	0.770	57.827	60.938	3.148	53.024	65.741	59.236
Obs20	1	64.286	58.930	5.356	1.754	0.814	57.287	60.573	3.159	52.549	65.310	58.520
Obs21	1	55.814	56.135	-0.321	-0.105	1.074	53.967	58.304	3.236	49.600	62.671	56.181
Obs22	1	53.333	54.644	-1.311	-0.429	1.007	52.611	56.678	3.215	48.152	61.136	54.805
Obs23	1	60.000	59.835	0.165	0.054	0.781	58.258	61.412	3.151	53.472	66.199	59.824
Obs24	1	55.385	56.108	-0.723	-0.237	0.633	54.829	57.387	3.118	49.812	62.404	56.141
Obs25	1	52.632	55.523	-2.891	-0.947	0.675	54.160	56.885	3.126	49.209	61.837	55.671
Obs26	1	64.286	58.930	5.356	1.754	0.814	57.287	60.573	3.159	52.549	65.310	58.520
Obs27	1	52.941	53.872	-0.931	-0.305	0.596	52.668	55.075	3.110	47.590	60.153	53.909
Obs28	1	65.455	63.562	1.892	0.620	0.992	61.559	65.565	3.210	57.080	70.045	63.339

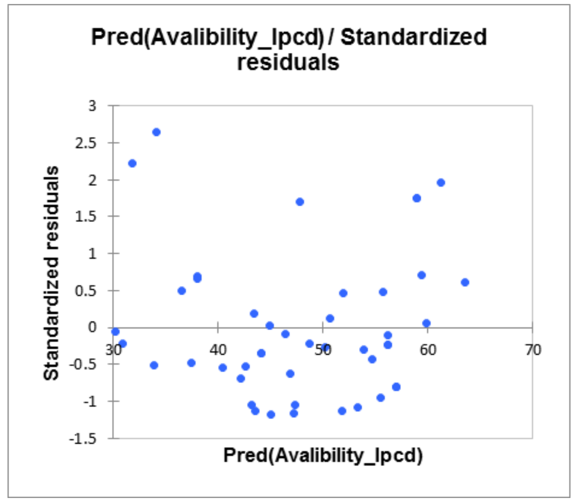
Obs29	1	54.545	57.013	-2.468	-0.808	0.741	55.517	58.510	3.141	50.669	63.358	57.168
Obs30	1	51.000	50.625	0.375	0.123	1.232	48.137	53.113	3.292	43.977	57.274	50.552
Obs31	1	45.000	46.898	-1.898	-0.622	1.078	44.721	49.074	3.237	40.360	53.436	47.168
Obs32	1	41.000	42.585	-1.585	-0.519	0.946	40.675	44.496	3.196	36.131	49.040	42.754
Obs33	1	43.000	44.076	-1.076	-0.353	0.991	42.075	46.077	3.210	37.594	50.558	44.203
Obs34	1	38.000	36.489	1.511	0.495	1.004	34.462	38.516	3.214	29.999	42.979	36.306
Obs35	1	40.000	37.980	2.020	0.662	1.023	35.914	40.046	3.220	31.478	44.482	37.724
Obs36	1	40.000	43.171	-3.171	-1.039	0.985	41.182	45.160	3.208	36.693	49.649	43.539
Obs37	1	43.000	44.076	-1.076	-0.353	0.991	42.075	46.077	3.210	37.594	50.558	44.203
Obs38	1	36.000	37.460	-1.460	-0.478	0.895	35.651	39.268	3.181	31.035	43.885	37.597
Obs39	1	40.179	38.045	2.133	0.699	1.131	35.761	40.329	3.256	31.471	44.620	37.706
Obs40	1	30.242	30.911	-0.669	-0.219	1.060	28.770	33.052	3.232	24.385	37.437	31.003
Obs41	1	30.000	30.165	-0.165	-0.054	1.105	27.933	32.398	3.247	23.609	36.722	30.190
Obs42	1	38.793	40.442	-1.648	-0.540	0.793	38.841	42.042	3.154	34.072	46.811	40.561
Obs43	1	32.328	33.893	-1.565	-0.513	0.894	32.088	35.698	3.181	27.469	40.317	34.039

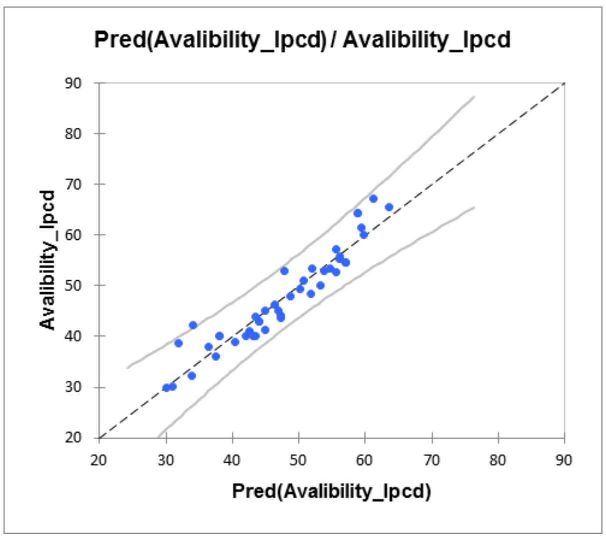
Obs44	1	38.571	31.803	6.768	2.217	1.492	28.790	34.817	3.398	24.941	38.666	29.678
Obs45	1	42.135	34.040	8.095	2.652	1.468	31.075	37.005	3.388	27.199	40.881	31.604

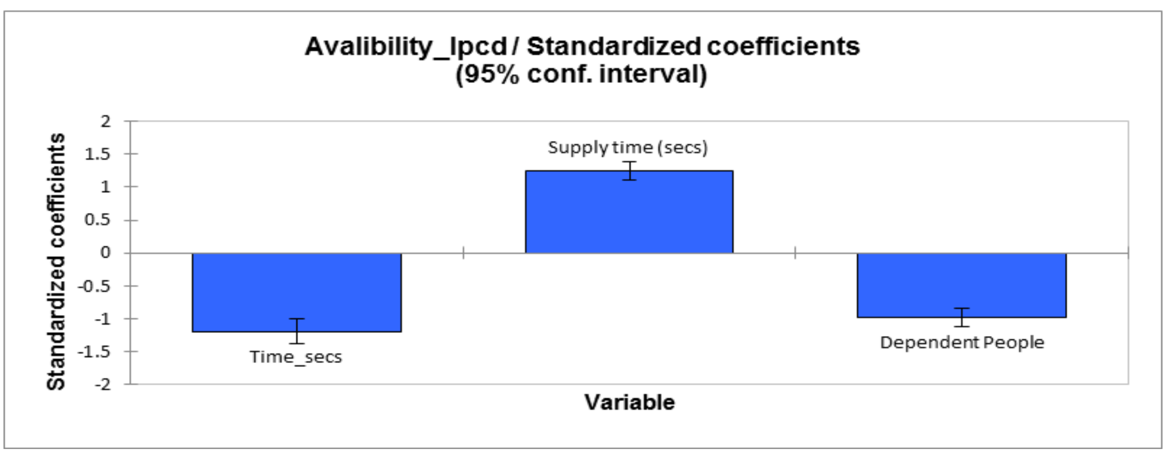
Slum	Observation No	Avalibility_lpcd	Time_secs	Supply time (hrs)	Supply time (secs)	Dependent HH	Dependent People
Ranigaritho ta Chalasani Nagar	1	44	5.5	4	14400	15	60
	2	55	5.5	4	14400	12	48
	3	41	5.8	4	14400	15	60
	4	50	6	4	14400	12	48
	5	55	6.5	4	14400	10	40
	6	67	6.7	4	14400	8	32
	7	57	7	4	14400	9	36
	8	53	7.5	4	14400	9	36
	9	40	7.5	4	14400	12	48
	10	49	7.3	4	14400	10	40
River bund low level Ranigaritho ta	11	40	6	4	14400	15	60
	12	44	8.2	4	14400	10	40
	13	45	8	4	14400	10	40
	14	44	6.8	4	14400	12	48
	15	46	7.8	4	14400	10	40
	16	48	7.5	4	14400	10	40
	17	48	6.2	4	14400	12	48
	18	53	8.5	4	14400	8	32
	19	62	6.5	4	14400	9	36
	20	64	7	4	14400	8	32
Devi Nagar	21	56	4.3	4	14400	15	60
	22	53	4.5	4	14400	15	60
Santhi Nagar	23	60	6	4	14400	10	40
	24	55	6.5	4	14400	10	40
	25	53	5.7	4	14400	12	48
	26	64	7	4	14400	8	32
	27	53	6.8	4	14400	10	40
	28	65	5.5	4	14400	10	40
	29	55	5.5	4	14400	12	48
Vambay Colony	30	51	3.5	2	7200	10	40
	31	45	4	2	7200	10	40
	32	41	3.7	2	7200	12	48
	33	43	3.5	2	7200	12	48
	34	38	3.2	2	7200	15	60
	35	40	3	2	7200	15	60
	36	40	4.5	2	7200	10	40
	37	43	3.5	2	7200	12	48
New Rajrajeswar ipet	38	36	6.2	2.5	9000	10	40
	39	40	7	2.5	9000	8	32
	40	30	6.2	2.5	9000	12	48
	41	30	6.3	2.5	9000	12	48

	42	39	5.8	2.5	9000	10	40
	43	32	5.8	2.5	9000	12	48
KL Rao Nagar	44	39	3.5	3	10800	20	80
	45	42	3.2	3	10800	20	80









Slum	Sample No	Alternative source dependency	Money_Spent more than 5% (Actual Value)	Money_Spent more than 5% (Predicted Value)
Ranigarithota Chalasani Nagar	1	2	2	2
	2	2	2	2
	3	2	2	2
	4	2	2	2
	5	2	2	2
	6	2	2	2
	7	2	2	2
	8	2	2	2
	9	2	2	2
	10	2	2	2
River bund low level Ranigarithota	11	2	2	2
	12	2	2	2
	13	2	2	2
	14	2	2	2
	15	2	2	2
	16	2	2	2
	17	2	2	2
	18	2	2	2
	19	2	2	2
	20	2	2	2
Devi Nagar	21	2	2	2
	22	2	2	2
Santhi Nagar	23	2	2	2
	24	2	2	2
	25	2	2	2
	26	2	2	2
	27	2	2	2
	28	2	2	2
	29	2	2	2
	30	1	1	1
	31	1	2	1
	32	1	2	1
Vambay Colony	33	2	2	2
	34	2	2	2
	35	2	2	2
	36	2	2	2
	37	2	2	2
	38	2	2	2

	39	2	2	2
	40	2	2	2
	41	1	2	1
	42	1	1	1
New Rajarajeswaripet	43	2	2	2
	44	2	2	2
	45	2	2	2
	46	2	2	2
	47	2	2	2
	48	2	2	2
	49	1	1	1
	50	1	2	1
	51	1	1	1
	52	1	1	1
KL Rao Nagar	53	2	2	2
	54	2	2	2

Slum	**Sample No**	**Dependent_HH**	**Time_ spent more than 30 min**	**Filling_time(secs)**	**Reliability**	**Alternative_source (Actual values)**	**Alternative_source (Predicted values)**
Ranigarithota Chalasani Nagar	1	15	1	5.5	1	2	2
	2	12	2	5.5	1	2	2
	3	15	1	5.8	1	2	2
	4	12	2	6	1	2	2
	5	10	2	6.5	1	2	2
	6	8	2	6.7	1	2	2
	7	9	2	7	1	2	2
	8	9	2	7.5	1	2	2
	9	12	1	7.5	1	2	2
	10	10	1	7.3	1	2	2
River bund low level Ranigarithota	11	15	1	6	1	2	2
	12	10	1	8.2	1	2	2
	13	10	1	8	1	2	2
	14	12	1	6.8	1	2	2
	15	10	1	7.8	1	2	2
	16	10	2	7.5	1	2	2
	17	12	2	6.2	1	2	2
	18	8	2	8.5	1	2	2

	19	9	2	6.5	1	2	2
	20	8	2	7	1	2	2
Devi Nagar	21	15	2	4.3	1	2	2
	22	15	2	4.5	1	2	2
Santhi Nagar	23	10	2	6	1	2	2
	24	10	2	6.5	1	2	2
	25	12	2	5.7	1	2	2
	26	8	2	7	1	2	2
	27	10	2	6.8	1	2	2
	28	10	2	5.5	1	2	2
	29	12	2	5.5	1	2	2
	30	1	1	5	1	1	1
	31	1	1	5.5	1	1	1
	32	1	1	5.3	1	1	1
Vambay Colony	33	10	2	3.5	4	2	2
	34	10	2	4	4	2	2
	35	12	1	3.7	4	2	2
	36	12	1	3.5	4	2	2
	37	15	1	3.2	4	2	2
	38	15	1	3	4	2	2
	39	10	1	4.5	4	2	2
	40	12	1	3.5	4	2	2
	41	1	1	4.2	4	1	1
	42	1	1	4.3	4	1	1
New Rajarajeswaripet	43	10	1	6.2	3	2	2
	44	8	2	7	3	2	2
	45	12	1	6.2	3	2	2
	46	12	1	6.3	3	2	2
	47	10	2	5.8	3	2	2
	48	12	1	5.8	3	2	2
	49	1	1	4.2	3	1	1
	50	1	1	4.5	3	1	1
	51	1	1	4.5	3	1	1
	52	1	1	4	3	1	1
KL Rao Nagar	53	20	2	3.5	2	2	2
	54	20	2	3.2	2	2	2

Parameter	Slum	Raniarithota Chalasani Nagar	River Bund North Ranigarithota	Devi Nagar	Santhi Nagar	Vambay Colony	Rajarajeswaripet	KL Rao Nagar
R1	Insufficiency	36	38	32	19	37	34	50
R2	Alternative Source Dependency	100	100	100	70	80	60	100
R3	Reliability	83	83	83	83	92	90	87
R4	Variation in availability	41	39	50	23	19	32	50
A1	Not having piped water access	100	100	100	70	80	60	100
A2	Spending more than 30 min	60	50	100	70	20	20	100
A3	Travelling more than 500 m	0	0	0	0	0	0	0
A4	Distance from natural source	0	0	0	80	40	70	100
C1	Spending more than 5% of income	100	100	100	90	90	70	100
U1	Insufficiency in consumption	14	18	16	7	23	21	28
U2	Variation in consumption	45	44	50	28	28	37	50
E1	TDS> 500 mg/lit	0	0	0	0	0	0	0
E2	HH level treatment	40	40	100	60	30	40	0
E3	Water related illness	40	40	100	40	50	50	100

R	A	C	U	E	SWPI
65	40	100	30	27	**52**
65	38	100	31	27	**52**
66	50	100	33	67	**63**
49	55	90	18	33	**49**
57	35	90	26	27	**47**
54	38	70	29	30	**44**
72	75	100	39	33	**64**

Annexure 7

Scenario Building

Scenario 1

Slum	Time to fill 1 litre bottle (sec)	Avg filling time (sec)	Dependent HH	Dependent Population	Supply time (Hrs)	Per capita water availability (lpcd)	Supply time doubled the present time (Hrs)	Percapita water availability (lpcd)	Average Water Supply	Supply time (Hrs)	Per capita water availability (lpcd)	Average water supply
Ranigarithota Chalasani Nagar	5.5	6.5	15	60	4	44	8	87	102	12	131	154
	5.5		12	48		55		109			164	
	5.8		15	60		41		83			124	
	6		12	48		50		100			150	
	6.5		10	40		55		111			166	
	6.7		8	32		67		134			201	
	7		9	36		57		114			171	
	7.5		9	36		53		107			160	
	7.5		12	48		40		80			120	
	7.3		10	40		49		99			148	
River Bund North Ranigarithota	6	7.3	15	60	4	40	8	80	99	12	120	148
	8.2		10	40		44		88			132	
	8		10	40		45		90			135	
	6.8		12	48		44		88			132	
	7.8		10	40		46		92			138	
	7.5		10	40		48		96			144	
	6.2		12	48		48		97			145	
	8.5		8	32		53		106			159	
	6.5		9	36		62		123			185	
	7		8	32		64		129			193	
Devi Nagar	4.3	4.4	15	60	4	56	8	112	109	12	167	164
	4.5		15	60		53		107			160	
Santhi Nagar	6	6.1	10	40	4	60	8	120	116	12	180	174
	6.5		10	40		55		111			166	
	5.7		12	48		53		105			158	
	7		8	32		64		129			193	

	6.8		10	40		53		106			159	
	5.5		10	40		65		131			196	
	5.5		12	48		55		109			164	
Vambay Colony	3.5	3.6	10	40	2	51	4	102	85	6	153	128
	4		10	40		45		90			135	
	3.7		12	48		41		82			123	
	3.5		12	48		43		86			129	
	3.2		15	60		38		76			114	
	3		15	60		40		80			120	
	4.5		10	40		40		80			120	
	3.5		12	48		43		86			129	
Rajarajeswaripet	6.2	6.2	10	40	2.5	36	5	73	69	7.5	109	104
	7		8	32		40		80			121	
	6.2		12	48		30		60			91	
	6.3		12	48		30		60			89	
	5.8		10	40		39		78			116	
	5.8		12	48		32		65			97	
KL Rao Nagar	3.5	3.4	20	80	3	39	6	77	81	9	116	121
	3.2		20	80		42		84			127	

Scenario 2 :

Slum	No. of House Holds	HH connection	HH size	Avg filling time/litre (sec)	Water one hour	Water Lpcd	Water for two hour	Water availability (lpcd)
Ranigarithota Chalasani Nagar	1840	1840	4	6.5	554	138	1108	277
River Bund North Ranigarithota	448	448	4	7.3	493	123	986	247
Devi Nagar	1101	1101	4	4.4	818	205	1636	409
Santhi Nagar	1919	1919	4	6.1	590	148	1180	295
Vambay Colony	2314	2314	5	3.6	1000	200	2000	400
Rajarajeswaripet	2794	2794	5	6.2	581	116	1161	232
KL Rao Nagar	628	628	5	3.4	1059	212	2118	424

Scenario 3:

KL Rao Nagar	Rajarajes waripet	Vambay Colony	Santhi Nagar	Devi Nagar	River Bund North Ranigarithota	Ranigarithota Chalasani Nagar	Slum
628	2794	2314	1919	1101	448	1840	**No. of House Holds**
628	2794	2314	1919	1101	448	1840	**HH connection**
5	5	5	4	4	4	4	**HH size**
314	1397	1157	960	551	224	920	**50% HH connection**
314	1397	1157	960	551	224	920	**50% HH community connection**
16	70	58	48	28	11	46	**No. of taps required**
3.4	6.2	3.6	6.1	4.4	7.3	6.5	**Avg filling time/litre (sec)**
5	5	5	4	4	4	4	**HH size**
1570	6985	5785	3838	2202	896	3680	**Dependent Population**
125600	558800	462800	307040	176160	71680	294400	**required water**
8000	8000	8000	6400	6400	6400	6400	**Water from One tap (litres)**
2118	1161	2000	1180	1636	986	1108	**2 hours**
4235	2323	4000	2361	3273	1973	2215	**4 hours**
6353	3484	6000	3541	4909	2959	3323	**6 hours**
8471	4645	8000	4721	6545	3945	4431	**8 hours**
12706	6968	12000	7082	9818	5918	6646	**12 hours**
14824	8129	14000	8262	11455	6904	7754	**14 hours**