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Costs of Providing Sustainable Water, Sanitation and Hygiene Services in Rural and Peri-Urban India

WASHCost (India) Inception Report

V. Ratna Reddy
Charles Bachelor
M. Snehalatha
M.S. Rama Mohan Rao
M. Venkataswamy
M.V. Ramachandrudu

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WASHCost (India) Project
CENTRE FOR ECONOMIC AND SOCIAL STUDIES
N. O. Campus, Begumpet, Hyderabad - 500 016, A.P., India
Web: www.cess.ac.in, email: postmaster@cess.ac.in

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V. Ratna Reddy[a], Charles Bachelor[b], M. Snehalatha[c], M.S. Rama Mohan Rao[d], M. Venkataswamy[e], M.V. Ramachandrudu[f]

I Background

Water, sanitation and hygiene services are central to addressing poverty, livelihoods and health. They are also critical in addressing the needs of poor communities and in achieving the Millennium Development Goals (MDGs). The efforts of Government to reach these targets are often subjected to many challenges. Despite huge investments in the sector in India, (more than $ 27,625 million in the last 60 years) the objective of providing access to water and sanitation to the entire population has yet to be achieved. According to the Government publications, 94 percent of the rural population has access to safe drinking water through 4 million hand pumps and 0.2 million-piped water schemes. At the same time, waterborne diseases affect 37.7 million Indians annually, 1.5 million children are estimated to die of diarrhoea alone and 73 million working days are lost due to waterborne diseases each year. The estimated annual economic burden is about $ 600 million a year, which is more than the annual expenditure ($ 460 million) of the sector. In the case of urban population the coverage is about 91 percent. However, the sources often provide irregular and scanty water supplies. Besides, the appalling sanitation conditions in most of the urban areas cause severe health hazards. It is estimated that India needs to invest $6700 million in urban drinking water and sanitation alone by 2015 in order to meet its MDG target (www.indiawaterportal.org).

Provision of drinking water and sanitation in India appears to be a Herculean task in terms of investment demands. The problems compound due to poor efficiency of the systems. A recent study of World Bank (2008) clearly brings out the inefficiencies in

[a] V. Ratna Reddy, Research Director, WASHCost (India) Project,
[b] Charles Bachelor, WASH Governance Specialist, IRC,
[c] M. Snehalatha, Country Coordinator, WASHCost (India) Project,
[d] M. S. Rama Mohan Rao, WRM Consultant, WASHCost (India) Project,
[e] M. Venkata Swamy, WASH Specialist, WASHCost (India) Project
[f] M. V. Ramachandrudu,Director, WASSAN

drinking water systems across states in India. Systems are often run below the designed capacities in terms of length of service (number of hours water supplied) and quantity of water supplied. While financial sustainability is widely recognised, resource sustainability is less understood at the policy level. As a result, costs of providing water do not take the resource protection / rehabilitation costs while calculating the unit costs. In the absence of appropriate costing and investments in the water and sanitation sector, slippage has become a common phenomenon. That is service levels deteriorate or fluctuate between full coverage and partial coverage or no safe source situations. Degradation of sources (well, tank, etc) as well as the resource (water) is the main reason for this.

The policy challenges / questions in this context include:

- ***How do we ensure sustainable WASH services to rural and urban users?***
- ***What are the costs of sustainable WASH service delivery?***
- ***Do the estimates include all the life cycle costs of WASH services?***
- ***Can communities own and manage WASH service delivery?***

II WASHCost (India) Project:

In order to search answers to these questions IRC (International Water and Sanitation Centre) Netherlands, has initiated the WASHCost (Water, Sanitation and Hygiene Cost) project in four countries viz., India, Ghana, Mozambique and Burkino Faso. Basically WASHCost is an ***action research*** project. The five-year WASHCost project (2008-2012) aims at improving sustainability, cost efficiency and equity of WASH service delivery in rural and peri-urban areas by identifying the factors influencing costs at each stage of WASH service delivery life cycle. The WASHCost project proposes to play a lead role in bringing about the transformation, working with Local and National Governments, resource centres, academic institutions, NGOs and international organizations in rural and peri-urban areas.

The focus areas of the WASHCost project include:

- o ***Environmental, institutional, social, financial sustainability of WASH service delivery***
- o ***Equitable access to poor, marginalized and unreached***
- o ***Cost efficiency and / or value for money at each stage of life cycle (Includes Capital, Operation and Maintenance, Capital maintenance costs etc)***

In addition to sustainable, equitable and cost efficient WASH service delivery, the WASHCost project will collect and collate information relating to the real disaggregated costs in the life-cycle of water and sanitation service delivery to poor people in rural and peri-urban areas involving decision makers and stakeholders at every level. It is planned that the data and expertise obtained will be used to develop an internet-based decision-making tool, which can be accessed by all the stakeholders for effective planning and implementation of WASH service delivery using the validated benchmarks and cost data that take account of worldwide experiences.

WASHCost has an inclusive approach to learning and changing practice by undertaking action research related to community participation in decision making, planning, implementation as well as operation and maintenance for developing efficient WASH service delivery keeping equity and sustainability central to the project. The project would proceed in a lesson-learning mode. The learnings will be shared with the concerned stakeholders with the overall aim of correcting, improving and building improved WASH policies and initiatives.

III Objectives

The WASHCost project aims to improve the sustainability, cost efficiency and equity of WASH service delivery in rural and peri-urban areas. The broad objectives of the project include:

- ***Specifically support the implementing departments, private sector, NGOs, etc. for effective and efficient WASH service delivery by:***
    - ***Developing appropriate methodologies for estimating life-cycle costs for sustainable service delivery.***
    - ***Identifying the life-cycle costs and factors that affect them***
    - ***Designing a range of decision support tools***

IV Setting[1]

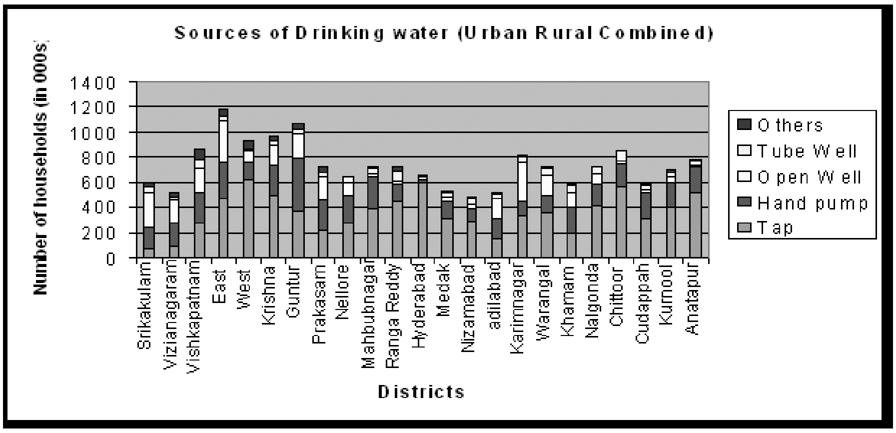
Within India, the state of Andhra Pradesh has been selected for the purpose of detailed exploration of various issues pertaining to WASH service delivery. Andhra Pradesh is geographically 4th largest State in the country with a population of 76.2 million. The state is endowed with a variety of physiographic features ranging from hills, undulating plains to coastal deltaic plains and divided into nine agro- climatic zones. Here we present the status of drinking water and sanitation services in the state.

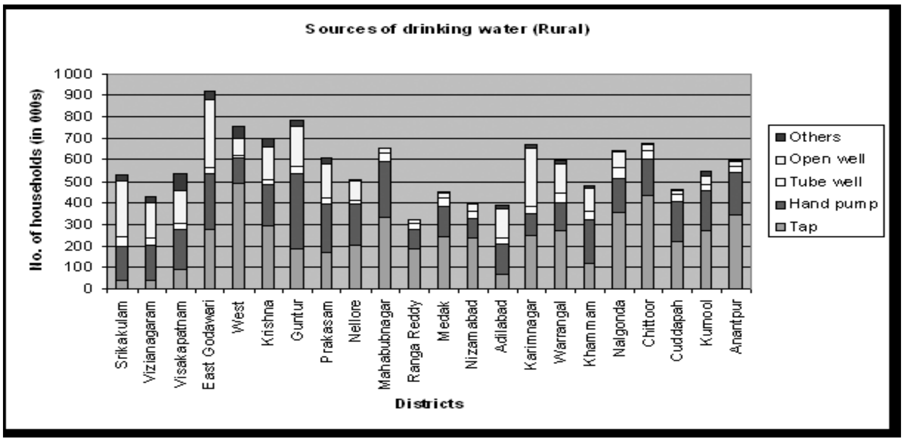
[1] The section mainly draws from the status papers prepared by RWSS and Urban Water Supply Department in collaboration with the WASHCost (India) team and from Jeena, Reddy and Rao (2009).

a) Drinking Water

As per the Census of India 2001 data on sources of drinking water for the state, only 48 per cent of the total households in the state are having access to tap water which is considered to be the safest source of drinking water. Out of the remaining households 26 per cent have access to hand pumps, 16.5 per cent to open wells and 7 per cent to tube wells. This shows that a vast majority of the households depend upon various groundwater sources for drinking water. A district wise analysis highlights the inter district variations in the coverage of tap water (Fig 1). Very few districts like Hyderabad, West Godavari, Chittoor, Anantpur and Ranga Reddy are having more than 60 per cent of the total households having access to tap water. Coastal Andhra region where the status of groundwater is better is incidentally has less access to tap water when compared to Telangana and Rayalseema regions. Access to tap water is as low as 10 per cent in Srikakulam district.

Figure 1. Sources of Drinking





Source: Census of India (2001)

Coverage of households with tap water in rural areas is dismal when compared to their counterparts in urban areas. In the urban areas while nearly 70 per cent of the total households (3001284 households) have access to tap water, it is as low as 40 per cent in rural areas (5104676 households). Only West Godavari and Chittoor districts have more than 60 per cent of the rural households with access to tap water followed by Nizamabad, Ranga Reddy, Medak, Nalgonda and Anantpur with more than 50 per cent of the total households with access to tap water. As per the survey of drinking water status in rural habitations, conducted by the National Habitation Survey[2] by the Department of Drinking water Supply, Ministry of Rural Development, only about 43 per cent of the habitations were fully covered[3] with drinking water (Fig. 2). But for Chittoor, in almost all other districts majority of the habitations are only partially covered with drinking water. Vishakapatnam also has considerable number of habitations that are not covered with drinking water or for whom a drinking water source/ point does not exist within 1.6 k.m. of the habitation in the plains or 100 meter elevation in hilly areas.

The National Habitation Survey 2003 also points that the water quality in over 70 per cent of the total habitations in Nalgonda is affected by fluoride. The percentage of fluoride-affected habitations is also very high in Anantapur (23 per cent), Karimnagar (20 per cent), Prakasam (17 per cent) and Guntur (14 per cent) districts.

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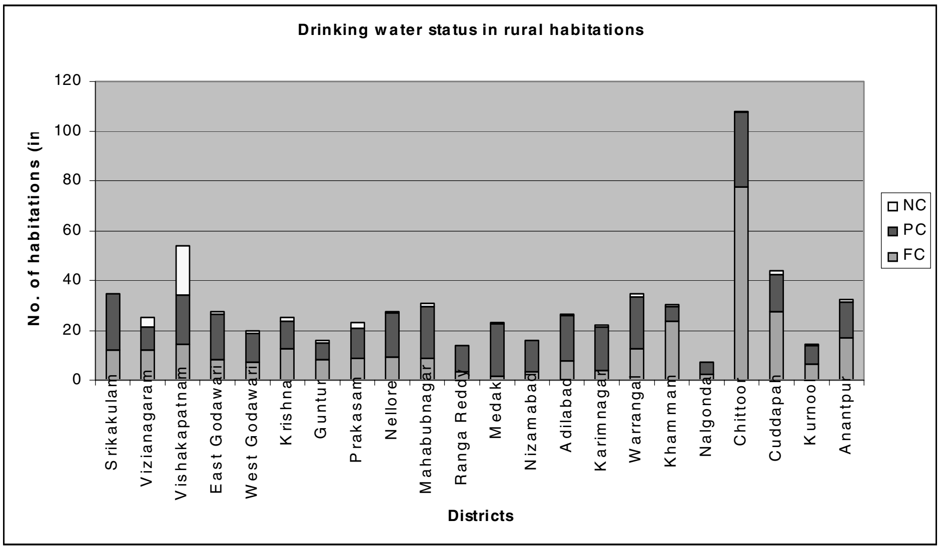
[2] The first nation wide rural habitation survey to assess the rural drinking water supply coverage status was conducted through the State Governments in the year 1991. The results were revalidated during 1993-94, verified in 1996-97 and updated in the year 1999-2000 (www.ddws.nic.in)

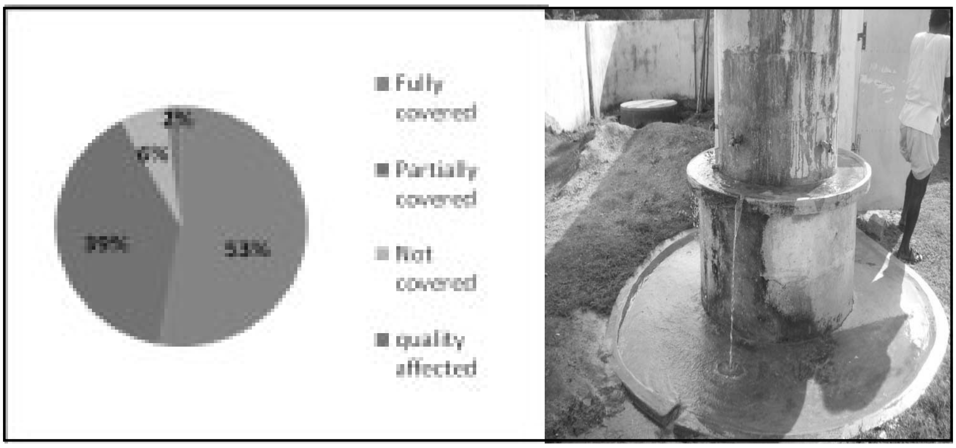
[3] FC (= Fully Covered) means that entire population in all the habitations including the main habitation is provided with drinking water as per the existing norms and guidelines of the Mission. PC (= Partially Covered) means that supply of drinking water is less than 40 litres per capita per day as per the existing norms and guidelines of the Mission. Habitations, which have a safe drinking water source/ point (either public/ private) within 1.6 k.m. in plains and 100 meter in hilly areas but the capacity of the system ranges between 10 lpcd to 40 lpcd, should be categorized as Partially Covered (PC). NC (= Not Covered) for the census village means there is not even a single safe source of drinking water in the village as per existing norms and guidelines of the Mission. The drinking water source/ point does not exist within 1.6 k.m. of the habitation in the plains or 100 meter elevation in hilly areas. (The source/ point may either be public or private in nature); Habitations having a source affected with quality problems such as excess salinity, iron, fluoride, arsenic or other toxic elements or biologically contaminated; Habitations where quantum of availability of safe water from any source is not enough to meet drinking and cooking needs (i.e. below 10 lpcd (www.ddws.nic.in).

Figure 2: Status of Rural drinking Water Coverage



Source: National Habitation Survey 2003 (Unvalidated) from ddws.nic.in

Figure 3: Rural Water Supply in Andhra Pradesh



Source: Dept of RWSS, Govt of AP

Rural Water Supply and Sanitation (RWSS) Department is the nodal agency responsible for planning, designing and implementation of water supply and sanitation facilities in rural areas of Andhra Pradesh. Groundwater is the major source of drinking water. As on 1st April 2008, RWSS has created 320545 hand pumps, 52457 piped water supply schemes and 490 comprehensive piped water supply schemes with an expenditure of Rs. 65830 ($1371) millions. Out of 71928 total number of habitations, about 38362 habitations are fully covered and about 27790 habitations are partially covered. Nearly 57 percent of rural population has access to drinking water supply at full level and 33 percent of population has partial access. Though the coverage is high, many of the villages are slipping back to partially covered / no safe source due to unsustainable source and improper management of WASH delivery systems resulting in quality or quantity problems (Fig. 3). Hence, the RWSS department is depending increasingly on surface water rather than on groundwater. About 20863 schools are provided with water supply facilities and 65916 schools are provided with sanitation facilities including 3.76 million individual sanitary toilets.

RWSS has prepared a Medium Term Sector Project with an objective of ensuring access to reliable, financially and environmentally sustainable and affordable WASH services to the (not covered) 4513 Habitations, 1263 Habitations of No Safe Source (NSS) and 27790 partially covered habitations with an outlay of Rs. 40220 ($838) millions by dovetailing funds under different programmes, including Rs. 1060 ($ 22) millions of World Bank assistance Programme. The project components consists of – Infrastructure development, Sector development and Programme Management.

The public Health and Municipal Engineering Department (PHED) functioning under Municipal Administration and Urban Development Ministry is the nodal agency for planning, design and implementation of water supply and sanitation facilities in Urban Local Bodies. Each of the Urban Local Body (ULB) is having an Engineering wing for implementation of water supply and sanitation facilities in addition to engineering works. The state has 122 ULBs, and three metro cities - Hyderabad, Vishakhapatnam, and Vijayawada. Urban population (20.50 million) in AP account for 27 percent of the total population. All the ULBs in the state are classified into Municipal Corporations (12) and Municipal Councils (110) based on the population in the area and the income generated. An urban local area with a population of not less than 25,000 could be declared as a municipality.

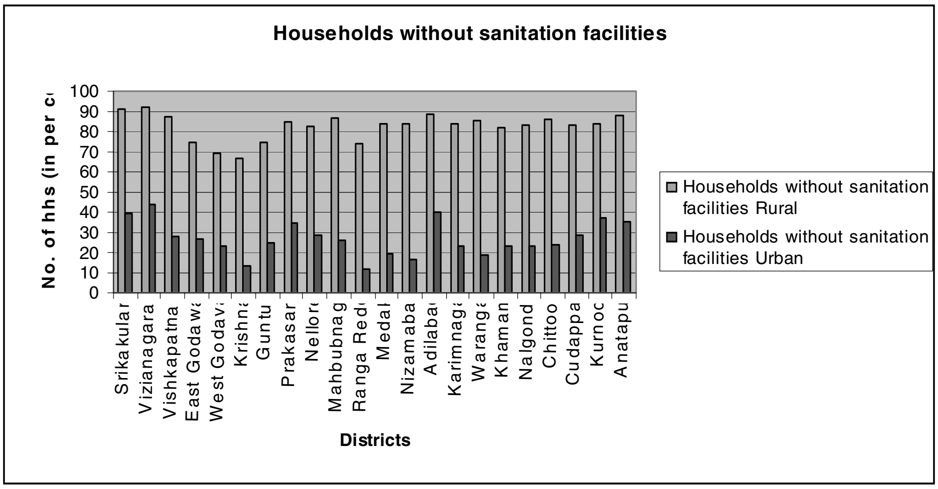
The per capita norms of urban water supply is 40 lpcd in case of public stand posts, 70 lpcd in case of towns without underground drainage and 135 lpcd in case of towns with underground sewerage system and 150 lpcd in case of Metropolitan cities having population more than one million. However, the present water supplies in majority of urban local bodies are far below as per the prescribed norms. Adequacy, equitable distribution and per-capita supply as per the prescribed norms are the major problems. The challenge for the state is to ensure that the infrastructure development for water supply and sanitation services are in commensuration with urban growth. The source of drinking water in urban areas is primarily from surface water and groundwater. Surface water from Reservoirs / Dams, rivers, canals, etc., and groundwater through bore wells form the sources of drinking water in urban local bodies. Of the 122 ULBs, 81 are being provided drinking water from Surface water sources constituting nearly 67 percent, and 31 ULBs with groundwater sources (25 percent) while the remaining 10 are having mix of surface and groundwater (8 percent). At present the daily cumulative water supply from the surface water sources is about 900.19 MLD as against the demand of 999.4 MLD with a deficit of 99.21 MLD. Similarly, the present daily cumulative water supply from groundwater sources is about 211.37 MLD as against the demand of 279.81 MLD with deficit of 68.44 MLD.

Several pilot studies have been conducted and the results have shown that water losses due to leakage, pilferage, etc, are in the order of 20 percent to 50 percent of the total flow in the systems. It has been noticed that maximum leakage occurs in the house service connections, i.e., the tertiary distribution networks. Since water supply is by and large intermittent, during non-supply hours when the system is not under pressure, external pollution often gets sucked into the system through the points of leak, causing health hazards. Therefore, a systematic approach towards reduction of leakage and preventive maintenance has to be an integral part of operation and maintenance on a regular basis. This would not only save considerable quantity of water but also increase revenues to make the systems self-sustaining.

b) Sanitation

As per the Census of India 2001, nearly 67 per cent of the households in the state do not have any latrine facilities within the house. Of the remaining households, which have sanitation facilities, only 18 per cent have water closet facilities while 8.5 per cent of the households use pit latrines and another 6.32 per cent use other types of latrines. The rural-urban differences in sanitation are considerable. While among the urban households only over 22 per cent do not have latrines in their houses, it is as high as 82 per cent in rural households (Fig.4). While water closet is the important type of latrines reported in urban areas, it is pit latrines in rural areas, with an exception in the Coastal Andhra region where water closets are found even in rural areas. Inter-district variations are marginal with regard to the non-availability of sanitation facilities in rural areas. In urban areas inter district variations have been observed. The coverage of sanitation facilities is better in Ranga Reddy and Krishna districts where only 12 and 14 per cent of the households respectively are not covered with such facilities. However, in districts like Vizianagaram, Adilabad and Srikakulam, the percentage of households without any sanitation facilities is as high as 40 per cent. Across regions, Rayalseema reports the maximum number of households without latrine facilities in urban as well as rural areas.

Figure 4. Percentage of households without sanitation facilities across districts in AP



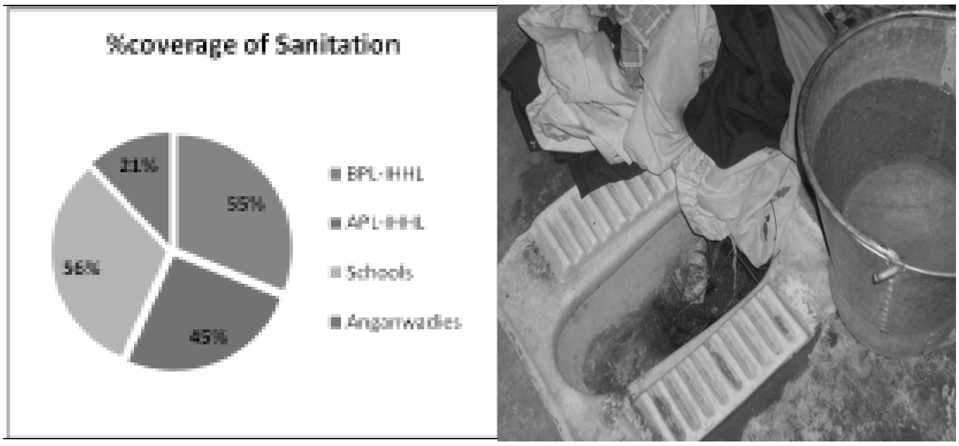
Source: Census of India (2001)

The percentage of households having bathroom facilities within their houses is also very low in the state. About 6709623 or 40 per cent of the households are having bathroom facilities within the house. Here also rural urban differences are more pronounced than across the district differences. In rural areas it is seen that only about 27 per cent of the households are having bathroom facilities within their houses where as the coverage is about 78 per cent in urban areas. The proportion of households with bathroom facilities in rural areas ranges from 8.35 per cent in Srikakulam to 42 per cent in Kurnool. In urban areas, in Hyderabad about 94 per cent households are having bathroom facility followed by Karimnagar district with 86 per cent coverage. Even in the case of urban households, Srikakulam retains the bottom position. The coverage of drainage facilities in the state is also very low. Nearly half of the households in the state do not have any drainage facilities. Out of the rest, with an exception to Hyderabad, over 38 per cent of the households are connected to open drains. Only in Hyderabad over 90 per cent of the households are connected to closed drains.

As per RWSS, in Andhra Pradesh 57 percent of the Below Poverty Level (BPL) families are provided with sanitation facilities. But, only 48 percent of these facilities are under usage. About 35 percent of the habitations have drainage facilities. However, the drains are constructed in a haphazard way without following levels resulting in water stagnation in many habitations causing ill effects. Solid waste management facilities are created in 4 percent of habitations but its management is very poor and unscientific. About 31 percent of people are dumping the waste in front of their houses and 44 percent are dumping at road side. Although the concept of sanitation has undergone qualitative changes during the recent years, there has been slow progress in the sanitary conditions compared to rural water supply. State Water and Sanitation Mission was established as per GoI guidelines to have Mission approach with an objective to cover problem villages, improve performance and cost effectiveness of ongoing programme, and to promote conservation measures for sustained water supply.

Total Sanitation Campaign (TSC) programme is being implemented in all 22 districts with support from Government of India and State Government as a comprehensive programme to ensure sanitation facilities in rural areas with a broader goal to eradicate the practice of open defecation. In fact, problems like open defecation continue to remain the only form of sanitation for the majority of the population in rural areas. Huge investments are being made by the central and state Governments and although there is substantial progress in construction of latrines, the usage is very low (Fig. 5). It is opined that the programme is mostly focused on the construction of Individual Sanitary Latrines (ISLs). Their usage, however, is low due to lack of space, inadequate water, poor maintenance, cultural aspects, etc. The main objectives of TSC programme are: to bring about an improvement in the general quality of life in the rural areas, to accelerate sanitation coverage with in a time frame, to generate felt demand for sanitation facilities through awareness creation and health education, to covers schools / Anganwadis and promote hygiene education and sanitary habits among students, provide separate toilets for boys and girls, to eliminate open defecation to minimize risk of

Figure 5: Sanitation Coverage in AP



Source: Dept of RWSS, Govt of AP

But usage of toilets is below 30%

***Note: BPL**: Below Poverty Line; **APL**: Above Poverty Line; **IHHL**: Individual House Hold Latrine* contamination of drinking water sources and food and to convert dry latrines to pour flush latrines, and eliminate manual scavenging practice wherever in existence in rural areas.

RWSS has established 51 water quality-testing laboratories spread all over the districts of Andhra Pradesh for analyzing drinking water samples. The Department of Drinking Water Supply, Ministry of Rural Development, Government of India launched the National Rural Drinking Water Quality Monitoring and Surveillance Program (NRDWQM&SP) during the year 2005-06 to build capacities of Gram Panchayats and to involve them in water quality testing and monitoring. The State Water and Sanitation Mission has been identified as a nodal agency for implementation of NRDWQM&SP in the state under the supervision of State Referral Institute. The key elements of a surveillance programme include monitoring, sanitary survey, data processing, evaluation, remedial and preventive actions and institutional analysis.

The major challenges that the RWSS department facing include:

- Source sustainability,
- Water quality,
- Operation and maintenance,
- Community involvement,
- Lack of awareness.

To address these problems, RWSS has initiated a number of measures for improving sustainability – demand driven approach by changing roles of the Department from provider to facilitator, devolution of O & M to PRIs, 100 percent O&M cost recovery from the communities, promotion of rain water harvesting structures, introduction of WALTA act, IEC activities, MIS, etc.

Major issues of water supply & sanitation in urban and per-urban areas are:

- Inadequate allocation of funds and inability of State Governments / ULBs to raise their share of 50 percent.
- Central assistance not linked to Efficiency or Reform.
- Source sustainability.
- Uneconomic tariff structure and insufficient generation of funds for O&M and capital costs.
- Absence of regulatory mechanism.

- No comprehensive plan for WS and sewerage system.
- Inadequate training of personnel

V Analytical Frame

WASHCost project deals with number of issues that need to be understood clearly. The aim of the project is to provide sustainable WASH services equitably in a cost effective manner. In the context of WASHCost the concepts used are defined in the following manner:

Life-cycle assessment follows a systems approach. Life cycle costs cover not only the cost of construction and provision of infrastructure but also ensure sustainability of the service in the long run and equitable service delivery. Real life-cycle costs of equitable and sustainable WASH service delivery can be disaggregated into a number of categories including the capital costs, recurrent operational costs, capital maintenance costs and direct and indirect support costs. Costs that may require increased attention, in the Indian context, include: pro-poor project design, institutional development and capacity, building hygiene awareness, source protection and / or water service delivery within locally-derived frameworks for integrated water resource management, designing delivery systems to mitigate risks of climate change and extreme events.

Sustainability means environmental, institutional, social and financial sustainability. Environmental sustainability mainly deals with source protection and safety in the long run (10-15 years).

Equity means service delivery to poor men, women, children, marginalized and unreached sections of the community. That is ensuring equity in access and delivery through appropriate system designing.

Cost efficiency means provision of WASH services in most cost effective manner. That is investments are optimum and ensure value for money.

Peri-urban users are those not directly served by (conventional) urban utilities but located on the periphery or very close to the urban areas.

In order to arrive at the life cycle costs we have adopted the RIDA (Resources, Infrastructure and Demand / Access) framework along with the cost components developed by IRC. Various cost components are defined and grouped under different categories viz., CapEx (hardware), CapEx (software), Costs of Capital, OpEx (O&M), CapManEx (renewal/replacement), Direct Support Costs (post construction activities, household level costs, Indirect Support Costs (Macro level planning and Policy). These cost components are more detailed than the standard cost components used in calculating the unit costs at the department level. This framework is adopted for drinking water as well as sanitation. Gist of this framework is presented in Tables 1a and 1b.

Table 1a: CIF-RIDA Framework (Drinking water)

Cost Component	Resources	Infrastructure	Demand/Access
CapEx Hardware Capital investment in fixed assets	- Costs of WASH-related land treatment: Source protection Such as flood control structures, large groundwater recharge structures, etc - Costs of inter-basin transfers	- Costs of water supply infrastructure: - Costs of water treatment plants: - Costs of "overdesign" relating to demands of floating populations, climate change mitigation - Costs of small-scale water supply infrastructure: Costs of installing water meters: - Costs of water quality monitoring:	- Community contribution to initial infrastructure costs - Costs of water supply infrastructure purchased by users - One-off connection charges: e.g. charge for connecting supply to individual houses
CapEx Software One-off work with stakeholders prior to construction or implementation	- Cost of resource assessments: - Design costs: - Regulation costs: - Costs of IEC, institutional development and capacity building - Costs of compensation for people displaced for dams or protection zones	- Infrastructure assessment costs: - Demand assessments costs: - Engineering design costs: - Costs of active stakeholder participation: - Costs of using specialist knowledge: - Costs of IEC, institutional development and capacity building - Cost of purchasing land on which to locate WASH infrastructure	- Costs of active stakeholder participation: - Costs of using specialist knowledge: - Costs of IEC, institutional development and capacity building: skills needed as part of developing and sustaining community-level organisations, in users O&M activities etc
Costs of capital	- Cost of interest payments:	- Cost of interest payments:	Cost of interest payments:

Table 1a: Contd...

Cost Component	Resources	Infrastructure	Demand/Access
OpEx Operating and minor maintenance expenditure	- Cost of maintaining structures - Costs of enforcing regulations - Possible payments to land users under "payment for environmental services" - Cost for raw water abstraction	- Cost of O&M infrastructure: - Costs of O&M: - Costs of monitoring - Rent of land - Cost for using of system - Costs of billing scheme: - Cost of complaints/breakdown system: - Costs of enforcing regulations: - Costs of leak detection: - Government subsidy of system:	- Profit margin of private operator: - Cost of filtration/ treatment - Payment water vendors/transport - Costs of paying tariffs to operator: - Contribution to OpEx of user - Opportunity cost of time collecting water
CapManEx Asset renewal and replacement cost	- Cost of rehabilitating or repairing structures particularly after extreme event Such as cyclones	- Costs of rehabilitating or repairing infrastructure	
Direct support costs (Post-construction support activities)	- Costs of supporting CBOs: - Costs of supporting PRIs: - Costs of long-term resource-related IEC and capacity building programmes	- Costs of supporting CBOs: - Costs of supporting PRIs: - Costs of long-term infrastructure-related IEC and capacity building programme	- Opportunity costs of participating in community-based organisations: water user committees, Self Help Groups
Indirect support costs Macro-level support, planning and policy making	- IWRM costs: -IT systems and support costs:	- IWRM costs: - Monitoring (at point of supply) costs: -IT systems and support costs: - GO supporting sector	

Table 1b: CIF-RIDA Framework (Sanitation)

Cost Component	Resources	Infrastructure	Demand/Access
Cap Ex Hardware Capital investment in fixed assets	- Costs of off-site black waste water treatment: - Costs of on-site grey waste water treatment/disposal - Costs of sludge disposal: Costs of storage of storm water:	- Costs of off-site black waste water transport and disposal structures: - Costs of off-site grey waste water disposal/treatment: - Costs of on-site (household and public) faecal or black waste water treatment/disposal: - of storm water drainage: - Additional pro-poor costs: - Costs of public on-site sanitation facilities: - Costs of small-scale waste water infrastructure: - Costs of "overdesign":	- Costs of waste water quality monitoring: - Costs of pollution: r
CapEx Software	- Cost of Environmental Impact Assessments: - Design costs: Regulation costs: Costs of IEC, institutional development and capacity building	- Infrastructure assessment costs: - Engineering design hardware costs: - Costs of CA: - Costs of using specialist knowledge: - Costs of IEC:	- Demand creation costs: - Demand assessments costs: - Costs of CA: - Costs of using specialist knowledge: - Costs of IEC:
Costs of capital	- Cost of interest payments:	- Cost of interest payments:	- Cost of interest payments:
OpEx Operating and minor maintenance expenditure	- Cost of operating and maintaining structures - Costs of enforcing regulations	- Cost of operating and maintaining public infrastructure listed above: Costs of O&M of public infrastructure: Cost of billing systems - Cost of monitoring	- Cost of consumer communications and complaints systems: - Costs of enforcing regulations: - Costs of cleaning materials

Table 1b:Contd...

Cost Component	Resources	Infrastructure	Demand/Access
CapManEx Asset renewal and replacement cost	- Cost of rehabilitating or repairing structures listed above	- Costs of rehabilitating or repairing infrastructure - Costs of emptying pit latrines: Costs of construction of new latrine pits/latrines:	- Costs of emptying pit latrines: - Costs of construction of new latrine pits/ latrines:
Direct support costs Post-construction support activities for local-level stakeholders, users or user groups	- Costs of supporting LG: - Costs of long-term environmental-related IEC and capacity building programmes - Cost of monitoring	- Costs of supporting community-based organisations: Cost of monitoring - Costs of supporting LG: Costs of long-term infrastructure-related IEC and capacity building programmes Costs of developing, updating and producing appropriate IEC materials and tools	- Costs of supporting community-based organisations: - Costs of supporting LG: specialist support at all levels, local-level artisan support - Costs of long-term IEC and capacity building:
Indirect support costs Macro-level support, planning and policy making	- IWRM costs: - Monitoring (at source) costs: IT systems and support costs	- IWRM costs: Monitoring (at point of discharge) costs: - IT systems and support costs: - Costs of developing, updating IEC materials.	- Cost of developing adequate policies and legal framework: - IWRM costs: - Health costs: -Monitoring costs:

Life Cycle Cost Assessment: A Framework

Life cycle cost assessment (LCCA) is a comprehensive tool often used in project evaluation, especially in the context of environmental sustainability of various investments leading to products or services. Though the basic principles of LCCA is nearly a century old it's systematic use is only about 25-30 years old (Salem, 1999). LCCA is an economic assessment or project appraisal tool that can be applied at any phase of the project life cycle. LCCA takes the whole chain and spread of activities required for production into consideration. These include even the externalities of the production process. Life cycle thinking is the conceptual idea behind LCCA that reflects the comprehensiveness of the approach in a systems perspective. Such a systems perspective is valid not only for the environmental dimension but also for social and economic dimensions (Salem, 1999). Despite its comprehensiveness and usefulness in project selection, its application rates are quite low, even in developed countries like the USA. A survey conducted among the urban authorities in the USA, it was revealed that only 40 per cent of the towns are adopting LCCA. Of these 40 per cent of the towns, only 29 per cent are using LCCA for water services (Arditi and Messiha, 1996 as quoted in Salem, 1999).

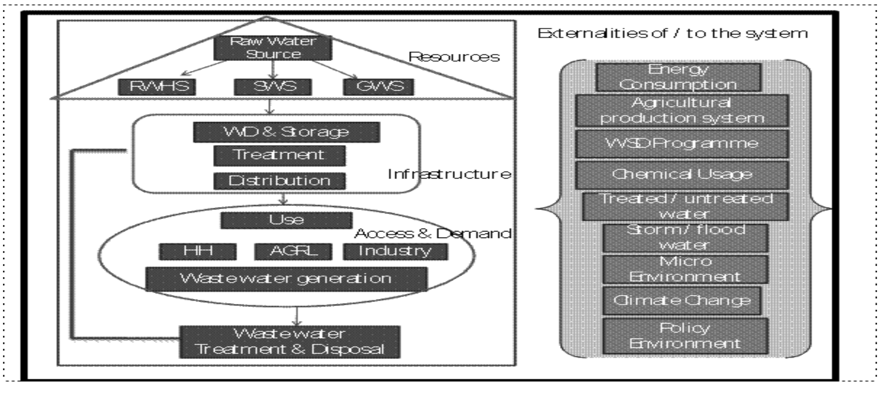
It is also argued that the applicability of LCCA in water and sanitation development projects is limited in scope in the context of developing countries, as the all pervasive social and political drivers are not adequately considered in the present LCCA tools (McConville, 2006). LCCA is also data intensive, often making it difficult to use for development work. A life cycle evaluation of development projects must incorporate diverse factors in a practical manner with a judicious mix of quantitative and qualitative aspects. Further, lack of formal guidelines and reliable past data, and difficulty in estimating future costs appear to be the main reasons for the tardy adoption of LCCA. The tool, therefore, must be consistent with successful development practices and simplified for use as a common tool. What we propose here is a combination of natural, socio, economic and political aspects that influence WASH service delivery over the life stages of the schemes. This could be achieved through a combination of methods and tools for understanding the dynamics of service delivery.

The comprehensive nature limits the practicability of LCCA's application. It is therefore necessary to define the system boundaries in order to reduce the complexity. The choice of system boundaries depends on the nature and type of project has been shown to have important implications on the results (for a review see Lundin, 2002) and needs to be carefully considered. The life cycle (or functional) boundaries define the unit processes to be included in the system *i.e.,* where upstream and downstream cut-offs are set. For the rural and peri-urban water systems four sets / levels of system boundaries can be identified (Figure 6). Resource boundaries (level 1) are defined to ensure resource sustainability and the aim to provide sustainable service delivery. The assessment at this level helps in understanding potential environmental benefits and costs and limited to understanding environmental sustainability of a water system.

The second set of system boundary pertains to infrastructure usually linked to the management agency / institution / organisation. This provides a more complete view of the system interms of technologies, design efficiencies, planning (viz., linking drinking water and sewage), etc. Often the agencies, though aware, are usually constrained by financial and legislative obligations and tend to over ride options that allow a move towards environmental sustainability. Such a perspective may limit the potential of the agency to identify major environmental impacts or improvements through the life cycle. The third set deals with the demand / access issues that are often dealt at the community / institutional / household. These pertain to access, competing demands (domestic, agriculture, industry, etc), water use practices, sanitation and hygiene practices, etc. Often this set gets marginal attention, if not ignored, at the project planning level. This set reflects and determines the adoptability to the system in terms of capacities (technologies), affordability (finance), awareness (quality, health, etc), attitudes (cultural), etc.

The fourth set represents the externalities of or to the system that are closely linked and surrounding the main system but beyond the scope of any LCCA as capturing of these aspects complicates the assessment. Surrounding systems interact and are critical for the functioning of the water systems. Energy consumption / supply is crucial for water pumping, treatment and distribution. Agriculture production or farming systems determine not only the demand for water but also affects the quality of water i.e., livestock based systems or intensive agricultural practices (chemical use). In the context of AP it exasperates the scarcity of groundwater. Similarly, implementation of soil and water conservation programmes (Watershed Development) in rural areas would have discerning impact on quantity and quality of water in the system. On the other hand, disposal of treated / untreated water or storm / flood water outside the system would also result in upstream / downstream externalities. Some of these externalities can be internalised with judicious planning. However, important these aspects are, we are not considering them in the present context.

Figure 6: LCCA System Boundaries for Rural and Peri-urban Water Supplies



Note: RWHS= Rainwater Harvesting Systems; SWS= Surface Water Systems; GWS= Ground Water Systems; HH= Households; AGRL= Agriculture.
Source: Adopted with modification from Lundin (2002)

Components of Life Cycle Cost Model:

A fully developed life cycle cost model will include various components that represent resources, infrastructure and demand and access sets. The cost components include not only the construction and operational costs but also the rehabilitation and IEC costs. The basic LLCA functional form should include the components as indicated in equation 1.

$$LCC_{th} = f\{\textstyle\sum_{t=1}^{n}(CapExhw_{th} ; CapExsw_{th} ; CapManEx_{th} ; CoCap_{th} ; DsCost_{th} ; IDsCost_{th}) ; OpEx_{th}\}$$

Where;

LCC_{th}	=	Life cycle costs of WASH services in year t and habitation h.
$CapExhw_{th}$	=	Capital expenditure on hardware (initial construction cost) in year t and habitation h.
$CapExsw_{th}$	=	Capital Expenditure on software in year t and habitation h.
$CapManEx_{th}$	=	Capital management expenditure (rehabilitation cost) in year t and habitation h
$CoCap_{th}$	=	Cost on capital in year t and habitation h
$DsCost_{th}$	=	Direct support costs in year t and habitation h
$IDsCost_{th}$	=	Indirect support costs in year t and habitation h
$OpEx_{th}$	=	Annual operation and maintenance cost in year t and habitation h.

These costs are essential to ensure WASH service delivery in the short to medium run at least. However, some of these costs are difficult to quantify, especially the direct and indirect costs. All the expenditures, except OpEx, are cumulative over the years and hence these costs are summation over the years i.e., from the beginning of the scheme till the latest year (2008) or for the time period chosen for the assessment. As some of these costs accrue over a period at different time points in the past. Unlike in the case of project evaluation here we are not assessing the net benefits or costs. Here we are assessing the costs that have occurred over a period of time for providing the present level of services over the life cycle of the scheme. In the case of schemes which are very old, we need to specify the time frame, as we may not be in a position to obtain the disaggregated costs. As these investments took place in the past we need to arrive at the present value of these investments in order to make the investments comparable with the investments in new schemes, especially in those where life cycles assessment is adopted. Accordingly, equation 1 can be written as:

$$LCC_{th} = f\left\{\sum_{t=1}^{n} pvf_{th}(\text{CapExhw}_{th};\ \text{CapExsw}_{th};\text{CapManEx}_{th};\text{CoCap}_{th};\text{DsCost}_{th};\text{IDsCost}_{th});\ \text{OpEx}_{th}\right\} \quad ...2$$

Where; pvf = present value factor at time t and in habitation h (1+r)t.

r = rate of interest or inflator.
t = time period.

Rate of inflation or the prevailing rate of interest may be appropriate for estimating the present worth. Other alternatives effective interest rate (rate of interest-inflation), etc could also be used. Once the whole life costs are estimated, unit costs and annualised costs can be worked out using the population, household, etc., at the habitation level.

Risk-Based Life Cycle Cost Analysis

In the case of new or recent schemes the service life could be taken based on standard life span of the scheme. While life span may not vary much the service levels are subject to variations due to risk and uncertainties surrounding the source per se. The risk and uncertainty are often high in the case of groundwater sources. The risk factor can be modeled using probabilistic phenomena and / or using the Bayesian Networks. That is by estimating the probability of groundwater going dry (well failure) in a particular location. In the event of risk the earlier equation (2) could be written as:

$$LCC_{th} = f\left\{\sum_{t=1}^{n} pvf_{th}(\text{CapExhw}_{th};\ \text{CapExsw}_{th};\ \text{CapManEx}_{th};\ \text{CoCap}_{th};\ \text{DsCost}_{th};\ \text{IDsCost}_{th});\ \text{OpEx}_{th};[Psf_{th}]\right\} \quad ....3$$

Where:

Psfth = Probability of source failure in time t and in habitation h.
Probability of failure varies across time periods (t) and locations (h).

This formulation is more appropriate in the cost of WASH services in India in general and Andhra Pradesh in particular, as the dependence of groundwater is quite substantial. In this case the total life cycle cost is modeled as a random variable that is the sum of several cost items. Of these variables the CapManEx is a random variable. The randomness or the probability of failure could be estimated using the observed values from the real life costing in different agro climatic zones. These observations can be complemented with expert opinions as, once the life cycle unit costs are estimated across number of locations (180), the determinants or drivers of life cycle costs can be identified through estimation of the life cycle cost function.

EFth	=	Economic factors in time t and habitation h
SFth	=	Social factors in time t and habitation h
IFth	=	Institutional factors in time t and habitation h
DFth	=	Demographic factors in time t and habitation h
TFth	=	Technological factors in time t and habitation h
Psfth	=	Probability of source failure in time t and habitation h
Uth	=	Stochastic variable

Natural factors include: rainfall, biophysical conditions; terrain; sources of water, etc. Economic factors include: income levels; economic composition; livelihood activities; agricultural productivity, etc.

Social factors include: social composition; social practices pertaining to water and sanitation; etc.

Institutional factors include: Type and nature of institutions; effectiveness of institutions; functioning of PR institutions; leadership; etc.

Demographic factors include: population size of the habitation; density; service coverage; etc.

Technological factors include: Type of scheme like single or multi-village scheme; technology used for filtering; etc.

Depending on the availability and nature of data, number of variables will be incorporated into the analysis. Multiple regression analysis could be used to identify the factors that influence the LCC in a significant manner.

VI Approach and Methodology

WASHCost (India) plans to adopt a phased and stepwise approach for the study in a lesson learning mode. This framework is relatively new and needs to be tested in the real life situations. As a first step number of tools are being developed and tested in test bed villages and peri-urban locations on a pilot basis. Based on the responses during piloting stage, these tools will be modified for adoption in the large-scale sample locations. Number of criteria were identified and discussed at Learning Alliances (advisory and working groups) meetings. These criteria include: rainfall, water quality, water scarcity, water source, type of scheme, village type, management and coverage of sanitation, hygiene levels, etc. But, reliable data at the habitation level on most of these criteria are not available. It is proposed to select the sites on the basis of agro-climatic zones, as these zones reflect the natural criteria like rainfall, water quality, water source and scarcity to a large extent.

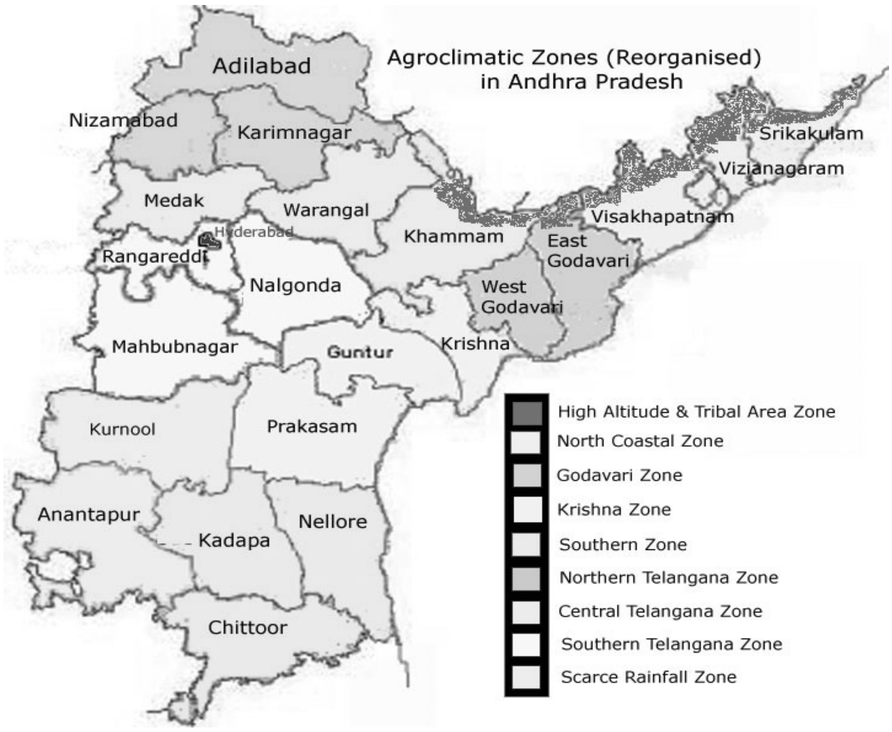
Andhra Pradesh is divided into nine Agroclimatic Zones (Map 1). A Stratified Sampling Design is adopted for the selection of sample units for the survey in each Agroclimatic Zone. Habitation is considered as a sampling unit for the survey. Depending upon the status of WASH (Water, Sanitation and Hygiene) services, each habitation is classified as Fully Covered (FC), Partially Covered (PC) or No Safe Source (NSS) due to unsustainable source and improper management of WASH services.

The habitation level data revealed that inter habitation variations are high across the Agroclimatic zones. In order to capture these variations in unit costs it is proposed to cover more number of habitations i.e., 180. Given the time and cost constraints, only the cost data from the line departments and Gram Panchayats will be collected from all these 180 habitations (Level 1). A sub-sample of 10 habitations from each zone will be selected for detailed analysis. About 50 households representing various socio-economic sections and other disadvantaged groups will be selected from each habitation. In the case of peri-urban locations 18 will be selected at level 1 and 9 will be selected at level 2 (Table 2). It may be noted that the number of Agroclimatic Zones and number of sample habitations could change as we proceed depending on the time and resources required. Accordingly we may restrict the number of Agroclimatic zones.

Table 2: Sampling Frame

Stage I	Stage II	Stage III	Stage IV
Agroclimatic Zones	Habitations- Level I	Habitations-Level II	Households
Nine	Rural: 9*20=180 Peri-urban: 9*2= 18 - Secondary data on unit costs from the Line departments and PRI	Rural:9*10=90 Peri-urban: 9*1=9 - GIS mapping - Listing of households - Detailed information at the village and community levels using qualitative techniques.	Rural: 90*50=4500 Peri-urban: 9*50=450 - Detailed quantitative and qualitative information at the household level.

Map - 1



For selecting the sample habitations in each Agroclimatic Zone, the following procedure is adopted:

- All the habitations will be classified into three strata namely FC, PC and NSS.
- The habitations in each stratum will be arranged in the increasing order of population size.
- Circular Systematic Sampling Scheme will be adopted to select desired number of habitations in the form of two independent sub-samples in each stratum.

Thus, the sampling design to select sample habitations in each Agroclimatic Zone is Stratified Systematic Sampling / Simple Random Sampling without replacement. If population size has no relevance for the study, we may use Simple Random Sampling without Replacement instead of Circular Systematic Sampling for selecting the sample in that stratum. The sample size and composition of the sample across strata may vary depending upon the composition of habitations in each stratum.

This sampling procedure was adopted for selecting sample of test bed villages and peri-urban location. Three villages and one peri-urban location were selected as pilots from the Agroclimatic Zone of Southern Telangana.

Methods:

Both qualitative and quantitative research methods would be used for eliciting the information at secondary as well as primary levels. Qualitative and quantitative methods would be used as compliments rather than substitute. For this purpose number of formats and check lists would be used. Qualitative methods such as Participatory Rural Appraisal, Qualitative Information Systems, etc., would be adopted. Quantitative information will be collected using the questionnaires and other formats.

Secondary information like the scheme details, cost structure of the scheme, source details, operation and maintenance information will be obtained from various sources viz., line departments (RWSS in the case of rural water supply and sanitation), Gram Panchayat, etc. This information will be validated wherever possible by using qualitative techniques like Focus Group Discussions (FGDs), etc. Primary data is generated using the questionnaires / formats at the household level and also through qualitative methods at the community level. Besides these, various tools and methods would be adopted for the purpose of process documentation, communication and advocacy and value for money, accountability and transparency related issues, (Table 3). All these methods and tools are being tested in the test bed sites and will be modified, fine tuned and adopted to new situations as per the requirement.

Table 3: Tools for Process Documentation, Communications Strategy and Value for Money

Key Objectives	Proposed Tools; Methods and Related Activities
Process Documentation	
Consolidating various good and not-so-good practices and processes related to sustainable and equitable WASH service delivery	-Write shops, Bench marking of Processes related to WASH Service Delivery -Process Monitoring of Selected Projects/ Villages
Codifying the processes from the available good and not-so-good processes and elicit enabling and disabling factors that influence sustainable and equitable WASH services	-Processing the Case Studies/ Good Practices/ Research Studies / Pilots to arrive at Lessons; Influencing Factors
Converting WASHCost fieldwork (Process Monitoring/ Action Research/ Pilots/ other means) into useable lessons for various categories of stakeholders.	-Production of communication material based on the above inputs from previous steps -Engaging services of various types of professional teams to produce required outputs

Table 3contd..

Key Objectives	Proposed Tools; Methods and Related Activities
To develop higher level of consensus, common understanding, appreciation among various project partners on WASH service delivery issues	-Workshops Learning Alliance Member/ Policy Makers/ Other stakeholders -Point Studies and field visits
Sensitizing various key actors on key issues related to WASH services (policy makers/ advisory group members/ learning alliance members/ others)	-Self Assessment Exercises at various levels based on the insights generated from field work
Communication &Advocacy Related	
Sharing experiences and lessons among various actors from time to time and communicating key lessons from the project to various stakeholders of WASH services	-Sharing Meetings; Exposure Visits; Joint Studies/ Papers by members of Learning Alliances
Developing interest and fostering cooperation within the WASHCost teams at various levels on concerned issues related to WASH services.	-Working Group meetings -Advisory Committee Meetings (LA)
To facilitate a process of change towards establishing better WASH service delivery which is sustainable and equity focused.	-Studies on Selected Themes related to WASHCost
Engaging with policy makers and practitioners on various themes related to WASH services and facilitate the evolution of better and enabling policies for WASH services based on lessons learnt and recommendations from the project insights	-Capacity Building Events of Project Partners and WASHCost Project Teams -Events for Policy Formulation.
Developing a shared understanding among various partners (internal and external to WASHCost teams) on various issues related to WASH Costs and services.	-Self Assessment by Communities -Under taking pilots based on recommendations from WASHCost project
Value for Money, Transparency and Accountability Related	
To assess the level of transparency and accountability related to processes in delivery of WASH Services	-Comparative analysis of WASH Service delivery in different situations
To understand the worth of investments made for providing various WASH services vis-à-vis coverage under type of facility	-Self Assessment by Communities on WASH Service Delivery -Role Analysis of Different Actors in WASH Service Delivery (Gap Analysis of Designed and Real Roles and Functions)

VII Expected Outputs

- ✓ Status Papers
- ✓ Institutional Mapping
- ✓ GIS mapping at the village level
- ✓ MIS software
- ✓ Process Documentation
- ✓ Communication and Advocacy Strategies
- ✓ Value for money
- ✓ Estimating unit costs of sustainable WASH services
- ✓ Identifying variations in unit costs and the factors influencing them

VIII Partners and Learning Alliances

- ❖ Core team: CESS (lead partner), WASSAN,LNRMI, RWSS and Local NGOs
- ❖ Learning alliances:
  - - Advisory Group
  - - Working Group
  - - RWSS
  - - NGOs at District, State and National level
  - - WASH Networks

IX Time Frame

The WASHCost project has a duration of five years that is divided into three phases viz., Inception Phase, Research Phase and Influencing and Embedding phase. Given the action research nature of the project it is engaged in continuous process of learning, updating information and engaging stakeholder dialogue for concurrent policy changes. Field studies would be taken up in a phased manner. After the pilots in the test bed sample sites, research studies will be taken up in about 20 sample sites during the first year, 40 sites each during the third and fourth years. A brief and tentative time line is given below.

Phase	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
Inception					
-Launching	X				
-Team Building	XXXX				
-Institutional Mapping	XXXX				
Research					
-Test Bed /Pilot	X	X			
-Field Study		XXX	XXXX	XXXX	
Influencing & Embedding	XXX	XXXX	XXXX	XXXX	XXXX

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