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Costs and Service per Technology in Rural Water Supply How Efficient are Multi Village Schemes?

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ABSTRACT

In terms of technology choices, the policy is moving towards multi-village schemes as far as rural water supply schemes in Andhra Pradesh, India, are concerned. This paper assesses the cost and service levels across different technologies that are operational in Andhra Pradesh. The main objective is to assess the cost effectiveness in terms of service delivery. Though the study covers eight different technologies or combinations of technologies, the main focus is on individual technologies like hand pumps, mini piped water supply schemes, single village schemes and multi village schemes. At the policy level the technology choice narrows down to single and multi-village schemes as far as public water supply schemes are concerned.

This paper is based on cost data generated from187 villages and service level data from 107 villages spread over 9 agro-climatic zones of Andhra Pradesh. While the cost data has been obtained from official documents, the service level data is based on the household data collected from more than 5,000 sample households spread over 107 villages. The Life Cycle Cost Approach has been adopted in analysing costs while the service ladder approach along with actual water use (quantity) data has been adopted in the case of service level analysis. Cost comparisons are made in terms of cost per capita per year for fixed as well as recurring costs and service level comparisons are made on four indicators viz., quantity, quality, accessibility and reliability. Besides, cost per unit of water is also assessed across the technologies using the actual water use at the household level. Important findings from the analysis include:

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- *Multi village schemes are not necessarily the best available option which could be due to the split operation and management of these systems between contractors and village panchayat. Evidence from other states that follow different Operation and Management approach would throw more light on this.*
- *Handpumps are the least cost option albeit with poor service levels and hence a preferred option during crisis.*
- *Relative shares of costs indicate that recurring costs are substantially higher in the case of Mini Piped Water supply, Single and Multi Village Schemes when compared to handpumps. This is mainly due to high operation and maintenance costs.*
- *Capital maintenance costs are more in the case of Single Village and Mini Piped Water Supply schemes.*
- *Irrespective of the technology, accessibility is the main concern as a majority of the sample households spend more than 30 minutes a day in fetching water. In the light of the increasing opportunity cost of labour this could result in substantial economic losses in general and welfare losses in the case where children are involved in fetching water.*

Irrespective of the technology, source sustainability needs to be addressed effectively and appropriate management options need to be adopted for each technology. Adapting to life-cycle cost approach could provide the much needed planning in terms of resource allocation to various components in this regard. The split management structure of multi village schemes does not augur well with decentralized resource management.

I Background

Technology has become critical for better service delivery of drinking water at scale. Technologies have evolved over time to meet the service demands of quantity, quality, accessibility and reliability. While handpumps were introduced initially to meet the quantity demands, especially during scarcity periods, the later technologies such as mechanised pumping, storage, distribution systems, etc., have helped in reducing the drudgery of the households in fetching water. Some of them such as deep bore wells have adversely affected the water quality in specific regions (Reddy and Kullappa, 2008). These technologies ranging from direct pumping (see table 1 for discretion) to single village schemes are localised with limited scale often covering one village. In the absence of proper planning, designing and governance these technologies failed to address the service delivery objectives.

Centralised multi-village schemes were initially introduced in the water scarce regions where sufficient groundwater is not available at the village level. Pumping schemes are located in the locations with reasonable groundwater potential and supplied to number of villages in the vicinity. A few centralised schemes also draw from surface water sources, again in the scarce rainfall regions like Rajasthan. The groundwater based schemes have become unreliable in many places and even redundant in some places due to unsustainable sources (Reddy, 1999). Source failure is more in the case of centralised schemes (multi-village) in drought prone areas that were dependent on groundwater that is available in specific locations. Failure of such schemes has proved expensive, inefficient and uneconomical. Besides, water quality has increasingly become a concern as the grounder tables have gone down over the years (Reddy and Kullapa, 2008). In order to address these twin problems, surface water dependent multi-village schemes (MVS) that draw water from the reservoirs have been promoted.

Policy thinking appears to be in favour of such schemes due to their perceived source reliability and water quality. This is very much reflected in the shift towards multi-village schemes in the recent years. Strategically, multi-village schemes are also viewed as future option for bulk water transfers (GoI, 2010). While these schemes have been observed to be more expensive in terms of one time per capita costs (World Bank, 2008), their performance in terms of service levels have not been assessed in comparison with other technologies or schemes. This paper attempts to address this issue in the context of Andhra Pradesh, India by comparing different technologies that are operational. Some of the issues in the context of policy shift towards multi-village schemes include: i) are multi-village schemes more efficient in terms of unit costs (per capita or per unit of water) and service levels in terms of quantity, quality, accessibility and reliability?; ii) do these schemes sustain better in the context of existing governance structure of the systems?

II Approach

This paper is based on the cost information generated from 187 habitations spread over 23 districts and nine agro-climatic zones of Andhra Pradesh. The sample villages were selected on the basis of a stratified sampling design in each of the agro-climatic zones[1]. A village is considered as a sampling unit for the survey. The sample villages represent the three categories (service/coverage status) of drinking water services in India: Fully Covered (FC), Partially Covered (PC) and No Safe Source (NSS). Cost data was obtained from the official records of the Rural Water Supply and Sanitation (RWSS) department at district level. This data was triangulated and crosschecked with the help of data generated from the village panchayat (local government). The Operation and Maintenance data was obtained from the village panchayat records. Service level data was collected with the help of a detailed household questionnaire canvassed among 50 sample households in each of 107 sample villages spread over 9 agro-climatic zones. These sample villages were selected from the larger sample of 187 villages spread across the 9 agro-climatic zones.

Life Cycle Cost (LCC) approach[2] is adopted to estimate the actual cost components of service provision. The costs assessed here cover the construction and maintenance of systems in the short and long term, taking into account the need for hardware and software, capital maintenance, operation and maintenance, cost of capital and the need for direct and indirect support costs, including training, planning and institutional pro-poor support (Fonseca, et. al., 2011). The 'cost of capital' component is not included in the present analysis as these costs are not represented in the official data as none of the sample schemes were dependent on borrowed funds. Only financial costs (i.e., public expenditure) are included in the analysis here, though households also invest in water infrastructure to complement the service levels.

Cost and Service level calculations[3]

Capital expenditure has two components, namely hardware (CapExHrd) and software (CapExSft). Establishment of water infrastructure (for abstraction, purification, storage, distribution etc), are part of capital expenditure on hardware. Capital expenditure on

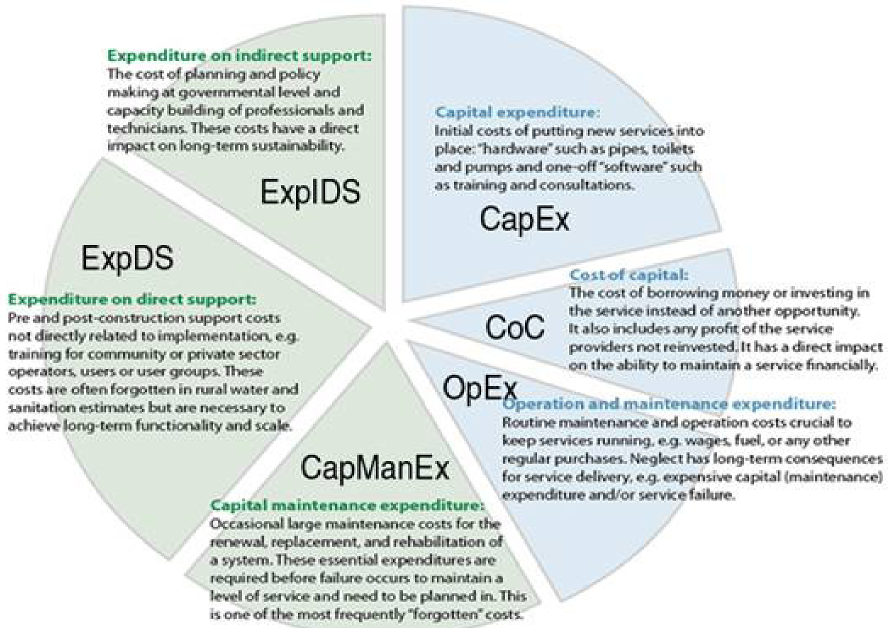
[1] Scientific sampling procedure was followed while selecting the sample habitations (See for details Reddy, et. al., 2009).

[2] For details see Fonseca, et. al., (2011) and other WASHCost publications at (www.washcost.info)

[3] For details see WASHCost (India), 2011.

software includes the costs of planning and designing the water schemes at village level. The capital costs, hardware as well as software are one-time costs. For the purpose of the present analysis we have taken into account only investments in infrastructure that is still functional. In most of the cases the system or infrastructure is non-functional when the source fails beyond rehabilitation i.e., drying up of a bore well or collapse of bore well. All the functional capital investments are cumulated over the years.

Picture 1: Life-cycle cost components (WASHCost 2010)



Capital maintenance expenditure (CapManEx) is another major expenditure item that is made for renewal and rehabilitation of the systems, i.e., replacement of major equipment like pump sets, boreholes, plant equipment, distribution systems, etc. Capital maintenance expenditure is also summed over the years. Operational expenditure (OpEx) made on regular maintenance of the systems, is incurred annually, and hence we have taken the average of the years for which data are available after bringing them to the current value. Expenditure on direct support costs (ExDS) are in the form of salaries of the staff, IEC activities, demand management initiatives, etc. Expenditure on indirect support costs (ExIDS) are the costs associated with macro planning and policy making at the national and state level. These costs are estimated based on the data from the planning and budgetary documents with the help of some assumptions and expert opinion[4].

[4] For details see WASHCost India (2011).

Since capital and capital maintenance expenditure are one time investments in the past they are converted to current values (2009) using the National GDP inflator for the specific years and converted to US dollars using the average 2009 exchange rate (US$ 1=INR 48.40). These costs are annualised using the normative life span and observed life of the systems. The data on normative life are provided by the department, which is nothing but the expected life of a specific component. The observed life span is the actual number of years the system (major component) lasts.

Service ladder approach[5] is adopted to assess the service level at the household and village level. Four indicators are used for assessing the service levels, viz., quantity, quality, accessibility and reliability. The level of service in each indicator is categorised as no service, sub-standard, basic, intermediate and high. And each level of service is defined separately for each indicator. While quantitative measure of litres per capita per day is used in defining quantity indicator, qualitative perceptions of the households are used to assess the service level in the case of quality, accessibility and reliability. Qualitative perceptions are arrived at using the Qualitative Information Systems (QIS) at the community level. Besides, quantitative data regarding quantity of water used at the household level is taken to estimate the cost per unit of water under different technologies.

Rural Water Supply Technologies

The sample villages represent all the existing technologies prevalent in the rural water supply. The 187 sample villages are divided in to eight groups based on the type or combination of technology used.

Picture 2: Type of Technologies

Hand Pump MPWS / SVS PWS CPWS / MVS

[5] The approach is developed at the global level for the WASHCost Project (see for details Moriarty, et. al., 2010).

They represent four pure technologies viz: Handpumps (HPs); Direct Pumping (DP) or Mini Piped Water Supply (MPWS); Single Village Schemes (SVS) and Multi Village Schemes (MVS). These technologies are used in 107 of the 187 sample villages while the remaining sample villages use different combinations of these four technologies (Table 1). Majority of the villages (45) fall in the Mini Piped Water Supply Schemes and Single Village Schemes combination. However, the villages with a combination of these technologies though analysed here may not be strictly comparable with the pure technologies, as the costs and service levels cannot be attributed to a specific technology. Moreover, these combinations are not part of a planned policy intervention. On the contrary, they are the result of ad hoc practice. Thus, comparing the villages that are served by a single technology would help in identifying the least cost options for the purpose of policy.

Though all these technologies and combinations coexist, the current policy focus is mainly on Single or Multi Village Schemes. Handpumps are no longer promoted as comprehensive rural drinking water schemes, but are used as emergency relief during droughts and in inaccessible locations such as hilly and tribal habitations. Some of the old and functioning handpumps are connected to electric motors in most villages i.e., converting them as sources for Direct Pumping or Mini Piped Water Supply Schemes. In the light of increasing size of the villages (population) coupled with increasing opportunity costs of rural labour and shortage of power, Direct Pumping or Mini Water Supply Schemes are not encouraged. The future technology policy for rural drinking water would be mainly focused on Single or Multi Village Schemes and the move is in favour of the latter.

Picture 3: Type of Storage: OHSR and GLSR

OHSR GLSR Cistern OHBR

(Over Head Storage Reservoir) (Ground Level Storage Reservoir)

Table 1: Distribution of Sample Villages by the Type of Technology in Rural Water Supply Schemes

Technology	Description	Source	Coverage (Population)	Number of ample Villages
1. Handpump (HP)	Water is available only through handpumps fitted to shallow aquifer.	Ground-water	Low (250)	22 (11)
2. Direct Pumping or Mini Piped Water Supply (DP or MPWS)	Electrical, usually submersible, pump is directly connected to the bore well. Water is available during pumping hours only in the simplest configuration serving a single habitation. Otherwise, it is provided with a battery of taps attached to a storage tank in which case water is available for longer periods	Ground-water	Medium (500)	34 (12)
3. Single Village Scheme (SVS)	Pipe network supply system with pumping, storage and distribution through public stand posts and provision for house connections as well. Water is filtered using sand filters in the case of surface water sources. And no filtering of water in the case of groundwater	Ground-water or surface water	Medium to large (more than 500)	33 (28)
4. Multi-Village Scheme (MVS)	Centralised supply system with large scale storage at central location. Water is drawn either from surface reservoirs or groundwater aquifers to a filter (surface water) and then supplied to a number of villages. Each village will have its own storage and distribution network.	Ground-water or Surface Water	Large to Very Large (number of villages)	18 (13)

contd...

contd...

5. MPWS+SVS	Villages that had mini piped water supply and then upgraded to single village schemes. Both are functional.	Ground-water or Surface Water	large (more than 500)	45 (19)
6. PWS+MVS	Villages that had mini piped water supply and are presently connected to multi-village scheme. Both are functional	Ground-water or Surface Water	Large to Very Large (number of villages)	11 (6)
7. SVS+MVS	Initially single village scheme and presently connected to multi-village scheme. Both are functional.	Ground-water or Surface Water	Large to Very Large (number of villages)	13 (12)
8. MPWS+SVS +MVS	Villages that had mini piped water supply then upgraded to single village scheme and presently connected to multi-village scheme. All are functional	Ground-water or Surface Water	Large to Very Large (number of villages)	11 (6)

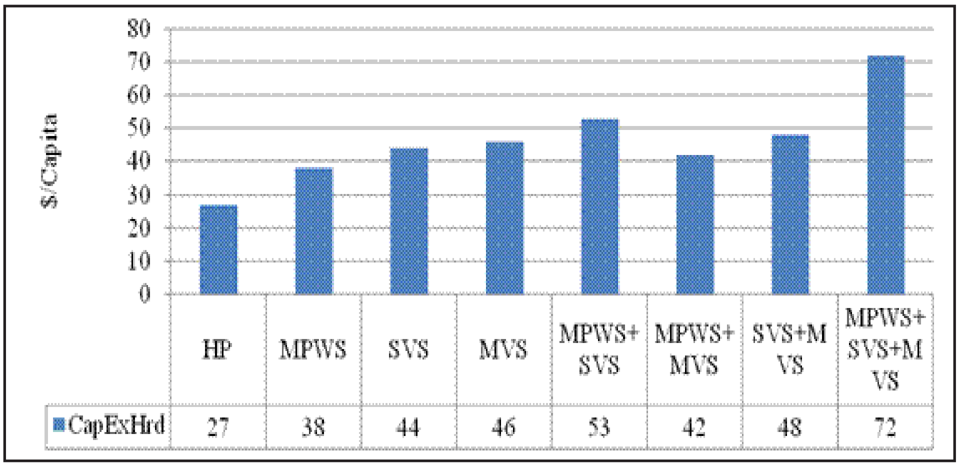
Note: Figures in brackets are the number of sample villages for which service level data are available.

III Cost of Provision per Technology

Fixed Costs

Fixed costs include the capital expenditure on hardware (infrastructure) and software (planning and designing). When the per capita sum of (cumulative) capital costs is taken into account, Multi Village Schemes are relatively speaking the most expensive of the pure technologies (Fig. 1). Handpumps are the cheapest followed by Direct Pumping / Mini Piped Water Supply and Single Village Schemes. Per capita costs are more in the case of villages that are served by multiple schemes. However, cost differences are statistically significant only in the case of handpumps and the combination of (MPWS+SVS+MVS). That is per capita costs of handpumps are significantly cheaper while those for MPWS+SVS+MVS are significantly more expensive when compared to other technologies. The differences in per-capita costs among the pure technologies (MPWS, SVS and MVS) are not significantly different. This is mainly due to the high variations in costs within the technologies (see Appendix Table A2).

Figure 1: Capital (cumulative) Expenditure Per Capita across Technologies



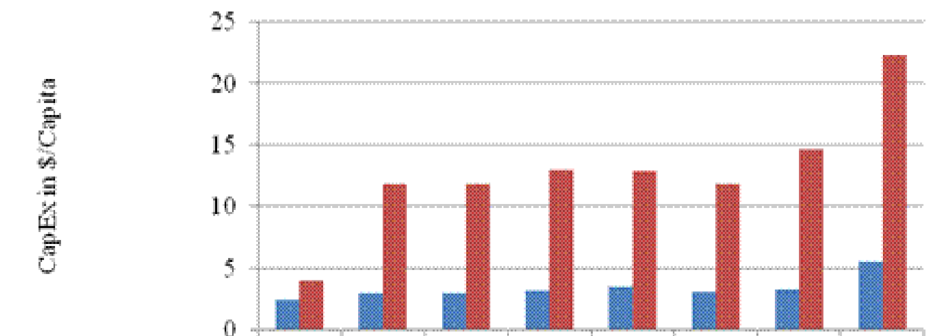
Annualised unit costs were calculated for normative as well as observed life of the schemes. While the normative unit costs reflect the ideal conditions of good asset management, observed unit costs represent the actual picture in the present management system[6]. The normative life span is worked out on the basis of economic and useful life of the systems, observed life span is the life of the systems in reality. The normative life span data are provided by the department (RWSS). Future service delivery requirements and their cost norms are arrived at by the department on the basis of normative life of the systems. Observed life span is often observed to be lower due to the reason that systems breakdown frequently due lack of maintenance or due to the geo-hydrology of the region (bore well failure). Besides, poor designing and implementation also speed up the decay of the systems. Similarly, in the case of new systems where break downs are few, the observed life span could be lower, pushing the costs up.

When capital costs are annualised the unit costs range between US$ 2.5 and US$ 5.6 per capita per year when normative life span is assumed (Fig. 2). However, this is different from the reality, as the unit costs are higher when observed life is taken into account. The unit cost of provision has gone up from US$ 2.5 (normative) to US$ 4 (observed) per capita per year in the case of handpumps i.e., 60 percent higher (Fig. 2). The difference between normative and observed unit costs is 4 times in the case of other

[6] It may be noted that while calculating actual capex costs non-functional systems were excluded, which is likely to over-estimate the actual costs of CapEx, especially when the failed hardware is older than still functioning hardware. The 'actual' costs of CapEx can therefore be interpreted as representing the upper limits in general and the costs based on normative life-spans representing the lower limits

technologies. The life span could be improved with investments or allocations towards capital maintenance, which are absent at present.

Figure 2: Fixed Costs per Capita Per Year with Normative and Observed Life Spans by Technology



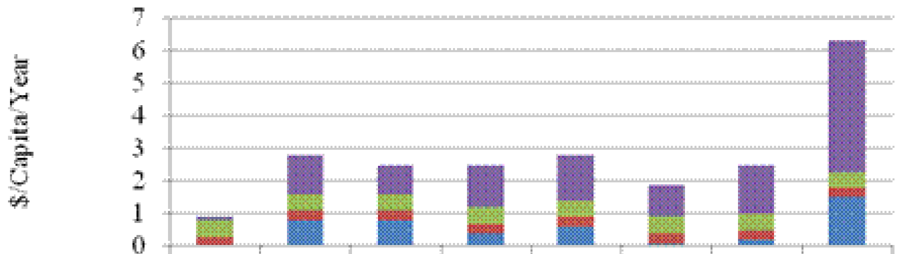
	HP	MPWS	SVS	MVS	MPWS+SVS	MPWS+MVS	SVS+MVS	MPWS+SVS+MVS
CapEx-Normative	2.5	3	3	3.2	3.5	3.1	3.3	5.6
CapEx-Observed	4	11.9	11.9	13	12.9	11.9	14.7	22.3

Recurrent costs

While capital or fixed costs are one time investments, recurrent costs are incurred on a regular basis in order to maintain the systems. These costs include capital maintenance (CapManEx), direct and indirect support costs (ExDS and ExIDS) and operation and maintenance costs (OpEx). These costs are also annualised on per capita basis. As far as pure technologies are concerned, the recurring costs range between US$ 0.9 per capita per year in the case of handpump and US$ 2.8 in the case of Mini-piped water supply (MPWS) (Fig. 3). Recurring costs of single and multi-village schemes are same at $ 2.5 per capita per year. The unit costs are as high as US $ 6.3 per capita per year in the case of a combination of three technologies. These cost differences are marginal and significant statistically only in the case of handpump and the combination of three technologies (MPWS+SVS+MVS) (Appendix Table A1).

Handpumps are the cheapest even in terms of recurring costs. The high unit cost in villages that are served with a combination of technologies could be due to the multiple schemes that need maintenance. For, all the technologies are functional and hence incur operation and maintenance costs along with other recurring costs (Fig. 3). In some cases the villages are upgraded to multi village schemes due to political reasons though they may not be in need of improved service levels. And, the unit costs of the combination of three technologies (MPWS+SVS+MVS) are significantly higher than that of other technologies (Appendix A1). The observed differences in unit costs are not, however, significantly different between any of the pure technologies. Multi-village schemes have not only high cumulative costs but have wide range and variations. As a result, the median value of cumulative cost of multi village schemes is lower when compared single village schemes (Appendix Table A2). This is mainly due to the reason that intra technology (i.e., inter village) variations are much higher than that of inter technology variations (Appendix Table A2).

Figure 3: Average Cost of Provision by Technology



	HP	MPWS	SVS	MVS	MPWS+SVS	MPWS+MVS	SVS+MVS	MPWS+SVS+MVS
OpEx	0.1	1.2	0.9	1.3	1.4	1	1.5	4
ExIDS	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
ExDS	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
CapManEx	0	0.8	0.8	0.4	0.6	0.1	0.2	1.5

Relative Costs

Relative costs are calculated using fixed as well as recurring costs (unit cost). The annualised relative costs by life cycle cost components show that the relative costs vary between normative and observed life spans. Though the infrastructure costs (CapExHrd) account for a major share they range between 73 % (HP) and 51 % (MPWS) between the technologies (Fig. 4a & 4b). However, these variations are marginal when observed life span is used i.e., ranges between 82 % (HP) and 84 % (MVS and SVS) (Fig. 5).

In the case of normative life span the share of operation and maintenance (OpEx) goes up as one moves from HP to MVS, while the share of Capital maintenance (CapManEx) cost is the highest (14%) in the case of SVS and DP/MPWS schemes. There is no Capital maintenance in the case of handpumps i.e., there is no case of handpump replacement in the sample villages[7]. Capital maintenance costs are on the lower side in the case of MVS due to the reason that these schemes are relatively new.

Picture 4: Type of Pumps

Picture 5: Type of Pipes

Metallic pipes

PVC pipes

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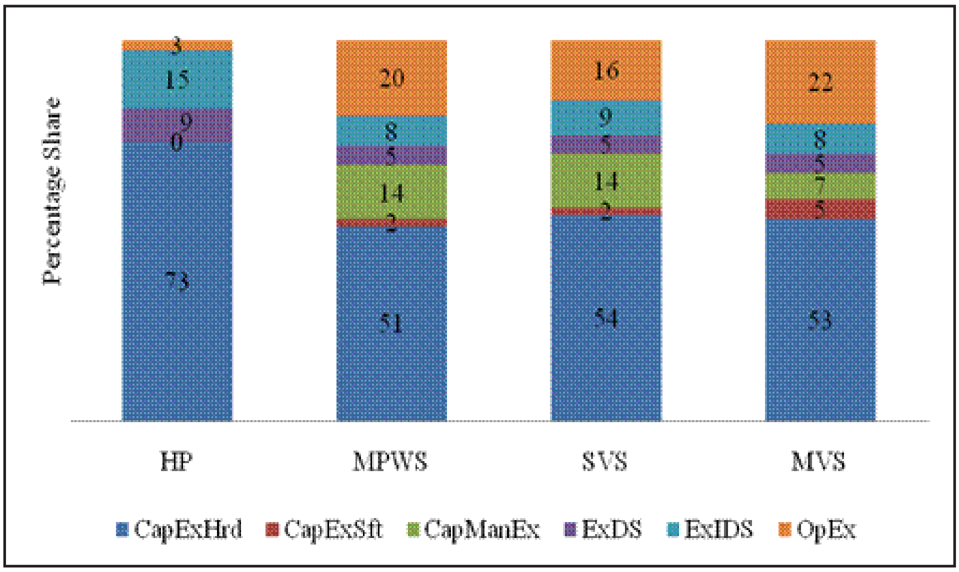
[7] In some villages handpumps are converted into direct pumping by attaching a motor.

In the case of observed life span also the relative shares are in the same order though the magnitudes differ. Even when observed life of the systems is taken into account operation and maintenance costs are high in the case MVS at 7 %[8] . While these costs are 2 % in the case of handpumps, they account for 4 % percent in the case of SVS and 6 % DP/MPWS and SVS. Capital maintenance is as high as 6 % in the case of SVS and DP/MPWS while it is 3 % in the case of MVS.

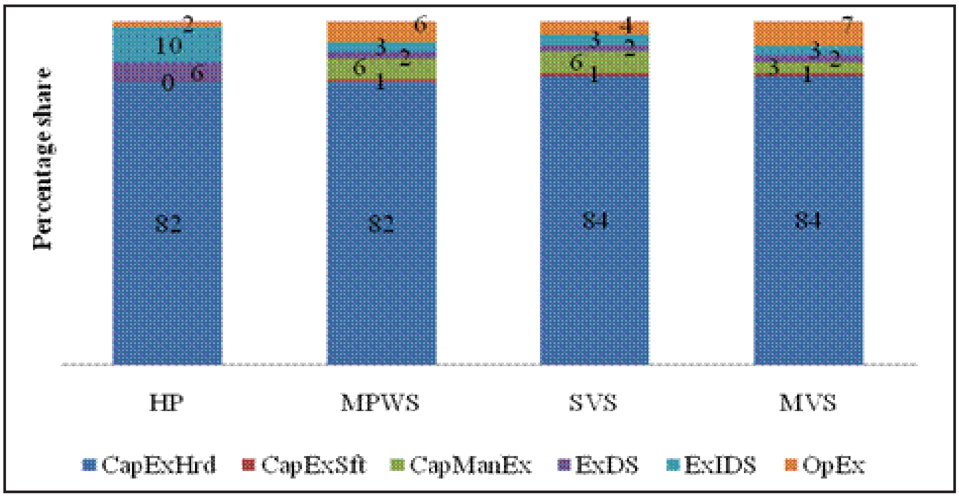
While the difference between the share of fixed and recurring costs is not much in the case of observed life span, the share of recurring costs is substantially lower for handpump in the case of observed life. This is mainly due to the high operational (OpEx) costs of the MVS, MPWS and SVS systems. SVS and MPWS schemes also have high CapManEx. This indicates that each technology has its cost advantages and disadvantages.

Figure 4a: Relative Shares (%) of unit costs (fixed+recurring) by Technology (Normative Life)



[8] Operation and maintenance costs are higher in the case of Multi-Village Schemes due to contract system. Operation and maintenance of these systems till the village point is given to private contractors, while village panchayat is responsible for operation and maintenance within the village. It is observed that these contractors are often appointed under political pressure rather than due to their qualified staff. This in turn results in

Figure 4b: Relative Shares of Unit Costs (fixed + recurring) by Technology (Observed Life)



Among the recurring costs operation and maintenance takes a major share followed by capital maintenance (Appendix Figures A1 and A2). The share of operation and maintenance costs goes down as we move from Multi Village schemes to Handpumps. While handpumps do not have any capital maintenance expenditure, capital maintenance is the highest for mini piped water supply schemes, as they are the oldest technologies being operated when compared to single and multi village schemes. Direct and indirect support costs also account for a substantial share. These costs however need to be linked with service delivery in order to assess the cost efficiency, which will be taken up in the next section.

IV Unit Cost versus Service provided per Technology

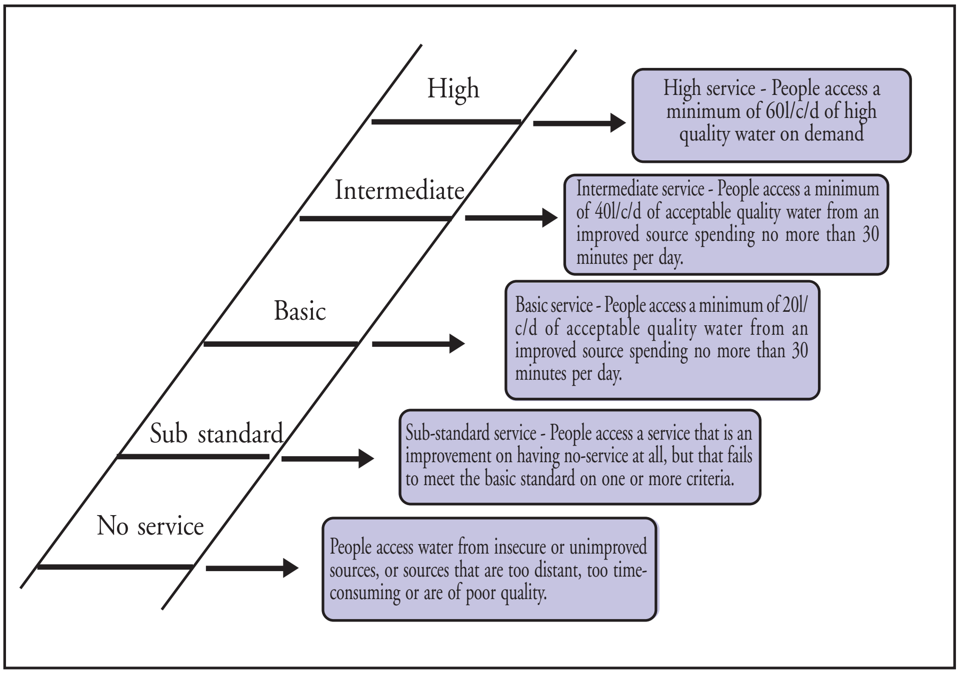
Service levels are assessed using four indicators of quantity, quality, accessibility and reliability following the service ladder approach[9]. And the levels of service for each indicator are categorised under five levels viz., no service, sub-standard, basic, intermediate and high. Each parameter is defined in terms of service received. These parameters are assessed using the household level data. Households are then grouped under different service levels based on the service they receive. Proportion of households falling in each category is presented for each technology. For the ease of analysis and clarity we have presented the proportion of households receiving basic and above service level, as the below basic service could be termed as poor service in the Indian context [10].

[9] WASHCost research follows a service ladder approach using four indicators viz., quantity, quality, accessibility and reliability.(for details see Moriarty, et. al., 2011).

[10] The detailed service levels are presented in the appendix (Figs. A3 to A6)

basic and above service level is defined as: Quantity: households receiving above 40 LPCD; Quality: acceptable as per user perception; Reliability: predictable supplies except during major breakdown and Accessibility: spending less than 30 minutes per day for fetching water.

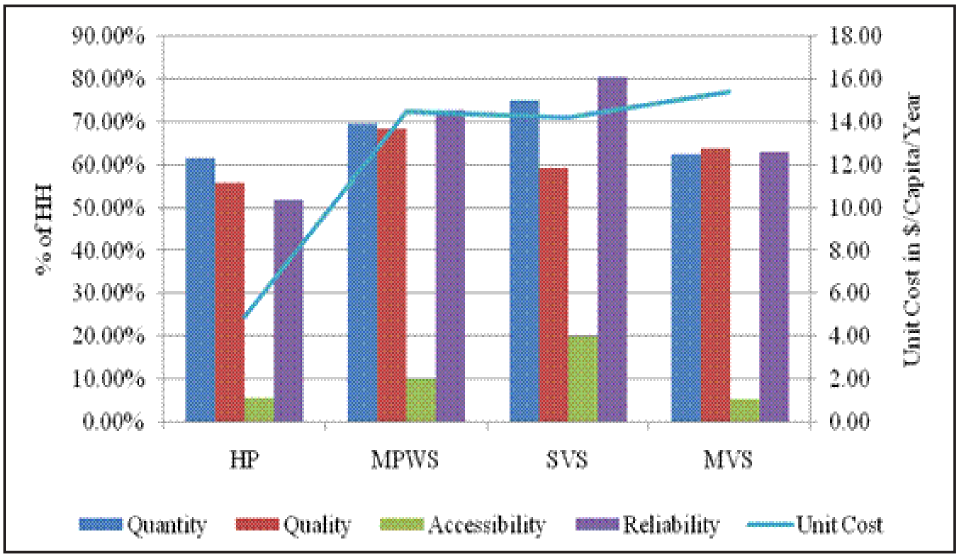
Fig 5: Water Service Ladder



Source: WASHCost Working paper-2, Ladders for assessing and costing water service delivery , www.irc.nl

More than 50 % of the households receive basic and above service in terms of quantity, quality and reliability (Fig. 6). Accessibility measured in terms of time spent on fetching water appears to be a major concern irrespective of the technology used. At the highest level only 36 % of the households are spending less than 30 minutes a day for fetching water (receiving above basic service) in the case of villages that have three technologies functioning simultaneously (MPWS+SVS+MVS). Accessibility is the lowest among MVS and HP villages. Unit costs would go up in the case of low accessibility when opportunity costs of time are taken in to account. Service levels are poor in all indicators in the case of HP villages. Among the pure technologies SVS is providing better service in terms of all the indicators except quality followed by MPWS. MVS villages compare poorly with both these technologies (MPWS and SVS) in all the indicators except quality, which is slightly better than that of SVS. The centralised distribution systems of MVS do not seem to be efficient in service delivery. And the differences in service levels are not statistically significant in most cases, especially between the pure technologies (Appendix Table A3). This again is due to the high intra technology variations emphasising need for a nuanced analysis of factors influencing the variations in service levels at the village level[11].

Figure 5: Service Levels (basic and above) and Unit Cost across Technologies



On the other hand, as mentioned earlier the differences in unit costs are not very different between these technologies, except that HP is the cheapest and the combination of three technologies (MPWS+SVS+MVS) is the most expensive. When unit costs are plotted against the service levels, it is clear that while HP is associated with poor service levels, the most expensive technology provides only marginally better service, that too in the case of quantity, quality and accessibility. On the other hand, SVS and MPWS provide relatively better services when compared to MVS. It may be noted that better quality and accessibility is also associated with buying water (Appendix A4 and A6). In the absence of buying water MVS would do well in terms of quality, due to its dependence on surface water sources. While these service levels are based on the proportion of households receiving specific level of service, the actual cost of provision in terms of cost per unit of water is not captured here. As cost per unit of water is an important indicator while comparing the technologies. This aspect is covered in the following section.

[11] This however is taken up as a separate analysis

Cost per unit of Water

Here we assess the cost per unit of water across technologies. For this we have estimated the actual use of water at the household level using the sample household data. The actual service received is the net of wastages from the water pumped. In general wastage is estimated at about 50 % of the pumped water (WASHCost India, 2010).

The total water consumption for the year under each technology (sample villages) is compared with the annualized cost per capita for the specific technology (sample villages). The ratio between annualized cost and the annual water use of the habitation gives the cost per unit of water. While the per capita service level is not very different across the technologies, especially the pure technologies, at the aggregate level, the cost per unit of water varies (Table 2).

Table 2: Cost per Unit of Water by Technology

Technology	Annualised cost / Cap (US$)		Annualised Cost (US$)*		Service in quantity (LPCD)+	Population Covered	Total amount of Water used (m3/Year)	Cost Per unit of Water US$/m3)	
	Normative	Observed	Normative	Observed				Normative	Observed
HP	3.8	5.2	26706	36546	40	7028	102609	0.26	0.36
MPWS	6.3	15.3	54394	132100	42	8634	132359	0.41	1.00
SVS	6.0	14.5	208344	503498	41	34724	519645	0.40	0.97
MVS	6.4	15.5	128883	312139	41	20138	301365	0.43	1.04
MPWS +SVS	6.9	15.5	239016	536920	40	34640	505744	0.47	1.06
MPWS +MVS	5.5	13.8	25663	64391	45	4666	76639	0.33	0.84
SVS + MVS	6.5	17.3	134544	358093	46	20699	347536	0.39	1.03
MPWS +SVS + MVS	12.6	27.4	105223	228817	38	8351	115828	0.91	1.97

Note: * Costs are unit costs (fixed+recurring) as calculated earlier multiplied by population covered under the technology. +These quantities are weighted average of summer and non summer water use.

Cost per unit of water is the lowest in the case of Handpumps and highest in the case of MVS as far as pure technologies are concerned in terms of normative as well as observed life of the systems. Among the combination of technologies, (MPWS +SVS+MVS) schemes have the highest cost per unit of water followed by MPWS+SVS, SVS+MVS and MPWS+MVS.

While costs in Handpump dependent villages are low their service levels are also low, especially in terms of reliability and accessibility. Single village schemes appear to be the best of the lot with better service indicators and relatively low costs, in terms of cost per capita per year as well as cost per unit of water. On the other hand, MVS has relatively high unit costs with low service levels when compared to MPWS. These unit costs provide the aggregate picture. A more detailed analysis of the factors responsible for these variations will be taken up as a separate study.

V Conclusions

This paper compares the unit costs and service levels provided across different technologies that are in operation in rural drinking water supply in Andhra Pradesh, India. Keeping the policy relevance in view our conclusions are restricted to the pure technologies viz., Handpumps; Direct Pumping or Mini Piped Water Supply; Single and Multi-Village Schemes. The following conclusions could be drawn from the analysis:

i) The average unit costs are about 3 times lower for handpumps.

ii) Multi village schemes are relatively more expensive though the cost differences are not statistically significant.

iii) Multi village schemes are associated with high (cumulative) capital costs with wide variations.

iv) Relative shares of costs indicate that all schemes are associated with high recurring costs when compared to handpumps, especially the operation and maintenance costs. On the other hand capital maintenance costs are more in the case of SVS and mini piped water supply schemes.

v) As far as service levels are concerned handpumps provide poor services in terms of reliability, accessibility and quality. Moreover, handpumps are not the commonly used technology, as they are used mostly to cope with scarcity conditions. At the policy level also, it is not a policy option due to the low preference at the community level.

vi) Single village schemes perform better in the case of services levels in terms of all the four indicators. However, the differences are not statistically significant.

vii) Irrespective of the technology, accessibility is the main concern as majority of the sample households spend more than 30 minutes a day in fetching water. In the light of increasing opportunity cost of labour this could result in substantial economic losses in general and welfare losses in the case where children are involved in fetching water.

viii) Multi Village Schemes are expensive even in terms of cost per unit of water despite their larger coverage of population.

It may be argued that multi village schemes are not necessarily the best available option. In fact, single village schemes appear to be more efficient despite all the draw backs. One reason could be that the operation and management of multi village schemes is split between contractors and village panchayat. Village panchayat does not have the control over quantum of water released and the time of release. On the other hand, village panchayat is in full control of the system in the case of single village schemes. Though the management problems at the village level are same for both the schemes, SVS are plagued with the additional problems associated with source sustainability, water quality, etc.

It would be better to address these issues and strengthen the SVS rather than moving towards multi village schemes, which are not efficient. What is more, MVS also will have source sustainability problems associated with climate change (IPCC, 2008). In either case source sustainability needs to be addressed effectively and the management becomes easier in the context of single village schemes with better planning. Adapting to life-cycle cost approach could provide the much need planning in terms of resource allocation to various components in this regard. Moreover, the split management structure of multi village schemes does not augur well with decentralized resource management.

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Appendix

Table A1: Statistical Significance of Difference between Unit Costs (observed / Normative) across Technologies (Paired 't' test)

Technology	HP	MPWS	SVS	MVS	MPWS+ SVS	MPWS +MVS	SVS+ MVS	MPWS+ SVS+MVS
HP	4.9/3.4							
MPWS	*/*	14.5/5.9						
SVS	*/*	NS/NS	14.2/5.6					
MVS	***/**	NS/NS	NS/NS	15.4/6				
MPWS+SVS	*/*	NS/NS	NS/NS	NS/NS	15.2/6.5			
MPWS+MVS	**/**	NS/NS	NS/NS	NS/NS	NS/NS	13.4/5.1		
SVS+MVS	*/*	NS/NS	NS/NS	NS/NS	NS/NS	NS/NS	16.9/6.2	
MPWS+SVS+MVS	**/*	NS/**	NS/**	NS/***	NS/***	NS/**	NS/**	26.9/12.1

Note: The mean values of each technology are compared with every other technology and the differences are tested for significance. In this table while top diagonal line gives the unit costs in terms of observed and normative life of the systems, the cells below the diagonal indicates where the difference between these technologies are statistically significant or not. NS=Not Significant. *; ** and *** indicate significant at 5 and 10 percent confidence level respectively.

Table A2: Cost of Provision by Technology: Variations across the Sample Villages (in US$ per capita/ Year)

	HP	MPWS	SVS	MVS
CapExHrd (cummulative)				
Average	26	38	44	46
Median	22	34	43	38
Range (Max-Min)	80-2	93-0.3	91-2	109-2
Coefficient of Variation	65	63	42	70
CapExHrd (Normative)				
Average	2.5	3	3.0	3.2
Median	2.4	2.7	3.2	2.7
Range (Max-Min)	8-0.2	9-0.03	6-0.2	9-0.2
Coefficient of Variation	66	68	40	66
CapExHrd (Observed)				
Average	4	11.9	11.9	13
Median	2.3	10.7	8.6	7.8
Range	16-0.2	38-0.3	55-0.3	42-2
Coefficient of Variation	99	83	90	93
CapExSft				
Average	0	0.08	0.05	0.3
Median	0	0	0.02	0.1
Range	0	1.2-0	0.3-0	3-0
Coefficient of Variation	0	261	149	236
CapManEx				
Average	0	0.9	0.8	0.4
Median	0	0	0.2	0
Range (Max-Min)	0	7-0	7-0	2-0
Coefficient of Variation	0	218	177	199
OpEx				
Average	0.07	1.2	0.9	1.3
Median	0	0.3	0.7	0.7
Range (Max-Min)	1.2-0	7-0	4-0.2	9-0
Coefficient of Variation	354	143	82	160
CapExDS	0.29	0.29	0.29	0.29
CapExIDS	0.47	0.47	0.47	0.47

Note: The low per capita CapEx cost in the case of MVS is due to the villages located at the head reach of the system where no or little investments (like overhead tank, etc) have taken place within the village.

Figure A1: Relative Shares of Recurring Costs: Normative

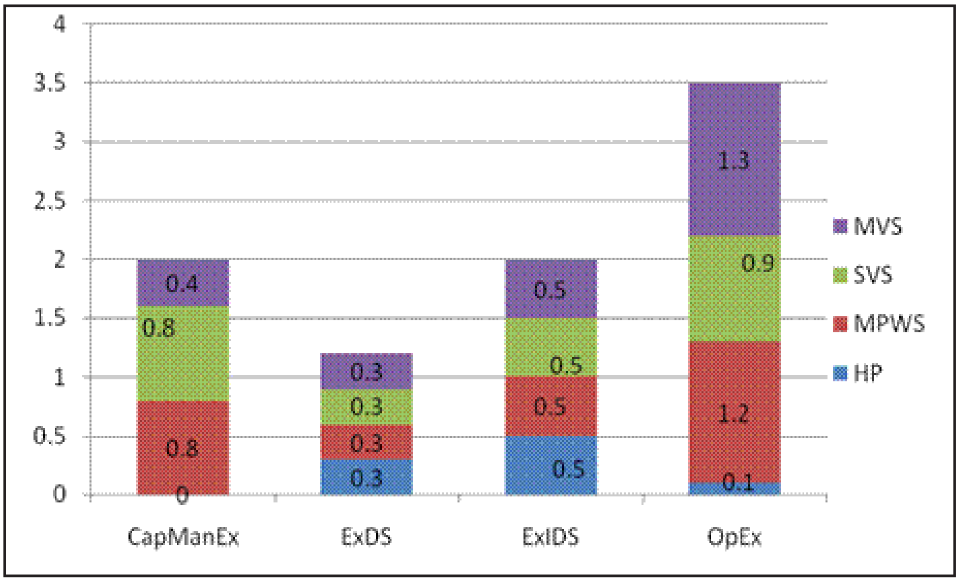

Figure A2: Relative Shares of Recurring Costs: Observed

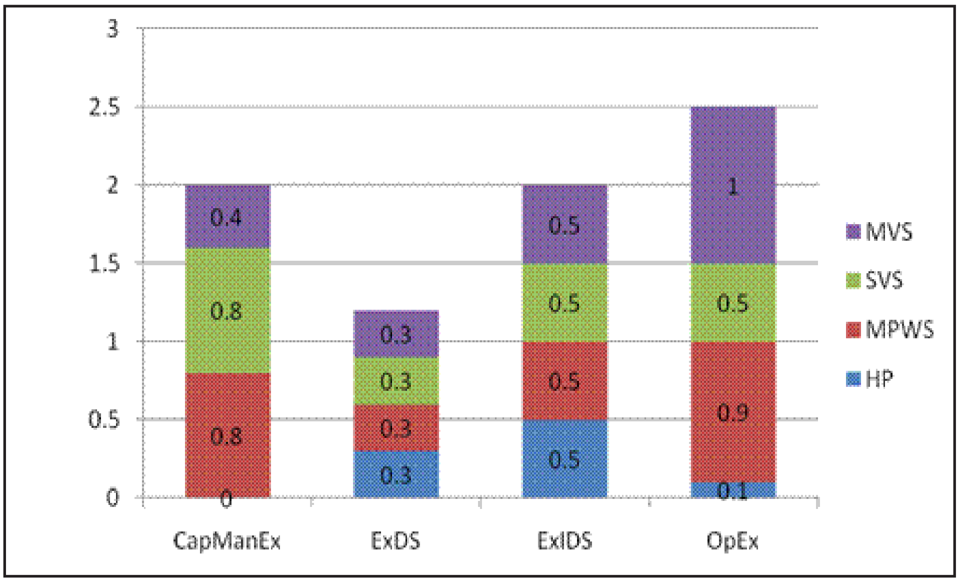

Figure A3: Service Levels in Terms of Quantity and Unit Cost (fixed + Recurrent) across Technologies

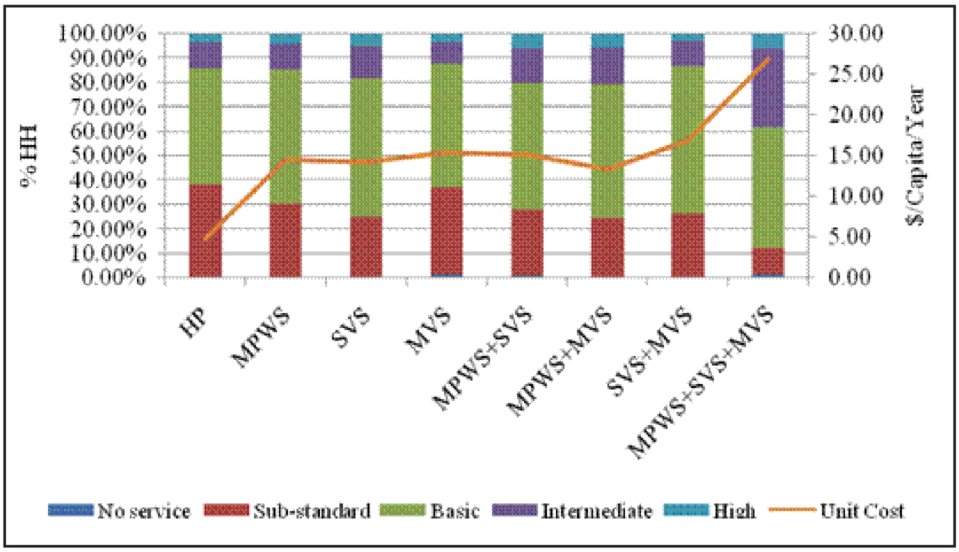

Figure A4: Service Levels in Terms of Quality and Unit Cost (Fixed + Recurrent) across Technologies

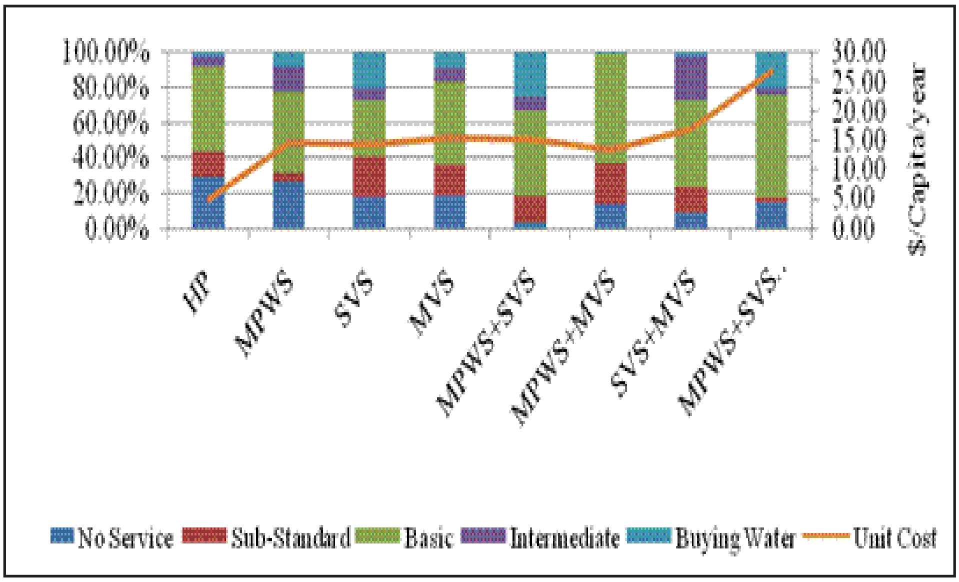

Figure A5: Service Levels in Terms of Accessibility and Unit Costs (Fixed + Recurrent) across Technologies

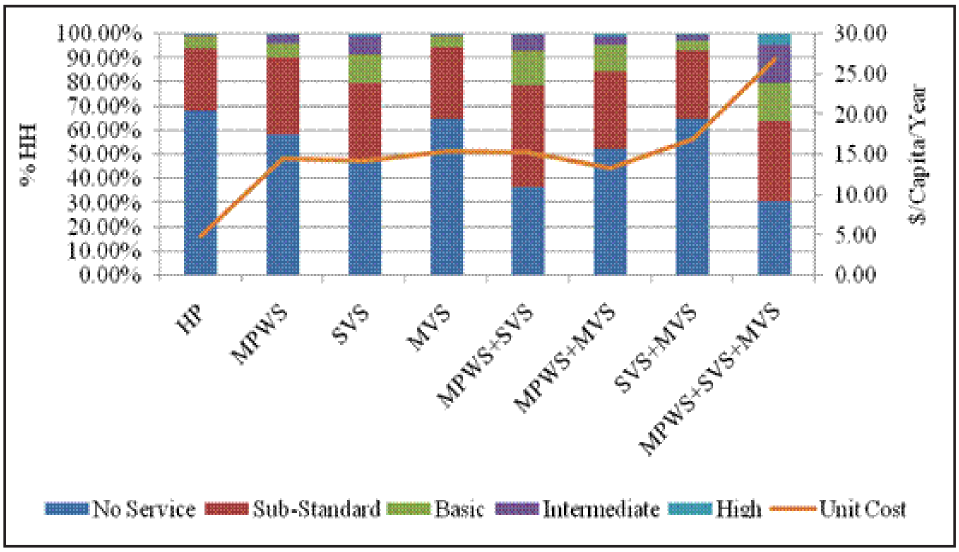

Figure A6: Service Levels in Terms of Reliability and Unit Cost (Fixed + Recurrent) across Technologies

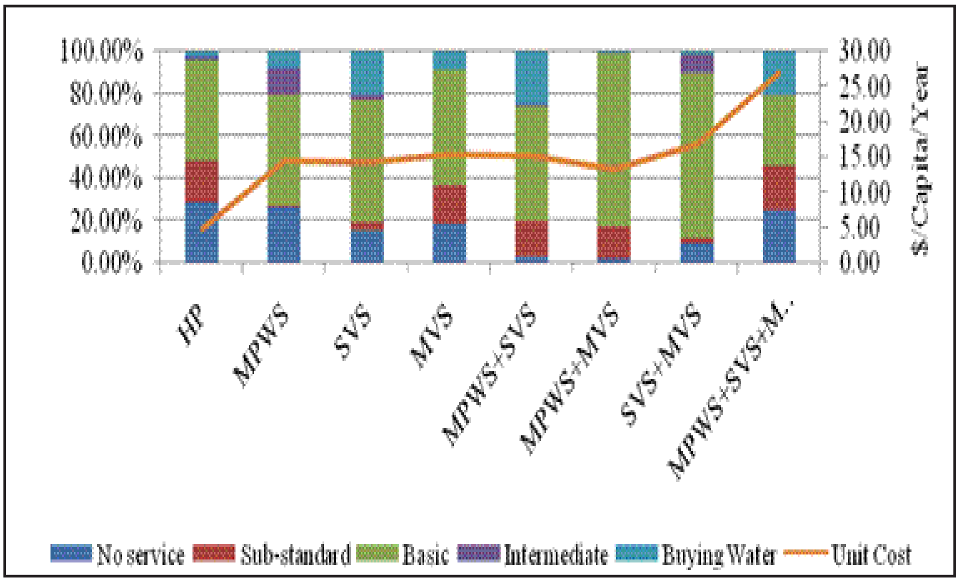

Table A3: Statistical Significance of Differences between Service Levels across technologies (Paired 't' test).

Technologies	Quantity	Quality	Accessibility	Reliability
HP/MPWS	NS	NS	NS	NS
HP/SVS	NS	NS	**	NS
HP/MVS	NS	NS	***	NS
HP / MPWS+SVS	***	NS	NS	NS
HP/SVS+MVS	NS	NS	NS	NS
HP/MPWS+SVS+MVS	NS	NS	NS	NS
MPWS/SVS	NS	NS	NS	NS
MPWS/MVS	NS	NS	NS	NS
MPWS / MPWS+SVS	NS	NS	**	NS
MPWS/MPWS+MVS	NS	NS	***	NS
MPWS/MPWS+SVS+MVS	NS	NS	***	NS
SVS/MVS	NS	NS	NS	NS
SVS/MPWS+SVS	NS	NS	*	NS
SVS / SVS+MVS	NS	**	NS	NS
SVS/MPWS+MVS	NS	NS	*	***
SVS/MPWS+SVS+MVS	NS	NS	*	NS
MVS/MPWS+SVS	NS	NS	NS	NS
MVS / MPWS+MVS	NS	NS	**	***
MVS/SVS+MVS	NS	NS	NS	NS
MVS / MPWS+SVS+MVS	NS	NS	***	**
MPWS+SVS/MPWS+MVS	NS	NS	**	NS
MPWS+SVS /SVS+MVS	***	NS	*	NS
MPWS+SVS /MPWS+SVS+MVS	***	NS	NS	NS
MPWS+MVS / SVS+MVS	***	NS	*	***
SVS+MVS / MPWS+SVS+MVS	NS	NS	**	**

Note: NS=Not Significant. ** and *** indicate significant at 5 and 10 percent confidence level respectively.

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