Working Paper No.121
WASHCost - CESS Working Paper No.22
September, 2012

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Factors Influencing Costs and Service Levels in Rural Andhra Pradesh

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Acknowledgements

This paper is part of an ongoing action research project, WASHCost, supported by IRC, The Netherlands, in four countries (India, Ghana, Mozambique and Burkina Faso) and is prepared by Professor.V. Ratna Reddy, Director, Livelihoods and Natural Resource Management Institute (LNRMI), Hyderabad and Research Director, WASHCost (India) Project. For more information on WASHCost project see www.washcost.info. Thanks are due to Dr. Christelle Pezon, WASH Governance Specialist, Burkina Faso, Ms. Catarina Fonseca, Project Director, WASHCost Project and Dr. Narayanamoorthy, NABARD Chair Professor and Director, Department of Economics and Rural Development, Alagappa University, Karaikudi, Tamil Nadu, India for their critical comments on the earlier drafts of the paper. However the usual disclaimers apply.

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ABSTRACT

Following the earlier analysis, this paper attempts to explain the variations in unit costs and service levels across the sample villages in Andhra Pradesh. The analysis is based on the data collected at the village and household level. Multiple regression analysis is used to estimate the cost drivers and factors influencing service levels. Number of dependent and independent variables have been identified from the available household data. The selected specifications are fairly good in explaining the variations in unit costs and service levels and the coefficients are consistent. The analysis of drinking water suggests that the relation between existing unit costs focused almost exclusively on capital expenditure and service levels is quite weak. Level of education, demographic and economic factors, technology and governance related factors appear to be influencing unit costs as well as service levels. The analysis not only emphasises some of the earlier observations but also provides new insights into explaining the variations.

The key policy messages from the analysis include:

i) Increasing the life of the system is critical for reducing the unit costs. The need to maintain the systems through allocations towards capital maintenance and ensuring required allocations towards operation and maintenance so that systems function efficiently despite their age. Maintaining the systems in good condition would not only reduce costs but also improve service levels.

ii) Avoid ad hoc investments or allocations towards extension and up gradation. Adaptation of life-cycle cost approach (LCCA) could help in minimising adhoc and wasteful expenditure on infrastructure. LCCA would also facilitate judicious allocation of resources to different components as mentioned above.

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iii) Improving literacy and education levels would not only help reducing the unit costs along with improving service levels in drinking water but also enhance efficiency in other related sectors like hygiene, health, education, etc.

iv) The existing governance structures appear to be too meagre to have any influence on unit costs. But they seem to have a positive impact on service levels. Improving the functioning and effectiveness of the governance indicators such as village water and sanitation committees could be a viable policy option in this regard.

v) Promotion of multi village schemes with surface water sources does not appear to be an optimal option in terms of its high cost as well as services delivered when compared with other options available. However, further research on multi-village schemes, especially based on the experience from other states, is needed to provide more evidence.

vi) High altitude and interior locations seem to suffer with poor service levels. These regions need priority treatment in the provision of drinking water.

vii) Scale economies in terms of population size have significant impacts on unit costs and service levels. While adopting cost norms these factors should be taken into account rather than adopting uniform policies across regions.

viii) While surface water sources are found to have a negative impact on quantity, they have a positive impact on accessibility.

ix) Social Diversity Index (SDI) has negative relation with accessibility indicating that homogenous communities (caste groups) are likely to have better access.

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I. Introduction

Costs and service levels in the provision of drinking water vary across regions and within the regions (across villages). Understanding these variations is critical for policy planning. Identifying various factors and determinants of costs and service levels would help identifying the policy initiatives that could enhance service levels and reduce unit costs. Besides, the analysis of factors influencing costs and service levels could also provide insights for future policies which need to be designed as per the expected socio-economic changes. The aggregate level analysis at agro-climatic zone level was not of much help in identifying the factors influencing costs and service levels (Reddy, et. al., 2011). These variations could be across socio-economic groups, demographic situations, geographical locations, technologies, source of water, etc. This paper makes an attempt to address this gap in understanding the reasons or factors influencing the variations across the villages in order to facilitate judicious allocation of resources and improved service delivery.

The inter-linkages between unit costs and service levels are established in this paper. Important aspects we have tried to address include: i) what are the factors influencing unit costs; ii) to what extent service levels are influenced by unit costs; iii) what are the cost components that influence service levels; iv) what are the non-cost factors that influence service levels, etc. The possible reasons or factors that explain the variations in unit costs and service levels could not be identified at the aggregate (State) level. Hence a disaggregated analysis at the village level forms the basis for identifying the factors.

Cost variations

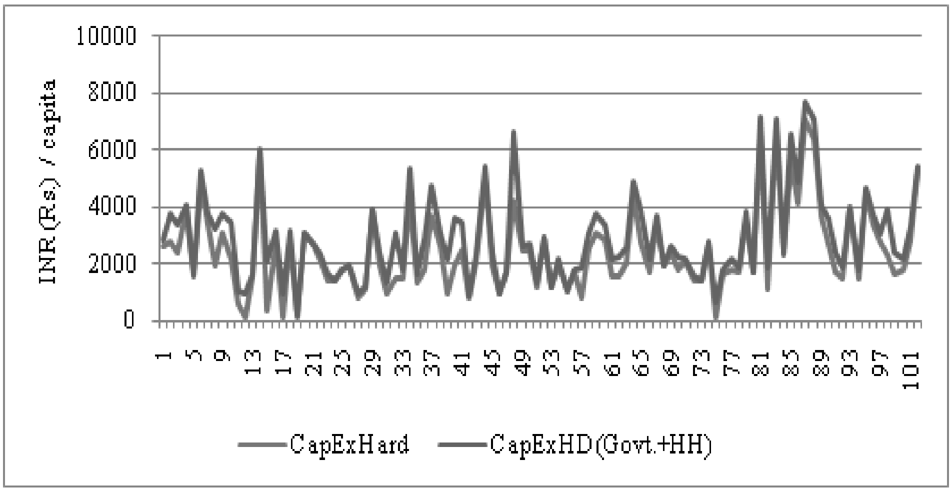
Within the cost components, variations are higher in the case of capital expenditure on hardware (CapExHrd) especially when measured in terms of cost per capita and cost per capita per observed year (Figs. 1 and 2). Cumulative unit costs on hardware (Govt. and Govt. + Households) show similar variation patterns in both cases. Variations are higher in the case of annualised costs (Fig. 2)[1]. While it was observed that variations in the life span of the systems is an important factor influencing unit costs, what explains these variations in life spans needs better understanding.

Service level variations

Similarly what are the factors other than life span that determine unit costs? Wide variations are observed also in the service levels provided (Fig. 3). Household perceptions (ordinal measure) rather than actual service received (cardinal measure) seem to vary more across sample villages. In order to address and explain the variations between the sample villages as well as between indicators this paper takes up the disaggregated analysis of costs and service levels at the village level.

The broad objective of the paper is to identify factors influencing unit costs and service levels. Such an analysis is expected to provide policy insights for sustainable service delivery with judicious allocation of costs. This paper is organised in to five sections. The approach and methodology is discussed in section two. Analysis of factors influencing costs and service level are presented in section three and four. And the last section makes some concluding remarks.

Figure 1: Variations in Cumulative Costs across Sample Villages



[1] Costs are annualised using the observed life of the systems. The high variations in the observed life of the systems across the villages further increases the variations.

Figure 2: Variations in Annualised Costs across Sample Villages

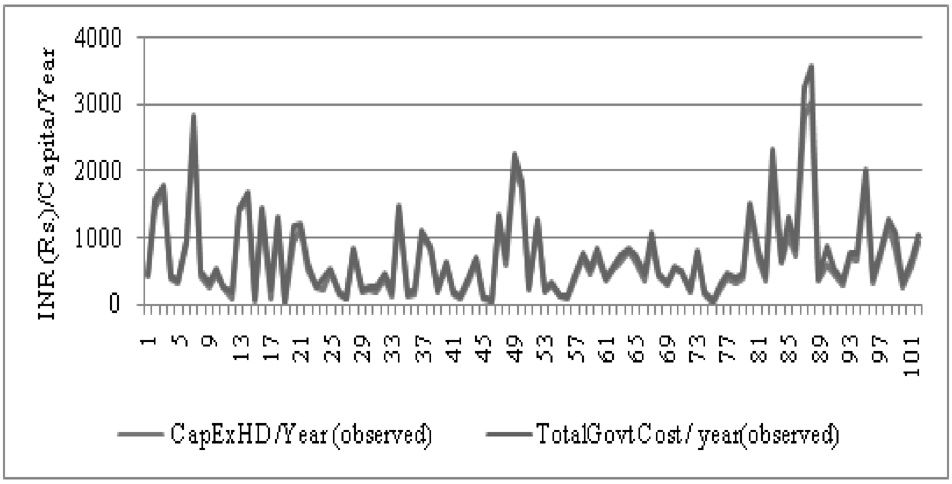
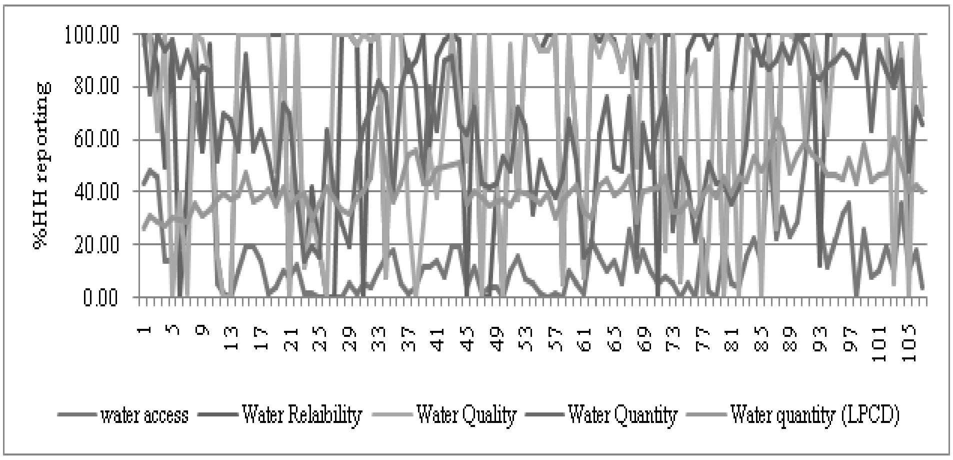


Figure 3: Variations in Service Levels across Sample Villages (Percentage of households reporting receiving above basic service level)



II Approach

Different indicators of cost and service levels are used as dependent variables. And a set of independent variables is identified from the village and household data using the correlation matrix. All the variables are standardised in per capita terms. The data set is based on 107 villages spread over 9 agro-climatic zones, which have cost as well as service level data. For the purpose of identifying the factors influencing unit costs and service levels multiple regression analysis has been adopted.

Variations in Costs
The basic specification for cost variations is as follows:

$DWCOST?_{vt}$= **f(Demographic**; Social;Eonomic;Source; Technical;Institutional)+ U_{vt} -1

Where;

$DWCOST_{vt}$= Drinking Water Cost in village 'v' and time 't'.
U_{vt}= Error Term

The independent variables are selected based on the theoretical considerations. These were selected from an exhaustive list of indicators generated from the village and household surveys, which are primarily used to identify the important variables with the help of simple correlation matrix. These indicators are broadly grouped under six groups viz., social; economic; demographic; source related; technical and institutional factors. Details of variable measurement and their theoretical / expected impact on unit costs are presented in table 1. Based on the extent of variations across villages we have included four dependent variables pertaining to unit costs. These include fixed costs per capita as well as per capita per observed year viz., fixed capital expenditure on hardware by the government per capita (CapExHrd-Govt) and the fixed capital expenditure on hardware by government per observed years (CapExHrd-Govt. observed) (Table 1). Total costs including fixed and recurring costs per observed year is another dependent variable (TExp-Govt). Total fixed capital expenditure by government and households (TCapExHrd) is also used as a dependent variable.

Independent variables under demographic factors include size of the village in terms of number of households and household size. Size of the village is expected to have a negative impact on unit cost due to the scale economies. Household size also may have negative impact though it is not clear how effective the scale economies would be at this level. On the contrary, larger household size may have higher household investments positively due higher water requirement. Social indicators include proportion of SC / ST households (percent SC/ST); Social Diversity Index[2] (SDI) and Level of Education (LEdu.). In the absence of a *priori* evidence on the impact of percent SC/ST and SDI indicators on unit costs, we hypothesise a positive or a negative impact which will be tested in this paper. Whereas level of education measured in terms of average years of schooling per household is expected to have a negative impact on unit costs. For, educated communities are expected to demand transparent management.

[2] Social Diversity Index (SDI) used in Verghese and Ostrom (2001).

Table : 1 Measurement and Expected Signs of the Selected Variables Pertaining to Unit Costs.

Variable	Measurement	Theoretical / Expected Impacts
DWCOST1-4	1) CapExHrd (Govt) = Per Capita Government Expenditure on Capital Expenditure- hardware in Rs.	Dependent Variables
	2) CapExHrd (Govt.+HH)= Per Capita total (govt. and household) capital expenditure on hardware in Rs.	
	3) CapExHrd (Govt) Observed= Per Capita Government Expenditure on Capital Expenditure- hardware per year (observed) in Rs. (fixed costs).	
	4) TExp (Govt) Observed= Per capita Total Govt. Expenditure (fixed + recurring) per year (observed) in Rs.	
VS	Village size (number of households in the village)	Negative
AFS	Average Family Size	Negative / Positive
percent SC/ST	Proportion of Scheduled Castes / Scheduled Tribe (lowest social category) households	Positive?
SDI	Social Diversity index ranging from '0 to 1", where '0' is no diversity and '1' is high diversity. Index of social heterogeneity $= 1 - \sum_{i}^{n} P^2$ Where Pi is the proportion of total population in the ith caste group.	Positive / Negative?
LEdu	Level of education (average number of years of schooling)	Positive / Negative
HHINC	Household Income (Rs. Per year)	Positive
FRMSIZE	Farm Size (net sown area per household)	Positive
percentHHBUY	percent of households buying water	Positive
HHExp-T	Household Expenditure on water (tariff)	Positive
HHExp-B	Household expenditure on buying water (bottled)	Positive / negative
DISTMRK	Distance from the Market Place (kms)	Negative
SOURCE	Source of Water measured as a Dummy variable (Goundwater=0; Surface water=1)	Positive / Negative ?
percentHC	Proportion of house connections	Positive
ZONE	Agroclimatic zones measured as dummy variable [(dummy 1= High Altitude Zone (HAZ), 2= North Coastal Zone (NCZ), 3= Godavari Zone (GZ), 4= Krishna Zone (KZ), 5= Southern Zone (SZ), 6= Scarce Rainfall Zone (SRZ), 7= Southern Telangana Zone (STZ), 8= Central Telangana Zone (CTZ), and 9= North Telangana Zone (NTZ)]	Positive / Negative?
TECH	Type of Technology measured as dummy [1=Hand Pump	

	(HP), 2=Direct Pumping (DP), 3=Single Village Scheme (SVS), 4=Multi-village scheme (MVS), 5=(HP+DP), 6= (DP+SVS), 7=(SVS+MVS), and 8=(DP+SVS+MVS)	Positive
$AGES_{vt}$	Age of the System (number years since established)	Positive / Negative
GI	Governance indicator (average score)	
	i) Institutional Space (IS) i.e., functioning of village water and sanitation committee; women / SC / ST participation in decision making and meeting of grama sabha (village gathering)on WASH issues	Negative
	ii) Involvement in Planning (IP)	
	iii) Involvement in financial Management (IFM)	
	iv) Involvement in Operation and Management of systems (IO&M)	
	v) Capacity Building Inputs (CBI)	
U_t	Error term	

Economic indicators include; household income (HHINC); farm size (FRMSIZE) household expenditure on water tariff (HHExp-T); household expenditure on buying water (HHExp-B); and distance from the market place (DISTMrkt). Of these household income and farm size reflect the economic status of the households at the village level. Villages with high average household income and farm size are expected to influence costs positively. For economically well off villages are expected to mobilise better funding for the water projects when compared to low income villages. In the case of farm size, larger farm size is often associated with rainfed or poor regions. In this case, the impact of farm size need not be positive. Similarly, average payment (tariff) for water is likely to be higher due to two reasons, viz., i) larger proportion of house connections indicated better economic situation, and ii) better compliance of tariff payments. While the former might have positive impact, the later may have negative impact. And household expenditure on buying water also could be due to two reasons i.e., a) better economic situation and b) poor quality of water. Both these factors may have opposite impact on unit costs. Therefore, these indicators could have either positive or negative influence on unit costs depending on the relative importance. On the other hand, better access to market may have negative influence on unit costs due to availability of material and low transport costs.

Source related variables include source of water (SOURCE) measured as dummy (groundwater=0 and surface water=1); water quality (WQ) measured as perception of the people (percent households reporting sweet / good water) and house connections (percent HC) which indicates the dependence on public source. In the case of source, groundwater is expected to be more expensive due to extraction costs when compared to surface water. However, in the case of multi village schemes, where surface water is brought in from far off places, the unit costs could be higher. We anticipate either a negative or positive hypothesis for this variable that needs to be tested. Better water quality is expected to reduce costs in terms of treatment and better functioning of the systems. Here we have also incorporated a dummy variable for the 9 agro-climatic zones. In the absence of data on hydrogeology, agro-climatic zones represent the natural conditions that determine source potential and fragility of each zone. Using this variable, we test the hypothesis whether natural factors influence unit costs or not. And we do not have any a *priory* expectation on the sign of this variable.

We have identified 8 technologies in the sample villages. These include four "pure" technologies like Hand Pumps (HP); Direct Pumping or Mini Piped Water Supply schemes (DP / MPWS); Single Village Schemes (SVS); and Multi-Village Schemes (MVS). The remaining four technologies are combinations of these four technologies such as HP + MPWS; MPWS + SVS; SVS + MVS and MPWS + SVS + MVS. These technologies are ranked as 1 to 8 in the same order. It is expected that the unit costs are expected to go up as the technology moves from 1 to 8, as multiple technologies are add-on investments over the existing systems. Age of the system (AGESyt) is measured as number of years the system (s) are functioning or providing the service. The longer the system is functioning, the higher would be the cumulative costs due to capital maintenance. On the other hand, annualised costs are expected to be lower in case of old systems. Therefore, age of the system is expected to have a positive impact on cost per capita and a negative impact on cost per capita per year.

Governance is measured using 19 indicators. For the present analysis these nineteen indicators are categorised under five groups (Table 1) and also an aggregate Indicator of Governance (GI). These include Institutional Space (IS) including i) functioning of village water and sanitation committee; women / SC / ST participation in decision making and meeting of *grama sabha* (village meeting) on WASH issues. Community involvement in planning (IP) includes the following indicators: feasibilty study; technical survey; system integration and extension. Capacity building inputs (CBI) including effectiveness of training and IEC activities. Involvement in the O&M systems (IO&MS) includes O&M of PSPs and HPs; water quality testing; solid waste management; waste water management and hygiene and sanitation. Involvement in financial management (FM) includes maintaining water and sanitation records; tariff collection and proactive disclosure. All the 6 indicators (including over all governance - GI) are used in the analysis in order to assess their relative importance in influencing the unit costs. All the governance indicators are expected to have a negative influence on unit costs. For governance is expected to increase cost efficiency due to transparency and better management practices (Reddy, et. al., 2009).

Variations in Service Levels

The basic specification for the analysis of service levels is as follows:

$DWSL_{vt}$=f(Demographic; Social;Eonomic;Source; Technical;Institutional)+ U_{vt}---2

Where;

$DWSL_{vt}$= Drinking Water Service Level in village 'v' and time 't'.

U_{vt}= Error Term

Here also the independent variables are selected based on the theoretical considerations. Variables are also identified with the help of simple correlation matrix. In the case of service levels some more economic (cost) variables are added to the list of independent variables listed above (Table 2). Service levels are available in quantity terms as well as qualitative perceptions of the households. Using the service ladder approach four service indicators are viz., quantity, quality, accessibility and reliability are measured. Households give scores to each of these indicator using five levels i.e., no service, sub-standard, basic, intermediate and high. In order to avoid the complication in measuring the variables and interpreting them, we have taken the proportion of households scoring above basic service level, which is close to service norms in India pertaining to the four indicators. Both quantitative and qualitative indicators are generated for summer and non-summer months. In the case of quantitative measures summer, non-summer and overall (year) quantities are taken in to account. Altogether we have included six dependent variables. These include: i) DWSLq-t= Drinking water service level in quantity total (LPCD); ii) DWSLq-s= Drinking water Service level in quantity during summer (LPCD); iii) DWSLq-ns= Drinking water Service level in quantity during non-summer (LPCD); iv) DWSLqn= Drinking water service level in quantity (percent households receiving basic and above); v) DWSLAc= Drinking water Service level in accessibility (percent households receiving above basic accessibility); and vi) DWSLr= Drinking water service level in reliability (percent households receiving above basic service level.

Table 2 Measurement and Expected Signs of the Selected Variables

Variable	Measurement	Theoretical / Expected Impacts
DWSL1-6	1) DWSLqt= Drinking water Service level in quantity (LPCD).-(Summer+Non-summer / Summer / Non-summer)	Dependent Variables
	2)DWSLqn= Drinking water Service level in quantity (percent households receiving basic and above).	
	3)DWSLAc= Drinking water Service level in accessibility (percent households receiving above basic accessibility).	
	4)DWSLr= Drinking water service level in reliability (percent households receiving above basic service level.	
AFS	Average Family Size	Negative
VS	Village size (number of households in the village	Positive
percent SC/ST	Proportion of SC / ST households	Positive / Negative?
SDI	Social Diversity index (see table 1)	Positive / Negative?
LEdu	Level of education (average number of years of schooling	Positive
percentHC	Proportion of house connections	Positive
HHINC	Household Income (Rs. Per year)	Positive
FRMSIZE	Farm Size (net sown area per household)	Positive
OpEx	Operation and Maintenance Cost Per capita per year (Rs./Capita)	Positive
CapExHrd	Capital Expenditure per capita / per observed year (Rs./Capita)	Positive
HHCapExHrd	Household Capital expenditure per capita (Rs./Capita)	Positive
HHExp	Household Expenditure on water (tariff) (Rs. / Capita)	Positive
HHExp-B	Household expenditure on buying water (bottled) (Rs. /capita)	Positive / Negative
percentHHBUY	percent of households buying water	Positive/Negative
DISTMRK	Distance from the Market Place (kms)	Positive
TIME	Time spent in Fetching water (Minutes/Capita/day)	Positive / Negative
OCT	Opportunity cost of Time (Rs. / Capita / day)	Positive / Negative

contd...

SOURCE	Source of Water Dummy (Goundwater=0; Surface water=1)	Positive
WQ	Water Quality (percent HH reporting sweet / good quality)	Positive
ZONE	Agro-climatic zones 9 (dummy 1, 2, 3, 4, 5, 6, 7, 8and 9) (see table 1)	Positive / Negative
TECH	Type of Technology (dummy 1, 2,3, 4, 5, 6, 7, and 8) (see table 1)	Positive
AGESyt	Age of the System (number years since established)	Negative
NNGP / NGP	Dummy variable representing NGP/NonNGP status of the village (NGP=1 and NNGP=0)	Positive
GI	Governance indicator (average score)	Positive
	i) Institutional space (IS)	
	ii) Involvement in Planning (IP)	
	iii)Involvement in financial Management (IFM)	
	iv)Involvement in Operation and Management of systems (IO&MS)	
	v)Capacity building inputs (CBI)	
Ut	Error term	

Most of the independent variables used in the cost analysis are retained in the service level analysis as well and a few additional cost variables are added in the service level analysis. However, the expected signs are different in the case of service level analysis. Most of the selected variables are expected to have positive impact on service levels (Table 2). Under demographic factors, size of the village is expected to have a positive impact on the service level, especially quantity, as the demand for water is expected to increase with population. Household / Average Family Size (AFS) is expected to have positive or negative impact. While larger households may use more water (litres per day), in per capita terms, they tend to use less (Reddy, 1999). On the other hand, larger households would have more people involved in fetching water and hence may increase water demand, though this may not apply in the case of house connections. Social indicators such as SC / ST households (percent SC/ST) and social diversity index (SDI) may influence service levels positively or negatively. Whereas level of education (LEdu.) is expected to increase the demand for water, as educated people tend to use more water for hygiene purposes.

Economic indicators include; household income (HHINC); farm size (FRMSIZE); Capital expenditure of government (CapExhrd); household capital expenditure (HHCapExHard); Operation and maintenance expenditure (OpEx); households buying water (percent HHBUY); household expenditure on water tariff (HHExp-T); household expenditure on buying water (HHExp-B); and distance from the market place (DISTMRKT). All these variable are expected to have positive influence on service levels though some of them (percent HHBUY and HHExp-B) could have negative impact as buying water may be a consequence of poor water service. Higher expenditure on fixed as well as recurring costs is expected to improve the service levels. Another important indicator that is part of economic costs of water provision is the time spent by the households in fetching water. Time variable is measured both in physical terms (TIME) and monitoring terms using the opportunity cost of time (OCT). These two variables may have positive or negative impact as we are not sure of the causality between service level and time variable. For, households may have to spend more time in fetching water due to poor service levels. On the other hand, a household's service level may be higher due to higher time spent on fetching water. Similarly, higher income households and villages close to markets (DISTMRKT) are expected to have higher demand for water. Average payment (tariff) for water is likely to have positive impact on service levels as more house connections means better access to water and better compliance of tariff payments demands better services. Household expenditure on buying water could have positive or negative influence on service levels as well, as explained in the case of unit costs.

In the case of source, surface water is expected to be more reliable compared to groundwater. We anticipate a positive impact of this variable on service level. The dummy variable for the 9 agro-climatic zones is used to test the hypothesis whether natural factors influence service levels or not. And we do not have any a *priory* expectation on the sign of this variable. The technology variables are expected to influence the service levels positively, as multiple systems are more reliable than a single system. Age of the system (AGESyt) is expected to influence service levels negatively due to the reason that functional efficiency goes down with age. And all the governance variables are expected to have positive impact on service levels due to better management practices. Another institutional related variable pertaining to the Nirmal Gram Puraskar (NGP) status of the village is also included. Though this status is related to sanitation, it is expected that the general institutional effectiveness is not necessarily confined to sanitation. The NGP status of the village, therefore, is expected to have a positive impact on service levels.

Ordinary Least Squares (OLS) estimates were used to regress the different dependent variables (DWSL1-6) against the selected independent variables. Descriptive statistics of the selected variables are presented in the appendix. Regressions were run on cross sectional data at the village level using the data from 107 villages (n=107). Various permutations and combinations of independent variables were used to arrive at the best fit. Multicolinearity between the independent variables was checked using the Variance Inflation Factor (VIF) statistic. Multicolinearity is not a serious problem as long as 'VIF' value is below 2. The best fit specifications were selected for the purpose of final analysis. Though we have also tried log linear estimates, only linear specifications are retained for the purpose of analysis as the log linear specification have poor explanatory power.

III Cost Drivers: Factors Influencing Unit Costs

The estimates indicate that the specifications using four dependent (exogenous) variables explain about 50 to 60 percent of the variations in existing unit costs across sample villages (Tables 3 and 4). Two of the dependent variables pertain to unit costs per capita and the other two are annualised unit costs using observed life of the systems i.e., per capita per year. It may be noted that specifications of annualised unit costs have relatively less explanatory power with fewer variables turning significant (Table 4). All the selected variables have the theoretically expected signs and the signs are consistent across specifications (see table 1). These specifications are also selected purposively, as they do not have multi-colinearity problem (correlation between independent variables). Number of variables turned out significant in the selected specifications.

Size of the village (number of households) has a significant negative impact on unit costs- total and annualised per capita costs. Due to economies of scale, unit costs tend to be lower as the population of the village increases. The magnitude of the estimates indicates that the scale economies in unit costs could be substantial as we move from small to big villages (see appendix table). Every 1percent increase in the average size of the village (327 households at present) would reduce the costs by 1.5percent. Per capita cost norms need to take the size of the village in to account while estimating the costs. Our estimates indicate that the unit costs would come down by 15 percent for an increase in size of the village by 33 households. That is Age of the system (AGESyt) has turned out significant in all the specifications. As expected AGESyt. has a positive impact on total unit costs and negative impact on per year costs per capita. While the cumulative costs are be more as the system becomes older because of replacement and rehabilitation costs. Even the operational expenditure costs are higher in the older systems. But, the per year costs tend to be lower as the age of the system increases. This indicates maintaining the systems for longer periods with appropriate allocations for capital maintenance (CapManEx) and operation and Maintenance (OpEx) would help reducing the overall unit costs. That is increasing the life of the system is critical for reducing the unit costs.

Table 3: Regression Estimates of selected Specifications: Unit Costs per capita

Variables	Dependent Variables			
Independent Variables	CapExHrd (Govt.)		CapExHrd (Govt.+HH)	
	Coefficient	VIF	Coefficient	VIF
(Constant)	850.43 (0.72)	---	1283.13 (1.17)	---
VS	-1.447* (-3.09)	1.57	-1.488* (-3.24)	1.55
AFS	513.324*** (1.72)	1.99	396.875 (1.44)	1.74
FARMSIZE	-207.405** (-2.57)	1.33	-187.885** (-2.44)	1.22
LEdu.	-75.440** (-2.27)	1.81	-67.668** (-2.06)	1.78
SOURCE	244.83 (0.81)	1.52	---	
percentHC	10.916** (2.34)	1.97	9.536 **(2.12)	1.86
TECH (HP)	-640.58 (-1.60)	1.45	-729.11 *** (-1.87)	1.40
TECH (SVS+MVS)	1494.04 (3.98)*	1.28	1642.872* (4.50)	1.22
TECH (MPWS+SVS+MVS)	1683.12* (2.81)	1.73	1903.69* (3.55)	1.40
HHExp-B	7.27*** (1.78)	1.57	6.899*** (1.70)	1.57
HHExp-T	0.651** (2.08)	1.85	1.61* (5.26)	1.78
AGESyt.	68.80* (2.66)	1.26	68.27* (2.66)	1.26
Zone (STZ)	1604.59* (3.44)	1.68	1624.61* (3.50)	1.68
Zone (SZ)	476.96 (1.33)	1.33	431.94 (1.22)	1.32
IS	9.25 (1.03)	1.61	8.20 (0.92)	1.60
R2	0.57	0.62		
Adjusted R2	0.50	0.56		
N	107	107		

Note: Figures in brackets are 't' values. *; ** and *** indicate level of significance at 1, 5 and 10 percent level respectively.

On the other hand, adding new systems or technologies to the existing ones could prove expensive as revealed in the case of combination of technologies. Combination of technologies, especially SVS+MVS and MPWS+SVS+MVS, are more expensive in terms of cumulative as well as unit costs. This calls for a proper planning in designing and implementing appropriate technology options. The ad hoc approach of upgrading the systems is proving to be expensive i.e., service levels are not growing proportionately to costs. On the contrary, hand pumps (HP) turned out to be negatively influencing the cumulative costs due to the obvious reason that HP is a low cost technology.

Average family or household size in the village has a positive impact on the total unit costs and negative impact on annualised costs. Given the increasing trend in nucleus families (GoI, 2011), total costs are likely to decrease while annualised costs are likely to increase. This goes against the general perception that providing water to more number of households with smaller family size would be more expensive than providing to less number of households with bigger family size. Though there is no theoretical basis for this, we presume that cost norms could be adjusted down words as the size of the households decline over the years.

Level of education (LEdu.) has turned out significant with a negative sign in the case of cumulative expenditure. Higher education levels in the village could provide the much needed checks and balances in the case of fund allocations and expenditure. Education can also help enhancing the activities and functioning of the institutions, formal as well as informal. Informed discussions and decisions could lead to efficient allocation of resources. Thus improving the literacy and education levels in the rural areas is critical for cost effective management of water systems.

Table 4: Regression Estimates of Selected Specifications: Unit Costs per Capita per Year

Variables	**Dependent Variables (Annualised)**			
Independent Variables	**CapExHrd (Govt.)**		**CapExHrd (Govt.+HH)**	
	CapExHrd (Govt.) observed	**VIF**	**TExp (Fixed+recurring) observed**	**VIF**
(Constant)	907.23* (8.66)	---	2063.25* (4.08)	---
VS	-0.57* (-3.47)	1.09	-0.55* (-3.04)	1.20
AFS	----	---	-203.14*** (-1.94)	1.23
percent HHBUY	----	---	-3.26 (-1.42)	1.60
TECH (HP)	----	---	-270.20 (-1.60)	1.29
TECH (SVS+MVS)	457.82* (3.15)	1.08	489.27* (3.12)	1.11
TECH (MPWS+SVS+MVS)	725.92* (3.53)	1.14	938.27* (4.11)	1.25
OCT	----	---	-0.20 (-1.34)	1.19
AGESyst.	-56.31* (-5.60)	1.07	-52.76* (-4.62)	1.23
Zone (STZ)	500.75* (2.98)	1.23	619.22* (3.21)	1.43
GI (CBI)	4.66*** (1.68)	1.14	4.71 (1.45)	1.38
R2	0.47	0.53		
Adjusted R2	0.44	0.48		
N	107	107		

Note: Figures in brackets are 't' values. *; ** and *** indicate level of significance at 1, 5 and 10 percent level respectively.

Land holding (net sown area) per household (FARMSIZE) has a negative influence on unit costs both cumulative and annualised. FARMSIZE is often used to represent the economic status of the households in the rural areas. While larger farm size means better economic status within a village, this is not necessarily true across villages. For it is observed that average farm size is higher in the dry or rainfed regions. That is villages with larger farm size are likely to represent dry regions. Extending the logic that unit costs are low in the dry regions indicates that the dry regions with larger average farm size has low unit costs. This emphasises the fact that provision costs are low in the less endowed regions.

As expected the coefficient of household expenditure on buying water (HHExp-B) and payment of tariff (HHExp-T) have turned out positive and significant in the case of cumulative costs. These two indicators as expected reflect the economic status of the villages, though buying water could be due to poor quality of water. The positive impact of economic status or economically well off villages indicate that these villages are likely to push costs up. This could be due to the reason that economically better of villages are likely to garner more funds for their schemes. Only one of the governance indicators i.e., capacity building inputs (CBI) turned out be negatively influencing costs, that too in the case of annualised costs. While better governance is expected to reduce the costs, the level of governance appears to be too meagre to have any impact on unit costs. That is, in the absence comprehensive governance interventions, capacity building of the communities may only end up adding to the costs (whatever little) rather than enhancing the service delivery.

IV Factors Influencing Service Levels

The regression estimates of factors influencing service levels were carried out on four different service variables and six specifications[3] (see Table 2) information. Dependent variables include both quantitative and qualitative variables. Quantitative variables are based on actual quantity used at the household level measured in Litres Per Capita per Day (LPCD). This variable is taken for summer, non-summer and the entire year[4]. Quantity is also measured in quality terms (household perception) i.e., percent of households reporting that quantity of water they receive is above basic. Both summer and non-summer perceptions are used for estimation purposes. Other service level indicators include household perceptions on access and reliability (percent households scoring above basic service level i.e., less than 30 minutes per day and predictable supplies

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[3] We have not included the water quality variable as it is expected to be determined mainly by the natural factors on which we do not have much information. Besides, the reliability of water quality testing is also an issue.

[4] The weighted average of summer (1/3) and non-summer (2/3) quantities are used to arrive at the total quantitity.

except during breakdowns). Summer, non-summer differences are not observed in the case of these two variables and hence only entire year scores are used. The selected specifications explain about 70 percent of the variations in service levels in quantitative as well as qualitative terms. The explanatory power of the non-summer variable is more when compared to summer and the entire year. Most of the selected variables have the expected signs (Tables 5, 6 and 7).

Quantity (Litres per capita per day-LPCD)

It may be noted that none of the fixed cost variables turned out significant in explaining the variations in service levels, especially quantity measured in LPCD (Table 5). Though one expects a direct relationship between expenditure on infrastructure and quantity of water supplied, these costs do not seem to have any bearing on the actual quantity received by the households. On the contrary, one of the governance indicators (GI-IO&MS) has revealed a positive and significant impact on water quantities received by the households in both the seasons. That is villages with better institutional arrangements, especially relating to O&M, appear to have better service levels. This indicates that governance factors play a more important role when compared to cost factors - or are a pre-condition for some of the expenditure to take place and make the expenditure effective. Average family size has a negative impact on household water use, which is due to the scale impacts. That is larger families tend to consume less water in per capita terms (Reddy, 1999). Farm size has a positive impact indicating that villages with bigger land holdings tend to get better water supplies. As discussed in the case of unit cost estimates that larger farm size is often associated with rain fed regions. It may be deduced that despite these regions having lower unit costs when compared with the endowed regions, their service levels appear to be better than that of endowed regions.

Level of education (LEdu.) turned out to be positive and significant, though only in the case of non-summer quantities. That is higher service levels are associated with higher education levels. Education is emerging as a critical factor in reducing unit costs and improving the per capita service level. Promotion of education and literacy levels is an important policy option for improving service levels not only for water supply but also for other services like health and hygiene (Reddy and Kullappa, 2008). Similarly, villages close to market (DISTMRKT) have higher consumption of water. Given the potential growth of urbanisation in the coming years the demand for water in the rural areas is likely to increase. The combined impact of increasing literacy and urbanisation is likely to increase the pressure on water services substantially. Such enhanced demand for water need to be taken into account while revising the norms and designing the systems in the rural areas.

Table 5: Regression Estimates of Selected Specifications of Service Levels (Quantity - (LPCD)

Variables	Dependent Variables (LPCD)					
Independent Variables	DWSLqt (LPCD-S+NS)		DWSLqt (LPCD-S)		DWSLqt (LPCD-NS)	
	Coefficient	VIF	Coefficient	VIF	Coefficient	VIF
(Constant)	46.45* (10.18)		52.70* (10.22)	---	43.82* (10.03)	---
AFS	-2.90* (-2.86)	1.11	-2.90** (-2.53)	1.1	-4.17* (-3.66)	1.6
FARMSIZE	0.87* (2.64)	1.07	1.01* (2.70)	1.1	0.99* (3.11)	1.1
LEdu.	---	---	---	---	0.18 (1.29)	1.7
DIST_MKT	---	---	---	---	0.14*** (1.96)	1.2
percentHHBUY	-0.03 (-1.15)	1.74	-0.03 (-0.95)	1.8	---	---
TECH (MPWS+SVS)	---	---	-2.77*** (-1.79)	1.2	---	---
TECH (SVS+MVS)	---	---	---	---	3.16** (2.03)	1.2
percentHHPAYTARIFF	---	---	---	---	-0.01 (-1.22)	1.3
ZONE (CTZ)	-7.85* (-4.16)	1.32	-10.63* (-4.94)	1.3	-6.20 * (-3.61)	1.3
ZONE (HAZ)	---	---	-3.19*** (-1.68)	1.1	---	---
ZONE (KZ)	11.91* (7.21)	1.27	10.49* (5.40)	1.4	11.22* (7.49)	1.2
ZONE (STZ)	16.63* (8.31)	1.48	16.83* (7.27)	1.6	16.48* (9.51)	1.3
ZONE (SZ)	9.14* (6.08)	1.13	7.21* (4.15)	1.2	9.50* (6.29)	1.3
GI (IO&MS)	0.11** (2.23)	1.51	0.11*** (1.84)	1.5	0.09 *** (1.69)	1.8
R^2	0.70		0.67		0.74	
Adjusted R2	0.68		0.63		0.71	
N	107		107		107	

Note: Figures in brackets are't' values. *; ** and *** indicate level of significance at 1, 5 and 10 percent level respectively.

Among the technologies, the combination of MPWS+MVS seems to provide poor quantities, while SVS+MVS combination has positive impact on quantity of water, it may be noted that SVS+MVS combination is also more expensive. On the other hand, none of the pure technologies have turned out significant in influencing service levels (quantity). Five of the nine agro-climatic zones turned out significant. Central Telangana (CTZ) and High Altitude (HAZ) zones have a negative impact on service levels and the impact is positive in the case Krishna (KZ); Southern Telangana (STZ) and Southern (SZ) agro-climatic zones. This indicates that agro-climatic conditions of these zones are favourable for improved service levels.

Quantity (perceptions)

Here we analyse the factors influencing the quantity of water measured in terms of perceptions of the households. Service levels when measured in terms of household perceptions about water quantity not only emphasis the earlier findings (LPCD) but also provide new insights. Here also none of the cost variables have turned out positive and significant. On the contrary annualised cost variable (CapEx-Observed) turned out to be negatively influencing the household perceptions about quantity (Table 6). This indicates that cost or expenditure in its present form may not ensure services-not even quantities. On the other hand, two of the governance (GI-O&MS and GI-IS) and an institutional indicator Non-Nirmal Gram Puraskar / Nirmal Gram Puraskar (NNGP / NGP) turned out significant with positive signs. This re-emphasises the importance of governance and institutional factors along with unit costs. Unlike in the case of LPCD, family size has turned out positive in the case of non-summer period. This could be due to the differences in perceptions of the households and the actual quantities they use. Similarly, households residing in the villages with hand pumps (HP) and mini piped water supply (MPWS) schemes perceive that they get better quantity (perceived).

Level of education (LEdu.) has turned out significant with a positive sign. This reemphasises the importance of education and literacy in influencing service levels. Age of the system (AGESyst.) has revealed a negative impact on the quantity perception of the households. That is, the older the water supply systems, the poorer the service levels. This is expected due to the reason that functional efficiency is likely to go down as the system becomes older, though this variable did not become significant in the case physical quantity (LPCD). SOURCE variable has revealed a significantly negative impact on service level. That is villages having groundwater as a source of water are likely to get better service in terms of quantity. This goes against the belief that surface water sources provide assured and reliable source of water. This could be due to the reason that most of the surface water schemes, especially single village schemes, are connected to tanks that are dependent on canal water (system tanks). These tanks, especially located in the tail ends and the uplands, sometimes get scanty supplies mainly during low rainfall years.

As in the case of physical quantities (LPCD) variable, five of the nine zones turned out significant in influencing the quantity perceptions of the households. While High Altitude Zone (HAZ) has a negative sign, all others have a positive impact. That is service levels in quantity are low in HAZ both in physical terms (LPCD) and perceptions of the households. This calls for policy attention to high altitude or interior regions in the provision of basic services. There are number of such in accessible locations in India, which need to be targeted on priority in the provision of water.

Interestingly, perceptions on quantity is inversely related to reliability and positively to water quality. Households perceive that reliability of water does not assure quantities. For, reliable supplies can be maintained even with poor water supplies. Reliability may depend on maintenance and management of the system. Whereas, quantities depend on other factors as well viz., source, technology, etc. This could be due to the reason the water systems are maintained well in the scarcity (low water availability) conditions, which is noticed in irrigation systems. It is observed that irrigation distribution systems are maintained well in the tail end locations where water is scarce when compared to head reaches (Reddy, 1998). On the other hand, households tend to use more water when water quality is good and vice- versa. Therefore, poor quality of water also results in low use of water.

Table 6: Regression Estimates of Selected Specifications of Service Levels (Quantity -percent HH scoring > basic)

Variables	Specifications					
Independent Variables	Water Quantity S1		Water Quantity S2		Water Quantity NS	
	Coefficient	VIF	Coefficient	VIF	Coefficient	VIF
(Constant)	68.42* (4.91)	---	35.44* (7.11)	---	-6.59 (-0.68)	---
AFS	-3.48 (-1.17)	1.09	---	---	2.83* (3.21)	1.12
SDI	-13.24 (-1.44)	1.94	---	---	---	---
FARMSIZE	1.80*** (1.76)	1.17	1.80***(1.87)	1.07	---	---
TECH (HP)	---	---	7.28 (1.49)	1.22	---	---
TECH (MPWS)	7.51 (1.56)	1.07	8.40*** (1.76)	1.08	---	---
LEdu.	---	---	---	---	0.75** (2.27)	1.26
SOURCE	---	---	---	---	-6.54** (-2.10)	1.15
percent HHBUY	---	---	---	---	-0.18* (-2.76)	1.87
TIMESPENT	---	---	---	---	0.001 ** (2.10)	1.47
CapEx (observed)	-0.001*** (-1.64)	1.58	---	---	---	---
Water Relaibity	---	---	-0.10 ** (-2.10)	1.67	---	---
Water Quality	---	---	0.07*** (1.75)	1.49	---	---
AGESyst.	-0.82** (-2.37)	1.26	---	---	-0.78* (-2.72)	1.10
ZONE (CTZ)	37.12* (6.83)	1.26	35.11* (6.70)	1.20	53.53* (10.46)	1.43
ZONE (HAZ)	-19.17 * (-3.15)	1.72	-15.55* (-3.12)	1.19	-16.32* (-3.70)	1.16
ZONE (KZ)	23.27* (4.98)	1.17	26.52* (5.55)	1.26	30.41* (6.86)	1.36
ZONE (STZ)	41.25* (7.04)	1.46	33.86* (6.34)	1.25	50.40* (9.21)	1.64
ZONE (SZ)	27.70 * (6.04)	1.20	34.15* (7.38)	1.26	30.54* (7.24)	1.31
GI (IS)	0.32* (2.94)	1.33	---	---	----	---
NGP/NNGP	---	---	---	---	0.44* (2.92)	1.94
GI (IO&MS)	---	---	0.61* (3.84)	1.70	11.19* (2.90)	1.52
R^2	0.66		0.67		0.81	
Adjusted R2	0.62		0.63		0.78	
N	107		107		107	

Note: S1= Summer specification 1; S2= Summer specification 2 and NS= Non-summer specification.

Figures in brackets are 't' values. *; ** and *** indicate level of significance at 1, 5 and 10 percent level respectively.

Proportion of households buying water (percent HHBUY) is inversely related to quantity perception. This indicates that households are forced to buy water to overcome the water shortages or to supplement the poor service levels. Thus buying water is more due to poor service levels in terms of quantity and quality rather than affordability. On the other hand, households perceive that higher the time they spend in fetching water, higher their service levels. The logic is that bigger households with higher proportion active members would fetch more water and use more water. This means that good service level in terms of quantity might result in poor service level in terms of accessibility i.e., trade-off between quantity and accessibility. This in fact, reflects the poor service even in terms of quantity.

Accessibility

Of all the service level indicators, access received lowest scores from the households (Reddy, et. al., 2011). Access is defined as time spent in fetching water. If a household spends less than 30 minutes per day (either distance or crowding-waiting time) then the household is categorised as having above basic service level. At the aggregate level (AP) more than 80 percent of the households receive less than basic (no or sub-standard services). Given the poor service levels concerning accessibility, it would be pertinent to examine the factors influencing accessibility across the sample villages. The specification turned out to be the best of all the specifications in terms of explanatory power i.e., 80 percent (Table 7). Majority of the explanatory variables turned out to be positively significant. From the policy point of view SVS and MPWS technologies provide better accessibility. In this regard replacing SVS with MVS does not seem to be ideal. Otherwise also MVS has not proved be better than SVS concerning accessibility (Reddy, et. al., 2012). This analysis reemphasises our argument that further probe, especially in other states, is necessary prior to going ahead with the promotion of MVS.

While surface water sources are found to have a negative impact on quantity, they have a positive impact on accessibility. This could be due to the reason that the waiting time may be less in the case of tank water when compared to well water. Moving towards surface sources or source protection investment that enhances the recharge and availability of groundwater would help improving accessibility. Given the positive relationship between water quality (WQ) and accessibility, improving source sustainability (source protection investments) could achieve twin objectives of better accessibility and quality service. Accessibility can be improved through wider coverage of house connections (percent HC). This has already found place in the new guidelines which aim at 100 percent coverage in terms of house connections by 2017 (GoI, 2010a). Accessibility is observed to be better in the case of NGP villages though NGP is not directly related to water supply (see table 2). However, the NGP status of a village reflects the active institutional presence and their effectiveness within the village. Therefore, strengthening and promotion of village institutions to manage water supply would be necessary to improve accessibility as well as other service indicators. But, the negative and significant relation between overall governance (GI) and accessibility does not support the argument that institutional strengthening could improve accessibility. This may be due to the specific efforts under NGP to improve the access to water.

Table 7: Regression Estimates of Selected Specifications of Service Levels (Access and Reliability)

Variables	Dependent Variables			
Independent Variables	Access		Reliability	
	Coefficient	VIF	Coefficient	VIF
(Constant)	7.89 *** (1.85)	---	-50.48 ** (-2.15)	---
AFS	---	---	22.28* (3.69)	1.57
percent SC / ST	---	---	-0.28* (-2.94)	1.05
SDI	-11.02** (-2.26)	1.75	---	---
FARMSIZE	-1.46 ** (-2.47)	1.26	---	---
LEdu.	---	---	-1.81** (-2.46)	1.69
DIST_MKT	-0.19 (-1.58)	1.10	---	---
GI	-0.18* (-2.94)	1.80	---	---
SOURCE	8.98* (4.23)	1.35	---	---
percentHC	0.24* (7.01)	1.99	---	---
TECH (MPWS)	6.05** (2.03)	1.24	---	---
TECH (SVS)	4.51** (2.10)	1.39	17.52* (2.75)	1.31
TECH (SVS+MVS)	---	---	12.90 (1.56)	1.19
TECH (MPWS+SVS+MVS)	---	---	-38.67* (-3.30)	1.27
HHExp-B	---	---	0.12 ** (1.96)	1.71
OCT	-0.00*** (-1.73)	1.49	---	---
HH CapExHD	0.01* (4.53)	1.44	---	---
WQ	0.05*** (1.93)	1.53	0.55* (7.87)	1.29
Zone (CTZ)	18.66* (5.78)	1.44	---	---
Zone (KZ)	---	---	23.18 ** (2.28)	1.93
Zone (SRZ)	---	---	32.13* (3.70)	1.21
Zone (STZ)	11.69* (3.46)	1.58	24.68 * (2.51)	1.43
Zone (SZ)	---		27.95 * (3.39)	1.35
NGP/NNGP	13.43 * (5.49)	1.54	---	---
OPEx	---	---	1.13* (3.89)	1.93
R^2	0.80		0.64	
Adjusted R2	0.77		0.58	
N	107		107	

Note: Figures in brackets are 't' values. *; ** and *** indicate level of significance at 1, 5 and 10 percent level respectively.

Household expenditure on infrastructure is positively associated with accessibility. Generally households invest in water infrastructure in order to overcome poor accessibility. Among the agro-climatic zones only Southern Telangana and Central Telangana zones have a positive impact on accessibility. The variables that have a negative impact on accessibility are farm size (FARMSIZE), opportunity costs of time (OCT) and social diversity index (SDI). In the case of farm size the accessibility is expected to be low in rain fed regions, as rainfed regions are characterised with larger farm size. As in the case of quantity, more time is spent in fetching water (OCT) due to poor access, i.e., walking long distances to get water. SDI has negative relation with accessibility indicating that homogenous communities (caste groups) are likely to have better access. This could be linked to the literature on collective strategies where homogenous groups (socially or economically) are more likely to cooperate better in managing the common good when compared to heterogeneous groups (Reddy, 1997).

Reliability

Basic and above service levels in terms of reliability are defined as predictable supplies except during breakdowns. Reliability (measured as predictable supplies) is observed to be high in majority of the sample villages. At the aggregate level about 80 percent of the households reported above basic service levels. The explanatory power of the specification is reasonably good at 64 percent. With regard to factors influencing reliability, operation and maintenance expenditure (OpEx) and SVS technology (TECH-SVS) have a positive impact on reliability. Allocations towards OpEx are more effective in enhancing the reliability, as OpEx helps in keeping the systems running. On the other hand, the combination of MPWS+SVS+MVS, which is more expensive and provides better service in terms of quantity, is not as reliable as SVS. This again suggests that SVS could be a cost effective option.

Water quality is positively associated with reliability. System breakdowns may be less in the case of good quality water when compared to low quality water (saline, high TDS, etc) though lack of reliability could also influences water quality. The positive association between household expenditure on buying water (HHExp-B) and reliability is due to the fact that households are forced to buy water when supplies are not reliable. Among the agro-climatic zones Krishna (KZ); Scarce Rainfall (SRZ), Southern Telangana (STZ); Central Telangana (CTZ); and Southern (SZ) zones have higher levels of reliability. The positive and significant association between farm size and reliability is in line with positive relation between SRZ and reliability. For, larger farm size is associated with scarce rainfall regions. Level of education (LEdu.) turned out to be negatively influencing reliability, which is difficult to explain.

V Conclusions

The analysis of cost drivers indicate that scale economies have revealed substantial impact on unit costs. That is unit costs are less in larger size villages and more in the case of villages with larger family size. Over time it is expected that family size is on the decline. Costing should take these changes in to account while fixing the norms. Unit costs tend to increase with the age of the systems. Though old systems tend to have low annualised costs due to larger denominator, costs can be reduced by maintaining the systems properly. That is increasing the life of the system is critical for reducing the unit costs. For this allocations towards capital maintenance and operation and maintenance are critical. Such regular up keep of the systems only can ensure sustainable service delivery. Unplanned and adhoc up gradation of the systems in terms of technologies enhances unit costs. Proper designing and planning with provision for extension and up gradation of service levels could help reducing the costs. The present approach of planning and allocation of funds to rural drinking water is not in the right direction, while the new guidelines (GoI. 2010b) seem to have corrected the course in terms of identifying the right issues and recommending appropriate allocations. Adopting life-cycle cost approach for designing the systems facilitates cost effective planning.

Economic factors coupled with policy support like achieving full coverage of house connections is likely to increase the unit costs. Cost norms need to be adjusted upwards while designing the schemes for full coverage of house connections. On the other hand, policy focus of improved literacy and education levels would help reducing the unit costs.

As far as service levels are concerned, the analysis brings out clearly that the influence of present low levels of expenditure on service level is limited. However, this is not to argue that costs do not matter in service provision - it just reflects how inadequate some of the allocations are at the moment. Allocations with heavy bias towards infrastructure (above 80percent) do not really help achieving the objective of sustainable service delivery. The analysis clearly shows that investments in infrastructure do not have any significant impact on access to water. In fact, household investments rather than public investments improve their access to water. Non cost factors like literacy, house connections, distance to market, governance and institutional factors significantly improve service levels. The only cost factor that has significant impact on service level is that of OpEx, which has a positive impact on reliability.

Old systems are less efficient in service provision as well. Maintaining the systems could improve efficiencies substantially. Groundwater sources are found to be more reliable in providing services. The analysis clearly indicates that MVS are not necessarily the best option for the provision of sustainable services. Governance and institutional factors are critical for improving the service levels. While surface water sources are found to have a negative impact on quantity, they have a positive impact on accessibility. Social diversity index (SDI) has negative relation with accessibility indicating that homogenous communities (caste groups) are likely to have better access.

The following policy options could help achieving sustainable service delivery.

i) Maintaining the systems through allocations towards capital maintenance and ensuring minimum allocations towards operation and maintenance so that systems function efficiently despite their age. Maintaining the systems in good condition would not only reduce costs but also improve service levels.

ii) Avoid adhoc investments or allocations towards extension and up gradation. Adaptation of Life-Cycle Cost Approach (LCCA) could help in minimising adhoc and wasteful expenditure on infrastructure. LCCA would also facilitate judicious allocation of resources to different components as mentioned above (i).

iii) Improving literacy and education levels would not only help reducing the unit costs in drinking water but also enhance efficiency in other related sectors like hygiene, health, etc.

iv) The existing governance structures appear to be too meagre to have any influence on unit costs. But they seem to have a positive impact on service levels. Improving the functioning and effectiveness of the governance indicators such as village water and sanitation committees could be a viable policy option in this regard.

v) Promotion of multi village schemes with surface water sources does not appear to be a rational option from the cost as well as service point of view.

vi) Agro-climatic conditions do influence costs and service levels, though we do not have enough information on hydrogeology. Similarly, scale economies have significant impacts on unit costs and service levels. While adopting cost norms these factors should be taken in to account rather than adopting blanket policies.

The next level of analysis should focus on making these conclusions generic for regions comparable across the country. Besides, identifying threshold levels of critical policy indicators would help informed targeting. These include age of the systems, size of village, size of the household, OpEx, etc.

References

Fonseca, C. et al., (2010); *Life-Cycle Costs Approach (Glossary and Cost Components)*, Briefing Note 1, IRC International Water and Sanitation Centre, The Hague, The Netherlands.

GoI, (2008); *Rajiv Gandhi National Drinking Water Mission*, Department of Drinking Water Supply Ministry of Rural Development, Government of India, New Delhi.

GoI, (2010a); Strategic Plan - 2010-2022: Department of Drinking Water and Sanitation- Rural Drinking Water, Ministry of Rural Development, Government of India.

GoI, (2010b); *Rajiv Gandhi National Drinking Water Mission - Movement towards Ensuring People's Drinking Water Security in Rural India - Framework for implementation 2009 - 2013* Department of Drinking Water Supply, Ministry of Rural Development, Government of India.

Moriarty, P. et al., (2010); WASHCost Working paper 2 - *Ladders for assessing and costing water service delivery*. IRC International Water and Sanitation Centre, The Hague, The Netherlands.

Reddy V. Ratna (1997); "Managing the Commons in Transitory Economics: Towards a Theory of Collective Action" Paper presented in the *International Conference of the European Society of Ecological Economics*, 4th to 7th March, Geneva.

Reddy V. Ratna (1998) "Institutional Imperatives and Co-Production Strategies for Large Irrigation Systems in India", *Indian Journal of Agricultural Economics*, Vol. 53, No. 3, July-September.

Reddy, V. Ratna (1999); "Quenching the Thirst: Means and Costs of Water in fragile Environments", *Development and Change*, (Blackwell), Vol.30, No.1, January.

Reddy V. Ratna and M. Kullappa (2008), "Social Cost-Benefit Analysis of Improved Water Quality in Rural Areas: An Exploratory Study in Coastal AP", *Journal of Social and Economic Change*, Vol. 10, No. 1, Jan-June.

Reddy V. Ratna; M. Gopinath Reddy and M. Srinivas Reddy (2009); "Decentralised governance and Human Resource Development: Democratic vis-a-vis participatory Institutions in Andhra Pradesh"; in S. Mahendra Dev; C. Ravi and M. Venkatanarayan (edited); Human Development in Andhra Pradesh: Experiences, Issues and Challenges, Centre For Economic and Social Studies, Hyderabad.

Reddy V. Ratna, N. Jayakumar; M. Venkataswamy; M. Snehalatha; and Charles Batchelor, et. al., (2011); "Cost of Provision: How good are Unconditional Allocations? A study of water services delivery in rural Andhra Pradesh, India', Working Paper 15; Centre for Economic and Social Studies, Hyderabad.

Reddy V. Ratna; M. Snehalatha and M. Venkataswamy (2012); "Costs and Service per Technology in Rural Water Supply: How Efficient are Multi Village Schemes?, Centre for Economic and Social Studies, Hyderabad.

Varughese, G and Ostrom, E. (2001), The contested role of heterogeneity in collective action: Some evidence from community forestry in Nepal. *World Development* 29 (5, May): 747-65.

Descriptive Statistics of Selected Variables

	Mean	Minimum	Maximum	Stdv.
VS	327	17	1718	284
AFS	4	3	6	0.50
percent SC / ST	31	0	100	26
SDI	0.5	0	0.7	0.21
FARMSIZE	2	0	8	2
LEdu.	22	11	32	4
DIST_MKT	10	1	41	7
GI (score)	15	0	79	17
percentHC	30	0	88	32
percent HHBUY	14	0	100	26
ExpDW-T	3	0	360	32
ExpDW-B-Summer	17	0	198	50
ExpDW-B-Non- Summer	23	0	251	456
Time Spent / Capita (min)	5244	2122	19386	2219
OCT	991	486	3029	345
DWSL q (LPCD) (S+NS)	42	26	72	9
DWSL q (LPCD) (S)	47	28	80	9
DWSL q (LPCD) (NS)	39	25	68	8.5
CapExHD DW (Govt.)	2301	0	7060	1539
CapExHD DW (Govt.) per year (observed)	622	0	3028	609
TCapExHD DW (Govt.) per year (observed)	716	0	3572	670
CapExHD DW(G+HH)	2811	139	7695	1618
DWSL-Access	15	0	83	17
DWSL- Relaibility (S)	74	0	100	38
DWSL- Relaibility (NS)	79	0	100	35
DWSL-Quality (S)	68	0	100	39
DWSL-Quality (NS)l	67	0	100	40
DWSL-Quantity (S)	64	14	100	24
DWSL-Quantity (NS)	42	0	96	28
AGESyt.	6	1	22	5
GI -IS	25	0	76	15
GI-CBI	17	0	75	17
GI-O&MS	22	1.25	57	11
GI-FM	17	0	79	17

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