

Design of Regional Rural Water Supply Schemes-A New Approach

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ABSTRACT

Quality of drinking water and its regular timely availability in adequate quantity to end users carry prime importance during design of any Regional Rural Water Supply Scheme (RRWSS) or multi-village scheme. RRWSSs are executed with a purpose of either providing potable water to quality affected areas or supplying water in sufficient quantities in water stressed areas. Presence of existing PWSS also affects the sustainability of a RRWSS as it gives an easy option for the village to opt out from the scheme. Villages that have cheaper water sources would not prefer RRWSS. Likewise those that truly face water scarcity are not satisfied with the 40 litres per capita per day (lpcd) provided by the schemes and demand either handpumps or individual PWSS even after execution of the schemes. As a result, cases of villages moving out of RRWSS and demanding new schemes are rampant. This implies reinvestment by the Government. Plight of RRWSSs is not at all encouraging. In spite of huge investment by the Government of Maharashtra, only 56.60% of schemes are functional. This study tries to find out the ingredients that would motivate a consumer to be loyal to a RRWSS. It studies the different dimensions of water supply relevant to consumers, significance of consumer surplus, and consumers' cost minimization problem before defining the states of nature under which a RRWSS can prove to be successful.

INTRODUCTION

Problem of water supply through Regional Rural Water Supply Scheme (RRWSS) can be classified into source problem and delivery problem. Source problems are created in schemes where the sources have dried up, sources are unable to cater to the entire requirement of the villages or water does not reach a particular village. Delivery problem arises due to mismanagement in delivery. Absence of meterization and improper fixation of tariff leads to grievances of the consumers as well as those maintaining the scheme. As the maintaining body is unable to recover costs it cannot make adequate investments in expansion or maintenance. As distribution becomes inefficient and supply unreliable, there is a negative effect on consumer confidence and willingness to pay creating a 'low-level equilibrium' where the fraction of households connected to RRWSS is low resulting in poor recovery and greater wastage of water. In depth study of designs / proposals of RRWSS reveal that a 'RRWSS centric' view has been adopted where the RRWSS is the sole entity that arranges, manages and distributes water to the villages. This type of approach overlooks few important parameters.

- Most of the villages have existing sources in the form of borewells / tubewells fitted with handpumps or individual piped water supply schemes with groundwater sources mostly. A large fraction of rural families rely on borewells / tubewells despite having piped water supply scheme. No piped water supply scheme either regional or individual supplies

water 24 x 7 and only few households have facilities to store water for the entire day. Hence dependability on multiple sources of water supply by majority of consumers renders the 'RRWSS centric' view inadequate.

- Some consumers prefer to rely entirely on handpumps. The wealthy consumers construct borewells in their yards to meet out their daily requirements.
- Unlike urban consumers, rural consumers do not consider groundwater as non-potable. Borewells / tubewells fitted with handpumps prove to be the cheapest source of 24x7 water supply in areas where groundwater table is high.
- Moreover rural consumers do possess cattle which they expect to be treated respectfully. In other words according to them water which is unfit for them is unfit for their cattle also.

Success of a RRWSS is thus a function of price, quantity, reliability and consumer satisfaction.

DIMENSIONS OF WATER SUPPLY

There are five dimensions of water supply relevant to consumers: modes of supply accessed by consumers, investments made by consumers in acquisition and storage of water, quantity of water, quality of water and season.

- **Modes of supply accessed by consumers:** Consumers have access to multiple modes of supply viz public borewells / tubewells fitted with handpumps, piped water supply connections, public standposts¹, private wells, public wells, private borewells/tubewells from where water is pumped through electric pumps and tankers. Quantity available through each mode is different and so is the cost and quality. Consumers make decisions on how much of a particular source to use so as to minimize their costs (including time costs), subject to constraints on quantity and quality. Essentially rational consumers rank the sources of water available to them from least to most expensive. They use as much as the least cost source available before switching to the next lowest cost source.
- **Investments made by consumers in acquisition and storage of water:** Wealthy consumers do construct borewells in their yards from where water is pumped for domestic as well as other uses. Where water is received regularly from piped water supply schemes consumers construct tanks in their yards which is filled through flexible pipes connected to their yard taps. Poorer households that do not have adequate storage facilities prefer to fill water from public handpumps or standposts as and when required. Houses mostly have yard taps compared to indoor plumbing in rural areas. Which option is to be used or which combination of options is to be utilized is dependent on the consumers' cost minimization problem. On basis of investments made by the consumers the households can be classified as unconnected, connected, well owners and tank

¹ Although discouraged by Government, public standposts are not completely eradicated. They constitute of a vertical pipe fitted with a tap. They are maintained by Gram Panchayats especially for slum areas, consumers below poverty line who cannot afford household connections and public places like markets, bus stands etc.

owners. Classifying consumers on the basis of investments has many advantages. First of all it determines which modes are available to the household. **Unconnected consumers** are those who are not connected to the utility. These consumers are dependent on handpumps, public wells, public standposts or tankers. **Connected consumers** have utility connections but they are typically yard taps. **'Well owners'** have borewells in their yards from where water is pumped into storage tanks. Well owners can also have access to house connections, handpumps or standposts. **Storage tank owners / Sump owners:** The difference between connected consumers and this category is that connected consumers have only yard taps. Wealthier consumers construct open storage tanks in yards which are filled from these taps. Houses in typical rural areas lack indoor plumbing. Water supply is intermittent. However in periurban villages houses do have indoor plumbing. In such cases owners construct sumps from where it is pumped to roof top reservoirs and try to create a decentralized 24 x 7 water supply. This categorization reveals the respective income groups. Unconnected are the poorest while well owners and sump owners are the wealthiest. Unconnected consumers are mostly the landless farmers or agricultural labourers. While connected consumers constitute of small farmers and marginal farmers. Big farmers are well owners or sump owners. Employed folks are sump owners.

- **Quantity of water:** Discretion of consumers regarding which mode to utilize also depends on the quantity of water received as well as collected. Individual PWSS or RRWSS are designed to supply water at the rate of 40 litres per capita per day (lpcd). However Village Water Security Plans² of villages Domak, Taroda, Kolvihir and Ashtoli of Morshi block of Amravati District (Maharashtra) reveal that when villagers were asked to assess their daily water requirements, it came out to an average of 75 lpcd. (Please refer Table 1). Poor families which do not have enough storage facilities can store water in buckets or pots during supply hours. Once they are empty the families resort to handpumps or public wells for their needs. Hence unconnected consumers use a combination of standpost and handpumps / public wells for catering their needs. At times of severe water scarcity these households prefer tankers to taking connections of RRWSS. Connected consumers are little well off than unconnected consumers. They do make storage facilities for catering to their 1 day water requirement. If water supply is not regular they too resort to handpumps or public wells. Under normal circumstances these consumers prefer individual piped water schemes to RRWSS. In absence of meters the RRWSS supplies water at the rate of 40lpcd stringently which does not satisfy the consumers while individual PWSS are made to supply water at the rate of 40lpcd to 120lpcd. As per Mathew, people carrying water for long distances do use significantly less than those who have water close to their homes, especially if it is available in the yard. In case of individual piped water supply schemes the consumers do exert significant amount of control on the quantity of water to be supplied. During scarcity connected consumers

² Village Water Security Plans were to be prepared under National Drinking Water Security Pilot Project launched by the Government of India through Ministry of Drinking Water in the year 2011. The project was implemented in 10 states (15 blocks) of the country. In the state of Maharashtra it was implemented in Morshi and Warud blocks of Amravati district.

first look out for new sources that can be connected to their existing piped water supply scheme. If the same is not feasible then only they opt for taking water from RRWSS. Well owners are generally indifferent to other modes of supply till their wells yield satisfactorily. They make use of household connections for drawing water for drinking and cooking. Rest all needs are catered from pumping water from borewell / tubewell. In seasons of water scarcity, they too would opt for individual piped water scheme since they can voice their opinion regarding hours and quantity of water supply. If no option of individual PWSS is available, well owners would opt for RRWSS. Sump owners / storage tank owners make the most use of piped water supply. These are the houses where the taps are continuously running during supply hours and may also fix booster pumps to draw maximum water. They are mainly responsible for lack of water to houses lying on the downstream. If proper habit of meterization and regular payment of tariff is inculcated these consumers can make a RRWSS successful. Another aspect which needs to be checked is availability of water for livestock. Although the present Government guidelines or resolutions do not mention provision of water for cattle in the scheme, the same needs to be considered in areas where water availability apart from the scheme is scanty or quality affected.

Table 1: Water Requirement (litres) for Various Domestic Use per Capita per Day (Assessed by villagers of 4 villages of Morshi block, Amravati District, Maharashtra, India)

Sr No	Particulars	Village				Average
		Ashtoli	Domak	Kolvihir	Taroda	
1	Drinking	5	5	5	4	5
2	Bathing	15	10	10	15	12
3	Toilet	10	5	4	30	12
4	Cleaning of Utensils	20	5	5	10	10
5	Cooking	4	10	-	2	4
6	Brushing	2	1	2	-	2
7	Washing of Hands & Feet	12	2	10	10	10
8	Washing of Clothes	-	7	10	20	10
9	Cleaning of House	-	10	4	-	4
10	Prayer	-	-	1	-	1
11	Others	-	-	-	5	5
	Total	68	55	51	96	75

Source: Village Water Security Plans of Ashtoli, Domak, Kolvihir and Taroda of Morshi block of Amravati District

- **Quality of water:** Quality of water is distinguished as potable and non-potable by consumers. Groundwater is considered to be potable unless it does not have unacceptable taste and colour. Well owners and sump owners do not prefer water of tankers for drinking and cooking. Under normal conditions if water supply from RRWSS is assured and regular well owners, sump owners and to some extent connected consumers would get addicted to the taste of treated water and would become loyal consumers of RRWSS.
- **Seasons:** Both quantity and quality of water available from each mode of supply varies over time. In this study normal season is defined as season other than scarcity. Scarcity is defined as situation where available potable water is less than 20 lpcd. As mentioned earlier unconnected consumers prefer handpumps, public wells, public standposts during normal seasons and tankers during scarcity. Connected consumers prefer individual piped water supply scheme and handpumps or public wells during normal seasons and RRWSS during scarcity. If put into habit of drinking treated water well owners would opt for RRWSS in all seasons. If no option of individual piped water supply is kept or sump owners are put into habit of drinking treated water sump owners too would opt for RRWSS.

CONSUMER'S COST MINIMIZATION PROBLEM

Economists define consumer surplus as the difference between what the consumer is willing to pay for a good and what they actually pay. Rural inhabitants of India find it difficult to accept the fact that water has to be purchased. But with increasing levels of literacy and discipline being inculcated by the Government, the notion is changing gradually. Government Resolution of Maharashtra No GraPaPu 1098/ PraKra 211/ PaPu 07 dated 14th December 1998 states that annual general water tax of Rs 75/- should be levied to all and those opting for household connections should be charged a minimum amount of Rs 360/- annually or whatever is appropriate for making the scheme self-sufficient. When it was found that Rs 360/- per year (Rs 30/- per month) is too less to run a scheme, the same was increased to Rs 720/- per year. As per Government of Maharashtra, Water Supply and Sanitation Department circular dated 19th July 2012, the minimum water tax to be charged for individual house connections in non-tribal areas is Rs 3/- per day. As a result customers of individual PWSS are being charged at a flat rate of Rs 90/- per month irrespective of water being received by them. In case of RRWSS where meterization is not compulsory the consumers are supplied at a rate of 40lpcd stringently at Rs 90/- per month minimum. Where meterization is compulsory the consumers are charged at telescopic rates depending on consumption as mentioned in Table 2.

Table 2: Tax per Unit Consumption of Water for Domestic Usage

Sr No	Consumption (litres)	Unit Consumption (1 unit = 1000 litres)	Water tax per unit consumption(Rs)
1	0 to 15000	0 to 15	6
2	15001 to 20000	15 < = 20	9
3	20001 to 25000	20 <= 25	12
4	25000 onwards	25 <	24

Source: MJP Notification No MJP/CE(WM)/AB/CR-14/792(3) applicable 1st July 2012 onwards

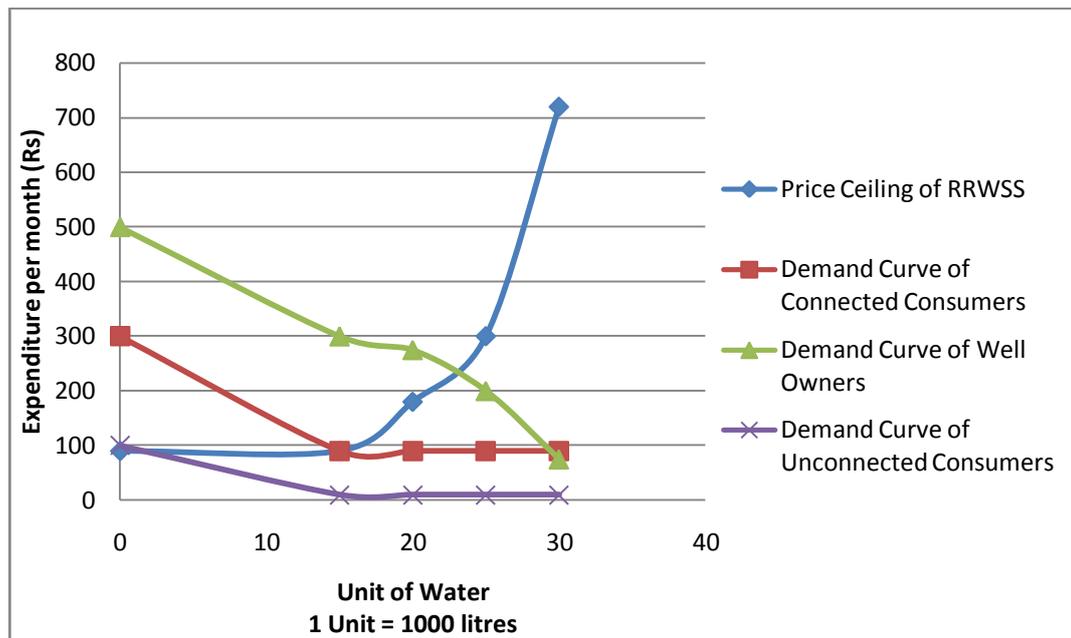


Figure 1: Consumer Surplus for various Modes of Supply of Potable Water

Consumers relying on public borewells / tubewells fitted with handpumps or public standposts are charged Rs75/- annually. Well owners who pump water generously require to spend Rs 300/- per month on an average on electricity bills.

Source: Compilation

With different modes of supply available to different types of consumers, the consumer surplus would be varying with respect to RRWSS. Consumer surplus can be calculated by measuring the area enclosed by the area enclosed between the demand curve and the price ceiling curve. Consumer surplus of well owners with respect of RRWSS would be maximum followed by that of connected consumers. Unconnected consumers are the last ones to connect to the RRWSS.

Hence while designing a RRWSS it is necessary to solve the consumer’s cost minimization problem taking into consideration the modes of supply, quantity consumed, the consumer

surplus, availability of water during scarcity periods and price of water obtained from various available sources.

TYPES OF RRWSS AND THEIR SUITABILITY

Another decision that requires to be made is the type of RRWSS to be constructed. The components of typical RRWSS are headworks, raw water pumping machinery, raw water rising main, water treatment plant, pure water pumping machinery, pure water rising main, master balancing reservoir, pure water leading main, elevated service reservoirs (ESR) and distribution system. All but last two components are common for all villages. Type of RRWSS depends on execution and onus of maintenance of these two components.

- **Type A:** Where the common components and separate components are maintained by two different departments. In this case water is brought to the respective ESR. Maintenance of the ESR and distribution system is done by the gram panchayat. Many times the execution of the ESR and distribution system is also done separately.
- **Type B:** Where the common components and separate components are maintained by the same department. In this case if the village does not have any existing ESR and distribution system, then the same are constructed else the existing infrastructure is taken over.
- **Type C:** Where the common components and separate components are maintained by the same department. However even if existing, ESR and distribution system are freshly executed. Existing infrastructure is not taken over. In other words an existing individual PWSS and RWSS can run parallel in a village.

Which type to adopt depends after evaluation of the following four criterion for each village proposed to be included in the RRWSS and then considered as a whole.

- **Economic Efficiency:** Net benefits from a given type can be estimated as the sum of the gains in consumer surplus and producer surplus; the latter defined as revenue generated less cost of production. If benefits exceed cost the policy is economically efficient.
- **Revenue maximization:** Although all RWSS are designed to be self sufficient, if the type adopted yields significant revenues, the utility may be more likely to promote and implement the policy, so determining profits to the utility is useful.
- **Financial viability:** By comparing average expenditure with average revenue generated, it can be determined if the utility can remain solvent without government incentives.
- **Possibility of complete ban on the construction of any infrastructure related to water supply:** Any other utility apart from that managing the RRWSS would not be able to construct any other source of water supply. This would increase the dependency of consumers on RRWSS. However it would be responsibility of the utility to provide sufficient water to the consumers who pay taxes regularly. Moreover care should be taken to check whether other sources are available for live-stock.

It is quite possible that the RRWSS may have to be executed in a combination of types also. In villages where water scarcity surfaces only during summer, water can be provided from the RRWSS to them in bulk during scarcity. Hence these villages fall under Type A. Where villages face severe water quality problem and there is no option of any other mode of supply, Type B can be adopted. In villages where the existing PWSS is running quite satisfactorily, a fraction of consumers may not be willing to get connected to RRWSS readily. Here Type C is most suitable. Gradually the consumers switch over to the RRWSS after evaluating its performance. Then automatically the type switches over to type B.

INFERENCE

- While considering a village for including in the proposed RRWSS, it would be necessary to check the modes of supply available, average daily consumption of water from each mode, investments already made, quality and the situation during scarcity.
- Consumers can be categorized into four types viz unconnected, connected, well owners and sump/storage tank owners. Agricultural labourers and landless farmers are unconnected, small and marginal farmers are connected, big farmers are well owners while employed are sump owners.
- Consumer surplus with respect to RRWSS is maximum for well owners and is infinitely small for unconnected. Hence where the majority of consumers are unconnected, it would be wise to construct recharge structures to keep the groundwater table at a satisfactory level than to proceed with the idea of providing RRWSS.
- With increased levels of service delivery, dependency of connected consumers on available modes of supply can be reduced.
- Since various modes of water supply are available, price of water cannot be increased beyond a certain limit. Hence unconventional methods like use of solar or wind energy should be thought of, for reducing the production costs.
- RRWSS can be classified into three types depending on the execution and maintenance of its common and separate components.
- The final decision for proceeding towards a RRWSS depends on the results of the four criterion test viz. economic efficiency, revenue maximization, financial viability and possibility of complete ban on the construction of any infrastructure related to water supply.

Table 3: Representation of Consumers' Choice Problem (Under Normal conditions)

Sr No	Category of Consumer	Modes of Supply					Quantity of Water drawn monthly per household (litres)	Expenditure incurred monthly (Rs)	Investment made by the consumer (Rs)	Comparison with RRWSS		
		Public Handpumps	Public Wells	Individual Household Connections	Private Wells	Tankers				Quantity of Water (litres)	Monthly Expenditure (Rs)	Investment to be made by consumer (Rs)
1	Unconnected	Yes	Yes	-	-	-	11250	6.25	0	11250	90	1200
2	Connected	Yes	Yes	Yes	-	-	11250	90	1200	11250	90	0
3	Well Owners	-	-	Yes	Yes	-	18000	400	35000	18000	162	1200
4	Sump / Storage tank Owners	-	-	Yes	-	-	18000	90	10000	18000	162	0

Source: Primary Data

Table 3a: Representation of Consumers' Choice Problem (During Scarcity Period)

Sr No	Category of Consumer	Modes of Supply					Quantity of Water Received per household monthly (litres)	Expenditure incurred monthly (Rs)	Investment made by the consumer (Rs)	Comparison with RRWSS		
		Public Handpumps	Public Wells	Individual Household Connections	Private Wells	Tankers				Quantity of Water (litres)	Monthly Expenditure (Rs)	Investment to be made by the consumer (Rs)
1	Unconnected	-	-	-	-	Yes	3000	6.25	2000*	11250	90	1200
2	Connected	-	-	-	-	-	6000	90	1200	11250	90	0
3	Well Owners	-	-	Yes	Yes	-	21000	500	35000	21000	252	1200
4	Sump / Storage tank Owners	-	-	Yes	-	-	8000	90	10000	18000	162	0

Source: Primary Dat

