DEVELOPMENT OF PERFORMANCE INDICATORS AND CRITICAL EVALUATION OF REGIONAL RURAL WATER SUPPLY SCHEMES OF GUJARAT STATE

THESIS
SUBMITTED FOR FULFILLMENT OF
REQUIREMENTS FOR THE DEGREE OF

Doctor of Philosophy

IN

CIVIL ENGINEERING

By

SHAH NIRAV G.

Guided By

PROF. A.S.PATEL

DEPARTMENT OF CIVIL ENGINEERING
FACULTY OF TECHNOLOGY & ENGINEERING
THE MAHARAJA SAYAJIRAO UNIVERSITY OF BARODA
VADODARA

JULY 2013

Certificate

This is to certify that the thesis entitled **"Development Of Performance Indicators and Critical Evaluation of Regional Rural Water Supply Schemes Of Gujarat State"**, which is being submitted to The M.S. University of Baroda by **Shah Nirav Govindlal** in fulfillment of the requirements for the degree of **Doctor of Philosophy in Civil Engineering** has been carried out by him under my supervision and guidance at the Faculty of Technology and Engineering, The Maharaja Sayajirao University of Baroda, Vadodara. The matter presented in this thesis has not been submitted for any other degree.

July 2013

Vadodara

Guide:

PROF. A.S.PATEL
Ph.D (Civil)
F.I.E., F.I.A.H., F.I.W.R.S., F.I.W.W.A.
M.I.S.T.E, M.I.G.S., M.A.S.C.E

PROF. A.S.PATEL
Head
Civil Engg. Dept.
Faculty of Tech. & Engg.
The M.S.University of Baroda
Vadodara

PROF. A. N. MISHRA
Dean
Faculty of Tech. & Engg.
The M.S.University of Baroda
Vadodara

INDEX

ACKNOWLEDGEMENT

I have no words to express all my gratitude, appreciation and reverence to my esteemed guide Dr. A.S. Patel, Professor & Head, Civil Engineering Department, Faculty of Technology & Engineering, The M.S.University of Baroda, Vadodara for his motivation and guidance to carry out this work. His valuable guidance and suggestions in framing out this research project have helped me to develop a vision & importance for the subject. His attitude towards understanding the subject made the difference. His attitude towards understanding the rural people explained me the social impacts of engineering project to life of human. I am extremely proud and obliged to have him as my guide and thank him profusely.

At this time, I cannot forget to express my great sentiments of regards and indebtedness to Shri B.K.Singhala, Ex.Member Secretary, Gujarat Water Supply and Sewerage Board, Gandhinagar, who has not only permitted but encouraged to undertake this research project. I also express my thanks to shri N.H.Patel, Chief Engineer, Gujarat Water Supply and Sewerage Board, Vadodara for sharing his experiences and providing intellectual guidance during various field visits. I feel myself favored to have his support for this study.

I would like to appreciate the co-operation and support of Shri Apoorva Oza, Shri Umesh Desai and the other staff of Agha Khan Rural Support India (AKRSP), Shroff Foundation and other NGOs for field visits and data collection in the region of Surendranagar, Saurashtra & Kachchh. I would like to specially mention Ms. Shaila Trivedi, Advantage India Limited, Ahmedabad for helping and framing out the Users' Data Survey work for four schemes under the study area. I would also like to thank

Mr. Anil Mudgerikar, UNICEF, Gandhinagar for awarding us the work of evaluation of 'Cluster Storage Strategy' and extending all support for the field visits and necessary data.

I heartily thank the office bearers and staff of various offices like State Water Data Centre (SWDC), Gujarat Water Supply and Sewerage Board (GWSSB), Water and Sanitation Management Organization (WASMO), Gujarat Jal Seva Training Institute (GJTI) and several others for supporting me in this study by providing me with the valuable data and access to their libraries.

I would also like to thank Prof. D.L.Shah, Prof. P.N.Sutaria (Ex- Head, Civil Engg. Dept.), Prof. (Dr.) H.M.Patel, Shri N.M.Bhatt, Shri A.R.Shah, Shri L.I.Chauhan, Ms. (Dr.) Geeta S. Joshi, Mrs. Arti D. Galgale, Shri Gaurang I.Joshi and all the staff members of the department who have played an important role in giving their valuable suggestions and support during the course of my study. I am also very much thankful to Dr. Sanskriti S. Mujumdar, for helping me in writing my final thesis works.

I consider myself extremely gifted to have a supporting family, who is the backbone of this work. I would also like to note that my parents have not only morally supported but also encouraged me to complete this work continuously. I would also appreciate the support of my wife Mrs. Biral Shah, who has also continuously helped and spent her valuable time from her share to this work.

I am indebted to my brother Dr. Sanjay and his family who have supported me during the whole study. I would be doing the least by thanking them profusely.

Last but not the least, I am highly obliged and thankful to all those whose mention may have been missed out but have not been forgotten.

I once again thank one and all sincerely.

(Nirav Govindlal Shah)

Dedicated to My Parents

EXECUTIVE SUMMARY

Rural India has more than 700 million people residing in about 1.42 million habitations spread over 15 diverse ecological regions. Meeting the drinking water needs of such a large population can be a daunting task. The non-uniformity in level of awareness, socio-economic development, education, poverty, practices and rituals and water availability add to the complexity of the task.

Under Rural Water Supply Program, various schemes like Hand pumps, Mini pipe, Piped water supply schemes (Individual or Regional – Multi villages) are being taken up according to the technical feasibilities till time.

Approximately 4306 different water supply schemes were implemented in Gujarat till 2009 benefiting 7,544 villages, 47 towns catering to approximately 1 crore people in the rural and urban area. Local water utilities made significant investments to install, upgrade, or replace equipment in order to deliver safe drinking water and protect public health. These water supply schemes are primarily based on the traditional local ground water or nearby surface water sources depending on the available water resources. However, to overcome problems of adequate water or acceptable water quality in local source, the Multi village water supply schemes came into existence. Later with the development of supply of bulk water and involvement of more number of villages or towns in single water supply scheme, Regional Rural Water Supply Schemes became common.

The concept of monitoring and evaluating the performance of water supply system was not a common practice in rural water supply sector of India. This concept was considered hypothetical in past as every matter related to water supply was the liability of state government. Now

the state of affairs is pole apart, the accountability has come on elected committees. The Performance Evaluation (PE) through various Performance Indicators (PIs) grouped under different aspects give comprehensive appraisal of water supply system, the outcome of which can be used for proper management.

OBJECTIVES OF THE STUDY

- To undertake observations on available infrastructure and distribution networks of water supply in Gujarat state with reference to regional rural water supply schemes
- To analyze the performance of regional water supply schemes with special reference to its source of water, coverage, quality of water, treatment facilities, technical efficacy & adequacy for the distribution of water
- To develop the performance indicators for overall service performance and financial management performance of RRWSS (Source sustainability, Adequacy of water, Service reliability, Acceptable water quality, Capital cost of water, Operation & Maintenance cost, Recoveries of tariffs and Community participation)
- To develop an Index which help in quantifying the overall performance of an RRWSS against various indicators under consideration
- To scale up the potential for development of efficient & equity water distribution amongst the village in various RRWSS
- To identify the impact of implemented schemes on socio economic activities & the overall life of the rural habitants

METHODOLOGY OF THE STUDY

As the water is subject of state in India, therefore, the responsibility of water supply for various needs of the society is mainly dealt by the state authority. As the state cater the demands from various sectors such as Irrigation water, Industrial water, Urban and Rural water, number of Government departments or subsidiaries of state government are involved. For managing the supply of bulk water in RRWSS mainly GWIL, SSNNL, Irrigation water department, various dam authorities and GWSSB are responsible. While for in-village water distribution system often the local authorities such as Taluka/Gram Panchayats, Pani Samitis and/or WASMO and some NGO's are responsible. Therefore, to understand the overall scenario of rural water supply schemes in Gujarat, data collected from above agencies, interactions with the officials and field visit in selected RRWSS have been made.

The selection of the representative RRWSS for study is carried out based on the following points keeping in mind:

- **Hydrology of the area**: Rainfall varies highly in the state of Gujarat. South Gujarat receive more than 1500mm rain fall per annum, middle Gujarat receive around 1000mm per annum, the Saurashtra region receive less than 600mm rain fall per annum while Kachchh region is partly a desert area and receive minimum rain fall. The prosperity of the area and quality & quantity of water is also highly varying. Therefore, four major schemes for the detailed evaluation are selected, one from the region of South Gujarat namely, RRWSS Variav group, Surat, two from the Saurashtra region namely RRWSS Gadhada group, Bhavnagar & RRWSS Ishwaria group, Amreli and one from the Kachchh region namely RRWSS Mandvi group, Kachchh.

- **Land use pattern/Urbanization:** The RRWSS Variav group, Surat representing South Gujarat (rich in water resources) cover the combination of industrial, urban and rural areas.
- **Water quality:** The Saurashtra region has the 1100 Km long costal belt. Surface water resources are limited & local ground water resources are not adequate in catering summer demands. Also, local ground water is suffering the water quality problems such as salinity (Total Dissolve Solids), Fluoride, Arsenic and other mineral matters. Therefore, RRWSS Gadhada group, Bhavnagar and RRWSS Ishwaria group, Amreli, at later time, shifted on reliable bulk water supply from Saurashtra Pipe line project.
- **Geography:** Kachchh is the largest district (geographical area wise) of Gujarat, located on the border of India and Pakistan covers largely the desert land with negligible water resources. Even though after the earthquake in the year 2001 and with the development of pipe line project based on river Narmada water, rapid growth of industries and construction of ports has been observed in the region. So from this point of view, RRWSS of Mandvi group and Kachchh group are therefore selected for the study.

A house to house survey has been initiated largely to collect the responses of Users' in above four selected RRWSS. The users' data survey work has been allotted to the Advantage India Private Limited, Ahmedabad with the financial support of GWSSB. The users' data survey cover about 2465 responses of 61 villages of four selected RRWSS (RRWSS Variav group, Surat – 863 responses and 20 villages, RRWSS Gadhada group, Bhavnagar – 559 responses and 14 villages, RRWSS Ishwaria group, Amreli – 581 responses and 14 villages and RRWSS Mandvi group, Kachchh – 462 responses and 13 villages). While

planning the users' data survey, villages are selected as per its distances from the head water works (head village, intermediate village and tail end village). A care has also been taken for selecting the users that they should largely represent the business, caste & sex group.

Further, in addition to above four selected RRWSS, for evaluating certain PIs, the overall RRWSS operated in South & Central Gujarat are undertaken. For evaluation of financial performance of RRWSS relying on bulk water supply in Saurashtra region, a separate study has been carried out with the GWSSB (Rajkot zone office) and GWIL officials.

As Cluster Storage Strategy is an optional part of in village water distribution system, a separate study has been carried out in the seven villages of two districts, Surendranagar and Kachchh. Based on the influencing factors such as population size, variation in caste & inter-caste conflict issues, availability of water, topography of the area, economic conditions in terms of agricultural and industrial growth in and around village and the success observed in CSS model; villages are grouped and desk study of documents developed by UNICEF, WASMO & GWSSB are studied and field visits are made for interaction with users' and managers of the schemes.

Based on the observations & findings of above studies, Performance Indicators are identified which can be used to design, monitor and/or evaluate the performance of new or existing regional rural water supply schemes.

FINDINGS AND CONCLUSIONS

Based on a study carried out for the critical evaluation of various RRWSS in Gujarat mainly two groups of performance indicators namely Service PIs and Financial Management PIs are identified.

Service Performance Indicators:

- Sustainability of Source

- Adequacy of Water
- Water supply Reliability
- Acceptable Water Quality

Financial Management Performance Indicators:

- Capital cost of Water
- Operations & Maintenance cost of Water
- Cost Recovery & Water Tariff
- Participation of Community at planning & Operation levels

From the studies it is concluded that the developed PIs for evaluation of service performance and financial management performance may be used separately. To quantify the overall performance in each group of indicators, Service Performance Index (SPI) and Financial Management Performance Index (FPI) may be calculated as per following equations.

$$SPI = \frac{\sum_{i=1}^{4} Ii\, Wi}{Wmax\ \sum_{i=1}^{4} Ii}\ x\ 100$$

$$and\ FPI = \frac{\sum_{i=1}^{3} Ii\, Wi}{Wmax\ \sum_{i=1}^{3} Ii}\ x\ 100$$

Where, Where, W= Weights assigned to each of the indicators based on their ratings; and I= Importance factor for each of the indicators based on their impact on overall service/financial management performance and its interrelation to other group indicators. Value of Weights for each of the group indicators is suggested based on its ranking such Excellent, Medium to High, Low to Medium and Poor performance. Importance factor is also suggested for each of the group indicators for the quantification of overall service and financial management performance of an RRWSS.

Further, from the findings, it is determined that it is not necessary that the RRWSS which are performing in a better way from service point

of view are also performing well from the financial management point of view. Further, the benchmarking values used for each PI may differ with site conditions. Therefore, benchmarking may be adopted within the group of schemes only and such PIs may be monitored continuously for the monitoring improvements in its performance. However, the same PIs may be used to set targets and policy guidelines. Based on the studies following policy guidelines can be set:

1. A district level (regional) planning is essential to identify areas where RRWSS would be more cost effective and sustainable. The bottom-up demand from the society for the scheme and top-down planning results in least cost option. Further watershed and aquifer information are important for the 'source' sustainability. Surface water based RRWSS justified mostly in areas marked by over exploited aquifers or by serious ground water quality problems with no alternate safe and sustainable source available locally (for eg. North Gujarat, Saurashtra and Kachchh region of Gujarat).
2. The present study reveals that the large scale RRWSS which usually serve urban population & industrial water demands in addition to rural domestic water demands often results in water scarcity to tail-end rural population due to continuous growing demands from urban population and rapid industrial growths, as the case observed in RRWSS, Variav group, Surat.. Adequate measures may be taken in decentralizing such schemes for rural and urban & industrial and other needs of water supply.
3. The analysis of survey data and analysis made on quantity of water supplied in various RRWSS determined that the actual water supplied is often less than the actual water demand. Therefore, household typically depends on multiple water source including private bore & tanker water supplies. This raises the overall cost

burden & less reliability of RRWSS with ultimate result of poor tariff recovery.

4. As per the norm of 250 persons per stand post which is based on assumption of output of 12 litres per minute. But, under study area at several villages, it was determined that the water pressure at stand post was low and the flow of only 3-10 litres per minute was available. This would not make possible for households to get 40 lpcd of water even if half of the persons have to share the stand post.
5. The findings of the survey determined that a large section of the rural people would like the convenience of a piped water supply connection in the house. This may lead in conflict with the norm of 55 or 70 lpcd of water in rural water supply. Such is the very common case with the most villages of Gujarat due to good agricultural & industrial growths taken place in last one or two decades, which lead the significant rise in per capita income of villagers.
6. The O & M cost needs to be properly assessed on regional basis and fully recoverable through tariff recoveries, except for high cost schemes. However, a transparent criteria needs to be developed based on local conditions to determine 'affordable' tariffs including criteria for socially disadvantaged groups. The O & M cost requirements in excess to affordable contributions may be provided through a subsidy scheme.
7. For better Operation & Maintenance of RRWSS, the bulk water supply and village level distribution may be unbundled. This may results in improved service delivery with feeling of own management for villagers. In such cases, GWSSB of state agency may control bulk water supply and Gram Panchayat or Pani

Samitis may responsible for equity water distribution & other M & R issues with tariff recoveries.

8. The low recovery of cost is often not due to non affordability or unwillingness to pay, but to do with the inadequate water supply services, the reluctance to pay of the household and the inability of the scheme management to collect the water charges. It is also found out that the stand post users are not charged at all in many piped or multi water distribution schemes (existence of private bore, pipe water supply by GWSSB & ESR with Stand post all together in the village) is also responsible for low cost recovery. On the contrary, there is strong demand from villagers for higher grade of services like piped water and more quantities with will to pay higher water charges also an encouraging to rural water supply sector of Gujarat.
9. Local watershed management plays an important role in catering the needs of water for drinking in most water scarce areas. Encouraging the construction of water recharging structures and adopting improved agricultural practices significantly changes the ground water quality and improves the water table in over-exploited aquifer zones.

LIST OF TABLES

LIST OF FIGURES

LIST OF CHARTS

ABBREVIATIONS

ARWSP	-	Accelerated Rural Water Supply Program
BCM	-	Billion Cubic Meter
CGWB	-	Central Ground Water Board
COD	-	Chemical Oxygen Demand
CPCB	-	Central Pollution Control Board
CSS	-	Cluster Storage Strategy
DI	-	Ductile Pipe
ESR	-	Elevated Service Reservoir
FC	-	Fully Covered
GIDB	-	Gujarat Infrastructure Development Board
GJTI	-	Gujarat Jal Seva Training Institute
GP	-	Gram Panchayat
GPCB	-	Gujarat Pollution Control Board
GRP	-	Glass Reinforced Pipe
GWIL	-	Gujarat Water Infrastructure Limited
GWSSB	-	Gujarat Water Supply and Sewerage Board
HDPE	-	High Density Poly Ethylene
HP	-	Horse Power
IRMA	-	Information Resource Management Association
KL	-	Kilo Litre
KM	-	Kilo Meters
KW	-	Kilo Watt
LPCD	-	Litres per Capita per Day
LPS	-	Litres Per Second
M & E	-	Monitoring and Evaluation
M & R	-	Maintenance and Repair
MLD	-	Million Litres per Day
MLM	-	Million Cubic Meter

MS pipe	-	Mild Steel pipe
NC	-	Narmada Canal
NC	-	Not Covered
NDWM	-	National Drinking Water Mission
NGO	-	Non Governmental Organization
O & M	-	Operation and Maintenance
PC	-	Partially Covered
PI	-	Performance Indicator
PRI	-	Panchayati Raj Institution
PVC	-	Poly Vinyl Chloride
RCC	-	Reinforced Cement Concrete
RDP	-	Reconstruction Development Program
RGNDWM	-	Rajiv Gandhi National Drinking Water Mission
RRWSS	-	Regional Rural Water Supply Scheme
RWS	-	Rural Water Supply
SEZ	-	Special Economic Zone
SMC	-	Surat Municipal Corporation
SP	-	Stand Post
SSNNL	-	Sardar Sarovar and Narmada Nigam Limited
SSY	-	Sujalam Sufalm Yojana
SUDA	-	Surat Urban Development Authority
UNICEF	-	United Nations' Children Fund
UT	-	Union Teritory
WASHE	-	Water Sanitation and Health Education
WASMO	-	Water and Sanitation Management Organization
WEDC	-	Water, Engineering and Development Centre
WEF	-	World Environment Federation
WHO	-	World Health Organization
WQAA	-	Water Quality Assessement Authority

1 INTRODUCTION

Water is life and access to safe and assured water is recognized as a universal human need and a fundamental human right.

The world wide scenario in terms of water availability is highly precarious. “We are in the midst of a water crisis that has many faces” cries out the United Nations report (2003). More than 1 billion people today are water poor and its incidences are too high. In the past few decades water has turned from an infinite to a finite renewable natural resource with a remarkably high degree of susceptibility to climate change and pollution because of the anthropocentric pressures. The alarming truth is that the water poverty is only going to worsen more and its relative scarcity is going to escalate further due to the non-commensurate inflation in its demand vis-à-vis growth in the population and various economic activities (United Nations report 2003).

It is projected that by 2025, an estimated 3.5 billion people (approximately 6.5 times the figure of 2000) will live in water-stressed countries (Asia-Pacific Forum for Environment and Development, 2002: 1) and by the middle of this century, at worst 7 billion people in 60 countries and at best 2 billion in 48 countries will be faced with the scourge of water scarcity. (United Nations report 2003:10)

1.1 Global Water Resources Scenario

About 71% of earth surface is covered with water. Total volume of water in hydrosphere is estimated to be 1.46 billion km^3 of which 97% is ocean water (not suited for human use due to high salt concentration) and rest 3% is available as fresh water. About 2.997% of it is locked up in ice cups or glaciers or is buried so deep that it costs too much to extract. Only

about 0.0035% of earth's total volume of water is easily available as soil moisture, exploitable ground water and rivers, lakes and streams (Patel A.S., 2008).

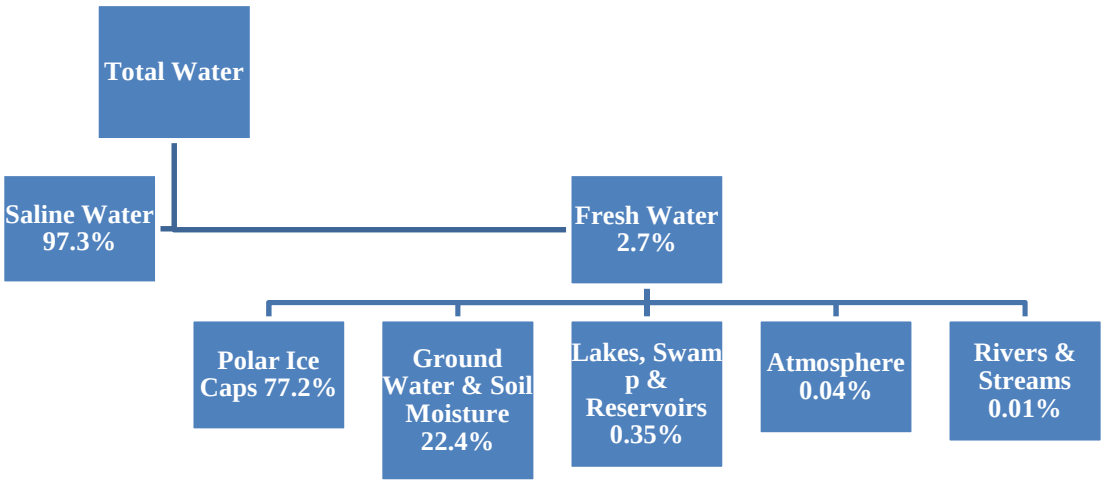


Figure 1.1 Distribution of Fresh Water Resources on Earth

(Source: Patel A.S., 2008)

1.2 Water Resources Scenario in India

The basic source of fresh water in India is the rainfall over the most part of the country and snowfall in the part of North India region. India, with a geographical area of nearly 3.3 million square kilometers experiences changes in climate. The rainfall varies from place to place and from year to year. Normal annual rainfall varies from 100 mm in Western India to over 1100 mm at Eastern India. Figure 1.2 shows the availability of fresh water resources in India (Patel A.S., 2008).

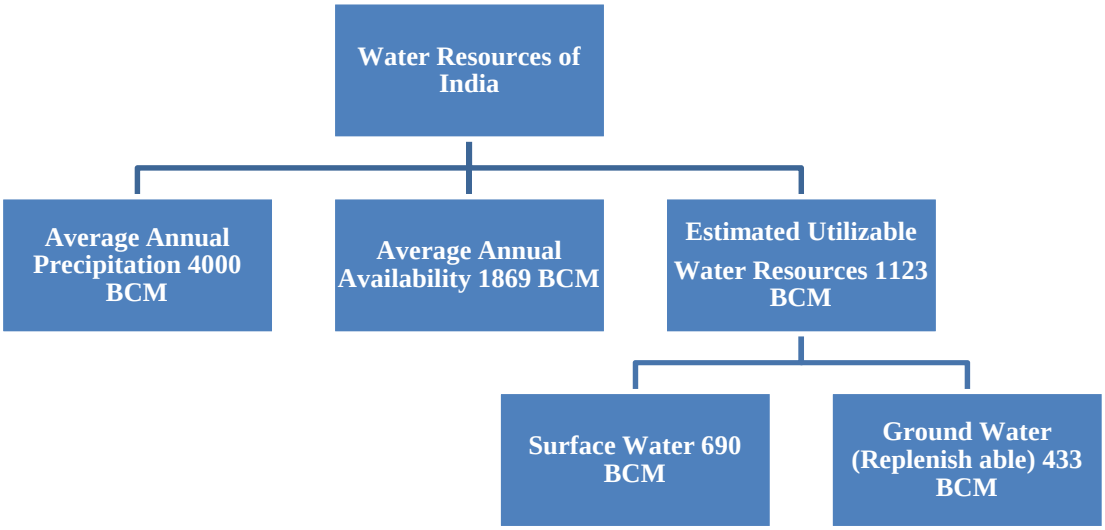


Figure 1.2 Availability of Fresh Water Resources in India (Source: Patel A.S., 2008)

1.2.1 Ground water potential of India

The ground water resources of the country have been estimated for freshwater based on the guidelines and recommendations of the GEC-97. The total Annual replenishable ground water resources of the country have been estimated as 433 billion cubic meter (BCM). Keeping 34 BCM for natural discharge, the net annual ground water availability for the entire country is 399 BCM. The Annual ground water draft is 231 BCM out of which 213 BCM is for irrigation use and 18 BCM is for domestic & industrial use.

1.2.2 Surface water potential of India

The availability of surface water in different water basins of India is as shown in Table 1.1.

Table 1.1 Showing Available Fresh Water in Different Water Basins of India (Source: Ministry of Water Resources, India and reproduced in Nigam Navin C., 1999)

Sr. No.	Name of the River Basin	Average annual available water (km^3/Year)	Sr. No.	Name of the River Basin	Average annual available water (km^3/Year)
1.	Indus (up to Border)	73.31	11.	Subernarekha	12.37
2.	a) Ganga	525.02	12.	Sabarmati	3.81
	b) Brahmaputra ,Barak & Others	585.60			
3.	Godavari	110.54	13.	Mahi	11.02
4.	Krishna	78.12	14.	West Flowing Rivers of Kutch, Sabarmati including Luni	15.10
5.	Cauvery	21.36	15.	Narmada	45.64
6.	Pennar	6.32	16.	Tapi	14.88
7.	East Flowing Rivers Between Mahanadi & Pennar	22.52	17.	West Flowing Rivers from Tapi to Tadri	87.41
8.	East Flowing Rivers Between Pennar and Kanyakumari	16.46	18.	West Flowing Rivers from Tadri to Kanyakumari	113.53
9.	Mahanadi	66.88	19.	Area of Inland drainage in Rajasthan desert	Negligible
10.	Brahmani & Baitarni	28.48	20.	Minor River Basins Draining into Bangladesh & Burma	31.00
				Total	**1869.35**

1.3 Water Resources Scenario in Gujarat State

The state of Gujarat is located between 20^0 06' to 24^0 42' North Latitudes and 68^0 10' to 74^0 28' East Longitudes in the west of India covering about 1,95,984 km^2 geographical area. Out of the total area nearly 1,09,314 km^2 is covered by the rocky formation and 86,670 km^2 by alluvium soil, of which 34,625 km^2 is brackish. The state has the longest coastline in the country measuring about 1600 km along with western part of India. Gujarat state has common borders with Rajasthan, Madhya Pradesh and Maharashtra states in North, East and South respectively and with Pakistan in the North West. The population of the state was 50.67 millions, as per 2001 census. For administrative purpose state has been divided into 26 Districts and 225 Talukas. Based on various parameters, the state can be divided into the regions namely, North Gujarat, Central Gujarat, South Gujarat, Saurashtra and Kachchh.

1.3.1 Variations in Rainfall

The state suffers from geo-climatic variations and climate related adversities. In Gujarat, 95 percent of the rainfall occurs during few days of monsoon period, especially during June to September. The visible difference in the rainfall received by the regions leads to a marked disparity in the availability of water. Except South Gujarat, which is flood prone, the entire state is drought prone. (Government of Gujarat. 2000: 3) While Kachchh gets less than 400 mm of annual rainfall and is a water-starved desert. In the Saurashtra region, the annual rainfall ranges from 400 to 800 mm. North-South Gujarat is relatively blessed- it gets rainfall between 800 to 2000 mm. Figure 1.3 shows the Mean annual rainfall over the various zones of Gujarat. From the graph it is noted that about 40%

of the total rainfall ie.130.205 km^3, that Gujarat receives; fall in South and Central of Gujarat.

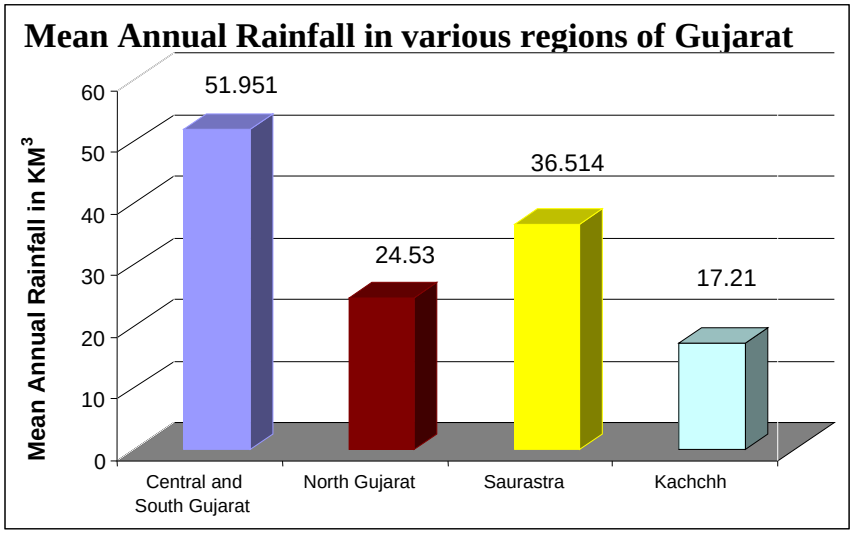


Figure 1.3 Graph Showing Rainfall Variations in the Various Zones of Gujarat

1.3.2 Potential Water Resources

Nature has endowed Gujarat with limited fresh water. The total renewable fresh water available, including the annual runoff from within the state and that allocated from the neighboring states, and all the natural recharge of ground water, is 54,593 MCM. This gives a per capita renewable fresh water availability of 1137 m^3 per annum for year 2001. Therefore, as per water stress index (Falkenmark and Widstrand, 1992), the state can be called 'Water Stressed'. But availability of water is heavily skewed towards south and central Gujarat, which has 69.5 % of the total renewable fresh water. At regional level per capita availability in other regions is much less, at 427 m^3 in North Gujarat, 734 m^3 in Saurashtra and 875 m^3 in Kachchh (IRMA 2001).

Water resources of Gujarat are divided into two distinct categories namely, a. Surface water resource and b. Ground water resource. Each of

these categories is a part of the earth's water circulatory system called the hydrologic cycle and is ultimately derived from precipitation. From the surface water resources point of view, the state can be divided into three major physiographic regions and total 185 river basins are located as under:

(1) South, Central and North Gujarat 17 Basins

(2) Saurashtra Region 71 Basins

(3) Kachchh Region 97 Basins

Figure 1.4 shows the surface water potential of the state and its sub division. This also indicates that the most available surface water resources are in the south and central Gujarat, whereas north Gujarat, Saurashtra and Kachchh water scarce for surface water availability.

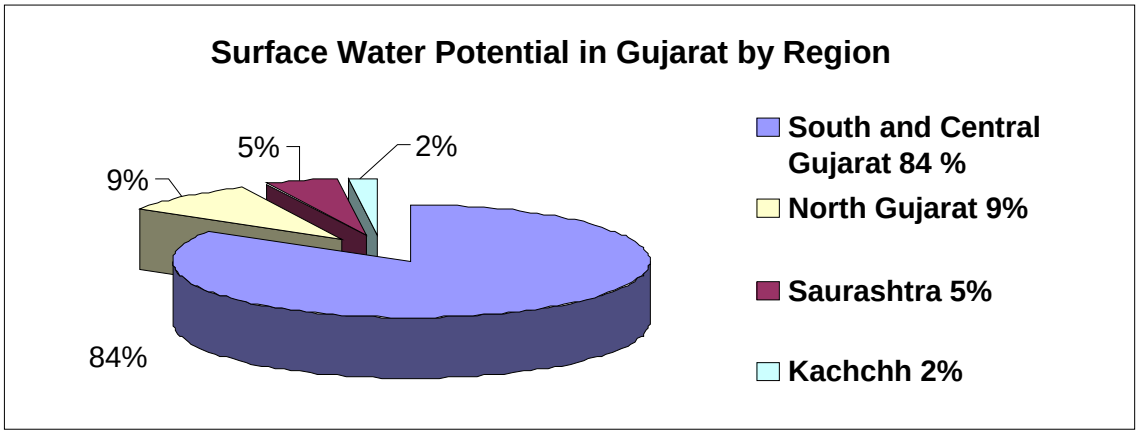


Figure 1.4 Graph Showing Surface Water Potential of Gujarat

The ground water potential of the state and its sub divisions are as shown in Figure 1.5. Ground water availability in the state is 7,465 MCM against the average annual draft of 6765 MCM (i.e 80%), which categorized the state into 'Over exploited'.

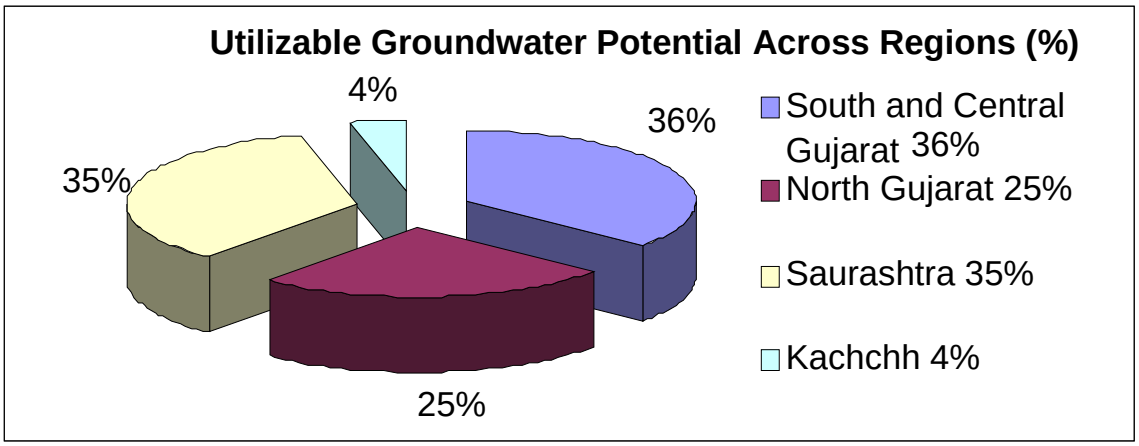


Figure 1.5 Graph Showing Ground Water Potential of Gujarat

1.4 Increases in Water Resource Demand

Since independence, India has witnessed an unprecedented increase in population. From a population of about 343 million in 1947, the population has grown at a rate of 2.04% to 1200 million in 2011. With an increasing number of mouths to feed, there has been an additional pressure on agriculture resulting in an increase in net sown area. High cropping intensity has also resulted in an increased demand for water resources. Domestic water need in the urban areas has also grown notably with the current urban population is about 31%. By the year 2050, the population is expected to reach around 1600 million, the per capita availability will drastically reduce and our country shall be water stressed in many river basins. The following Table 1.2 shows probable water availability against each year in India.

Table 1.2 Water Availability in India (Source: Patel A. S., 2008; Water Management)

Year	Available Water (KL/Year/Capita)
1000	70,000
1850	10,000
1950	5,177
2000	1,820
2025	1,400 (likely population 1300 million)
2050	1,140 (likely population 1600 million)

The demand for fresh water has been identified, as the quantity of water required to be supplied for specific use and includes consumptive as well as necessary non-consumptive water requirements for the user sector. The total water withdrawal/utilization for all used in 1990 was about 518 BCM or 609 m^3/capita/year. Estimates for total national level water requirements, through an iterative and building block approach, have been made for the year 2025 and 2050 as shown in Table 1.3, based on a 4.5% growth in expenditure and median variant population projections of the United Nations. The country's total water requirement by the year 2050 will become 1,422 BCM which will be much in excess of the total utilizable average water resources of 1,086 BCM.

Table 1.3 Showing Projected Water Requirements in BCM for Different Uses in India (Source: National Commission for Integrated Water Resources Development Plan, 1999)

Category of Water Use	**Year 2025**	**Year 2050**
Irrigation	688	1008
Domestic	52	67
Industries	67	81
Energy	13	40
Inland Navigation	4	7
Flood Control	-	-
Forestation	67	134
Ecology	10	20
Evaporation	42	65
Total	**942**	**1422 (**all values in BCM)

Viz. a viz. the demand for water in Gujarat state has also increased due to the growth of population, industrialization, urbanization and improved sanitation facilities. The population of the state has increased from 20.6 million in 1961 to 50.67 million in 2001. It has also been

observed that the per capita use of water has increased from 40 lpcd in years 1960's to 70-100 lpcd in year 2000.

1.5 Water Quality Management

Water Quality is a major environmental concern in developing countries. Pollution of waters of rivers, streams and lakes is mainly the fallout of rapid urbanization, industrialization and inadequate storage of flood flows for meeting the needs of water supply and sanitation sectors. The main sources of water pollution are discharge of domestic sewage and industrial effluents, which contain organic pollutants, chemicals and heavy metals, and runoff from land based activities such as agriculture and mining. Further, bathing of animals, washing of clothes and dumping of garbage into the water bodies also contribute to water pollution. All these factors have led to pollution of rivers, lakes, coastal areas and groundwater seriously damaging the eco-systems. The rapid urbanization, industrialization and increasing use of chemical fertilizers and pesticides etc. have made our rivers and water bodies highly polluted. Water Quality Assessment Authority (WQAA) has been setup to effectively coordinate and improve the work of water quality monitoring by various organizations.

In Gujarat, about 78 % of the drinking water supply is based on ground water resources (GWSSB 2005). But the quality of available ground water is not fit for consumption in many regions owing to excessive salinity, fluoride and/or nitrate. The state having the longest coastline of 1600 km in the country and excessive withdrawal of ground water from coastal aquifers has lead to ingress of seawater in the coastal aquifers rendering many thousands of drinking water and irrigation wells useless in coastal areas of Kachchh and Saurashtra (Bhatia, 1992; Kumar 1995). Every year on an average 0.5 to 1.0 km distance from the coastline is affected by salinity ingress (Barot, 1996). Also, in the state many of the

habitants are suffering from more than one quality problem. Central Ground Water Board (CGWB) in 2005 in its annual report shown that out of 26 districts of the state, 20 are suffering partly by salinity problem, 18 are suffering partly by fluoride problem, 17 are partly affected by chloride and 22 are partly affected by nitrate. In addition to above, there are problems of contamination arising from solid and liquid waste disposal from industries and human settlements. The regions around the major industrial centers like Ahmedabad, Vadodara, Bharuch, Ankleshwar, Surat, Navsari, Valsad and Vapi have polluted water sources, which have adversely affected their drinking water sources. Figure 1.6 shows the percentage villages of various districts of Gujarat suffering from the various water quality problems (Source: GWSSB 2003).

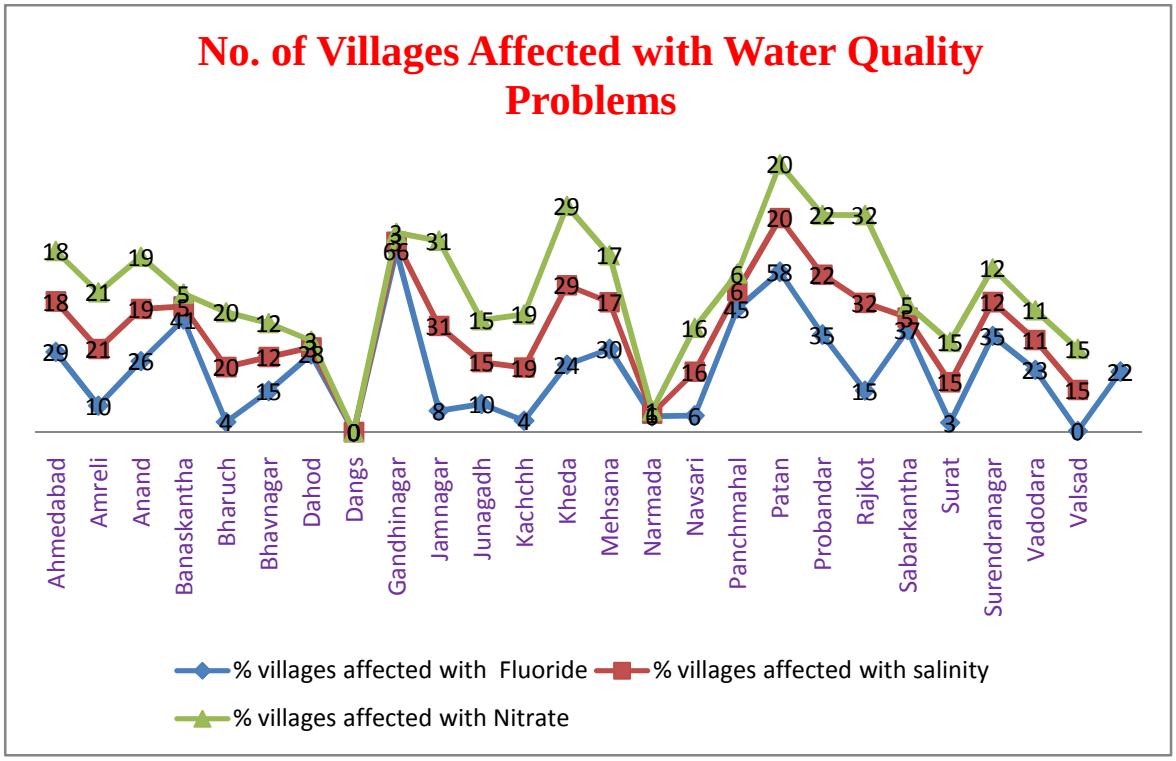


Figure 1.6 Graph Showing Villages of Gujarat Affected with Water Quality Problems (Source: CPCB)

1.6 Need of National Water Policy and Gujarat State Water Policy

In India, considering the availability and its variation in spatial and temporal dimensions it is found that the proper utilization of water is the most effective way for meeting the twin objectives of socio-economic development and environmental protection. Keeping this in consideration, the Government of India felt the need for the National Water Policy (NWP) for optimum utilization of the available water resources. Subsequently, India adopted its NWP in September, 1987. Since then, due to the emergence of a number of issues and challenges in the development and management of the water resources, the NWP (1987) was reviewed and updated in 2002. It clearly states that "As country has entered the 21st century, efforts to develop, conserve, utilize and manage this important resource in a sustainable manner, have to be guided by the national perspective". The issues of requirement for institutional mechanism for multi-sectoral, multi-disciplinary and participatory approach, participation of stakeholders and specially women community in policy decision are being strongly addressed by the NWP. Issues such as irrigation planning, resettlement and rehabilitation, financial and physical sustainability (water pricing), participatory approach to water resources management, encouraging private sector participation, monitoring the water quality (principle of 'Polluter Pay'), conservation of water, need for information system, watershed management, adequate safe drinking water facilities for the entire population in both urban rural areas are some of the amply stressed issues of NWP (2002).

With an ultimate goal of preserving and protecting the water resources of the state, Gujarat State Water Policy (2004) prioritize the utilization of water resources such as for 1. Drinking water 2. Irrigation 3. Hydro power 4. Ecology 5. Agro industries and other industries and 6. Other uses, Fisheries, Navigation, etc. Further, Adequate and safe drinking water facilities shall be provided to the entire population both in urban and in rural areas. Planning shall be done considering provision for drinking water as primary requisite in the irrigation and multi-purpose projects to come up in the future. Available water shall be provided on priority basis for use for human and livestock where there is no facility for assured drinking water supply at present. Following actions in state policy were noted to fulfill this necessity:

- Increase shall be made in the provisions in the budget for qualitative gradual improvements in the distribution of water for domestic and livestock uses in the urban and rural sectors
- Water tariff shall be increased gradually for self-reliant operations of pipeline projects in the urban and rural sectors. Standards/ criteria shall be decided for quality of water
- Strict control shall be exercised for discharged matters/ substances and harmful pollutants degrading water resources and deteriorating water quality
- Privatization of urban water distribution system shall be encouraged eg. To hand over work of reading of meters, etc.
- 8215 villages and 135 towns/ cities of Saurashtra, Kachchh and North Gujarat shall be covered under Narmada based projects
- Private sector shall be created for utilization of water. Panchayat institutions and domestic water user associations shall be involved

for participation in rural water supply system and taking proper decisions. Private and non Government sectors shall be encouraged

- Financial support (force) shall be provided to the rural water supply system

1.7 Scenario of Water Supply Sector and Water Supply Schemes Working in Gujarat State

As per Constitution of India 'Water is a subject matter of State'. Therefore, the responsibilities for the development of water supply sector are of concern to the state Governments. The State Governments on their part fulfill such responsibilities through state level functional authorities or the local bodies.

1.7.1 Water Supply Sector in Gujarat State

For the purposes of planning in the State of Gujarat, four different segments are considered separately for the water supply sector namely; Bulk water supply schemes, Water supply schemes for rural and smaller urban areas, Water supply schemes for larger urban areas, implemented by Municipal Corporations and Supply of water to large industrial users and industrial estates by GIDC.

The implementing and administrative agencies of these segments are different. However, at planning and policy formulation stage entire water resource of the state and its management is considered in an integrated way while approaching real challenges and to set priorities. The institutional structure of water supply sector in Gujarat state is as shown in Table 1.4.

Table 1.4 Institutional Structure of Water Supply Sector in Gujarat State

Agency	Jurisdiction	Role
Administration and regulation		
Department of Narmada, Water Resources, & Water Supplies	State level	Regulatory oversight of the water sector in the State Oversight of State government owned corporations involved in the Implementation and operation of water schemes
Department of Urban Development	State level	Oversight of urban local bodies, excluding corporations, in matters of financial, planning and management issues. Regulation of political and administrative appointments in the local authorities
Municipal Corporations	Major cities	Provision of retail water supply services for domestic and industrial purposes in the area of their jurisdiction
Municipalities & Nagar Palikas	Smaller Cities	Provision of retail water supply services for domestic and industrial purposes in the area of their jurisdiction
Gram Panchayats	Villages	Provision of retail water supply services for domestic and industrial purposes in the area of their

Agency	Jurisdiction	Role
		jurisdiction
Gujarat Industrial Development Corporation	State level	Mainly Implementing water supply and sewerage schemes for urban local bodies
Implementation and Operation		
Gujarat Water Supply and Sewerage Board (GWSSB)	State level	Mainly Implementing water supply and sewerage schemes for urban local bodies. Operation of some schemes. Inspection of schemes where State government fund is provided.
Gujarat State Drinking Water Company Limited	State level	Bulk transmission and bulk supply of drinking water to local bodies, GWSSB, and Industrial estates
Sardar Sarovar and Narmada Nigam Limited	State level	Wholesale supply of water
Gujarat Water Infrastructure Limited	State level	Development & Maintenance of Water Infrastructure for Bulk transmission and bulk supply of drinking water
Department of Narmada, Water Resources, and Water Supplies	State level	Operation and maintenance of some river schemes like the Ukai Dam

1.7.2 Water Supply Schemes in Gujarat State

Gujarat Water Supply and Sewerage Board (GWSSB) is an organization which is involved in the overall supply and management of Drinking water to most rural areas of Gujarat. However, Table 1.5 shows the role and responsibilities for various water supply schemes in Gujarat state.

Table 1.5 Roles and Responsibilities in Various Water Supply Schemes of Gujarat State

Schemes	Implementation	Financing	Operations & Maintenance
Municipal Corporation Water supply projects	Municipal Corporation	Corporation finances	Municipal Corporation
Small & medium Urban Water S upply Projects	40% by Municipalities 60% by GWSSB	75% as grant released under state non plan for the period 1-4-08 to 31-01-09 (Yr. 2008-09)	Municipality
Rural Water Supply Projects	GWSSB	State Government grant	GWSSB
Bulk Water Supply Schemes	GWSSB	GWSSB	GWSSB

In rural water supply sector mainly two types of schemes are undertaken namely, 1. Individual water supply scheme, which involves the supply and management of water restricted to single village or habitation and 2. Regional or Multi-village water supply scheme, which

involves several villages and hamlets for the supply and management of water. Traditionally, the water supply schemes are planned based on local available source, however, during the summer season as local source get dry, scheme fail to supply water. However, Under Rural Water Supply Program, various schemes like Hand pumps, Mini pipe, Piped water supply schemes (Individual or Regional – Multi villages) are being taken up according to the technical feasibility of drinking water source under state budget from time to time:

(1) Hand Pump:

As the rural areas are characterized by hilly terrain, hand pump is the technically feasible source of drinking water. While considering one hand pump per 50 persons, total number of 1,11,543 hand pumps are installed in rural areas as on up to 2008 in the state of Gujarat.

(2) Mini Pipe:

This scheme consist of installation of single phased power pump on bore of 165mm dia., water will be stored in a storage tank of @ 10000 liters capacity and then distributed on stand post. Up to 2008, 1186 mini pipe schemes are completed in the state of Gujarat.

(3) Regional Water Supply Scheme:

Where individual water supply scheme is not feasible, Regional Water Supply Schemes are being implemented based on assured/ sustainable drinking water sources. Approximately 413 schemes were implemented in Gujarat benefiting 7,544 villages, 47 towns catering to approximately 1 crore people in the rural and urban area of Gujarat state. Local water utilities made significant investments to install, upgrade, or replace equipment in order to deliver safe drinking water and protect public health. However, most of these schemes are now shifted to reliable surface water source.

In RRWSS often source of water is common for several villages/towns, either based on ground water or surface water. Further, water conveyance system may include the common infrastructure like

intake structure, head works, pumping machineries, water treatment plant, bulk water storage at main head works. However, the in-village water distribution system in RRWSS may differ from village to village. Most of villages in RRWSS may contain common storage sumps for collection of water from RRWSS (in full need or part) and from local source, if any available (in full need or part). Thereafter water may be distributed in village by either of the systems namely; by ESR & SP system, Individual piped water supply system, Cluster Storage Tanks and/or the combination of above.

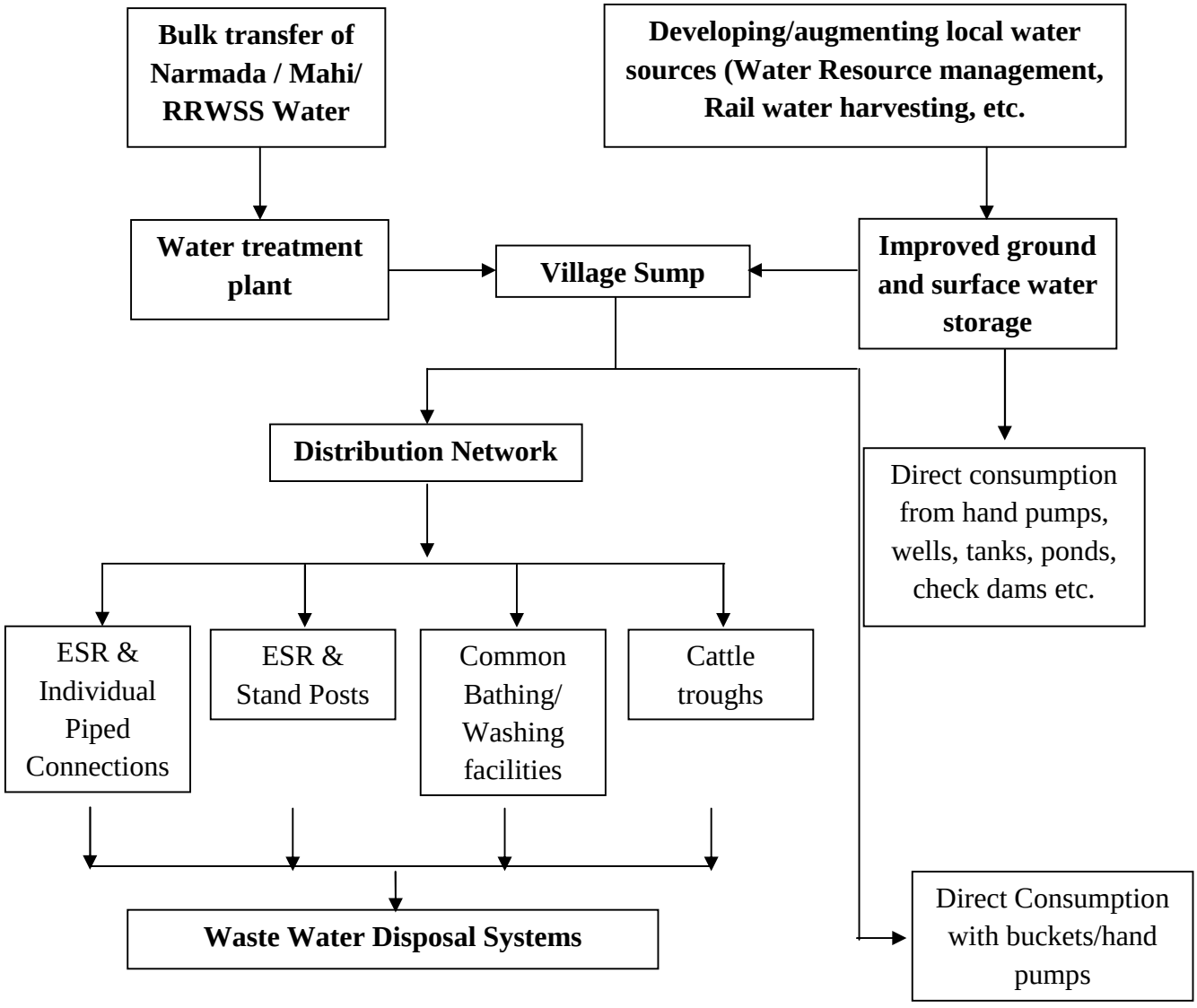


Figure - 1.7 Chart Showing Typical Water Supply Model Under Various RRWSS of Gujarat State

It is also noted that in RRWSS of Gujarat, various authorities or subsidiaries of state government are involved. For managing the supply of bulk water usually GWIL, SSNNL, Irrigation water department, various dam authorities and GWSSB are responsible. While mainly for in-village water distribution system often the local authorities such as Taluka/Gram Panchayats, Pani Samitis and/or WASMO and some NGO's are responsible.

(4) Sujalam Suphalam Yojana:

The State government has identified 10 worst water scare districts of North Gujarat, Central Gujarat, Saurashtra and Kachchh, which are being covered under the Sujalam Suphalam Yojana (SSY). These districts are Ahmedabad, Patan, Banaskantha, Gandhinagar, Mehsana, Sabarkantha, Dahod, Panchmahal, Surendranagar and Kachchh.

(5) Integrated Tribal Development Program:

Under this program, backward areas of tribal like, 25 villages of Vansada Taluka and 30 villages of Dharampur Taluka, 45 villages of Kaparada Taluka aggregating to 100 villages are taken up under community managed water supply and sanitation program.

(6) Swajaldhara/ Sector Reform Program:

The in- village water supply facilities are provided through Water and Sanitation Management Organization (WASMO) under the principles of Swajaldhara and Sector Reform, in which 90% of estimated cost is borne by Government of India/ Government of Gujarat and rest 10% is taken from local body. The schemes are planned, implemented and maintained and operated by Pani Samities.

1.8 Role of Regional Water Supply Schemes (RWSS) in Gujarat- Development and Investments

In the late 1970's and the early 1980's the state government introduced large regional water supply schemes to transfer bulk water supply to problem villages. Important among these were the first in Banaskantha district started in 1978 (working in early 1980's) covering 102 villages of that district, which was supported by the Netherlands government and the World Bank. In the XIth plan the government spent Rs. 650 million on rural water supply and sanitation. In 1980-81 to 1990-91 at the cost of Rs. 5.72 billion regional water supply of transferring bulk water to problem villages and individual schemes based on local water resources were planned in state master plan.

The number of regional schemes was very small until about 1980 (nine in 1970 and 43 in 1980, each covering about three to seven villages). It jumped to 209 in 1990 and to 444 in 2000. It is also noted that the about 60% of the schemes were implemented in the Saurashtra and Kachchh, which corresponds to the problem of local water sources in these regions in terms of quality and quantity.

As per the record of GWSSB (Table 1.6), during the 1990-2000, the state government spent about Rs. 31.54 billion to supply water. Also, in 1990-2000, alone private expenditure on drinking water was about Rs. 4.94 billion. Of this 2.14 billion were spent on purchasing domestic water purifying equipments, Rs. 1.61 billion on buying unbranded purified water in small and big packages, Rs. 880 million on branded water bottles and packages and Rs. 300 million on private tankers (Hirway, 2002). It shows that even after huge expenses, the water supply problem in the state was persistent.

1.9 Importance of Monitoring and Evaluation

The monitoring and evaluation is traditionally being used as a part of management tool. These ascertain the program objectives and also serve as basis for the accountability in the use of program funds. The evaluation of the rural water supply program in India is being done mainly through periodic physical and financial progress reports, visits of area officers and other government officials, and evaluation studies and sample surveys conducted from time to time. Although, the outcomes of such evaluations reflect regarding fulfillment of the objectives or accountability of funds, the sustainability of schemes and the social impacts of the scheme need to be ensured. Therefore, in checking overall effectiveness of water supply schemes it is necessary to develop several Performance Indicators.

Table 1.6 Expenditure of Gujarat State on Drinking Water Supply During 1990-91 to 1999-2000 (at 1999-2000 prices & in Rs. Crores) (Source: GWSSB Reports, Master Plans of GWSSB for different years)

Year	Expenses on Regional Water Supply Schemes by GWSSB		Expenses on Water Tankers by GWSSB	Expenses on Reverse Osmosis/Desalination plants		Expenses on Defluoridation plants		Total Expenses
	Capital cost	Operation & Maintenance		Capital cost	Operation & Maintenance	Capital cost	Operation & Maintenance	
1990-91	295.62	11.39	5.08	0	0	0	0	312.09
1991-92	201.18	13.72	22.6	0	0	0	0	237.50
1992-93	219.83	12.57	2.93	0	0	0	0	235.33
1993-94	157.5	12.04	13.07	0	0	0	0	182.61
1994-95	155.67	12.31	0	0.53	0	4.7	0.47	173.68
1995-96	158.05	11.22	1.01	0.41	0	1.91	0.19	172.79
1996-97	281.29	11.17	0.2	0.93	0.61	4.58	0.46	299.24
1997-98	288.2	8.7	0.13	0.88	0.57	19.34	1.93	319.75
1998-99	347.63	9.12	7.23	0.83	0.55	32.33	3.23	400.92
1999-00	717.13	8.09	7.41	0	0	79.35	7.93	819.91
Total	2540.81	110.33	59.66	3.58	1.73	142.21	14.21	3153.82

1.10 Need of Performance Indicators

Performance Indicators (PIs) can be defined as variables, whose purpose is to measure change in process or function. They can be used to track the performance of the whole system or to a particular element of the system. These can be used to monitor the progress of process and also to evaluate the outcome of the process. The performance indicators may be quantitative or qualitative in nature. The main features of the performance indicators are Purpose, Visibility, Definition, Control Power, Computation, Consistency, Comparability, Aggregation and Integrity. Therefore, a PI may be a measurement that describes how well an entity is meeting its objectives. It is also to be noted that it may vary with time. For example, frequency and seriousness of leaks & length of time it takes to deal with those repairs are time dependant variable. Such time dependant variables are difficult to interpret meaningfully when view at and isolated point in time. However, in such cases 'how often it occurs?' may be determined and this requires continuous monitoring and benchmarking from time to time and from project to project may help in improving or achieving project objectives.

The factors which are essential to be taken into account while selecting the performance indicators are identification of area of control, relevance of measurement with respect to area of problem, magnitude of problem, acceptance, relation with other indicators and the users other than responsible for water supply schemes ie. The Administration, Operation and Maintenance personnel of water supply schemes. It may be extravagant to decide on PIs including all the features and incorporating all the factors mentioned above. The decision on PIs also depends on the availability and reliability of inputs for its estimation. Establishing threshold value or benchmarks are also the important in the process of development of PIs and evaluating performance of the project.

2 LITERATURE REVIEW

The entire literature review has been carried out by referring to various papers published in the journals and conferences, manuals and reports published by the eminent National and State government and non-government agencies, World Bank, Asian Development Bank, World Environment Federation; Water, Engineering and Development Centre, etc. However, which are found most important & relevant to the present study are documented as follows.

2.1 Background on Water Supply

Water – a precious gift of nature is to large extent mismanaged resource globally. In spite of the huge investments and considerable progress made in the water supply sector all over the world, providing safe water to the un-served and under-served has been the challenging task faced by the most developing countries.

Jimenez A., and Perez-Forguet A., (2010), discussed a number of weaknesses such as low quality of water services, lack of sustainability of constructed infrastructure, difficulties for targeting the poor and inadequate internal information systems that continue undermining strategies for poverty eradication. Also suggested recommendations include new paradigms for the provision of rural water supply such as adoption of water supply as a service that is monitored and supported by the government and needs-based allocation of projects at community level.

Nath K.J. (2002), reported that the failure to provide safe drinking water & adequate sanitation services to all people is, perhaps, the greatest development failure of 20th century. Providing safe drinking water & sanitation to 1 billion unserved people in the next decade would be the

most critical challenge for the humanity as a whole, but most specifically for the national governments in the developing countries.

2.1.1 History of Indian Rural Water Supply

Since the provision of clean drinking water has been given priority in the Constitution of India, with Article 47 conferring the duty of providing clean drinking water and improving public health standards to the State, Rural water supply programs in India can be noted into several distinct phases.

1949: The Environment Hygiene Committee (1949) recommends the provision of safe water supply to cover 90 per cent of India's population in a timeframe of 40 years.

1950: The Constitution of India confers ownership of all water resources to the government, specifying it as a state subject, giving citizens the right to potable water.

1969: National Rural Drinking Water Supply program launched with technical support from UNICEF and Rs.254.90 crore was spent; with 1.2 million bore wells being dug and 17,000 piped water supply schemes being provided.

Transition from technology to policy

1972- 73: Introduction of the Accelerated Rural Water Supply Program (ARWSP) by the Government of India to assist states and union territories to accelerate the pace of coverage of drinking water supply.

During the period 1972-1986, the major thrust of the ARWSP was to ensure provision of adequate drinking water supply to the rural community through the Public Health Engineering System.

1981: India as a party to the International Drinking Water Supply and Sanitation Decade (1981- 1990) declaration sets up a national level Apex

Committee to define policies to achieve the goal of providing safe water to all villages.

1986: The National Drinking Water Mission (NDWM) is formed.

1987: Drafting of the first National Water Policy by the Ministry of Water Resources.

Also, with the launch of Technology Mission in 1986-87, renamed in **1991-92** as Rajiv Gandhi National Drinking Water Mission (RGNDWM); Stress on water quality, appropriate technology intervention, human resource development support and other related activities were introduced in the Rural Water Supply sector.

1994: The 73rd Constitutional Amendment assigns Panchayati Raj Institutions (PRIs) the responsibility of providing drinking water.

1999-2000: Government had considered and approved a proposal to bring about a package of reforms in the rural water supply sector to address major areas of concern namely, coverage of habitations, quality problems in drinking water and sustainability of sources and systems.

For ensuring sustainability of the systems, steps are initiated to institutionalize community participation in the implementation of rural drinking water supply schemes through sector reform. Sector reform ushers in a paradigm shift from the '**Government-oriented supply-driven approach**' to the '**People-oriented demand-responsive approach**'. The role of the government is envisaged to change from that of service provider to facilitator. The Government had also stipulated that 20% of the annual outlay under Accelerated Rural Water Supply Program (ARWSP) be earmarked for implementing reform projects. Under reform, 90 per cent of the infrastructure is funded by the government, with the community contributing 10 percent of the remaining. The reforms initiative, so launched on a pilot basis as Sector Reform Projects in 67

districts of 26 States by the Government of India, was scaled up in December 2002 to cover the entire country as 'Swajaldhara'.

In June 2002, Government approved relaxation of 'coverage' norms under ARWSP to provide for 55 lpcd with a source within 0.5 km in the plains and 50 meter elevation in the hills after coverage of all Not Covered (NC)/ Partially Covered (PC) rural habitations in that State is achieved as per the then existing norms of 40 lpcd with a source within 1.6 km and elevation of 100m. This relaxation was subject to the condition that beneficiaries of the relaxed norms were willing to share a part of the capital cost (which should not be less than 10%) and shoulder full responsibility for subsequent operation and maintenance. Further, in case of quality affected villages or in multi-village schemes where the capital cost was very high, the schemes could be executed and implemented by Government departments and water was to be supplied to individual villages at the periphery of each village. For drinking water distribution within the village, the beneficiaries would share a part of the capital cost (which should not be less than 10%) and shoulder full responsibility for subsequent operation and maintenance of the village water distribution network, while Government Department/Board would maintain the main water supply system up to the village. Government/Board could also collect water rates from the panchayat/village communities for bulk supply of water for drinking purposes. Such water charges and the village O&M cost would be fully met by the users/beneficiaries.

2004: All drinking water programs are brought under the umbrella of the Rajiv Gandhi National Drinking Water Mission (RGNDWM).

2005: The Government of India launches the Bharat Nirman Program for overall development of rural areas by strengthening housing, roads, electricity, telephone, irrigation and drinking water infrastructure. The

target is to provide drinking water to 55,069 uncovered habitations; those affected by poor water quality and slipped back habitations based on 2003 survey, within five years.

2007: Pattern of funding under the Swajaldhara scheme changes from the previous 90:10 central-community share to 50:50 centre-state shares. Community contribution is now optional.

The approach paper for the XIth five year plan calls for a comprehensive approach which encompasses individual health care, public health, sanitation, clean drinking water, access to food and knowledge about hygiene and feeding practice. It also states the need to upscale more schemes related to community management of water reducing the maintenance burden and responsibility of the state. It is envisaged to provide clean drinking water for all by 2009 and ensure that there are no slip-backs by the end of the XIth five year Plan.

The Rural Water Supply (RWS) sector has now entered the next phase with major emphasis on ensuring sustainability of water availability in terms of potability, adequacy, convenience, affordability and equity while also adopting decentralized approach involving PRIs and community organizations. Adequate flexibility is afforded to the States/UTs to incorporate the principles of decentralized, demand driven, area specific strategy taking into account all aspects of the sustainability of the source, system, finance and management of the drinking water supply infrastructure. Adoption of appropriate technology, revival of traditional systems, conjunctive use of surface and ground water, conservation, rain water harvesting and recharging of drinking water sources have been emphasized in the new approach.

With right-based approaches taking roots in the sector, ‘access to safe and clean drinking water’ being treated almost as a fundamental right, a new set of challenges is emerging in the sector. Fixing the quality

standards, independent laboratories for quality checks, its enforcement, grievance redress systems for quality problems, tariff systems, source sustainability, equity, etc. are the new emerging challenges.

2.1.2 Issues and Challenges

In India today, more than 96 percent of rural habitations - or 720 million people - have access to water infrastructure to supply them least 40 lpcd of water. This wide coverage is a reflection of the investments made by the Government of India over the years. But, while access to water supply has increased over the years, this does not always translate into reliable, sustainable and affordable water services. This is mainly due to the following reasons:

- **Most schemes are planned, implemented and managed by state engineering agencies** and a supply driven approach was followed. The various government departments in charge of the sector often have overlapping responsibilities.
- **Beneficiary groups are generally not involved** in the design, implementation and maintenance of schemes and the involvement of Panchayati Raj Institutions (PRIs) (local governance bodies) is limited.
- **Subsidies are often poorly targeted and ad hoc.** This increases the possibilities of schemes being inefficiently managed, thereby continuously adding to an increasing number of defunct/partially defunct schemes.
- **Depleting groundwater tables / deteriorating groundwater quality** is a continuing threat.

Monitoring systems focus on infrastructure creation, rather than **provision of services**.

Traditionally, rural water supply has followed a supply-driven approach with access to safe water being considered a social good. The

financial and operational limitations of the supply-driven approaches led to a fundamental policy shift. In 1999, a demand-driven approach was piloted. In 2003, the pilot was scaled up as a nationwide Swajaldhara Program. Community-led decision making, community sharing of costs, and emphasis on service delivery are central to these new programs. However, hardly 10-15% of the entire RWSS funding is channeled through these programs. The main challenge now is the effective implementation and scaling-up of the decentralized demand-responsive service delivery systems.

Opportunities for Improving Service Delivery

- **Clarify Functions of State Rural Water Supply Institutions.** As the role of the state shifts to that of a facilitator, and funds, functions and functionaries are decentralized to PRIs and user committees, it is important to clarify the role of state institutions and agencies in the sector.
- **Strengthen Community Participation.** Several examples in Uttaranchal, Rajasthan, Karnataka and Kerala show that community participation has been successful in improving rural water service delivery. Special training programs (especially for accounting, procurement, financial management) are required to improve the functional capacity of PRIs and user committees. Local communities and PRIs should have a complete understanding of the likely O&M cost of various technology options, determined by technical feasibility, user preferences, and willingness to contribute towards capital and O&M cost.
- **Transfer O&M Responsibilities of Single Village Schemes to PRIs.** State governments should hand over existing Single Village Schemes to PRIs/user committees, after requisite rejuvenation and repair works are carried out. It is important that these assets belong

to the Gram Panchayats, and O&M responsibilities are fully borne by beneficiaries.

- **Establish Cost Sharing Principles.** Although the programs aim to see that O&M cost is fully recovered through user charges (except for high cost schemes which are not affordable), transparent criteria need to be developed to determine affordable contributions and the required state subsidy to ensure that the poor are not hit.
- **Carry out Independent Appraisal of Multi Village Schemes.** Multi Village Schemes should be taken up only when Single Village Schemes are not technically feasible.
- **Address Groundwater Depletion and Quality Issues.** The Groundwater Act needs to be effectively implemented. Also, Water Quality Monitoring Programs need to be better designed and routinely implemented.
- **Implement Monitoring &Evaluation (M&E) Systems.** M&E indicators need to provide a comprehensive coverage of inputs, processes, outputs and outcomes.

Barot J.M. (1996), addressed the challenges into water supply especially for rural India. By siting example of Gujarat, explained what are the systems available, which are the emerging constrains and how they can be redressed into water supply.

Pal Brij (2012) discussed the historical development of rural water supply in ancient India and recommendations of various committees with the focus of fund allocation under various Five Year Plans.

2.2 Role of Monitoring, Evaluation and Performance Indicators in Rural Water Supply Schemes

2.2.1 Role of Monitoring in Performance Evaluation

Periodical monitoring is the key in evaluation of performance of the project and to assess how far the objectives are achieved. In rural water supply projects also monitoring of several parameters on regular intervals helps in checking the overall performance. This helps the implementing authorities in new planning and making policies for the future schemes too.

Shah Binay (1998), presented a methodology for an appraisal and prioritization of rural water supply schemes in Nepal with reference to major factors like technical viability, needs assessment/hardship, community's willingness to participate, financial resources, etc.

Azuma M. and Jayakaran S. (2001), reported the study dealing with the issues of transition and growth of the community-based operation and maintenance system before and after adoption of the National Water Policy (Zambia) and the Water, Sanitation and Health Education (WASHE) concept in Zambia. This comparative study focuses roles of the village water committees, which have gradually evolved from the groups for maintenance of water supply facilities to those for policy/decision making in improvement of their living conditions. Secondly, changes in support system by the local administrations and approaches of interventions by the external agencies were examined.

Mazumdar K. (2002), reported that the dynamics of rural transformation at the grass roots level in India requires a proper understanding of the relationship between technology and society and also economy at the village and the household levels. The selection of a suitable technology is not an isolated activity, but need to be based on

delivering the choice level of service in a way, which will be effective, equitable, sustainable, efficient and replicable.

The World Bank report (2008), mainly covers the states of Andhra Pradesh, Karnataka, Kerala, Maharashtra, Orissa, Punjab, Tamil Nadu, Uttar Pradesh, Uttarakhand and West Bengal. The study largely covers the rural population of the states and the schemes cover hand pumps, mini water schemes, single village schemes, multi village and regional schemes. This has found that the overall efficiency of schemes under demand-driven programs is greater than that of schemes under supply-driven programs. However, the study is a 'reality check' on the existing design of schemes and do not largely involve the large and regional rural water supply schemes. The outcome of the study also limited to the region specific and may not be applicable to all state or regional conditions without making appropriate changes.

2.2.2 Issues related to Water Tariff, Cost recoveries and Affordability

Landge Hemant C., et.al. (2008), suggested the basic criteria for designing the survey format to derive appropriate information, methodology to assess willingness to pay and level of affordability of the beneficiaries. This methodology is used to assess willingness to pay and affordability of three towns of Maharashtra.

Dhanabalan M. ((2009), described the methodology and procedures to fix the water tariff in water supply schemes. The water tariffs design was to harness the objectives of the 24 X 7 service delivery in Hubli-Dharwad, Belgaum & Gulbarga Municipal Corporations in state of Karnataka, Which mainly categorize the water tariff structure for domestic consumer, non domestic consumer and commercial/industrial consumer.

Kartic P.N.L. and Yohan G. (2009) presented a basic conceptual framework for understanding the main practical issues and challenges relating to cost recovery of providing water supply services in Vijaywada Municipal Corporation. The case study mainly focuses on the analysis of the subsidies and cross subsidies received in urban municipal area for water supply services among the Above & Below Poverty Line consumers, metered and non-metered consumers and residential & non residential (Commercial) consumers.

2.2.3 Role of Community or Users in Water Supply Services

Tripathi S.K. and Lal Bharat (2001), reported the reforms in Indian rural water supply sector and community participation initiatives of Uttar Pradesh, Kerala and West Bengal was reported as successful.

Mazumdar K. (2002), emphasizes on the advantage of investing in community participation activities has been tremendous and the cost involved in this support is not necessarily expensive (about 2.5-3% of the project cost). Thus, the major challenges in India is to develop the capacity and capability within the government agencies to plan for, manage and to some degree coordinate mobilization of support from both the Gram Panchayats and the communities.

Mhaisalkar V.A. and Gawalpanchi R.R. (2002), reported the success of Borujwada, taluka Saoner, Maharashtra rural water supply scheme due to involvement of community participation in the various stages of scheme namely, planning and design, construction and operation and maintenance. Also, study reveals the importance of community education in the overall improvement in personal health and hygiene.

Vasavada Shilpa (unpublished paper), carried out a situation analysis of Women’s participation in Swajaldhara and recommended the

important role and involvement of the women in various Pani Samitis to at least 50%.

Olatunji Timothy (2003), emphasized the importance of community participation in the sustainability of rural water supply. Community effort at maintenance is largely hindered by lack of spares and adequate institutional support. Water service providers in the rural areas must work closely with the community empowering them in decision making as regards site selection, choice of technology, community involvement, etc. It is when the community participates freely and willingly that a water supply project stands a good chance of providing long-term benefits.

Shanthasiri H.K.S. and Wijesooriya R. (2004), carried out a case study on community involvement in rural water supply of Sri Lanka and reported various advantages such as feel of ownership, decision making amongst beneficiary, concerns for non revenue water, etc. and disadvantages such as time-consuming activity, non participation in labor contribution, non acceptance for chlorination due to traditional habits and reluctance for installation of water meters due to its high cost.

2.2.4 Performance Indicators – Development as Needs

Identification and development of an indicator the evaluation of progress or overall performance is common management practice. In rural water sector, despite large involvement of community and significant expenses occurred worldwide, Performance Evaluation based on specific indicators was not so popular before one or two decades.

Stephen David A. (2000), described the Key Performance Indicators developed for the several rural water supply of schemes in South Africa’s Reconstruction and Development Program (RDP). The Performance Indicators derived fall into three categories, namely, Quality

of Service, Financial Health and Accountability of Water Committees. However, they are not taking into account the positive (or negative) impact which the social, cultural and political environment can have on a scheme's viability and sustainability.

Soley Foster and Thogersen Jens (2003), carried out a monitoring and evaluation of rural water supply in Ghana and revealed the importance of monitoring and evaluation system and also noted that the four main performance indicators serve as basis of the monitoring and to estimate the community's overall operation and maintenance performance namely, Management performance, Operational performance, Maintenance performance and Hygienic Operation performance.

Still D.A. and Balfour A.F. (2006), described the efforts and role of various agencies in South Africa for the evaluation and monitoring initiatives in water supply sector. They reported that the monitoring program with scores of indicators, are failed due to non sustainability in practice. They suggested Water quality, Reliability and Source sustainability are only the Key Performance Indicators for evaluation of health of the water supply schemes.

Dwivedi Arun Kumar and Bhadauria Sudhir Singh (2007), have defined the Performance Indicators as variables, whose purpose is to measure change in process or function. They have categorized the Performance Indicators for performance evaluation of water supply namely, Users' opinion & Satisfaction PI's, Management PI's, Financial PI's, Level of Service PI's and Materials, Parts & Equipments PI's and Personnel PI's. However, this fails to include the role of community participation, affordability issues, willingness to pay, water tariff and subsidy issues, which are obviously affecting the sustainability of the water supply schemes.

The World Bank (2008) study was an attempt to check the performance of the rural water supply schemes implemented in 10 states (excluding Gujarat). This covers largely the only the rural water supply schemes based on Hand pumps, Mini water supply of single or several villages and few multi village or regional water supply schemes. The main objective also was to compare the performance by certain indicators in demand driven and supply driven water supply schemes.

2.3 Justification for the Present Study

The concept of monitoring and evaluation is not a new one. As stated above various researchers, policy makers and implementing bodies have used the concept of monitoring and evaluation for respective water supply schemes with different objectives. Each of study reveals the specified objectives related to the scheme only. Most studies were carried out on single village schemes or several are on multi village schemes, emphasizing the success related to scheme.

India is not a nation with only diversity of culture, religion and language but also geographic conditions, altitudinal and agro-climatic conditions make it a mega diverse. Further, in India, Constitutionally, Drinking water supply is a State Subject and hence, drinking water to rural habitations are provided by state governments. Being multiple states of India, every state with mega diversities of social, political and economic conditions, the water supply approaches and policies also changes from state to state.

Regional Rural Water Supply Schemes implemented in the state of Gujarat have witnessed major transformations in last two decades or so from its supply-driven to demand-driven or combination of both for bulk water supply as supply-driven and distribution as demand-driven, shift of

local source to sustainable and reliable surface water source, etc. make important to study.

It is therefore proposed to conduct comprehensive study for the critical evaluation and development of Performance Indicators which are applicable for such Regional Rural Water Supply Schemes. Such work has not been attempted and it is indispensable to develop PIs for RRWSS. The study will be useful to derive the future strategies for the development of water policies of the state for rural habitations.

2.4 Objectives of the Study

- To undertake observations on available infrastructure and distribution networks of water supply in the state of Gujarat with reference to regional rural water supply schemes
- To analyze the performance of regional water supply schemes with special reference to its source of water, coverage, quality of water, treatment facilities, technical efficacy & adequacy for the distribution of water
- To develop the performance indicators for overall service, management and financial performance evaluation of RRWSS (Source sustainability, Adequacy of water, Service reliability, Acceptable water quality, Cost on capital, operation & maintenance, Recoveries of tariffs)
- To scale up the potential for development of efficient & equity water distribution amongst the villages in various RRWSS
- To identify the impact of implemented schemes on socio economic activities as well as the overall life of the rural habitants

2.5 Methodology of the Study

As the water is subject of state in India, therefore, the responsibility of water supply for various needs of the society is mainly dealt by the state authority. As the state cater the demands from various sectors such as Irrigation water, Industrial water, Urban and Rural water, number of Government departments or subsidiaries of state government are involved. For managing the supply of bulk water in RRWSS mainly GWIL, SSNNL, Irrigation water department, various dam authorities and GWSSB are responsible. While for in-village water distribution system often the local authorities such as Taluka/Gram Panchayats, Pani Samitis and/or WASMO and some NGO's are responsible. Therefore, to understand the overall scenario of rural water supply schemes in Gujarat, data collected from above agencies, interactions with the officials and field visits in selected RRWSS have been made.

The selection of the representative RRWSS for study is carried out based on the following points keeping in mind:

- **Hydrology of the area**: Rainfall varies highly in the state of Gujarat. South Gujarat receive more than 1500mm rain fall per annum, middle Gujarat receive around 1000mm per annum, the Saurashtra region receive less than 600mm rain fall per annum while Kachchh region is partly a desert area and receive minimum rain fall. The prosperity of the area and quality & quantity of water is also highly varying. Therefore, four major schemes for the detailed evaluation are selected, one from the region of South Gujarat namely, RRWSS Variav group, Surat, two from the Saurashtra region namely RRWSS Gadhada group, Bhavnagar & RRWSS Ishwaria group, Amreli and one from the Kachchh region namely RRWSS Mandvi group, Kachchh.

- **Land use pattern/Urbanization:** The RRWSS Variav group, Surat representing South Gujarat (rich in water resources) cover the combination of industrial, urban and rural areas.
- **Water quality:** The Saurashtra region has the 1100 Km long costal belt. Surface water resources are limited & local ground water resources are not adequate in catering summer demands. Also, local ground water is suffering the water quality problems such as salinity (Total Dissolve Solids), Fluoride, Arsenic and other mineral matters. Therefore, RRWSS Gadhada group, Bhavnagar and RRWSS Ishwaria group, Amreli, at later time, shifted on reliable bulk water supply from Saurashtra Pipe line project.
- **Geography:** Kachchh is the largest district (geographical area wise) of Gujarat, located on the border of India and Pakistan covers largely the desert land with negligible water resources. Even though after the earthquake in the year 2001 and with the development of pipe line project based on river Narmada water, rapid growth of industries and construction of ports has been observed in the region. So from this point of view, RRWSS of Mandvi group and Kachchh group are therefore selected for the study.

A house to house survey has been initiated largely to collect the responses of Users' in above four selected RRWSS. The users' data survey work has been allotted to the Advantage India Private Limited, Ahmedabad with the financial support of GWSSB. The users' data survey cover about 2465 responses of 61 villages of four selected RRWSS (RRWSS Variav group, Surat – 863 responses and 20 villages, RRWSS Gadhada group, Bhavnagar – 559 responses and 14 villages, RRWSS Ishwaria group, Amreli – 581 responses and 14 villages and RRWSS Mandvi group, Kachchh – 462 responses and 13 villages). While

planning the users' data survey, villages are selected as per its distances from the head water works (head village, intermediate village and tail end village). A care has also been taken for selecting the users that they should largely represent the business, caste & sex group.

Further, in addition to above four selected RRWSS, for evaluating certain PIs, the overall RRWSS operated in South & Central Gujarat are undertaken. For evaluation of financial performance of RRWSS relying on bulk water supply in Saurashtra region, a separate study has been carried out with the GWSSB (Rajkot zone office) and GWIL officials.

As Cluster Storage Strategy is an optional part of in village water distribution system, a separate study has been carried out in the seven villages of two districts, Surendranagar and Kachchh. Based on the influencing factors such as population size, variation in caste & inter-caste conflict issues, availability of water, topography of the area, economic conditions in terms of agricultural and industrial growth in and around village and the success observed in CSS model; villages are grouped and desk study of documents developed by UNICEF, WASMO & GWSSB are studied and field visits are made for interaction with users' and managers of the schemes.

Based on the observations & findings of above studies, Performance Indicators are identified which can be used to design, monitor and/or evaluate the performance of new or existing regional rural water supply schemes.

3 OVERVIEW OF RRWSS UNDER STUDY

The key measures taken on policy level to cater the demand of water in the Gujarat state include transfer of water from water surplus areas by Sardar Sarovar Project, interlinking of State's rivers and the development of Water Supply Grid for Gujarat, Sujalam Sufalam Yojana, construction of check dams and rainwater harvesting structures and the Regional Water Supply Schemes for rural-urban areas in last decade.

The State Wide Drinking Water Supply Grid (Figure 3.1) has been mooted as solution to the drinking water woes especially for the Saurashtra and Kachchh region of the state. It should also be noted that the water grid project involves a long gestation period and requires ample financial resources for building a network of effective water conveyance infrastructure.

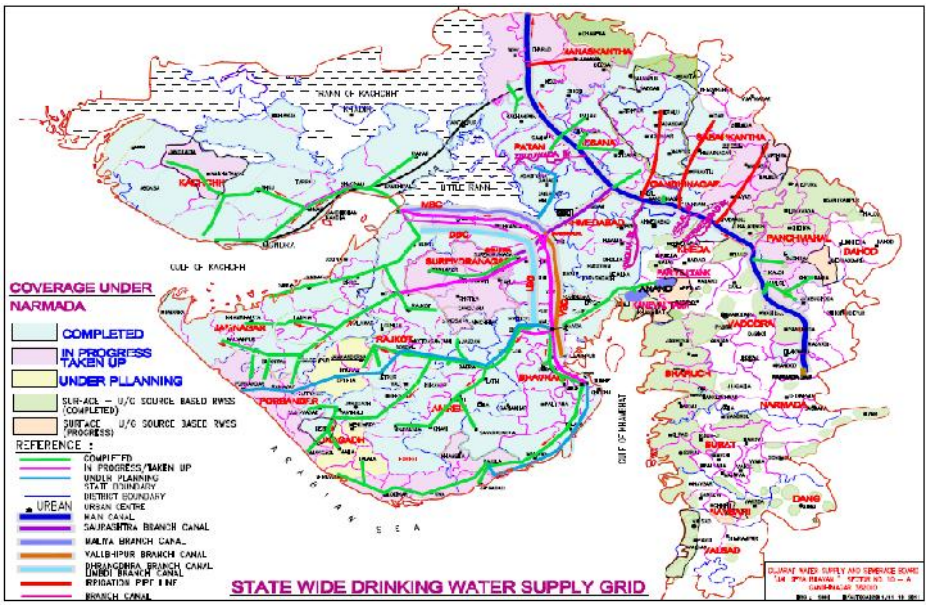


Figure 3.1 Map showing the Water Supply Grid of Gujarat

(Source: www.gwssb.org, July, 2012)

Gujarat state is having very wide diversities of population density, available water resources, rural and urban areas with and without industrialization, etc. Therefore, the mode of water supply in different

areas is also different and from time to time different types of water supply schemes were implemented with various objectives and scopes. For the present study four groups of RRWSS are selected covering detailed study. However, for evaluation of certain Performance Indicators, group schemes of South & Central Gujarat and Saurashtra group schemes based on Saurashtra pipe line project and Narmada bulk water supply are also undertaken for the study.

3.1 Criteria for the Selection of RRWSS for the Study Purpose

Source of the water, Population under coverage area, Geographical region (coastal, desert, water available and water scarce area), etc. are considered as selection criteria for the representation of various RRWSS implemented. Four groups of schemes are selected for detailed study and evaluation using Performance Indicators.

3.1.1 Variations in Hydrology

In terms of total quantity of rainfall, South and Central Gujarat receives the highest quantum of rainfall with mean annual precipitation of 51.95 km^3. Saurashtra follows with this 36.514 km^3 and North Gujarat with 24.53 km^3 and Kachchh receives a total of 17.21 km^3 of water as the mean and annual rainfall. Thus 40% of total rainfall that Gujarat receives falls in South and Central Gujarat. The Utilizable Ground water potential across the south and central region is also high about 36%.

3.1.2 Variations in Geology

The North Gujarat and Saurashtra region of Gujarat are consist of rocky strata with rich in minerals including Fluoride. The Saurashtra and

some part of South Gujarat is having long sea coast. This coastal segment is almost straight and trending NW-SE and characterized by uneven substrate of submerged miliolitics. Kachchh is falling in the desert part of the state. The South and the Central region of the Gujarat are having flat lands with good agriculture potential.

3.1.3 Variations in Source of Water & Availability of Water

The South Gujarat and the Central Gujarat is having the maximum surface water resources of the state. Also, most rivers flowing through are perennial and the availability of surface as well as the ground water is high compare to the rest part of the state. Due to rocky area in Saurashtra, most water resources are in the form of ground water and that too either from the unconfined aquifers or if alluvial area then the water is tapped by tube wells. Most of the rivers flowing through North Gujarat and Saurashtra are non-perennial. Kachchh being a desert area, availability of water resources are very scarce.

3.1.4 Variations in Population and Type of Coverage

Few of the RRWSS are covering the population of urban area, though their main objective is to provide water supply to the rural regions. In some of the RRWSS the water is made available to cope up the needs of Irrigation and/or Industries along with domestic water supply. However, most of the RRWSS are implemented with a objective of supplying the water for domestic needs of rural region, especially where no or limited local water resources are available.

Based on the above selection criteria, the RRWSS selected for the study are listed in Table 3.1.

Table 3.1 List of Selected RRWSS Under Study (Source: GWSSB)

Name of the Scheme	Main Source of Water	Population under coverage as per census 2001	No. of Villages/towns covered	Average Rainfall of region	Geo hydrology of Region
Variav Group, Surat-South Gujarat	Tapi river (perennial river)	6,11,795	156/0	>1500 mm/Annum	Alluvial soil, Rich in surface water and ground water resources
Gadhada Group, Bhavnagar-Saurashtra Region	Bulk water supply from Saurashtra pipe line project based on Mahi-pariej Yojna	1,43,471 (Year: 1991)	67/1	<600 mm/ Annum	Rocky area, taping water from unconfined aquifer
Ishwariya group, Amreli-Saurashtra Region	Bulk water supply from Saurashtra pipe line project based on Mahi-pariej Yojna	93,498	49/1	<600 mm/ Annum	Rocky area, taping water from unconfined aquifer & High fluoride content in ground water
Mandvi Group, Kachchh-Partly Desert Region	NC 11 & NL 22 from Maliya Branch of Narmada canal	72,261	71/0	<300 mm/ Annum	Desert area, saline ground water & scare surface water

3.2 Population Forecast and Water Demand

3.2.1 RRWSS Variav Group, Surat

This RRWSS covers 156 villages of three talukas namely Choryasi, Olpad and Kamrej of Surat district. Most of these villages are located on the periphery of Surat city. The total population of group area from year 1971 to 2001 as listed in Table 3.2.

Table 3.2 Population under RRWSS Variav Group, Surat, as per Census of India

Year	Population, as per Census of India
1971	1,77,253
1981	2,40,599
1991	3,39,001
2001	5,44,260

While working out the population projection by various methods of demographic projection, it was observed that due to 36% rise in Year 1981-1991 decade and 47 % rise in Year 1991-2001 decade.

Further in this RRWSS, 29 villages of Choryasi taluka are now included in Surat Municipal Corporation (SMC) area due to expansion of Surat city limits owing to urbanization. Therefore, to calculate the water demand for rural area was considered as 60 lpcd instead of semi urban area category and for SMC area it was considered as 135 lpcd. This RRWSS also covers the water demand of 55 MLD of Surat Urban Development Authority (SUDA) and 5 MLD for Special Economic Zone (SEZ). Therefore, the Ultimate design water demand considerations include 24.72 MLD (21%) of rural water requirement and 93.16 MLD (79%) of urban and industrial water requirement.

Table 3.3 Projected Population and Water Demand, RRWSS Variav Group, Surat

Village/Town covered	Population				
	1991	2001	2004 (Base Year-25% increase per 15 year)	2019	2034
Choryasi, Kmarej, Olpad,	333892	544260	611795	764750	917703

3.2.2 RRWSS Gadhada Group, Bhavnagar

Government of Gujarat spared 275 MLD of water for the Saurashtra pipe line project from Mahi-Pariej project and Kanewal storage pond which include the Bhavnagar, Rajkot, Amreli, Pipavav Industry & Bhal area of Ahmedabad. In Gadhada group mainly 67 villages and 1 town Gadhada are covered. Further, Gadhada group water distribution system is divided into four sub groups based on topography and ease of hydraulic flow conditions. Table 3.4 shows the projected population and water demand for the design. Against the present water demand, 250 MLD of water is available for Bhavnagar, Amreli district and Jasdan Taluka of Rajkot district & hence 46 LPCD water is considered for supply, but on completion of Narmada canal based project, 70 LPCD water can be supplied into the scheme.

It is also noticed that Out of 67 villages only 49 villages are taking water at present. These villages reduced to nearly 30 in monsoon. The villages not taking water depend on local source and thus at present in the scheme actually 1,19,358 souls taking water though it cover 1,53,764 souls.

Table 3.4 Projected Population and Water Demand Estimate of Water Distribution Groups among RRWSS Gadhada Group, Bhavnagar

Sr. No	Name of Sub group	No. of Villages/Town	Population in Year 1991, As Per Census	Population Projected in Year 2011 (Water Demand in MLD@ 46 LPCD)	Population Projected in Year 2031 (Water Demand in MLD@ 70 LPCD)
1	Holaya	13	20793	27447 (1.26)	42983 (3.0)
2	Viravadi	21	33341	44011 (2.03)	68773 (4.82)
3	Raliyana	24	46017	60743 (2.79)	94921 (6.65)
4	Adtala	9/1	43320	57183 (4.20)	89351 (7.62)
	Total	**67/1**	**143471**	**189384 (10.28)**	**295938 (22.09)**

3.2.3 RRWSS Ishwaria Group, Amreli

In this RRWSS also the water is made available at present from Saurashtra pipe line project based on Mahi-Pariej project at present. Hence, at present 46 LPCD water is considered for supply, but on completion of Narmada canal based project, 70 LPCD water can be supplied into the scheme. Table 3.5 shows the population forecast and the water demand for Ishwaria group.

Table 3.5 Projected Population & Water Demand Estimate for the RRWSS Ishwaria Group, Amreli

No.Of Villages/Town Covered	Population in Year 1991, As Per Census	Population Projected in Year 2011 (Water Demand in MLD@ 70 LPCD)	Population Projected in Year 2021 (Water Demand in MLD@ 70 LPCD)	Population Projected in Year 2031 (Water Demand in MLD@ 70 LPCD)
49- Villages	79665	105156 (7.36)	131449 (9.2)	164314 (11.5)

It is also noticed that Out of 49 villages, 12 villages are not taking water at present as they depend on the local water sources.

3.2.4 RRWSS Mandvi Group, Kachchh

The RRWSS Mandvi group is mainly divided in two sub groups. One which is completed covering 40 villages of Mandvi and the other cover Mau region having 31 villages. Prior to the water supply made available through Narmada Bulk Water Supply pipe line project, the scheme relied upon 6 tube wells. At present Mandvi region is mainly served from Bulk water supply pipe line project via sub head works at Madanpura and Bidada. The population for the base Year 2001 is considered as 72,261 (as per the census). Based on this the projected populations are considered for design as 85,648 (Year 2011), 90,331 (Year 2016-Intermediate) and 1,08,394 (Year 2031). The water demand assessment was planned at 70 LPCD. Based on this the estimated water demands are 5.93 MLD (Year 2011) and 8.10 MLD (Year 2031).

3.3 Details of Distribution Network for RRWSS Under Study

Various infrastructure facilities for the distribution network in different RRWSS under study & its salient features are listed as under.

3.3.1 RRWSS Variav Group, Surat

In this scheme the main source of water river Tapi which is a perennial river. The water is drawn from the upstream of the weir at village Singanapore, constructed in 1995 on river Tapi to prevent sea water intrusion into the river and to create water body for ensuring safe water supply during lean periods. This weir has total storage capacity of 31 MCM which is found to be adequate to meet the water requirements of Surat city as well as surrounding villages.

An intake well of 8 meter inside diameter is constructed by sinking method, which is 15 meter deep from the river bed and a pump house of 12 meter diameter above it, is constructed. The intake well is jointed with embankment through 7.5 meter wide Mild Steel Approach Bridge. The intake well is ideally located in deep portion of the river so that due to high velocity of water weed growth can be avoided

Presently for the treatment of water 60 MLD water treatment plant is constructed and commissioned in the year 2003-04 (phase-I). The water treatment plant is consisting of conventional water treatment units such as pre aeration, flocculation, clarification, rapid sand filters and post chlorination units. During the visit, overall housekeeping and performance of the plant found satisfactory.

In this project many varieties of pipes are used. The details of pipes from main head work to various sub head works are listed as in Table 3.6

Table 3.6 List of Pipes Used in RRWSS Variav Group, Surat

Type of pipe	Pipe diameter in mm	Length in M
M.S. pipe	1626 mm Ø, 8 mm thick	12750
	1118 mm Ø, 7 mm thick	13100
	914 mm Ø, 6 mm thick	150
	813 mm Ø, 6 mm thick	4800
	711 mm Ø, 6 mm thick	1450
	660 mm Ø, 6mm thick	2600
	610 mm Ø, 6mm thick	2070
	559 mm Ø, 6mm thick	7730
GRP pipe	600 mm Ø, 6 Kg/Cm^2	9750
	500 mm Ø, 6 Kg/Cm^2	500
DI pipe- Class K – 7	500 mm Ø	4030
	450 mm Ø	4255
	400 mm Ø	3724
	350 mm Ø	11755
	300 mm Ø	16792
	250 mm Ø	13190
	200 mm Ø	14012
	150 mm Ø	4887
	100 mm Ø	14629
	80 mm Ø	3665
Total Length of pipe used = 0.24 M/Capita (2001 census) Ø = Diameter		

The total pipes used for this RRWSS consists of DI-64 km, BWSE-25 km, MS-28 km, GRP-6 km, and PVC-93 km. It is also noted that the GRP, PVC & HDPE pipes have 'C' value more than 150, reduce the cost of electricity in water conveyance.

It also noticed that near the slum area of Surat & Surroundings, people play with the Air relief valves and results in losses & thefts. Also, the ownership issues are common where the pipeline supplying water in many part of the Surat city area is of GWSSB and the roads and storm water drains are under Surat Municipal Corporation. This leads to the repairs and maintenance problems.

3.3.2 RRWSS Gadhada Group, Bhavnagar

Gadhada regional water supply scheme is covered under Mahi pipe line project. The main source is from Pariej and Kanewal tank in Kheda district. The tanks are filled from the Limbassi branch of the Mahi irrigation project. The pipe line alignment is from Pariej to Indrana – Wataman – Piply – Wadheda – Botad - Gadhada. About 275 MLD of water from this is reserved for the Saurashtra pipe line project. And the main source of this RRWSS is Saurashtra pipe line project.

The design capacity of water treatment plant is 1385 m^3/hour (22 hrs. of run) where as the actual quantity of water pumped in to the system was observed during field visit about 5.5 MLD i.e. 250 m^3/hour. It is also noted that the plant was constructed and commissioned in 2006-07 and most units are performing well & overall house- keeping is good.

The pumping machineries are installed for transmitting water as well as lifting water from sump or filtration plant to overhead tanks. Table 3.7 shows the details of pumping machineries.

Table 3.7 Details of Pumping Machinery in RRWSS Gadhada Group, Bhavnagar

	Location	Hours of pumping	Capacity in LPS	Head in M	H.P.
Gadhada	Gadhada HW	16	23	40	20
Adtala	Adtala HW	12	51	35	40
Holaya	Gadhada	16	22	50	25
	Holaya	12	50	35	40
	Bhimdad	12	11	30	7.5
Raliyana	Gadhada	16	49	30	35
	Raliyana	12	111	40	95
	Dhasa	12	26	30	20
Viravadi	Gadhada	16	35	70	55
	Viravadi	12	80	30	50
	Itariya	12	5	30	5

During the studies, in Holaya group working hours for two pumps are calculated (from 1/6/2007 to 10/6/2007) as average to 11.30 hours, whereas per the population of 2007, working hours required are 10 hours only. This shows that the actual running hours of pump are more than calculated running hours for the period.

During visit in the Raliyana group few problems of the impeller in the pump are noticed and the actual discharge received is 22 LPS instead of 41 LPS as per design.

Table 3.8 shows the overall storage capacity in the scheme.

Table 3.8 Detail of Storage Facility for Each Group of RRWSS Gadhada Group, Bhavnagar

Sr. No.	Name of Group	Sump Capacity Lac Litres	R.C.C. E.S.R. at Group Head Works	R.C.C. E.S.R. 12 m. Height at Village level	R.C.C. Elevated Cistern 5.0 m height at Village level
1	Holaya-13 Villages	10.00	5.0 Lacs Lit Cap. & 20.0 m Height	3 Nos.	10 Nos.
2	Viravadi-21 Villages	16.00	8.0 Lacs Lit Cap. & 20.0 m Height	9 Nos.	12 Nos.
3	Raliyana-24 Villages	20.00	12 Lacs Lit Cap. & 25.0 m. Height	6 Nos.	18 Nos.
4	Adtala-9 Villages	10.00	5.0 Lacs Lit Cap. & 22.0 m. Height	5 Nos.	4 Nos.

3.3.3 RRWSS Ishwaria Group, Amreli

Ishwaria group RRWSS was design for 15 years-Intermediate and 30 years- Ultimate life. This RRWSS group is also a part of the Saurashtra pipe line project and taps the water from it which is originating from the source river Mahi. Out of 49 villages as per design,

about 37 villages demanding about 7.36 MLD (Year 2007) are receiving the water.

The water treatment plant consists of all conventional units such as Alum storage tanks, Flocculation and Clarification units, Rapid Sand Filters and Chlorinators with a total capacity of 10 MLD, commissioned in Year 2004-05.

To pump raw water from clear water sump at water treatment plant, two numbers of 65 HP capacity (Discharge capacity-102 LPS & 36 M Head) are provided, out of which one operate at a time and another acts as stand by. Also, at 19 villages, 38 numbers of pumps with 10 HP capacities are provided to lift the water from underground sump to Elevated Service Reservoir. It is also noted during the visits, some of the pumps at various villages including Kedichand group & Haripura are under repairs for long time and water supply relies on single pump without any stand by.

A clear water sump and ESR facilities are provided at some villages, as shown in the Table 3.9. However, at certain villages the elevated cisterns are provided with the underground sumps.

Table 3.9 Sump & ESR facilities in RRWSS Ishwaria Group, Amreli

Name of sub head work	Sump / ESR	Capacity in Lac Litres
Near village Toda	Sump	2.0
	ESR	1.0, 19 m. height
Akala village	Sump	2.0
	ESR	1.0, 13 m. height
Lalavader	Sump	50,000 lit
	ESR	50,000 lit,12 m. height
Haripura	Sump	5.0
	ESR	2.0, 12 m. height
Vitthalpur	ESR	2.7, 18 m. height

3.3.4 RRWSS Mandvi Group, Kachchh

This RRWSS mainly consists of two head works namely Bidada and Madanpura. For lifting the water and supply in distribution network, 50 HP (37 KW) capacity with 75 M head & discharge capacity of 92 LPS pump is fitted at Bidada head works and 100 HP (75 KW) capacity with 108 M head & discharge capacity of 35 LPS pump is fitted at Madanpura head works. For the treatment of water based on river Narmada, water treatment plant was constructed and commissioned in the year 2004 with a design capacity of 410 m^3/hr. Six number of storage reservoirs were constructed in the various distribution zones as per the following Table 3.10. It is noted during the field visits that the total storage including these six storage reservoir (60%) is about the 90% of total water requirement.

Table 3.10 Details of Storage Reservoirs in RRWSS Mandvi Group, Kachchh

Sr. No.	Type of Storage	Capacity	Location
1.	Open RCC Sump	50 Lac Litres – 1 No.	At Bidada HW Site
2.	RCC Sump	30 Lac Litres – 1 No.	At Bidada HW Site
3.	RCC Sump	20 Lac Litres – 1 No.	At Madanpura HW Site
4.	RCC ESR	13 Lac Litres 12 M height –1 No.	At Bidada HW Site
5.	RCC ESR	3.57 Lac Litres 12 M. height –1 No.	At Bidada Village
6.	RCC ESR	10 Lac Litres 12 M height –1 No.	At Bhadai Moti Village
Total Storage Capacity		126.57 Lac Litres	

Further, it is also noticed that the water received through Narmada Pipe line NC -11 is received at Bidada head works and after treatment it is conveyed to Bidada and Bhadai zones through separate lines with Valves fitted on it. The overall distribution comprises of the following type of pipes. (Table 3.11)

Table 3.11 Details of Pipes Used in RRWSS Mandvi Group, Kachchh

Type of pipe	Size in mm	class	Length in M
DI pipe	400	K-9	700
	350	K-9	8700
	300	K-9	6000
	250	K-9	29550
	200	K-9	15700
PVC pipe	160	6 Kg / sq cm	13500
	140	6 Kg / sq cm	28800
	110	6 Kg / sq cm	19700
	90	6 Kg / sq cm	32500
Total Length of pipe used = 0.47 M/Capita (2001 census)			

4 CRITICAL EVALUATION OF SERVICE PERFORMANCE USING DEVELOPED INDICATORS

Level of service is an important aspect for the performance evaluation from the suppliers as well as consumers' point of view. This aspect directly relates the perceived benefits of the services provided which the users' entertain against the cost paid by them or spent by the suppliers. Similarly, the management aspects involve the administration capabilities for the supply of various services to the users.

Sustainability of source, adequacy of water, reliability of water supply, acceptable water quality amongst the users', awareness in users' for water supply services, etc. are some key indicators used for the performance evaluation of various RRWSS in the present chapter.

4.1 Sustainability of Source

Most of the water supply schemes were traditionally designed based on locally available water source. However due to non-perennial surface water source during summer it became dry, was not uncommon in many water supply schemes. Similarly, with the increase in ground water withdrawal; the ground water table progressively declining. Therefore in schemes based on ground water sources, Due to decline in water table and deterioration in the quality of ground water, source failure is very common. In summer, these sources are also getting dry and water supply fails.

Gujarat is having 1100 km long coastal belt. Due to over withdrawal of the ground water, sea water intrusion takes place and ground water become saline.

Some of the schemes which were designed based on small ponds or water supply from branch irrigation canals were also failed due to non

sustainable source in overstressed summer season. Also, the quality of surface water in some of the industrial and urban belts is deteriorating due to pollution problems.

Therefore, for the sustainability of any water supply scheme, it is very much necessary to select the appropriate and reliable source.

4.1.1 RRWSS Variav Group, Surat

The source of RRWSS Variav group, Surat, is intake well which is located in the u/s of causeway constructed on river Tapi, near Surat city. The river Tapi is having main catchment in the state of Maharashtra; a second largest Ukai dam of Gujarat is constructed on this river. Kakrapara weir is also situated on this river. River Tapi is perennial moreover, due to Ukai and Kakrapara weir and the sufficient quantity of water is available throughout the year. The cause way is constructed on river Tapi near Surat city and has a storage capacity of 31 MCM which is adequate with the water requirement of Surat city as well as rural and other users. So, source is sustainable as far as the water availability is concerned. However, due to the construction of another well for potable water demand of the Surat city and high silting rate, some issues of source sustainability are also raised in past few years.

The river Tapi has faced floods for many years, for example in the year 1968, 1974, 1998, 2002 & 2006. During the flood, silting rate increased which may affect in longer time.

It has been stated by Central Pollution Control Board that the stretch of the river Tapi, that passes through the city of Surat is moderately polluted. Tapi waters at Ukai Dam and at Mandvi were upgraded to Class A (drinking water source without treatment but after disinfection) in 1997 from class B (useful for outdoor bathing only) in 1991. The waters at Kathor Bridge after entering the city are put under

class B. It has been observed that there has been a rise in the COD (Chemical Oxygen Demand) level at all three locations namely, near Ukai dam, Mandvi & Kathor Bridge.

During the flood high turbid water may disturb the filtration plant. Algal growth has also been observed due to stagnation of water in source, which may deteriorate the quality of source water.

4.1.2 RRWSS Gadhada Group, Bhavnagar and RRWSS Ishwaria Group, Amreli

These water supply schemes have a main source Pariej and Kanewal tanks. The tanks are filled from the Limbassi branch of the Mahi irrigation project. Vegetative growth in this tank is very high and that is not regularly removed. This vegetative growth is not only affecting the quality of water as well as functioning of intake structure. During the consecutive draught years, the source may fail, for example, during 1985 to 1987, Gujarat has faced draughts. The silting process may reduce live storage of the pond and in long term it requires desilting process.

4.1.3 RRWSS Mandvi Group, Kachchh

The Mandvi group RRWSS is designed on the bulk water supply pipe line to Kachchh by NC 11 and NC22. These pipe lines are filled from an intake structure constructed in Malia Irrigation branch of Sardar Sarovar Project. So, source is sustainable. After facing earthquake in year 2001, in this region, Government gave higher subsidies for industrial development. Many industries came after this earthquake. The main water supply source is also this bulk water supply lines. The irrigation project recovers higher revenue or water charges from these industries for water supply as compared to drinking water supplies. So, industrial

withdrawal of water is much higher as compare to the quantity at design level. So, tail end villagers may not get sufficient water from this source.

4.2 Adequacy for Water Supply

In June 2002, Government approved relaxation of 'coverage' norms under ARWSP to provide for 55 lpcd with a source within 0.5 km in the plains and 50 meter elevation in the hills after coverage of all NC/PC rural habitations in that State is achieved as per the then existing norms of 40 lpcd with a source within 1.6 km and elevation of 100m. This relaxation was subject to the condition that beneficiaries of the relaxed norms were willing to share a part of the capital cost (which should not be less than 10%) and shoulder full responsibility for subsequent operation and maintenance. The norm of 40 lpcd for humans is based on the following requirements:

Table 4.1 Potable Water Quantity Requirement for Various Purposes

(Source: Manual on Water Supply and Water Treatment, 1999)

PURPOSE	QUANTITY IN LPCD
Drinking	03
Cooking	05
Bathing	15
Washing utensils and house	07
Ablution	10
Total	**40**

The norms have been established by the Government of India in order to attain a network facility for providing an acceptable level of water consumption within a stipulated time frame. However, the term 'acceptable level' is crucial and subjective as it decides the level of

satisfaction in evaluation of service performance of the water supply program. Therefore, in the face of resource constraint, the tendency is to impose economy measures. It is also observed that most of the RRWSS in the state of Gujarat are designed to supply 40 lpcd for the initial phases and at a later stage it may consider 70 lpcd norms.

Further, it is difficult to evaluate the 'adequacy of water supply' for different groups in RRWSS, as number of villages and habitations involved are more in numbers as well as their locations vary from headwork. Therefore, in selected RRWSS, adequacy of water is checked by analyzing technical data provided by GWSSB and by carrying out user data survey in certain villages. The results of the user data survey is grouped in the three categories namely, villages located near headwork- Head Villages, villages located near medium distances from the headwork- Intermediate Villages and villages located away from headwork- Tail Villages. (Note: Approximation is carried out on map and advice of GWSSB officials are used for judging the distances from headwork)

4.2.1 RRWSS Gadhada Group, Bhavnagar

In RRWSS Gadhada group, Bhavnagar, the demand assessment was planned at 46 lpcd from Mahi-Pariej project, and upon the receipt of water from Narmada canal project, it can be considered 70 lpcd. During the study period it is observed that only 49 villages are taking water from 67 villages and 1 town, as per design. The villages not taking water depend upon bores/ local source. It is also noted that the common bore and pumping stations are receiving free electricity. It is also noted that some of the villages mix their bore water with the GWSSB water supply to augment their supply.

The total quantity of raw water as per actual design is about 7.07 MLD (presently about 6 to 6.5 MLD) but the quantity of water received is averaging to 5.5 MLD.

During the field visits, in several villages, the actual water available is found about 90 to 100 lpcd.

Table 4.2 Number of Responses of Users' Data Survey for 'Adequacy of Water' in RRWSS Gadhada Group, Bhavnagar

Category of Villages in RRWSS, Gadhada Group, Bhavnagar	Total Number of Responses collected
Head Village	120
Intermediate Village	168
Tail Village	271
Total	559

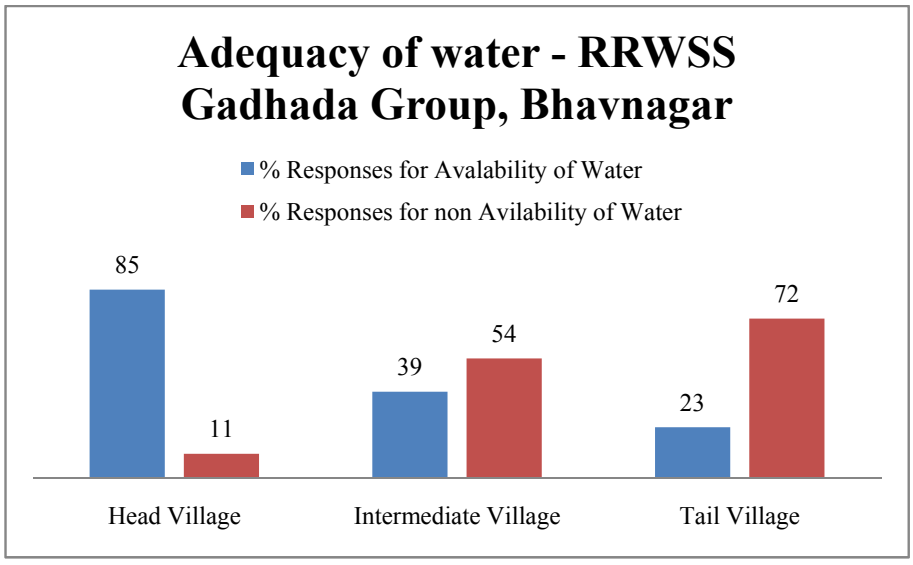


Figure 4.1 Graph showing the % Responses for 'Adequacy of Water' in RRWSS Gadhada Group, Bhavnagar

4.2.2 RRWSS Ishwaria Group, Amreli

As per the design of the scheme, rate of water supply is 70 LPCD considering the water available from Narmada canal based project (partially), which is confirmed during the site visit that the actual rate of water supply is 70 LPCD as per GWSSB staff. For assessing the total quantity supplied water, the number of hours are calculated for pumps at headwork for certain month data, this shows the average of about 5 MLD water supply, which is in slight shortage of the estimated about 6 to 6.5 MLD for population estimates. However, it is also noticed that only about 39 villages were supplied the water as 12 villages are not taking water and rely on own/local source. Further, during the field visit, actual measurements are carried out at consumers' end, which counted about 100 to 140 LPCD. In the user data survey, the responses are satisfactory for Head and Intermediate villages, whereas in Tail end villages, about 60% respondents are getting adequate water.

Table 4.3 Responses of Users' Data Survey for 'Adequacy of Water' in RRWSS Ishwaria Group, Amreli

Number of Responses collected	Responses for Availability of Water	Responses for Non-Availability of Water	Total Responses
Head Village	66	3	69
Intermediate Village	163	35	198
Tail Village	121	82	203
Total	350	120	470
Remark # User not responded for this question are not considered for the evaluation purpose			

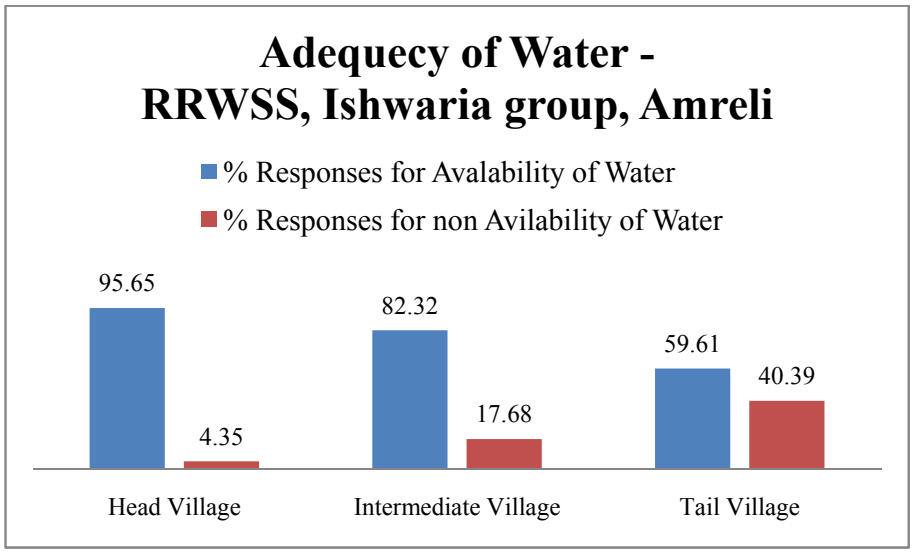


Figure 4.2 Graph showing the % Responses for 'Adequacy of Water' in RRWSS Ishwaria Group, Amreli

4.2.3 RRWSS Mandvi Group, Kachchh

In Users' data survey, about 462 responses were collected for the RRWSS Mandvi group. The variations for the availability and non availability of water are determined for Head, Intermediate and Tail end villages of the scheme. Table 4.4 is showing the overall distribution of responses collected throughout the scheme for categories of village with reference to its distance from headwork. Whereas from figure 4.3, it is revealed that the tail end villagers are mostly not receiving the water from the RRWSS; which may due to inadequate bulk water supply in the scheme.

Table 4.4 Responses of Users' Data Survey for 'Adequacy of Water' in RRWSS Mandvi Group, Kachchh

Number of Responses collected	Responses for Availability of Water	Responses for Non-Availability of Water	Total Responses
Head Village	174	66	240
Intermediate Village	34	67	101
Tail Village	2	119	121
Total	210	252	462
Remark # User not responded for this question are not considered for the evaluation purpose			

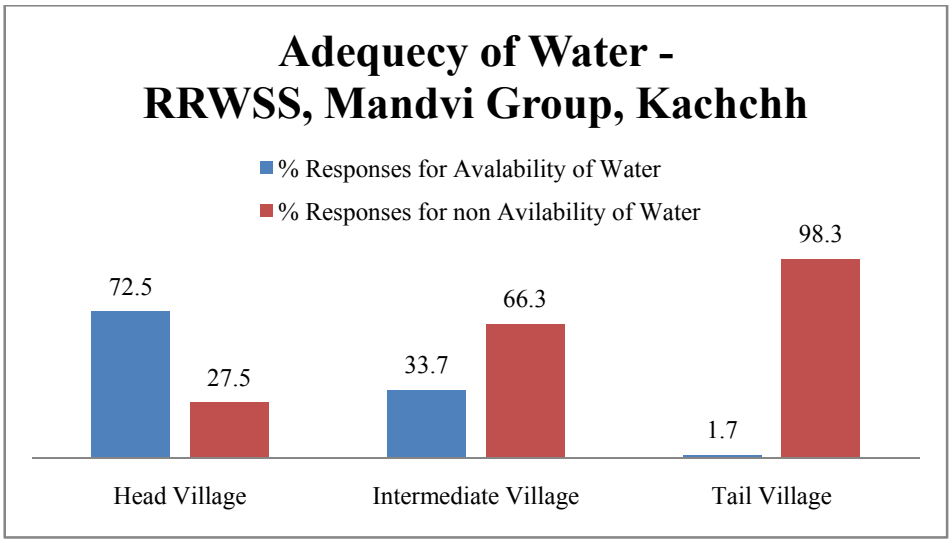


Figure 4.3 Graph showing the % Responses for 'Adequacy of Water' in RRWSS Mandvi Group, Kachchh

Further, the study has also been carried out for the overall availability of water and its variations through various seasons, that is, monsoon, winter and summer. The figure 4.4 clearly indicates that the services for overall availability of water is more in case of RRWSS Variav group compare to RRWSS of Saurashtra and Kachchh, where water is scarce. Also, in RRWSS Variav group, water is available in adequate for summer season, which is not the case in schemes of Saurashtra. The RRWSS Mandvi group is seriously suffering from inadequate water availability point of view in most seasons of the year.

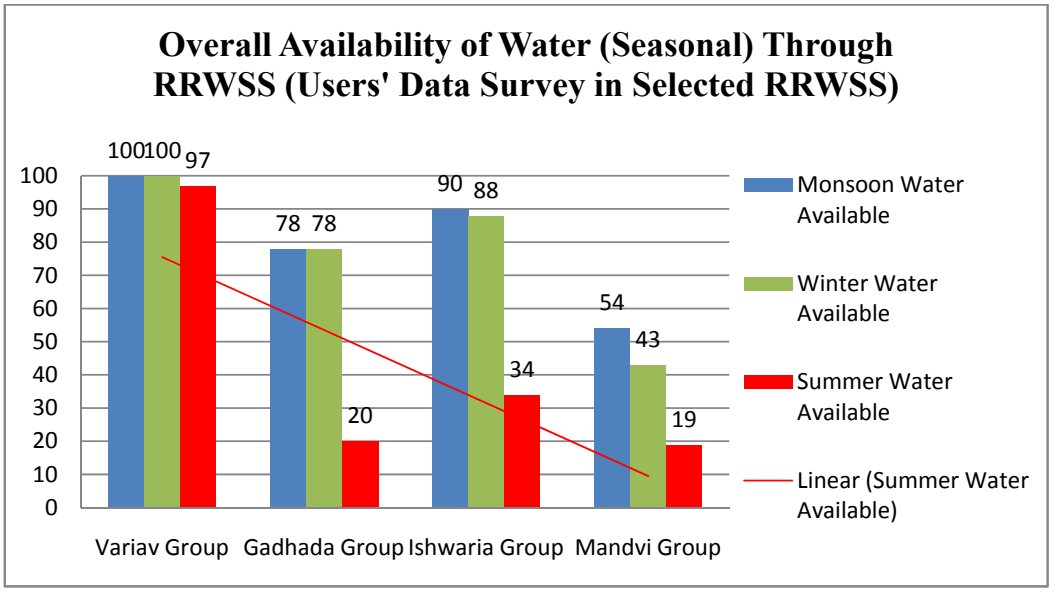


Figure 4.4 Graph Showing the % Responses for 'Overall Availability of Water' Through Various Seasons in Selected RRWSS

4.3 Reliability for Water Supply

Reliability is not a simple indicator to assess, and yet in terms of users' satisfaction which is ultimately more important for the sustenance of water supply scheme. The assessment of reliability is quite complex in practice of water supply as it rely on several variables. For example, if the pump is not working for one or two days, but the supply tank (ESR) is large enough to supply at all taps, then there is no impact on reliability. Similarly, if a feeder pipe breaks, and one of the many regions' taps are not receiving water, still as most users' are receiving water except those 5-7% users, but most users are still happy with the service. If another main pipe, such as rising main, breaks and all users are not receiving the water for few days, then it is considered as serious problem. Therefore, a reliability of service needs to be measured carefully for a particular scheme.

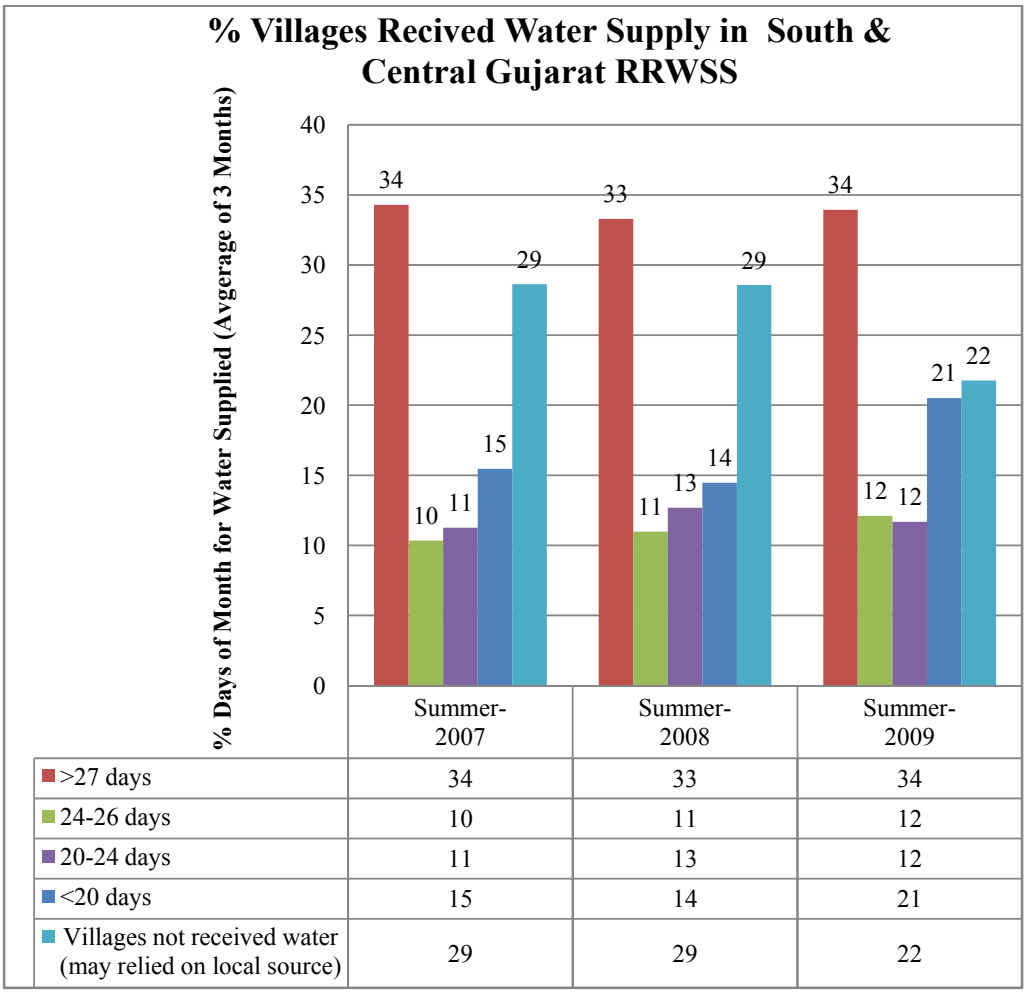
A characteristic of many Regional Rural Water Supply Schemes is that the bulk water supply is discontinuous, particularly in the case of stand-alone systems reliant on pumps, excessive water withdrawal from front end villages, inadequate water in source during summer, etc. The cause of the failure may or may not be beyond the control of local Pani Samitis. Therefore, in the evaluation process for RRWSS, indicator selected is for the percentage days of month for which water received, especially in summer season.

$$\boldsymbol{Indicator = \frac{Number\ of\ days\ water\ received}{Number\ of\ days\ in\ the\ Month}}$$

For the evaluation of water supply reliability indicator, a group of regional rural water supply schemes of whole South & Central Gujarat are selected.

Table 4.5 Showing Frequency of Water Received in Number (Average) of Villages for Summer Season for South & Central Gujarat Schemes (Source: GWSSB)

South & Central Gujarat Schemes	**Water received for number of days in month (Average of 3 months)**				
Water Supplied	**>27 days**	**24-26 days**	**20-24 days**	**<20 days**	**Villages not received water (may relied on local source)**
Summer-2007	974	294	320	439	813
Summer-2008	939	310	358	408	806
Summer-2009	892	318	307	539	572



	Summer-2007	Summer-2008	Summer-2009
>27 days	34	33	34
24-26 days	10	11	12
20-24 days	11	13	12
<20 days	15	14	21
Villages not received water (may relied on local source)	29	29	22

Figure 4.5 Graph Showing % Villages Received water in Summer Season (Reliability of Water Supply) for South & Central Gujarat Schemes

Chart 4.1 and 4.2 are showing the gap of water for supply against the water demand in various RRWSS of Saurashtra and Kachchh region. The detailed analysis of water supplied or received through bulk water supply based on river Mahi and Narmada has been carried out along with the staff of GWSSB recently. The calculation of water demand at each headwork is carried out using the population census data of Year 2011 against the actual water supplied for two months of January (chart 4.1) and February (chart 4.2). These charts are clearly indicating that at many headworks the gap between the water supplied and actual water demand

lies even in the mid of winter season. In the RRWSS situated near the front end of supply projects it is noticed that villages mostly receiving the water even higher than the actual demands. The reason for this may be due to availability of good quality water against the deep sources of underground local sources, users like to withdraw more water from the bulk water supply based RRWSS water. On the contrary, it is noticed that till the bulk water supply projects are under progress and substantial works need to be commissioned in next few years, the tail end head works are not able to get the sufficient water as per the actual demand, therefore, such RRWSS performance is seriously affected.

4.4 Acceptable Water Quality

It is common knowledge that the management of water resources dates back to 5th Century B.C. when, 'Treatise on Air, Water and Place' became part of the Hippocratic Corpus. Yet it is wonder that humanity realized only in 19th Century A.D. that water is one of the important determinants of health and disease. Even in this computer era of phenomenal scientific and technological developments, it is rather disconcerting that there are still constraints in achieving water quality assurance especially in the rural areas of developing countries like India and others.

Based on the stipulations of the World Health Organization and US Public Health Services, Bureau of Indian Standards in their IS:10500-1991 'Specifications for Drinking Water' have exhaustively stipulated limits for water supply and monitoring authorities for adoption and certification to ensure clean and hygienically safe water for human consumption.

When the theoretical knowledge of treatment remains intact universally, in the practical implementation the system suffers widely due to inherent defects, lack of systematic approach and co-ordination.

Common defects include lack of frequent monitoring of raw water quality especially turbidity, poor maintenance of clarifier, ineffective desludging, irregular filter backwashing and algae removal without parallel standby system for continuous treatment. The ritualistic lackadaisical approach in dosing coagulant chemicals results in deterioration of water quality in addition to mud ball formation in filters resulting in ineffective filtration, growth of micro organisms, deterioration of filtered water clarity even compared to raw water; Haphazard chlorination causes either super chlorination and consumer aversion or in-adequate chlorination, lack of contact time resulting in ineffective disinfection. Recontamination of treated water is the worst in that the treatment cost becomes anfractuous and also leads to incidence of waterborne diseases.

Invariably the distance between treatment works and supply area is too long as in Regional Rural Water Supply Schemes and hence the water from the main is stored in service reservoirs and distributed. In such cases there is every possibility of dissipation of chlorine in the mains and hence secondary chlorination to impart a residual of at least 0.1-0.2 mg/lit at consumers' tap after 30 minutes contact time is essential.

As water is distributed in network of pipes, the quality may suffer also due to

1. Corrosion of pipes
2. Flushing which dislodges foreign matter
3. Ingress of dirt and living organisms through leaks
4. Cross connections and contamination
5. Water hammer and surge
6. Growth of organisms including bacteria, algae, schizomycetes, worms and insects
7. Solution of metals with which the water comes in contact

The deterioration may be subtle, discouraging and more difficult to correct than undesirable characteristics of water.

Therefore, it is well known that selection of sources, treatment and maintenance of water supply infrastructure is not possible without the monitoring and evaluation on water quality.

Water quality at source, after treatment & disinfection practices employed at various stages of water distribution network is studied. Grab sampling is done with the help of field staff and water quality is checked for various parameters in all selected schemes. Users' data survey carried out also taken into consideration while summarizing the various facts. Figure 4.6 shows the water quality satisfaction in selected RRWSS during the users' data survey. It is clear from the response of users' that in most schemes, water received through regional scheme meet the satisfactory water quality.

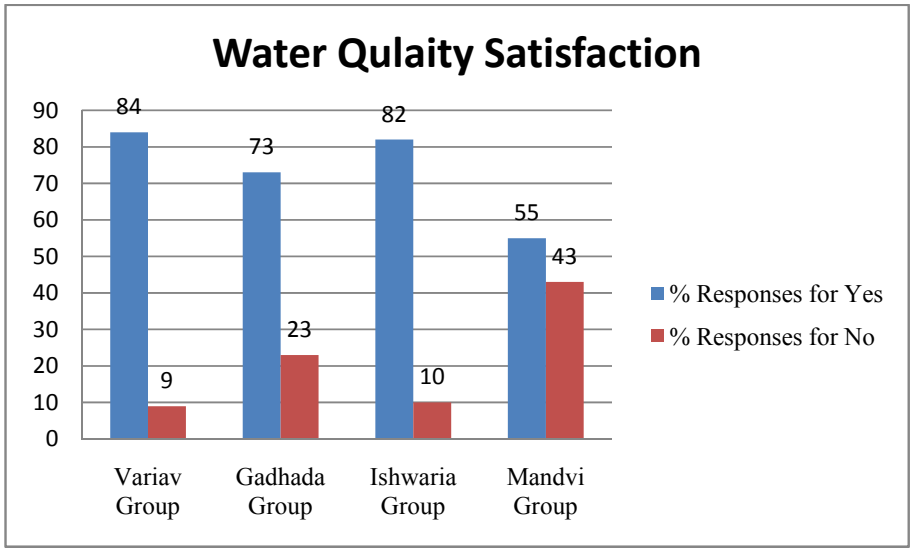


Figure 4.6 Users' Data Survey Results on Water Quality Satisfaction in Selected RRWSS

In users' data survey another important outcome received is that in all schemes most villagers' are aware about the chlorination. During the field visits, it is noticed that the Gram Panchayats and local NGOs' are

making good publicity for the awareness for water and sanitary hygiene. Figure 4.7 shows the results of Users' Data Survey on awareness of chlorination in selected RRWSS.

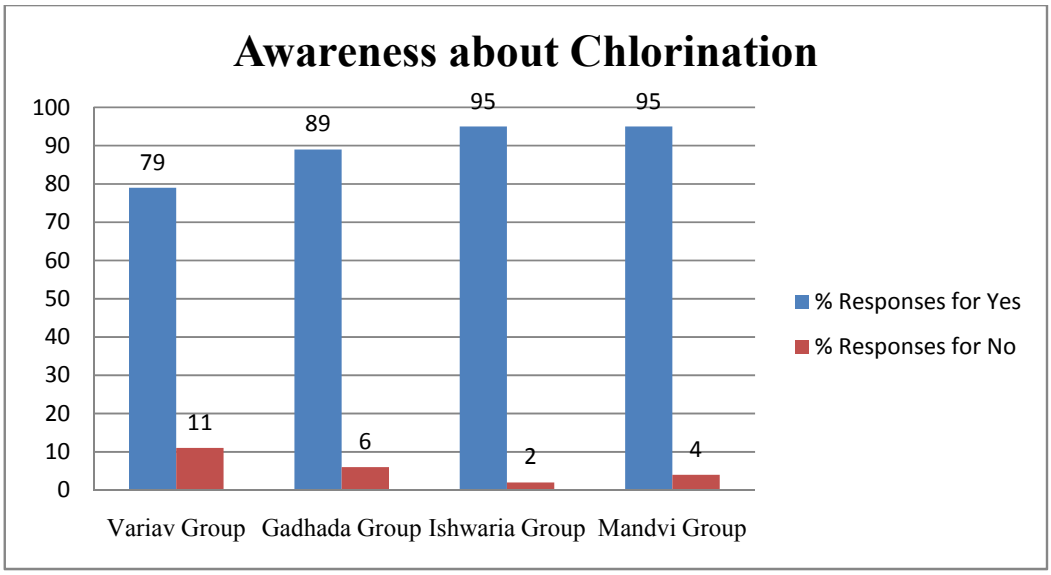


Figure 4.7 Users' Data Survey Results on Awareness of Chlorination in Selected RRWSS

In the study it is also tried to check the awareness of users regarding various treatment methods for the water which they consume. Therefore, in Users' Data Survey, information regarding the awareness regarding domestic methods of treatment such as boiling, filtration, use of chlorine tablets, bleaching powder, use of alum and commercial purifiers, etc. has been covered. Figure 4.8 is showing that the methods such as boiling, use of purification tablets and filtration are popular in most schemes. Further, the RRWSS Mandvi group scheme shows the less awareness for above methods compare to other schemes. This may be due to none or less presence of NGOs, WASMO and/or social organizations in the region active to create awareness in water quality.

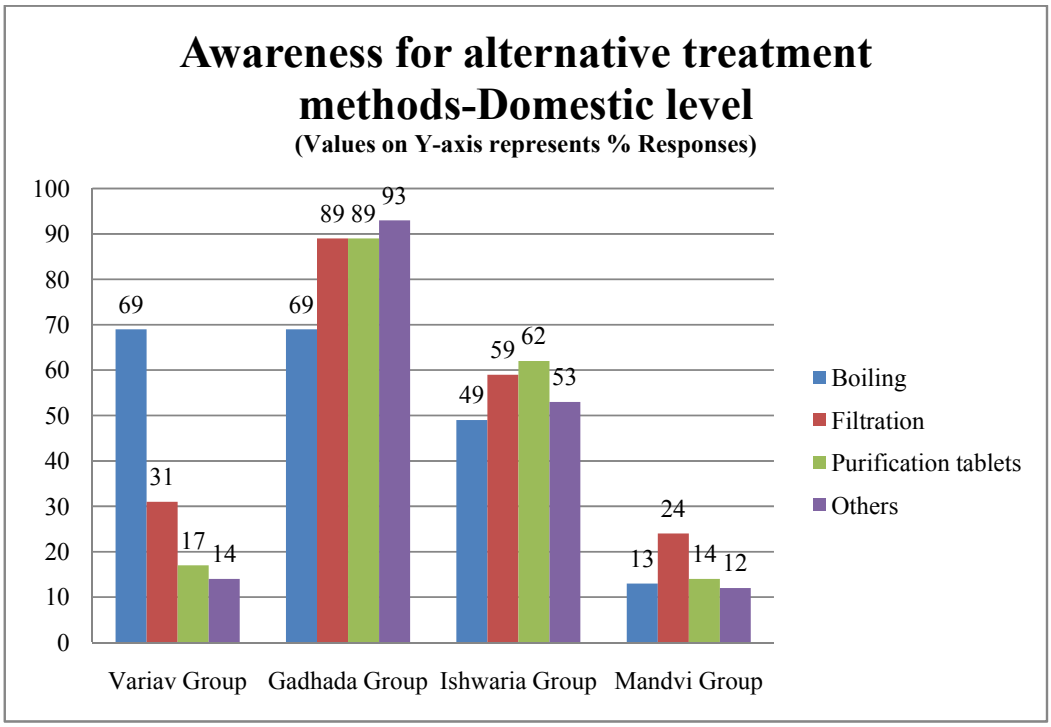


Figure 4.8 Users' Data Survey Results on Awareness for Alternative Treatment Methods Used on Domestic level

4.5 Service Performance Index (SPI)

Service performance is dependent of four indicators as discussed and is as listed below.

- Sustainability of Source
- Adequacy of Water to tail enders
- Water supply reliability
- Acceptable water quality

For the determination of overall service performance, the above indicators can be rated as excellent, medium to high, low to medium and poor. Further, to evaluate the overall service performance of any scheme, importance of all or some of the above indicators may be kept same or different depending on the necessity or importance of above indicators in

the scheme or site specific conditions. So, to evaluate the overall service performance, an Index value may be calculated as per Equation 4.1. Service Performance Index (SPI) can be expressed as

$$SPI = \frac{\sum_{i=1}^{4} Ii\, Wi}{Wmax\, x \sum_{i=1}^{4} Ii}\ x\ 100 \quad \text{Equation 4.1}$$

$$SPI = \frac{I_1W_1+I_2W_2+I_3W_3+I_4W_4}{W_{max}(I_1+I_2+I_3+I_4)} \text{ X } 100 \quad \text{Equation 4.2}$$

Where, W= Weights assigned to each of the indicators based on their ratings; and I= Importance factor for each of the indicators based on their impact on overall service performance and its interrelation to other indicators.

SPI varies from 0 to 100, 100 being the maximum index value with all factor rated as excellent. 0 is the minimum index value that a service can have when all the factors have a 'poor' rating. In general, higher is the index value; better is the service performance of the scheme.

In order to define performance of a service based on the ratings as an Index (numerical value), four ratings may be assigned as weights (0 to 1). The selection of weights for above ratings requires skillful observations which may vary from field conditions. For a present study of Gujarat state, the selected value of weights is as per Table 4.6 (Excellent Performance, W = 1.0, Medium to High Performance, W= 0.65, Low to Medium Performance, W= 0.35, Poor Performance, W = 0.0).

Importance factor (I) attached with Sustainability of source, Adequacy of water to tail enders, Water supply reliability and Acceptable water quality can be same for all or different, as per the user's judgment. The value of the importance factor may differ as per the site specific conditions such as RRWSS lying in the water rich area or water scarce area (i.e importance of water to villagers for drinking in presence/absence of water available from an alternative source).

Table 4.6 Showing Ratings and Weights Assigned for the Various PI's for the Evaluation of Service Performance of an RRWSS

Service Performance Indicator	Rating	Description	Weight Assigned
Sustainability of Source	Excellent Performance	Perennial surface water, Sustainable ground water source with continuous water recharge	W_1= 1.0
	Medium to High Performance	Perennial surface water source with limited availability, ground water source with seasonal recharge	W_1= 0.65
	Low to Medium Performance	Non perennial surface water source, Non sustainable ground water sources with seasonal recharge	W_1= 0.35
	Poor Performance	Non sustainable ground water sources with unknown recharge	W_1= 0.0
Adequacy of Water to tail enders	Excellent Performance	Available water through supply during non monsoon periods > 70 lpcd	W_2= 1.0
	Medium to High Performance	Available water through supply during non monsoon periods between 40- 70 lpcd	W_2= 0.65
	Low to Medium Performance	Available water through supply during late summer periods < 40 lpcd but for other periods between 40-70 lpcd	W_2= 0.35
	Poor Performance	Available water through supply during most periods of year < 40 lpcd	W_2= 0.0
Water supply reliability	Excellent Performance	Water supplied during non monsoon periods >27 days/month	W_3= 1.0
	Medium to High Performance	Water supplied during non monsoon periods between 20-27 days/month	W_3= 0.65
	Low to Medium Performance	Water supplied during non monsoon periods <20 days/month but in other periods > 20 days/month	W_3= 0.35
	Poor Performance	Water supplied during whole year is < 20 days/month	W_3= 0.0
Acceptable water quality	Excellent Performance	Source water meets potable water quality criteria with least/conventional water treatment throughout year	W_4= 1.0
	Medium to High Performance	Source water may turn up to non potable category during summer, but adequate treatment facilities available	W_4= 0.65
	Low to Medium Performance	Source water become non potable category during summer and no treatment facilities/ alternate sources	W_4= 0.35
	Poor Performance	Source water become non potable category during most period of year except during monsoon period & no treatment facilities/ alternate sources	W_4= 0.0

Further, from the study it is also revealed that the ‘Sustainability of source’, ‘Adequacy of water to tail enders’ and ‘Water supply reliability’ are also mutually related and rely partially on each other. Therefore, to evaluate the overall SPI, the selection of importance factor for each PI needs to be carefully selected. In a present study of the Gujarat state for various RRWSS under study area the value of the weights and importance factor selected are as per Table 4.7.

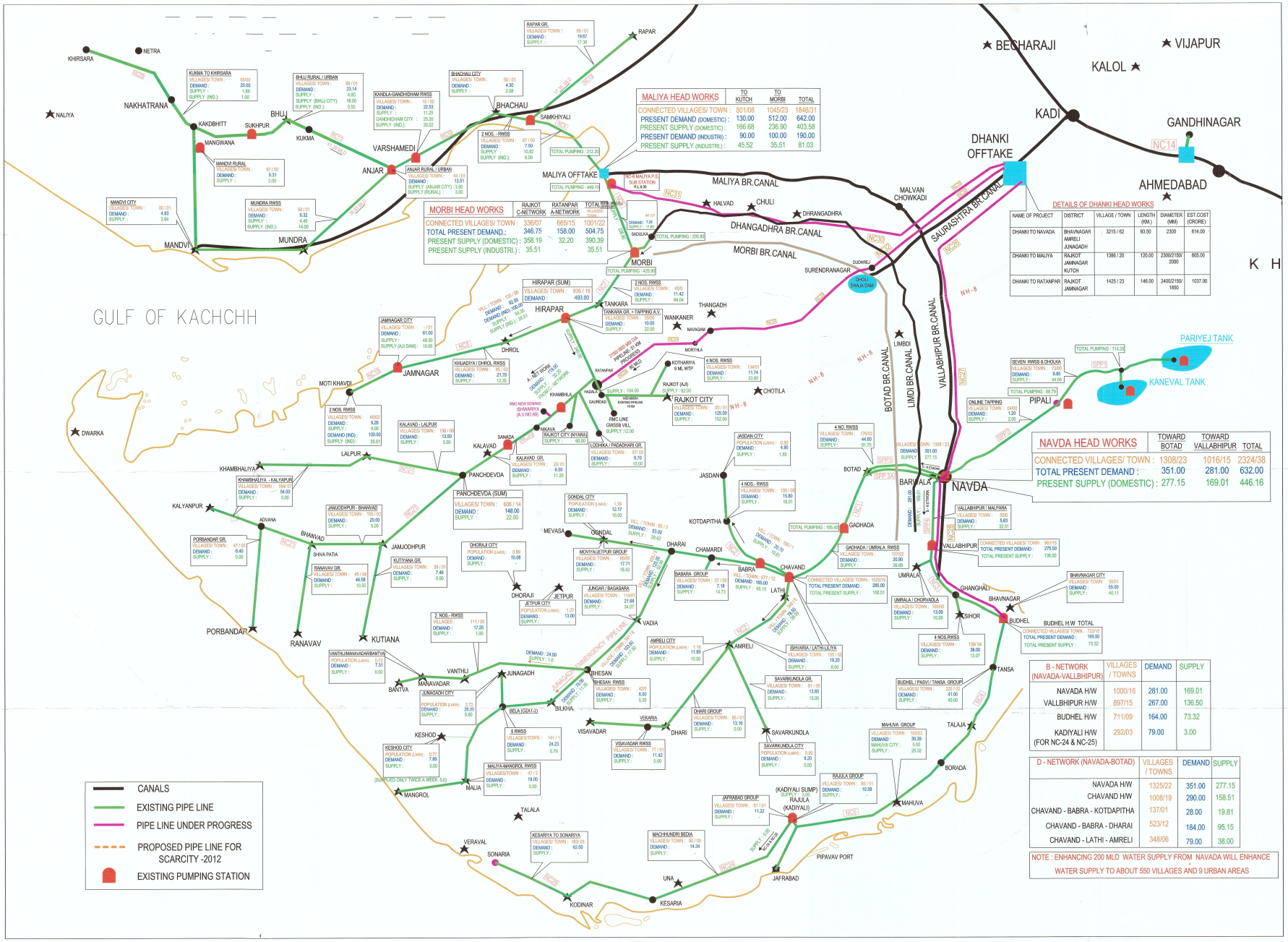
Following assumptions are also made for calculating the overall SPI for above schemes are as under:

1. Service Performance Indicators such as ‘Sustainability of source’ and ‘Acceptable water quality’ are much more important at planning stage of any RRWSS, whereas the 'Adequate water supply to tail enders' & 'Water supply reliability' are more important at the operating stage of any RRWSS. By keeping this in central focus, while calculating SPI for four schemes under study the importance factor for later two PI’s are doubled.
2. Weights given for the ‘Sustainability of source’ indicator is assigned as 0.65 for the Gadhada, Ishwaria & Mandvi RRWSS by keeping in mind that though the RRWSS’s are relying on sustainable surface water of river Narmada but indirectly on pumping and on other operations of Narmada water supply pipe networks.
3. The ratings for the overall SPI value is interpreted as:

Value of SPI	**Performance Rating**
>80	Excellent Performance
>55-80	Medium to High Performance
>35-55	Low to Medium Performance
0- 35	Poor Performance

Table 4.7 Showing Service Performance Index value for various RRWSS under study area

Name of the RRWSS	Weight (W) & Importance Factor (I)	Service Performance Indicator				Overall SPI value	Performance Rating
		Sustainable water source	Adequate water to tail enders	Water supply reliability	Acceptable water quality		
Variav Group, Surat	W	1.0	0.65	1.0	1.0	88.33	Excellent Performance
	I	1.0	2.0	2.0	1.0		
Gadhada Group, Bhavnagar	W	0.65	0.65	0.65	1.0	60.83	Medium to High Performance
	I	1.0	2.0	2.0	1.0		
Ishwaria Group, Amreli	W	0.65	0.35	0.65	1.0	50.83	Low to Medium Performance
	I	1.0	2.0	2.0	1.0		
Mandvi Group, Kachchh	W	0.65	0.0	0.35	1.0	50.83	Low to Medium Performance
	I	1.0	2.0	2.0	1.0		



MALIYA HEAD WORKS	TO KUTCH	TO MORBI	TOTAL
CONNECTED VILLAGES/ TOWN :	801/08	1045/23	1846/31
PRESENT DEMAND (DOMESTIC) :	130.00	512.00	642.00
PRESENT SUPPLY (DOMESTIC) :	166.68	236.90	403.58
PRESENT DEMAND (INDUSTRI) :	90.00	100.00	190.00
PRESENT SUPPLY (INDUSTRI.) :	45.52	35.51	81.03

MORBI HEAD WORKS	RAJKOT C-NETWORK	RATANPAR A-NETWORK	TOTAL
CONNECTED VILLAGES/ TOWN :	336/07	665/15	1001/22
TOTAL PRESENT DEMAND :	346.75	158.00	504.75
PRESENT SUPPLY (DOMESTIC) :	356.19	32.20	390.39
PRESENT SUPPLY (INDUSTRI.) :	35.51	-	35.51

DETAILS OF DHANKI HEAD WORKS

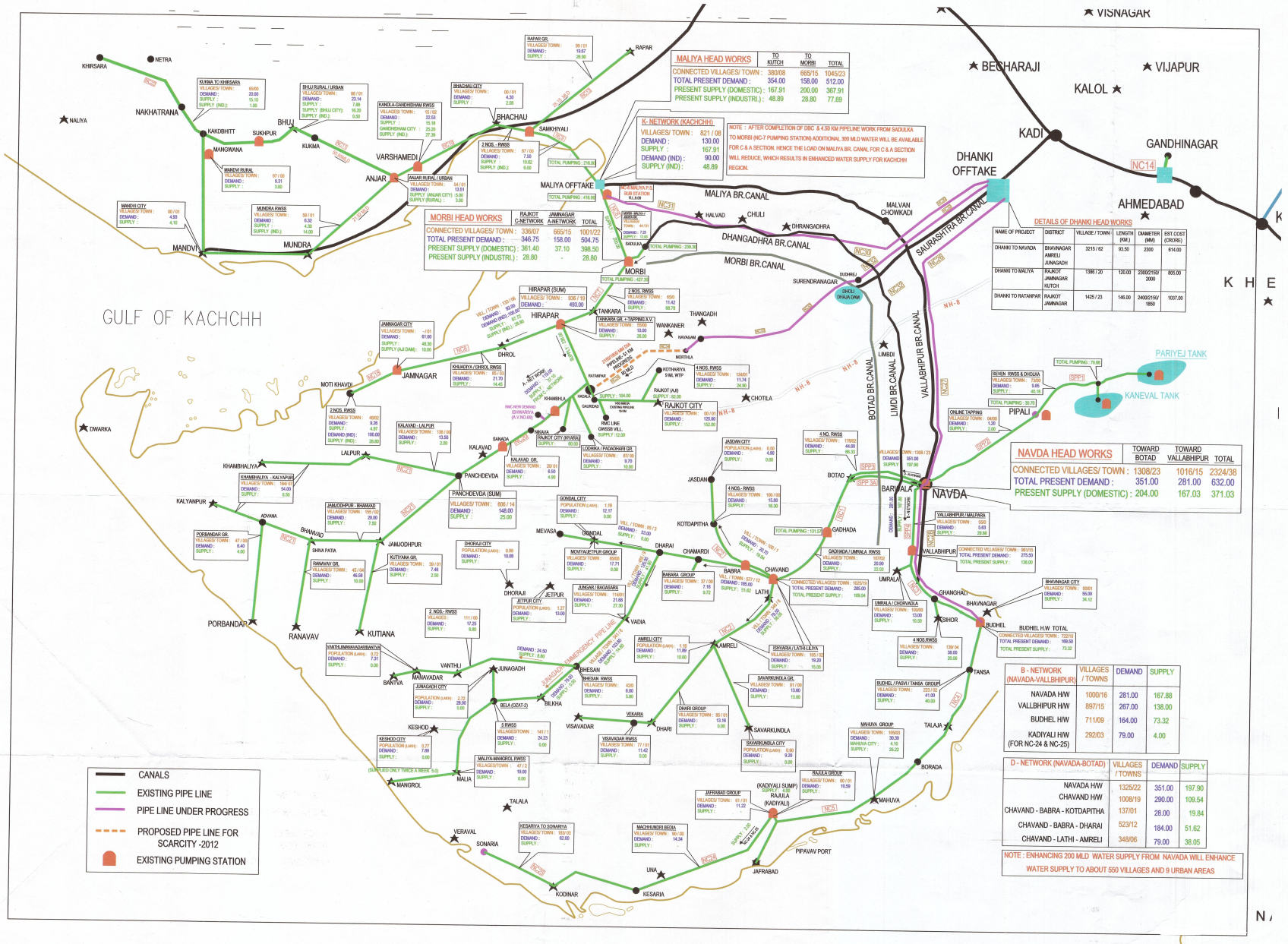
NAME OF PROJECT	DISTRICT	VILLAGE / TOWN	LENGTH (KM.)	DIAMETER (MM)	EST.COST (CRORE)
DHANKI TO NAVADA	BHAVNAGAR AMRELI JUNAGADH	3215 / 62	93.50	2300	614.00
DHANKI TO MALIYA	RAJKOT JAMNAGAR KUTCH	1386 / 20	120.00	2300/2150/ 2000	805.00
DHANKI TO RATANPAR	RAJKOT JAMNAGAR	1425 / 23	146.00	2400/2150/ 1950	1037.00

NAVDA HEAD WORKS	TOWARD BOTAD	TOWARD VALLABHIPUR	TOTAL
CONNECTED VILLAGES/ TOWN :	1308/23	1016/15	2324/38
TOTAL PRESENT DEMAND :	351.00	281.00	632.00
PRESENT SUPPLY (DOMESTIC) :	277.15	169.01	446.16

B - NETWORK (NAVADA-VALLBHIPUR)	VILLAGES / TOWNS	DEMAND	SUPPLY
NAVADA H/W	1000/16	281.00	169.01
VALLBHIPUR H/W	897/15	267.00	136.50
BUDHEL H/W	711/09	164.00	73.32
KADIYALI H/W (FOR NC-24 & NC-25)	292/03	79.00	3.00

D - NETWORK (NAVADA-BOTAD)	VILLAGES / TOWNS	DEMAND	SUPPLY
NAVADA H/W	1325/22	351.00	277.15
CHAVAND H/W	1008/19	290.00	158.51
CHAVAND - BABRA - KOTDAPITHA	137/01	28.00	19.81
CHAVAND - BABRA - DHARAI	523/12	184.00	95.15
CHAVAND - LATHI - AMRELI	348/06	79.00	38.00

NOTE : ENHANCING 200 MLD WATER SUPPLY FROM NAVADA WILL ENHANCE WATER SUPPLY TO ABOUT 550 VILLAGES AND 9 URBAN AREAS


GULF OF KACHCHH
KHIRSARA
NETRA
NAKHATRANA
NALIYA
KUKMA TO KHIRSARA
BHUJ RURAL / URBAN
KAKDBHITT
SUKHPUR
BHUJ
KUKMA
MANGWANA
MANDVI RURAL
MANDVI CITY
MANDVI
MUNDRA
MUNDRA RWSS
KANDLA-GANDHIDHAM RWSS
VARSHAMEDI
ANJAR
ANJAR RURAL / URBAN
BHACHAU CITY
BHACHAU
2 NOS.- RWSS
SAMKHIYALI
RAPAR GR.
RAPAR
TOTAL PUMPING : 216.00
MALIYA OFFTAKE
TOTAL PUMPING : 416.00
MALIYA BR.CANAL
MALIYA HEAD WORKS
TO KUTCH
TO MORBI
TOTAL
CONNECTED VILLAGES/ TOWN : 360/06 665/15 1045/23
TOTAL PRESENT DEMAND : 354.00 158.00 512.00
PRESENT SUPPLY (DOMESTIC) : 167.91 200.00 367.91
PRESENT SUPPLY (INDUSTRI.) : 48.89 28.80 77.69
K- NETWORK (KACHCHH)
VILLAGES/ TOWN : 821 / 08
DEMAND : 130.00
SUPPLY 167.91
DEMAND (IND) : 90.00
SUPPLY (IND.) : 48.89
NOTE : AFTER COMPLETION OF DBC & 4.50 KM PIPELINE WORK FROM SADULKA TO MORBI (NC-7 PUMPING STATION) ADDITIONAL 300 MLD WATER WILL BE AVAILABLE FOR C & A SECTION. HENCE THE LOAD ON MALIYA BR. CANAL FOR C & A SECTION WILL REDUCE, WHICH RESULTS IN ENHANCED WATER SUPPLY FOR KACHCHH REGION.
MORBI HEAD WORKS
RAJKOT C-NETWORK
JAMNAGAR A-NETWORK
TOTAL
CONNECTED VILLAGES/ TOWN : 536/07 665/15 1061/22
TOTAL PRESENT DEMAND : 346.75 158.00 504.75
PRESENT SUPPLY (DOMESTIC) : 361.40 37.10 398.50
PRESENT SUPPLY (INDUSTRI.) : 28.80 - 28.80
MORBI BR.CANAL
DHANGADHRA BR.CANAL
SADULKA
TOTAL PUMPING : 239.36
MORBI
TOTAL PUMPING : 427.36
HALVAD
CHULI
DHRANGADHRA
MALVAN CHOWKADI
SURENDRANAGAR
DUDHREJ
DHOLI DHAJA DAM
SAURASHTRA BR.CANAL
DETAILS OF DHANKI HEAD WORKS
NAME OF PROJECT
DISTRICT
VILLAGE / TOWN
LENGTH (KM.)
DIAMETER (MM)
EST.COST (CRORE)
DHANKI TO NAVADA
BHAVNAGAR AMRELI JUNAGADH
3215 / 62
93.50
2300
814.00
DHANKI TO MALIYA
RAJKOT JAMNAGAR KUTCH
1398 / 20
120.00
2300/2150/ 2000
805.00
DHANKI TO RATANPAR
RAJKOT JAMNAGAR
1425 / 23
146.00
2400/2150/ 1850
1037.09
VISNAGAR
BECHARAJI
VIJAPUR
KALOL
KADI
GANDHINAGAR
NC14
DHANKI OFFTAKE
AHMEDABAD
K H E
HIRAPAR (SUM)
VILLAGES/ TOWN : 936 / 10
DEMAND : 493.00
HIRAPAR
2 NOS. RWSS
TANKARA
TANKARA GR. + TAPPING A.V.
WANKANER
THANGADH
NAKAGANI
MORTHALA
DHROL
JAMNAGAR CITY
JAMNAGAR
KHUDHIYA / DHROL RWSS
MOTI KHAVDI
2 NOS. RWSS
DWARKA
KOTHARIYA 9 ML WTP
4 NOS. RWSS
RAJKOT (AJI)
RAJKOT CITY
CHOTILA
LIMBDI BR.CANAL
LIMDI BR.CANAL
VALLABHIPUR BR.CANAL
BOTAD BR.CANAL
PARIYEJ TANK
KANEVAL TANK
SEVEN RWSS & DHOLKA
PIPALI
ONLINE TAPPING
KALAVAD - LALPUR
KALAVAD
SAMADA
RAJKOT CITY (NYARA)
LODHIKA / PADADHARI GR.
KALAVAD GR.
LALPUR
KHAMBHALIYA
KHAMBHALIYA - KALYANPUR
PANCHDEVDA
PANCHDEVDA (SUM)
KALYANPUR
JAMJODHPUR - BHANVAD
ADVANA
PORBANDAR GR.
BHANVAD
SHIVA PATIYA
RANAVAV GR.
KUTIYANA GR.
JAMJODHPUR
PORBANDAR
RANAVAV
KUTIANA
GONDAL CITY
GONDAL
MEVASA
MOVIYA AUTOPUR GROUP
DHORAJI CITY
DHORAJI
JETPUR
JETPUR CITY
JUNAGADH CITY
JUNAGADH
VANTHLI
VANTHLI(MANAVADAR/GARBHAVTVA)
MANAVADAR
BANTVA
BHESAN RWSS
BHESAN
BILKHA
BELA (OZAT-2)
VISAVADAR
VISAVADAR RWSS
KESHOD
KESHOD CITY
MANGROL
MALIYA-MANGROL RWSS
MALIA
TALALA
VERAVAL
SONARIA
KESARIYA TO SONARIYA
UNA
KODINAR
MACHHUNDRI BESIA
KESARIA
JASDAN CITY
JASDAN
KOTDAPITHA
DHARAI
CHAMARDI
CHAVAND
BABRA
BABRA GROUP
LATHI
AMRELI
AMRELI CITY
ISHVARIYA / LATHI LILIYA
SAVARKUNDLA GR.
DHARI GROUP
SAVARKUNDLA
SAVARKUNDLA CITY
RAJULA GROUP
(KADIYALI SUMP)
RAJULA (KADIYALI)
JAFRABAD GROUP
JAFRABAD
PIPAVAV PORT
MAHUVA GROUP
MAHUVA
TALAJA
BORADA
4 NO. RWSS
BOTAD
BARWALA
NAVDA
VALLABHIPUR / MALPARA
VALLABHIPUR
GADHADA
GADHADA / UMRALA RWSS
UMRALA
UMRALA / CHORVADLA
GHANGHALI
BHAVNAGAR
SIHOR
BUDHEL
BUDHEL H.W. TOTAL
BHAVNAGAR CITY
BUDHEL / PADVI / TANSA GROUP
TANSA
4 NOS.RWSS
NAVDA HEAD WORKS
TOWARD BOTAD
TOWARD VALLABHIPUR
TOTAL
CONNECTED VILLAGES/ TOWN : 1308/23 1016/15 2324/38
TOTAL PRESENT DEMAND : 351.00 281.00 632.00
PRESENT SUPPLY (DOMESTIC) : 204.00 167.03 371.03
B - NETWORK (NAVADA-VALLBHIPUR)
VILLAGES / TOWNS
DEMAND
SUPPLY
NAVADA H/W 1000/16 281.00 167.88
VALLBHIPUR H/W 897/15 267.00 138.00
BUDHEL H/W 711/09 164.00 73.32
KADIYALI H/W (FOR NC-24 & NC-25) 292/03 79.00 4.00
D - NETWORK (NAVADA-BOTAD)
VILLAGES / TOWNS
DEMAND
SUPPLY
NAVADA H/W 1325/22 351.00 197.90
CHAVAND H/W 1008/19 290.00 109.54
CHAVAND - BABRA - KOTDAPITHA 137/01 28.00 19.84
CHAVAND - BABRA - DHARAI 523/12 184.00 51.62
CHAVAND - LATHI - AMRELI 348/06 79.00 38.05
NOTE : ENHANCING 200 MLD WATER SUPPLY FROM NAVADA WILL ENHANCE WATER SUPPLY TO ABOUT 550 VILLAGES AND 9 URBAN AREAS
CANALS
EXISTING PIPE LINE
PIPE LINE UNDER PROGRESS
PROPOSED PIPE LINE FOR SCARCITY -2012
EXISTING PUMPING STATION
N

5 CRITICAL EVALUATION OF FINANCIAL MANAGEMENT PERFORMANCE USING DEVELOPED INDICATORS

Substantial expenditure has been incurred by the Government of India as well as different states including Gujarat in last few decades on rural water supply schemes. However, very little is known on how effective this expenditure has been in providing safe water to rural people on sustainable basis. Also, hardly there is any analysis of the cost of water supply schemes, cost recovery and the impact of technology choice and institutional arrangements on the cost of service is done. The present study is done with the main intention of providing directions and alerting the policy makers with respect to the functionality and sustainability of the Regional Rural Water Supply Schemes with the inclusion of financial aspects.

5.1 Methodology adopted

Combination of data collected by house hold survey and fund flows from Gujarat Water Supply and Sewerage Board (GWSSB) has been collected. Data collected covers the four representative schemes and several other schemes of South & Central Gujarat and Saurashtra region which are implemented by GWSSB. The survey data relates to 2007-08 and the other data collected from GWSSB covers the period from 2005-2010.

5.2 Unit Cost

Knowledge of the real unit cost of the water is essential to understand the financial health of the scheme, and also for setting of appropriate tariffs. Usually, the Unit cost is categorized into two main

components, namely, Capital cost and Operation and Maintenance (O & M) cost.

5.2.1 Capital Cost

In typical Institutional arrangement of India, the fund flow for supply-driven and demand-driven rural water schemes is reported as shown in Figure 5.1.

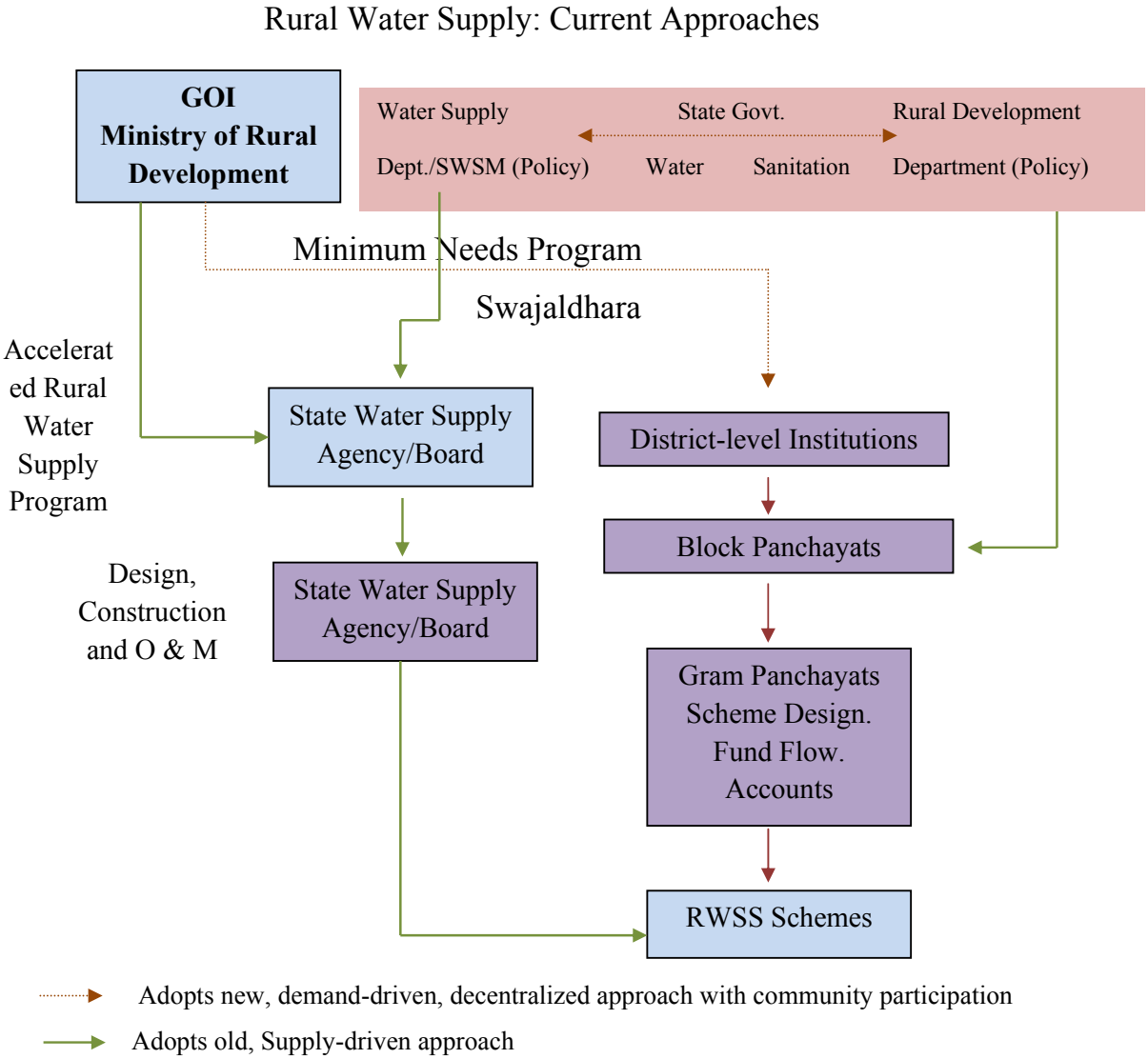


Figure 5.1 Chart showing Key Institutions and financial flows-current approaches (Source: Report of World Bank, 2008 on Review of effectiveness of Rural Water Supply Schemes in India)

It is also revealed from World Bank studies (2008) in India that typically capital costs are relatively much higher in supply-driven schemes than demand-driven. Further in multi village or regional schemes with piped water supply, the capital cost averages to Rs. 6000 per household (2005-06 prices) (Rs. 10,000 or more in 16% cases & Rs. 20,000 or more in 4% cases per household), however this varies greatly with local conditions.

5.2.1.1 Capital Cost of Investments in RRWSS Under Study

In RRWSS of Variav group, Surat, the cost of the approved scheme was Rs. 94.46 crores out of which expenditure incurred was Rs. 53.14 crores till 2005 (1st phase) which was borne by the GWSSB. In phase-2 the major part is covering the urban area of Surat Municipal Corporation which was completed in 2008. Time of completion of this project has been more than three years due to heavy rain and delay in getting permissions from railway and forest departments. The Cost Per Capita worked out as:

a. As per Year 2003 : Rs. 1295.12

b. As per Year 2011 : Rs. 1036.09

c. As per ultimate stage (2034) : Rs. 972.82

In RRWSS of Gadhada group, Bhavnagar, the total estimated cost of the scheme was Rs. 36.87 crores, as shown in Table 5.1. However, the actual expense till the completion of the scheme was Rs. 27.70 crores. Reason for the savage in capital cost is due to change in the alignment of bulk water pipeline during construction phase. The cost per capita is worked out to be Rs. 2298.52 (Year 2011) and Rs. 1470.90 (Year 2031). The cost per KL is worked out to be Rs. 5.80 (Year 2011) and Rs. 3.71 (Year 2031).

Table 5.1 Showing Details of Cost of the RRWSS Gadhada Group, Bhavnagar

Sr. No.	Name of Group	No. of Villages	Gross Cost in Rs.
1	Group Common Components	----	3,06,72,120
2	Holaya Group (No.12)	13	5,71,24,600
3	Viravadi Group (No.13)	21	11,58,10,000
4	Raliyana Group (No.14)	24	12,23,25,000
5	Adtala Group (No.15)	09	4,27,58,200
	Total	**67**	**36,86,89,920**

In RRWSS Ishwaria group, Amreli, the total estimated cost was Rs. 13.75 crores against the actual expenses of Rs. 13.98 crores in year 2003, on the completion of scheme. The reason for higher expenses was due to higher cost in railway crossing works, little change in site of head works and pipe line alignment. The cost per capita is worked out to be Rs. 1470 (Year 2001 census) and Rs. 837 (Year 2031). The cost per KL is worked out to be Rs. 2.51 (Year 2031).

In RRWSS Mandvi group, Kachchh, the total estimated cost was Rs. 15.12 crores against the actual expenses of Rs. 11.61 crores; however the work for 2nd phase not fully completed till 2007-08. The cost per capita is worked out to be Rs. 1607 (Year 2001 census) and Rs. 1071 (Year 2031). The cost per KL is worked out to be Rs. 2.11 (Year 2031). Table 5.2 summarizes the capital cost of above four RRWSS of the study undertaken.

Table.5.2 Showing Capital Cost of Various RRWSS Under Study

Sr. No.	Name of the RRWSS	Typical features	Capital cost per capita	Capital cost per KL	Remark
1.	Variav Group, Surat	Source: surface water (perennial river Tapi) Ultimate capacity: 93.16 MLD + 24.72 MLD Surat city + Rural area Ultimate population: 9.71 lacs (Year:2034)	**Rs. 972.82 (Year:2034)**	**Rs. 1.33**	Source is near to supply and most conveyance is through gravity
2.	Gadhada Group, Bhavnagar	Source: Bulk water supply by Mahi-pariej pipe line from weir constructed on river Mahi Ultimate capacity: 17.55 MLD, Ultimate population: 2,50,655 (Year:2031)	**Rs.1470.91 (Year:2031)**	**Rs.6.53 (Year:2001) & Rs.3.71 (Year:2031)**	Source is away from region and conveyance rely on bulk water supply through pipes under pressure
3.	Ishwaria Group, Amreli	Source: Bulk water supply by Mahi-pariej pipe line from weir constructed on river Mahi Ultimate capacity: 7.36 MLD (Mahi pipeline) + 9.2 MlD (Narmada Pipeline) = 16.5 MLD Ultimate population: 1, 64,314 (Year:2031).	**Rs. 1470 (Year:2001) & Rs. 837 (Year:2031)**	**Rs. 2.51**	Source is away from region and conveyance rely on bulk water supply through pipes under pressure
4.	Mandvi Group, Kachchh	Source: Surface water through NC 11 & NC 22 of Maliya Branch of Narmada Canal Ultimate capacity: 8.10 MLD Ultimate population: 1,08,394 (Year:2031)	**Rs. 1607 (Year:2001) & Rs. 1071 (Year:2031)**	**Rs. 2.11 (Year 2001)**	Source is away from region and conveyance rely on bulk water supply through canal & pipe network

It has been noted that in most of the RRWSS, overall capital cost found out in the range of Rs. 800-1700 per capita. These capital costs are low due to reasons that the cost is shared by number of villages or habitations and many villages are involved which averages the high initial investments of the scheme.

5.2.1.2 Operation and Maintenance (O & M) Cost for Various RRWSS

$$\boldsymbol{Indicator = \frac{Total\ O\ \&\ M\ cost}{KL\ of\ water\ supplied\ and/or\ Per\ Capita/Annum}}$$

Operation & Maintenance cost mainly include the cost of pumping or lifting (electricity bills) the water from its source to the treatment plants and/or to the head works, cost of chemicals in water treatment plants including alum (in surface water sources-seasonal) & chlorine (in ground water and surface water), cost of maintenance, repairs & replacements (M & R) for various operative/moving parts and equipments including pumps, treatment plant equipments and the overall salaries of administrative and maintenance staff.

A component-wise break-up of the O & M cost per KL for RRWSS is important, as several components like cost of pumping or the electricity bills play an important role in the overall O & M of the scheme. The study has been carried out for the schemes undertaken for the study.

In RRWSS Variav group, Surat, the overall annual O & M costs are found out for the year 2006-07 (Table 5.3). It is noted that the actual O & M expenditure was Rs. 66.40 /capita. The O & M cost of water was Rs. 2.56/ KL. It is also noticed that there was a heavy flood in the Surat city for year 2006, in which a significant damage was occurred in the main pipe lines and pumping machineries. This has also increased some cost of Maintenance and Repairs for that year.

Table 5.3 Showing Actual O & M Cost in RRWSS Variav group, Surat (Year 2006 – 07)

Name of sub head works	Number of villages included in the scheme	Benefited Population (Year 2001)	Actual expenditure on O & M for Year 2006-07 (Rs. Lacs)
Sandhiyer	35	57045	39.65
Panesara	38	72910	37.29
Ambheta	7	5785	20.80
Dumas – I	9	27470	20.50
Dumas – II	4	4816	12.84
Hajira	15	59998	27.82
Budia	10	67423	37.30
Total	**118**	**2,95,447**	**196.20**

In RRWSS Gadhada group, Bhavnagar, the overall annual O & M charges are found out for the year 2006-07. It is noted that the actual O & M expenditure was Rs. 45.20 lacs against the estimated cost of Rs. 53 lacs, that is less by 14.71%. The O&M cost on present population is determined as Rs.29.40 /capita and Cost of water for O & M is determined as Rs. 2.06/KL.

In RRWSS Ishwaria group, Amreli, the overall annual O & M cost was found out for the year 2006-07, which is as per table 5.4.

Table 5.4 Showing Actual O & M Cost and Its Components in RRWSS Ishwaria group, Amreli

O & M cost components	Actual Cost
Chlorination	Rs. 8,57,760
Annual maintenance contract (manpower)	Rs. 12,00,000
Repairing of miscellaneous components	Rs. 30,000
Establishment	Rs. 6,20,196
Fuel	Rs.35,980
Chemicals	Rs. 66,253
Charges for raw water to water resources department borne by GWSSB	Rs. 1 per Kilo Litres Therefore, for 5 MLD Rs. 13,25,000 for an year
So, Total O & M cost (2006-07)	Rs. 43.25 lacs/98,000 souls = **Rs. 42 per capita** **& Rs. 3.26 per Kilo Litres** **(Supply about average of 5 MLD)**

In RRWSS Mandvi group, Kachchh the annual O & M has been given to the private agency for Rs. 5,50,000 gross for running the treatment plant of 9.85 MLD. The establishment charges for the year 2006-07 was Rs 5,30,859. Estimated O&M charges for electric consumption were about Rs. 3 Lacs per year. It is also estimated that about 3600 Kg of Chlorine gas & about 3000 Kg of Alum used for water disinfection and treatment. It is also noted that for year 2005-07 the water from NC-11 line was not received satisfactory and therefore some expenditures for last two years were reduced. However, the overall Per Capita Cost for O & M on present population is Rs. 54.79 (2006-07).

Table 5.5 summarizes the O & M cost of above four RRWSS. This shows the high variation in the cost from scheme to scheme.

Table.5.5 Showing Actual O & M Cost of Selected Four RRWSS (Year 2006-07)

Sr. No.	Name of the Scheme	Actual O & M cost		Remark
		In Rs. per capita	In Rs. per KL	
1.	Variav Group, Surat	66.40	2.56	In year 2006, major flood damaged main pipes and pumping machineries at different head works
2.	Gadhada Group, Bhavnagar	29.40	2.06	------
3.	Ishwaria Group, Amreli	42	3.26	------
4.	Mandvi Group, Kachchh	54.79	N.A.- As actual rate of supplied water is not available for year 2006-07	Requires long distant for conveyance through pipe lines and pumping cost

Further the detailed analysis has been carried out to determine the break-up of the total O & M cost in various RRWSS of South and Central

Gujarat is given in Annexure III and the average cost in surface water and ground water based schemes are as shown in table 5.6.

Table.5.6 Showing Average Cost of O & M in Various RRWSS of South & Central Gujarat (Based on Source of Water)

Type of RRWSS	Average Cost of O & M Cost Component						
	Cost of Raw water Rs./ KL	Treatment cost Rs./KL	Pumping cost. of water Rs./KL	O & M of Distribution pipeline Rs./KL	O & M of P.M. Rs./KL	Total Exp. for Distribution Rs./KL	Grand Cost in Rs./KL
Ground water based RRWSS	0.00	0.10	2.33	4.24	0.56	7.22	7.22
Surface water based RRWSS	1.14	1.0454	2.5885	1.1546	0.2269	5.0154	6.1531

Figure 5.2 & 5.3 show the Graphs plotted for the percentage cost for the different components in the total O & M cost derived for the average cost of various RRWSS based on surface water and ground water source respectively in south and central Gujarat. From the graph it is obvious that the cost of water and treatment are quite higher in surface water based schemes as compare to the schemes based on ground water source. As the cost of O & M of pumping and cost of distribution depend much on the topography of the area and system of water supply to village, they are not much affected based on surface water or ground water as source of the scheme.

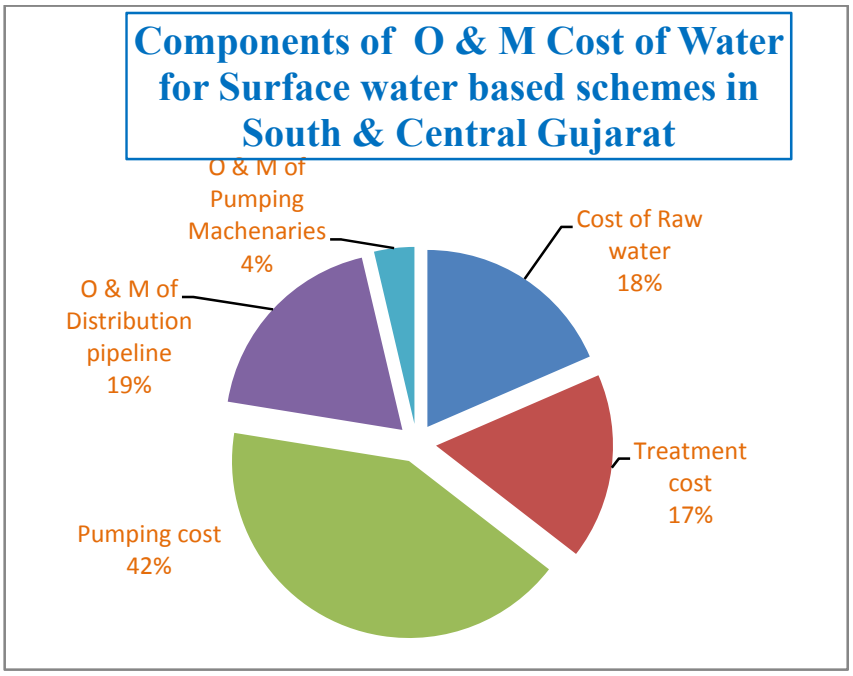


Figure 5.2 Graph Showing the Components of O & M Cost in RRWSS Based on Surface Water in South & Central Gujarat

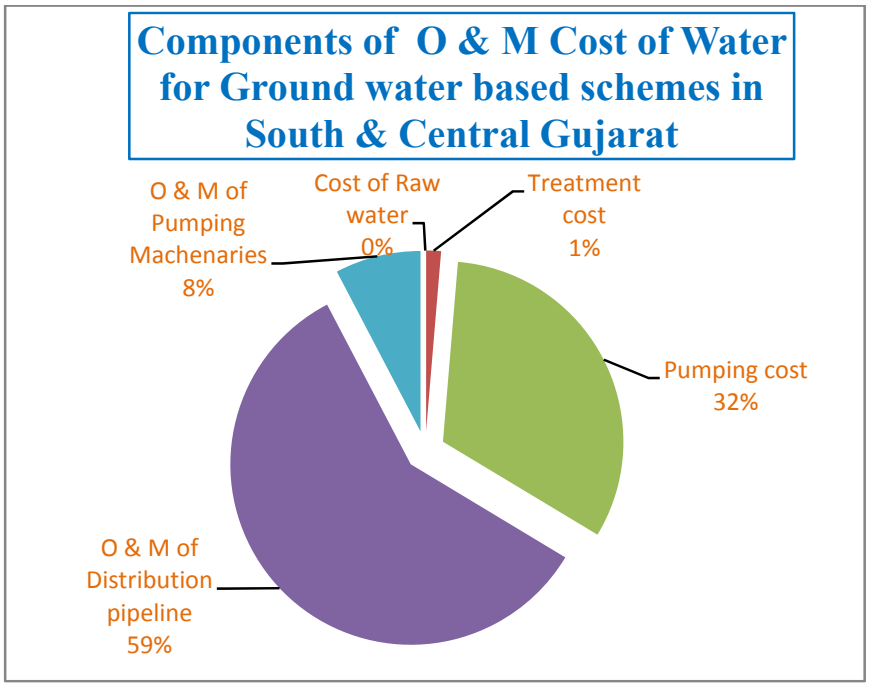


Figure 5.3 Graph Showing the Components of O & M Cost in RRWSS Based on Ground Water in South & Central Gujarat

The different data and analysis of O & M cost signifies the importance of pumping cost (electricity bills-subsidies) and therefore the detailed study on actual O & M cost with the current electricity charges has been carried out for the whole Saurashtra region, where the most RRWSS relies on bulk water supply either through Narmada canal network or bulk water pipe lines. The details of the O & M cost per KL, at different head works only are shown in chart 5.1. The calculation sheets for the same are listed in Annexure –II. The rate analysis for the O & M cost of water treatment plant based on surface water has also been carried out for the evaluation of actual O & M required for the treatment in RRWSS. Table 5.7 shows the O & M (Rate Analysis) for water treatment at various head works in Saurashtra region. The observed M & R charges at various head works vary significantly and in some head work, they are significantly high for example at Dudhala & Rojki- head work. Further, it is noticed that the cost of chemicals are about Rs. 0.15, cost of electricity is about Rs. 0.12 and the M & R charges are as low as to about Rs. 0.06 only.

However, it is also noted that the actual O & M for the water treatment plants are approximately 1% only in ground water based RRWSS; whereas about 17% in case of surface water based RRWSS in South & Central Gujarat.

Table 5.7 Showing O & M (Rate Analysis) for Water Treatment At Various Head Works In Saurashtra Region

Rate Analysis for M & R cost of treatment plant				
Name of Headwork	**capacity Cum. / Hr**	**Duration of M & R in months**	**M & R in Rs. (as per tender)**	**Cost of M & R in Rs. Per KL (excluding material cost)**
Hirapar	420	24	6,00,000	0.08
Hadala	590	24	6,00,000	0.06
Rajula	1170	24	7,20,000	0.04
Morzar	700	24	7,20,000	0.06
Dhari	200	24	4,80,000	0.14
Simran	1750	24	7,20,000	0.02
Rojki	920	24	12,00,000	0.08
Dudhala	167	24	7,20,000	0.25
tansa pasvi	2080	24	1600000.00	0.05
Average cap.	**690**	**---**	**Average rate**	**0.06**
Alum dosage 30 mg per liter for 1000 liter considering above dosage: 30 x 1000 = 30000 mg that is 30 GM/KL Taking rate of alum as Rs. 3330 per MT: **Amt required for alum = Rs. 0.099 say Rs. 0.1/KL**			**chlorine dosage 5mg per liter** for 1000 liter considering above dosage: 5 x 1000 = 5 GM/KL Taking rate of chlorine as Rs. 9400 per MT: **Amt required for chlorine = Rs. 0.047 say Rs. 0.05/KL**	
So, Total Expenditure for Treatment of 1 KL of Water				
Amt Req. for M & R Treatment plant in Rs.	Amount Required for chlorine in Rs.	Amount Required for Alum in Rs.	Amount Required for meeting Energy cost of Treatment plant operations in Rs.	Total O & M cost for the Treatment plant in Rs.
0.06	**0.05**	**0.1**	**0.12**	**0.33**

5.3 Water Tariff and Tariff Recovery

Economic efficiency, sustainability, equity, affordability, willingness to pay and willingness to charge, etc are conflicting objectives to induce distortion and undeliverable effects for most of water supply schemes.

5.3.1 Water Tariff

While deciding water tariff, there are little consensus and controversy among reformers, policy makers and administrators. Even though this may not become a focus of criticism, but striking a balance in between is a must. Following are the factors defining water tariff:

- The water tariff shall be very simple, easy to explain, understand and implement
- The water tariff shall be generally acceptable to public/political leaders and finance agencies
- The water tariff is quite different from direct equity
- Economic efficiency on financial/social cost: The volumetric charge is set equal to marginal cost of additional quantity of water. There is no real economic incentive to economize water use.
- Equity and fairness: This is to treat similar customer equally. There is no discrimination in between rich and poor.
- Affordability: Water services are basic right to be provided regardless of whether they can pay for that or not. The water prices are to be kept low. The water supply shall be free or at minimal cost at least to poor through subsidies. The subsidy by Government of India is 4%.

5.3.2 Tariff Recovery

Cost recovery is a major concern in the present day context in investment. This is especially true in the sector when return from is not up to mark as in other production sectors. Water supply is a sector where return cannot be attained, since it yields no benefit other then assisting the community toward better health and safe environment.

The present policy of the government is thereby tuned towards participation from the beneficiaries in each investment whereby participatory role of the beneficiaries is ensured. By such measures the beneficiaries are not only contributing towards such investment but also earn a sense of ownership. It also induces a sense of proper maintenance of such capital investments and establishes a means by which the authority can rely on the society towards operation and maintenance of the installation.

5.3.3 Finding on Water Tariff and Tariff Recovery in Selected RRWSS

In RRWSS Variav group, Surat, the tariff recovery was reported as Rs. 45.10/capita per annum (2006-07) against the actual water expenses for the O & M of Rs. 66.41/capita. It is noticed that the actual norm fixed by the Govt. of Gujarat for water tariff recovery under this RRWSS is fixed as Rs. 14/capita/annum.

This tariff recovery is significantly high in terms of per capita water tariff fixed by the Government of Gujarat. The main reason for the same is due to the supply of 50% of total capacity that is 60 MLD out of 120 MLD is supplied to various industries on commercial basis. This results in balancing the tariff recovery from rural area with the share of industrial water charges. However, in this case the population of urban region of Surat is also included & the data reported that the people of

rural area were not paying the water charges regularly but only recovery is through urban area of Surat city and industries.

In RRWSS Gadhada group, Bhavnagar, the tariff recovery was reported as just Rs. 1.5 lacs (Year 2006-07) against the actual bill of Rs 21.52 lacs (as per norms of Rs. 14/capita/annum) of GWSSB to various Gram Panchayats. It is also noticed during the field visits that the most village people are capable of paying such low water tariff in the region.

In RRWSS Ishwaria group, Amreli, the water tariff recovery for year 2006-07 was nil against the norms of Rs. 14/capita/annum fixed by the Government of Gujarat for this scheme. Insufficient water availability during the summer, occasional poor water quality, poor mentality for paying the water charges against the traditional mind set of free water, and no efficient system set by state department for water tariff recovery were some of the important reasons noted during the field surveys. However, the suggestions were made for the water tariff recoveries to state local officials such as display of banners, pictures and slogans on water infrastructure facilities provided for the region, copies of the O & M cost of the previous year statement should be supplied to each beneficiary Gram Panchayat and Street play and/or other such cultural activities should be carried out to bring awareness among the people.

In RRWSS Mandvi group, Kachchh, the water tariff recovery for the period of June 2005 to March 2007 was Rs. 81,114 that is Rs. 3862.57 per month against the M & R expenses of Rs. 2,20,444 per month (average) that is about 1.75% of M &R only. The reason for low recoveries may be due to insufficient and irregular water supplies through NC 11 pipe line during this period.

5.4 Community Participation for Effective Management of RRWSS

To promote sustainability and effectiveness, community participation approach in rural water supply sector in is recent trend in present Government policy of supply driven approaches. Instead of emphasizing technical knowledge and inputs only, there is a need to focus on way of sharing other relevant tasks with communities. Community participation is not a new concept, but its application in the planning, implementation and maintenance of water supply system calls for a partnership approach.

For rural water supply system, the technology package should be simple, efficient, cost effective and economic. In other words, whatever technology is chosen, it must be sustainable with the resource available to the community.

During the studies, two important points are observed, such as 1. Different communities are not necessarily uniform in their needs and capabilities and 2. Within the communities themselves, user needs and readiness to pay/contribute also varies. As a result, a mixture of service levels particularly with respect to accessibility and per capita supply may be necessary.

The communities not only have to be informed on the project but the implementing agency must, in the first place, work with them to identify their needs and capacities. To give both the agency and the communities a good overview of the conditions and issues that have to be taken into account, it may be necessary to gather baseline data on water use and needs, socio-economic status and health and hygiene conditions of the communities concerned.

It has also been observed that community can participate in O & M by providing volunteers for training as local operators or caretakers; by paying for operation, maintenance, repairs, replacements, by problem reporting and through social control as individuals and community. However, it is also a fact that neither the implementing authority nor the community can accomplish all technical & other socio-economic matters of village water distribution system, therefore a successful performance can be achieved with good team work, communications and transparent policies.

5.5 Financial Management Performance Index (FPI)

The financial management performance of any RRWSS is dependent on the following four indicators.

- Capital cost of Water
- Operations & Maintenance cost of Water
- Water Tariff & Cost Recovery
- Community Participation

From the study of an indicator 'Capital cost of water', it is determined that the capital cost of Variav RRWSS, Surat is just Rs. 1.31 per KL, whereas same is ranging from Rs. 2.11 to Rs. 3.71 per KL for the Gadhada, Ishwaria and Mandvi RRWSS. Though all schemes are relying on surface water as source, their ultimate cost is almost double or higher. The main reason for that is the Variav scheme is situated on flat topography with minimum needs of pumping and also the overall length of pipe network required is also less compare to other three RRWSS, whereas other three RRWSS of Saurashtra and Kachchh are relying on very long pipe network of Narmada based canal & pipe network, undulant topography (rising topography for pipe network) and huge pumping machineries' cost. The similar type of cost estimates are received for the various RRWSS and the capital cost of water for each of

the RRWSS mainly rely on type of the source, topography of the area and the overall length of the pipe network, etc. Also, once the scheme is commencing and it reaches to an operational stage, this indicator plays a less important role in day to day performance of the scheme. Due to these reasons, it is suggested to monitor this indicator independently at the planning of any new RRWSS.

Therefore, to evaluate a Financial Management Performance Index (FPI), the equation 4.1 can be reduced as under.

$$\text{FPI} = \frac{\sum_{i=1}^{3} \text{Ii Wi}}{\text{Wmax} \sum_{i=1}^{3} \text{Ii}} \; x\,100 \qquad \text{Equation 5.1}$$

$$FPI = \frac{I_1W_1+I_2W_2+I_3W_3}{W_{max}(I_1+I_2+I_3)} \; X\,100 \qquad \text{Equation 5.2}$$

Where, W= Weights assigned to each of the indicators based on their ratings; and I= Importance factor for each of the indicators based on their impact on overall service performance and its interrelation to other indicators.

FPI varies from 0 to 100, 100 being the maximum index value with all factor rated as excellent. 0 is the minimum index value, when all the three factors have a ‘poor’ rating. In general, higher is the index value; better is the financial management performance of the scheme.

In order to define performance of a service based on the ratings as an Index (numerical value), four ratings may be assigned as weights (0 to 1). The selection of weights for above ratings requires skillful observations which may vary from field conditions. For a present study of Gujarat state, the selected value of weights is as per Table 5.8 (Excellent Performance, W = 1.0, Medium to High Performance, W= 0.65, Low to Medium Performance, W= 0.35, Poor Performance, W = 0.0).

Table 5.8 Showing Ratings and Weights Assigned for the Various PI's for the Evaluation of Financial Management Performance of an RRWSS

Financial Management Performance	O & M cost of water	Excellent Performance	Is half or less of water tariff- Ist half life/design period & Is equal or less of water tariff- IInd half life/design period	W_1= 1.0
		Medium to High Performance	Is half or less of water tariff- Ist half life/design period & Is 2/3rd or equal of water tariff- IInd half life/design period	W_1= 0.65
		Low to Medium Performance	Is half or equal of water tariff- Ist half life/design period & Is equal or more of water tariff- IInd half life/design period	W_1= 0.35
		Poor Performance	Is equal or more of water tariff- Ist half life/design period & Is more than water tariff- IInd half life/design period	W_1= 0.0
	Cost recovery & water tariff	Excellent Performance	At Tail reach villages cost recovery is > 70% of total tariff & at Head reach villages cost recovery is > 90% of total tariff	W_2= 1.0
		Medium to High Performance	At Tail reach villages cost recovery is 50- 70% of total tariff & at Head reach villages cost recovery is 70- 90% of total tariff	W_2= 0.65
		Low to Medium Performance	At Tail reach villages cost recovery is 30- 50% of total tariff & at Head reach villages cost recovery is 50- 70% of total tariff	W_2= 0.35
		Poor Performance	At Tail reach villages cost recovery is < 30% of total tariff & at Head reach villages cost recovery is < 50% of total tariff	W_2= 0.0
	Community participation	Excellent Performance	Formation of Pani Samitis and involvement of Gram Panchayats in cost sharing of the RRWSS and involvement in O & M of RRWSS	W_3= 1.0

		Medium to High Performance	Involvement of Gram Panchayats, formation of active Pani Samitis and involvement only in O & M of RRWSS, No capital cost sharing of RRWSS	W_3= 0.65
		Low to Medium Performance	Partial involvement of Gram Panchayat and Pani Samitis in O & M of RRWSS, No capital cost sharing of RRWSS	W_3= 0.35
		Poor Performance	No formation of Pani Samitis, Hardly any role of Gram Panchayat in O & M of RRWSS, No capital cost sharing of RRWSS	W_3= 0.0

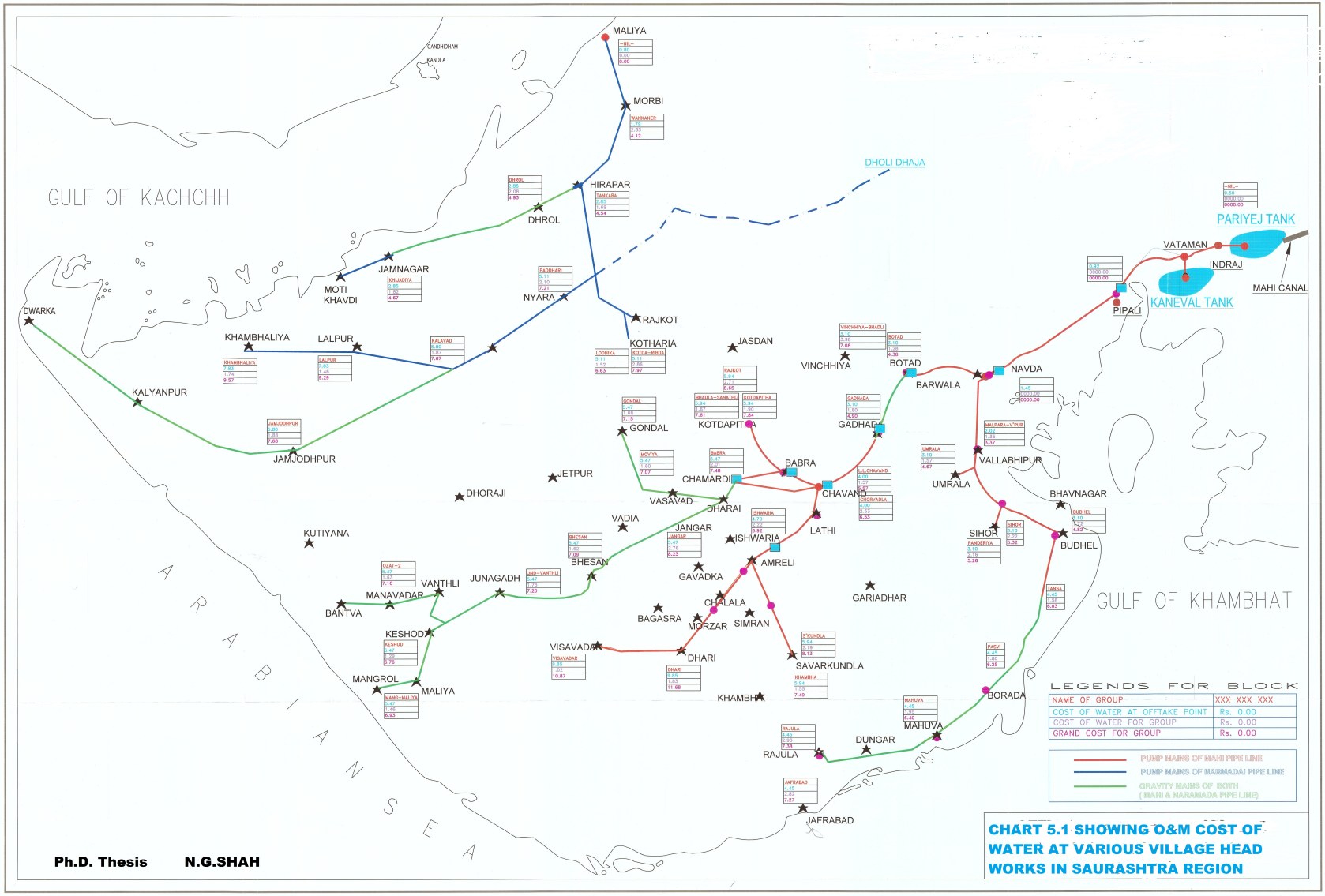
Further, for the selection of importance factor for the above three indicators, it is assumed that the indicator 'Community participation' may be assigned less importance under the presence of strong governmental/organizational infrastructure. So, by keeping this in mind for the present study, the indicators such as 'O & M cost of water' and 'Cost recovery & water tariff' are assigned the double (2.0) importance factor compare to it.

Based on the above selected weights, the overall FPI is calculated for the selected four groups of RRWSS of different regions of the Gujarat state. The selected weights, importance factor and FPI for each RRWSS are as per Table 5.9.

Table 5.9 Showing Financial Management Performance Index Value for Various RRWSS Under Study Area

Name of the RRWSS	Weight (W) & Importance Factor (I)	Financial Management Performance Indicator			Overall FPI	Performance Rating
		O & M cost of Water	Cost recovery & water tariff	Community participation		
Variav Group, Surat	W	0.65	0.35*	0.65	53	Medium Performance
	I	2.0	2.0	1.0		
Gadhada Group, Bhavnagar	W	0.65	0.0	0.65	39	Low to Medium Performance
	I	2.0	2.0	1.0		
Ishwaria Group, Amreli	W	0.65	0.0	0.35	33	Poor Performance
	I	2.0	2.0	1.0		
Mandvi Group, Kachchh	W	0.65	0.0	0.0	26	Poor Performance
	I	2.0	2.0	1.0		

Note: * in case of Variav RRWSS, major portion of the water tariff recovery is from the industries using the water and the semi urban area of the newly covered area of the Surat Municipal Corporations, therefore, it is selected as 0.35


GULF OF KACHCHH
GULF OF KHAMBHAT
ARABIAN SEA
DHOLI DHAJA
MALIYA
MORBI
HIRAPAR
DHROL
JAMNAGAR
MOTI KHAVDI
NYARA
RAJKOT
KOTHARIA
DWARKA
KHAMBHALIYA
LALPUR
KALYANPUR
JAMJODHPUR
JASDAN
VINCHHIYA
BOTAD
NAVDA
BARWALA
PIPALI
PARIYEJ TANK
KANEVAL TANK
VATAMAN
INDRAJ
MAHI CANAL
GONDAL
KOTDAPITHA
GADHADA
VALLABHIPUR
UMRALA
BHAVNAGAR
BUDHEL
SIHOR
JETPUR
DHORAJI
CHAMARDI
BABRA
CHAVAND
DHARAI
VASAVAD
VADIA
JANGAR
ISHWARIA
LATHI
AMRELI
KUTIYANA
BHESAN
GAVADKA
CHALALA
BAGASRA
MORZAR
SIMRAN
GARIADHAR
VANTHLI
JUNAGADH
MANAVADAR
BANTVA
KESHOD
MANGROL
MALIYA
VISAVADAR
DHARI
SAVARKUNDLA
KHAMBHA
BORADA
MAHUVA
DUNGAR
RAJULA
JAFRABAD
LEGENDS FOR BLOCK
NAME OF GROUP
XXX XXX XXX
COST OF WATER AT OFFTAKE POINT
Rs. 0.00
COST OF WATER FOR GROUP
Rs. 0.00
GRAND COST FOR GROUP
Rs. 0.00
PUMP MAINS OF MAHI PIPE LINE
PUMP MAINS OF NARMADAI PIPE LINE
GRAVITY MAINS OF BOTH
(MAHI & NARMADA PIPE LINE)
CHART 5.1 SHOWING O&M COST OF WATER AT VARIOUS VILLAGE HEAD WORKS IN SAURASHTRA REGION
Ph.D. Thesis N.G.SHAH

6 CRITICAL EVALUATION OF CLUSTER STORAGE STRATEGY FOR VILLAGE WATER DISTRIBUTION SYSTEM OF RRWSS

This chapter mainly discusses a thorough review for the concept of Cluster Storage Strategy (CSS) against the functioning of conventional system, which includes Elevated Service Reservoir (ESR) and Stand Post (SP) or individual piped connection as village water distribution system. The present Study is a review on the functioning of CSS in several villages of the state of Gujarat, which is carried out by means of technical data evaluation and the study of social impacts including villagers' perception and expectations gathered during field visits. The output of a study is useful in scaling-up of such systems for other village water distribution systems in most developing countries too.

6.1 Background

Rural water supply system in developing countries is designed to cater demand of potable water to communities for domestic purposes such as drinking, cooking, bathing and hygiene. This requires supply of high-quality water on a sustainable basis. In the developing world, families (especially women in India) spend a considerable amount of time trying to get sufficient water for these uses. The potable water supply system usually comprises traditional sources of water, such as rivers and open wells, which are often contaminated and distant from the household. Improved rural water supply systems include a range of technologies from protected wells equipped with manually operated hand pumps to more complex gravity-flow or pumped piped water systems connected to houses or Elevated Service Reservoir (ESR) and Public Stand Posts (SP's): often the case in RRWSS. The technical solution is very location

specific and will depend on a range of characteristics such as community demand, affordability and willingness to pay, community size and household density, water resources and electricity availability, and topographical issues.

The traditional village water distribution system in RRWSS often includes an Elevated Service Reservoir (ESR) & Stand Post (SP) or individual piped connections. It is common that the villages with population less than 3000 and limited water availability consist of SP's as village distribution system, while the villages with population greater than 3000, good economic developments and sufficient water availability consist of individual piped connections. Either of these systems stores the total water requirement into an underground sump near ESR and this water is then pumped to the ESR. Later the stored water in ESR is distributed in various time zones to different parts of village through SP's or individual house-to-house connections.

It is often noted that the traditional piped water distribution through ESR & SP or house-to-house connections system is susceptible to various disputes like disparity in distribution, deficiency of pressure & untimely supply hours. To address such issues, an alternative strategy 'Cluster Storage Strategy (CSS)' has been implemented in several villages of Gujarat state with the collective efforts of UNICEF, WASMO & GWSSB in past decade. In CSS, water is received from RRWSS or local source is directly pumped for distribution to the storage tanks located among the small clusters or hamlets of families residing together. Capacity and placement of storage tanks, within a cluster can be worked out based on the topography and population to cater with design norms of supply of individual at 70 lpcd. These tanks would act as transformers in water distribution system. On one hand, they will secure the required quantitative share of the community in the cluster storage tank, and on the

other hand also protect the excessive withdrawal by other clusters. In short, each cluster or household gets equitable water supply and thus also serves the intended purpose of social inclusion.

6.2 Methodology adopted for evaluation of CSS

Desk study of documents developed by the UNICEF, WASMO & GWSSB was carried out and the technical design of the alternative distribution systems was carried out. To understand whether the CSS functions or not, seven villages of two districts, Surendranagar & Kachchh were considered under the study. Based on the influencing factors such as population size, variation in caste & inter-caste conflict issues, availability of water, topography of the area, economic conditions in terms of agricultural and industrial growth in and around village and the success observed in CSS model, villages are grouped and summary of their main features is as shown in Table 6.1. Interactions with village people including household women, Pani Samitis of village & NGO working in the area were carried out.

Table 6.1 Showing Details of Different Villages and Their Features Under Study Area

Name of the Village/feature	Village Groups						
	Group A		Group B		Group C		
	Village: Khintla District: Surendranagar	Village: Mokasar District: Surendranagar	Village: Paddhar Taluka Bhuj District: Kachchh	Village: Dhori Taluka Bhuj District: Kachchh	Village: Hodko District: Kachchh	Village: Nana Bandha District: Kachchh	Village: Ghadiyado (Banni) District: Kachchh
Population	330 families, @2300 persons	260 families @1250 persons Located in Clusters	457 Families, @2159 people	1200 Families, @4200 people	100-120 families, @450 people – Scattered population	45-50 families, @200 people – Scattered population	60 families, @250 people – Scattered population
Topography of village	Low to High Elevation (Uneven)		Flat to slightly downward from source		Flat		
Main Business	Agriculture		Agriculture, Animal Husbandries, Labor	Agriculture, Animal Husbandries, Handicraft (Bharatkam)	Animal Husbandries, Handicraft (Bharatkam)		
Caste Variations	Koli , Darbar, Harijan, Rabari, Vaghari, etc.	Koli , Darbar, Harijan, Rabari, Vaghari, etc	Aahir, Rabari, Muslim, Bawa, koli	Aahir, Harijan, Darbar, Kapadi, Bawaji,	Muslims, Rabari		

Name of the Village/feature	Village Groups						
	Group A		Group B		Group C		
	Village: Khintla District: Surendranagar	**Village: Mokasar District: Surendranagar**	**Village: Paddhar Taluka Bhuj District: Kachchh**	**Village: Dhori Taluka Bhuj District: Kachchh**	**Village: Hodko District: Kachchh**	**Village: Nana Bandha District: Kachchh**	**Village: Ghadiyado (Banni) District: Kachchh**
				Lohana			
Availability of Water	Medium to Scarce in summer		Medium to sufficient throughout the year		Scarce through most part of the year except monsoon (desert area)		
Source of Water	RRWSS based on source water from Nimdi Dam (@ 2 KM length of Pipe line)	Bore well & Check dam (for recharge) near it	Bore Well (with 80,000 lit capacity sump)- @ 4 km away from village and RRWSS	RRWSS based on Bore well	RRWSS, based on Narmada Water Pipe line		
Whether CSS successful or not?	Yes- Most successful		Redundant- As House-to-House connection allotted in some continents and multiple schemes of water supply exists with sufficient water availability		Yes		

6.3 Observations and Findings

The outcome of the study is separated in two groups, namely 1. Techno-Economic Aspects and 2. Social Aspects.

6.3.1 Techno- Economic Aspects

(i) Capital costs: While referring the capital cost for the infrastructure building of both CSS and ESR & SP system for a typical case of one village Paddhar as mentioned in Table 6.2, the traditional system would cost Rs. 8.08 lacs while the CSS would cost Rs. 8.80 lacs, i.e. the CSS is 9% more expensive if the tanks are of HDPE. However, if the cluster storage tanks were of masonry, then the CSS would cost Rs. 7.13 lacs, i.e. 11.7% less than the traditional system.

In case of CSS design, residual pressure requirement is substantially reduced over the conventional ESR & SP system. This reduces the capital cost of distribution pipes as well as it reduces the chances of frequent breakage in pipes. Also, wastage/loss of water due to breakage reduces to a great extent.

It was also noted during the field visits that wastage was very less in case where the Cluster Storage (CS) tanks are located underground. Because in such system water need to be fetched by the hand pump from the CS tank, while CS tank located on or above ground or in SP system, if 1-2 taps are broken (common case in most villages) then the wastage of water will be higher due to continuous leakages.

Table 6.2 Showing Comparison of Cost for the Infrastructure Needs in CSS versus ESR & SP

ESR & SP system components	**CSS system components**
SP with 4 taps – Each of Rs. 3500 X 8 nos. so, total = Rs. 28,000	16 SP with 2 taps each Rs. 2290 so, total = Rs 36,640
R.C.C. Tank 2 nos., each of 40,000 litres capacity (total 80,000 litres capacity) Each of Rs. 1,16,960 so, total = Rs. 2,33,920 (with sluice valve)	16 nos. Masonary Tanks Each 5000 litres capacity of Rs. 18,800 so, total = Rs. 3,00,000 (with sluice valve and ball cock) OR 16 nos. HDPE Tanks Each 5000 litres capacity of Rs. 29,230 So, total = Rs. 4,67,680 (with sluice valve and ball cock)
Distribution pipes P.V.C. material 2700 meter length so, total = Rs. 3,38,625	Distribution pipes of P.V.C. material 3000 meter length so, total = Rs. 3,76,000
ESR (25,000 litres capacity) = Rs. 1,37,500	Not Required
Under Ground sump R.C.C. (50,000 litres capacity) = Rs. 70,000	Not Required
Total = Rs. 8,08,045	**Total = Rs. 7,13,690 (22% less, if masonary tanks) OR Total = Rs. 8,80,570 (9% more, if HDPE tanks)**
Reference: Training Manual for Trainers of CSS, GJTI	

(ii) Operational costs: There does not seem to be much difference in the operational costs – as in most villages the main operational cost is that of a system operator. However, the real major operational cost is power, which is 100% subsidized by the Government. As far as power consumption is concerned, it would be assumed that pumping cost to high level ESR would be higher. Also, as experienced by the villagers in the

village Mokasar, the traditional system required frequent power use as different communities would want water at different times, while in the CSS; power was used only once to fill the CS tanks. It was also noted that the power saving (particularly in states where demand far exceeds supply) in CSS would be substantial over time.

6.3.2 Community Perception & Social impacts

Based on the visits to seven villages of study area, it was found that the CSS provides an equitable and socially inclusive drinking water supply in the village. In all these villages, those who were laborers, who were more remotely located and who were of the minorities/lower castes, all of them were enthusiastic about the CSS because it provided substantial water storage near their houses. Since the number of households accessing one tank is limited to maximum of about 25 to 30 households only, the chances of any conflict or domination were reduced considerably. In villages, since many of the scheduled castes live in hamlets, this decentralized storage system resulted in these groups getting their own cluster storage tank to manage, and have little dependency on the non-scheduled castes for accessing water.

In the traditional system, since the water supply is erratic (based on when the power comes and when the SP's get water from ESR), the households who do not go to the fields get better access, while laborers get less and later access. Since in CSS, the water is stored, the women can access it at any time – reducing the need to do excessive storage at the household level, and helping the laborers return home from work without much worry. In Kachchh also, where villagers go out for work, and distances are vast, this storage near the house provides relief to the women. Both pastorals and non-pastorals feel comfortable with the new system, as there is enough water for humans and cattle.

Women repeatedly mentioned how much time was saved, and in village Mokasar, the women who were farm laborers, specifically mentioned that since drinking water was available whenever they wanted in adequate quantities, it was a huge improvement in quality of their lives. Earlier, in the ESR & SP scheme, they had to rush from work (if working in nearby fields) during power supply duration as water was distributed from the ESR to the different SP's only during power supply periods. For those who went for labor further away from the main village, the women had to go out again in the evening after a full day's labor work to collect water from nearby wells or beg the village leaders to get the SP water started. In summer, it would be worse, as even local hand pumps/wells would be non-functional. In village Khintla the leaders mentioned that because the water was well chlorinated, illness has come down dramatically in the village and they estimated that there was a saving of Rs. 1.5 – 2 lacs annually in health costs! The nearby doctor in village Sudambda had started noticing that patients from village Khintla were reducing. In the village Hodko, where WASMO is piloting a solar panel based pumping system and CSS in each *vand* (cluster), women mentioned that there were less quarrels between them for water (earlier they would compete to access the water available for limited time). The women mentioned that 1.5 hours of time was saved daily. In village Khintla and Nana Bandha, women mentioned that earlier, even during the labor season, their capacity to work and earn more was limited by water availability and timings. Earlier they used to fill water at 9.30 a.m. and then only leave for work, now they leave for work at 7.30 a.m. as water is stored in CS tanks nearby and no individual storage is required.

In the Banni area of Kachchh, since their livelihood is based on cattle, the earlier limited and erratic water availability led to quarrels between the pastorals who need more water (for cattle) and those who

need water only for domestic consumption. Spending two to three hours daily for water was not unusual in this area. In village Ghadiyado, the villagers have made a modification to the cluster storage tank by diverting the water spilling down the hand pump to the cattle trough, so that there is no wastage at all. Villagers also experienced that milk production has increased because of the increased water availability.

6.4 Potential to Scale up in Village Water Distribution in RRWSS

It was noted that primarily, degree of success of CSS is highly dependent on the population size, variation in caste & inter-caste conflict issues, availability of water, topography of the area, and economic conditions in terms of agricultural and industrial growth in and around the village.

In case of villages (Group-A) located at higher elevation from the source, and the availability of water is medium (other than summer) to scarce (in summer), population size is medium or small and inter-caste conflicts are high and low to medium economic growth conditions, CSS model proves to be the most efficient.

In case of villages (Group-B) located in flat to slightly downward topography, and the availability of water is adequate throughout the year, population size is medium or high and no inter-caste conflicts and economic growth in terms of agricultural and industrial development is good, CSS becomes redundant as the water distribution system has been shifted from collective to individual. Like all technologies which change to match the societies needs for individual service (common landline to individual mobile, common flour mill to household flour unit etc.) in the large, relatively prosperous and semi urbanized villages of Padhhar and

Dhori of district Kachchh, the individual house connections has rendered the CSS redundant. As the villagers mentioned, the CSS was useful relative to the earlier ESR & SP, traditional system, and was used for about two years, but after individual connections were given, the CS tanks are of no use, except where there is common water use (temples etc.).

As per the technical evaluations, despite the minimal cost savings due to implementation of CSS in flat topography region, which is the case of villages (Group C), CSS prove to be quite efficient. However, in case of group C villages, scarce availability of water throughout the year and remotely located clusters of small size population were the main driving factors in making CSS most efficient.

Potential to Scale up Individual Piped Connections

The Villages where reliable source of water is available throughout the year, availability of sufficient water, high population density, flat or even topography and per capita income is high, there is a lot of potential to use individual piped connections for village water distribution.

Potential to Scale up ESR & SP

The Villages where reliable source of water is available for most period of the year, availability of sufficient water, medium population density, heterogeneous but relatively united communities, flat or even topography and per capita income is medium to low, there is a lot of potential to use ESR & SP system.

Potential to Scale up CSS

The semi arid region, where water availability is scarce, local source of water is non-reliable, low population density, villages with uneven topography, social structure is heterogeneous & with inter-caste conflicts, there is a lot of potential to use the cost effective CSS.

7 CONCLUSIONS & RECOMMENDATIONS

Based on a study carried out for the critical evaluation of various RRWSS in Gujarat mainly two groups of performance indicators namely Service Performance Indicators and Financial Management Performance Indicators are identified.

Service Performance Indicators:

- Sustainability of Source
- Adequacy of Water
- Water supply Reliability
- Acceptable Water Quality

Financial Management Performance Indicators:

- Capital cost of Water
- Operations & Maintenance cost of Water
- Cost Recovery & Water Tariff
- Participation of Community at planning & Operation levels

From the studies it is concluded that the developed PIs for evaluation of service performance and financial management performance may be used separately. To quantify the overall performance in each group of indicators, Service Performance Index (SPI) and Financial Management Performance Index (FPI) may be calculated as per following equations.

$$SPI = \frac{\sum_{i=1}^{4} Ii\, Wi}{Wmax\, x \sum_{i=1}^{4} Ii}\ x\ 100$$

$$and\ FPI = \frac{\sum_{i=1}^{43} Ii\, Wi}{Wmax\, x \sum_{i=1}^{3} Ii}\ x\ 100$$

Where, Where, W= Weights assigned to each of the indicators based on their ratings; and I= Importance factor for each of the indicators based on their impact on overall service/financial management

performance and its interrelation to other group indicators. Value of Weights for each of the group indicators is suggested based on its ranking such Excellent, Medium to High, Low to Medium and Poor performance. Importance factor is also suggested for each of the group indicators for the quantification of overall service and financial management performance of an RRWSS.

Further, from the findings, it is determined that it is not necessary that the RRWSS which are performing in a better way from service point of view are also performing well from the financial management point of view. Further, the benchmarking values used for each PI may differ with site conditions. Therefore, benchmarking may be adopted within the group of schemes only and such PIs may be monitored continuously for the monitoring improvements in its performance. However, the same PIs may be used to set targets and policy guidelines. Based on the studies following policy guidelines can be set:

1. A district level (regional) planning is essential to identify areas where RRWSS would be more cost effective and sustainable. The bottom-up demand from the society for the scheme and top-down planning results in least cost option. Further watershed and aquifer information are important for the 'source' sustainability. Surface water based RRWSS justified mostly in areas marked by over exploited aquifers or by serious ground water quality problems with no alternate safe and sustainable source available locally (for eg. North Gujarat, Saurashtra and Kachchh region of Gujarat).
2. The present study reveals that the large scale RRWSS which usually serve urban population & industrial water demands in addition to rural domestic water demands often results in water scarcity to tail-end rural population due to continuous growing demands from urban population and rapid industrial growths, as

the case observed in RRWSS, Variav group, Surat.. Adequate measures may be taken in decentralizing such schemes for rural and urban & industrial and other needs of water supply.

3. The analysis of survey data and analysis made on quantity of water supplied in various RRWSS determined that the actual water supplied is often less than the actual water demand. Therefore, household typically depends on multiple water source including private bore & tanker water supplies. This raises the overall cost burden & less reliability of RRWSS with ultimate result of poor tariff recovery.
4. As per the norm of 250 persons per stand post which is based on assumption of output of 12 litres per minute. But, under study area at several villages, it was determined that the water pressure at stand post was low and the flow of only 3-10 litres per minute was available. This would not make possible for households to get 40 lpcd of water even if half of the persons have to share the stand post.
5. The findings of the survey determined that a large section of the rural people would like the convenience of a piped water supply connection in the house. This may lead in conflict with the norm of 55 or 70 lpcd of water in rural water supply. Such is the very common case with the most villages of Gujarat due to good agricultural & industrial growths taken place in last one or two decades, which lead the significant rise in per capita income of villagers.
6. The O & M cost needs to be properly assessed on regional basis and fully recoverable through tariff recoveries, except for high cost schemes. However, a transparent criteria needs to be developed based on local conditions to determine ‘affordable’ tariffs including

criteria for socially disadvantaged groups. The O & M cost requirements in excess to affordable contributions may be provided through a subsidy scheme.

7. For better Operation & Maintenance of RRWSS, the bulk water supply and village level distribution may be unbundled. This may results in improved service delivery with feeling of own management for villagers. In such cases, GWSSB of state agency may control bulk water supply and Gram Panchayat or Pani Samitis may responsible for equity water distribution & other M & R issues with tariff recoveries.
8. The low recovery of cost is often not due to non affordability or unwillingness to pay, but to do with the inadequate water supply services, the reluctance to pay of the household and the inability of the scheme management to collect the water charges. It is also found out that the stand post users are not charged at all in many piped or multi water distribution schemes (existence of private bore, pipe water supply by GWSSB & ESR with Stand post all together in the village) is also responsible for low cost recovery. On the contrary, there is strong demand from villagers for higher grade of services like piped water and more quantities with will to pay higher water charges also an encouraging to rural water supply sector of Gujarat.
9. Local watershed management plays an important role in catering the needs of water for drinking in most water scarce areas. Encouraging the construction of water recharging structures and adopting improved agricultural practices significantly changes the ground water quality and improves the water table in over-exploited aquifer zones.

SCOPE FOR FURTHER STUDY

Financial aspects such as cost of investments, Operations and Maintenance cost in Regional Water Supply Schemes along with the role of direct subsidies and cross subsidies involved need separate study for the long term financial sustainability of the water supply sector in rural areas, especially.

REFERENCES

Azuma M and Jayakaran S, 2001, Paradigm shift in rural water supply program, 27th WEDC Conference on People and systems for water, sanitation and health, Lusaka, Zambia, pp 271-273

Barot J.M., 1995, Sustainability of rural water supply, 21st WEDC Conference on Sustainability of water and sanitation systems, Kampala, Uganda, pp 161-164

Baumann Erich, Rural water supply network making a difference, 31st WEDC International Conference on Maximizing the benefits from water and environmental sanitation, Kampala, Uganda, pp 339-342

Dhanabalan M., 2009, Change in management policy approach for rational water tariff towards full cost recovery ensuring affordability for poor, 41st Annual Convention of IWWA on Water utility and security management, Hyderabad, India, pp 209-220

Dwivedi Arun Kumar, Bhadauria Sudhir Singh, 2007, Rural water supply system - A framework for performance evaluation, Journal of Indian Water Works Association, April-June, Vol.XXXIX, No.2, pp 99-104

Dwivedi Gaurav, Rehmat, Dharmadhikary Shripad, 2002, WATER : PRIVATE, LIMITED -Issues in Privatisation, Corporatisation and Commercialisation of water sector in India, Aadarsh printers & publishers, Bhopal, India

Falkenmark, M and C Widstrand (1992), Population and Water Resources: A delicate balance, Population Bulletin, Washington: Population Reference Bureau

Gujarat Water Supply and Sewerage Board, http://www.gwssb.org/

Gurinder Gulati, Cluster Storage Stratedgy: a viable approach toward water security in Gujarat, http://www.unicef.org/india/ resources_ 1710.htm

Handbook on Drinking Water Treatment Technologies, 2011, Ministry of Water and Sanitation, Government of India, India

Jimenez A., Perez-Forguet A., 2010, Challenges for water governence in rural water supply: lessons learned from Tanzania, International Journal of Water Resource Development, 26:2, pp 235-248

Kallidaikurichi Seetharam and Rao Bhanoji, 2009, Index of Drinking water adequacy of Asian economies, Research Paper Series: LKYSPP09-014-IWP002, National University of Singapore, http://ssrn.com/abstract =1464688

Karthik P.L.N., Yohan G., 2009, A case study on subsidies in water sector of Vijawada Municipal Corporation, 41st Annual Convention of IWWA on Water utility and security management, Hyderabad, India, pp 231-239

Landge Hemant C., Gupta Rajesh and Katpatal Yashwanth B., 2008, Willingness to pay and affordability survey for urban water supply schemes, Journal of Indian Water Works Association, April-June, Vol.XXXX, No. 2, pp 93-102

Manual on Water Supply and Treatment, Central Public Health and Environmental Engineering Organization, Ministry of Urban Development, New Delhi, May, 1999

Mazumdar K., 2002, Institutional issues: rural water supply in India, Journal of the IPHE, India, No. 3, pp 16-19

Mehta Nihar, 2008, Critical Evaluation of Regional Water Supply Scheme-A case study of Variav RWSS, Surat, M.E. Dissertation, The M.S.University of Baroda, Vadodara

Mhaisalkar V.A., Gawalpanchi R.R., 2002, Considerations in sustainable rural water supply with focus on community participation, Journal of the IPHE, No.1, pp 26-29

Ministry of Drinking Water and Sanitation, Government of India, http://www.mdws.gov.in/

Misra Smita, 2008, Inefficiency of rural water supply schemes in India, Policy paper based on the World Bank study on review of effectiveness of rural water supply schemes in India, PS Press Services Pvt. Ltd., New Delhi

Misra Smita, 2008, Multi village water supply schemes in India, Policy paper based on the World Bank study on review of effectiveness of rural water supply schemes in India, PS Press Services Pvt. Ltd., New Delhi

Misra Smita, 2008, Norms for rural water supply in India, Policy paper based on the World Bank study on review of effectiveness of rural water supply schemes in India, PS Press Services Pvt. Ltd., New Delhi

Misra Smita, 2008, Operation and maintenance expenditure and cost recovery, Policy paper based on the World Bank study on review of effectiveness of rural water supply schemes in India, PS Press Services Pvt. Ltd., New Delhi

Misra Smita, 2008, System of monitoring and evaluation, Policy paper based on the World Bank study on review of effectiveness of rural water supply schemes in India, PS Press Services Pvt. Ltd., New Delhi

Misra Smita, 2008, Willingness of household to pay for improved services and affordability, Policy paper based on the World Bank study on review of effectiveness of rural water supply schemes in India, PS Press Services Pvt. Ltd., New Delhi

Mosse Roberto, Sontheimer Leigh Ellen, 1996, Performance Monitoring Indicators, Handbook, World Bank technical paper number 34, Library of Congress cataloing-in-publication data, Washington, USA

Nath K.J., 2002, Reaching the unreached, Journal of the IPHE, India, No. 4, pp 12-14

National Rural Drinking Water Program- Movement towards Ensuring People's Drinking Water Security in Rural India, Framework for Implementation, Department of Drinking Water Supply, Ministry of Rural Development, Government of India, April, 2010 Source: http://swajal.uk.gov.in/files/pdf/NRDWP_GuidelineApril_10.pdf

Nigam Navin C. 1999, Technological challenges for water management, Journal of Indian Water Works Association, Vol. XXXI, No. 2, pp 87-100

Olatunji Timothy, 2003, Towards making rural water supply work and sustainable, 29th WEDC International Conference on Towards the millennnium development goals, Abuja, Nigeria, pp 134-135

Pal Brij, 2012, Five year plans and rural water supply in India: A critical analysis, Journal of Developing Country Studies, ISSN:2225-0565 (online), Vol.2, No.3, pp 26-37

Panda Ramesh Chandra, 2002, Community particpation in rural drinking water supply, Journal of the IPHE, India, Special WEDC issue, No. 4, pp 16-20

Patel A.S., Shah D.L., 2008, Water Management: Conservation, Harvesting and Artificial Recharge, New Age International Pvt Ltd Publishers, India

Popawala Reena, Shah N C, 2012, Sustainable urban water management systems: a review of status with focus on Surat city of Gujarat state in India, Journal of Indian Water Works Association, July-September, Vol. XXXXIV, No. 3, pp 185-193

Rama Chandraiah C., 2004, Right to drinking water in India, Centre for Economic and Social Studies, woking paper No. 56, Hyderabad, India

Rama Mohan R.V., 2003, Rural water supply in India: Trends in institutionalizing people's participation, Journal of Water International, Volume 28, No. 4, pp 442-453

Report on Bharat Nirman -Water Supply, Source: http://www.mdws.gov.in/bharatnirman/DMU-Report.pdf

Report on evaluation study of rural water supply in Nagaland, 1986, Government of Nagaland, Number 11

Report on Frame work for implementation of Rajiv Gandhi National Drinking Water Mission,2010, Department of Drinking Water Supply,

Ministry of Rural Development, Government of India, http://www.ddws.nic.in

Shah Binay, 1998, Appraisal of rural water supply schemes, 24th WEDC Conference on Sanitation and water for all, Islamabad, Pakistan, pp 319-321

Shailendra J.K.S., Aravinda H.B. and Lokesh K.S., 2012, Quality of Life Index (QoLI) development for rural areas considering the impact of water supply and sanitation, Journal of Indian Water Works Association, January-March, Vol. XXXXIV, No. 1, pp 27-29

Shanthasiri H.K.S. and Wijesooriya, 2004, Case study on community involvement in rural water supply Sri Lanka, 30th WEDC International Conference on People-centred approaches to water and environmental sanitation, Ventiane, Lao PDR, pp 311-314

Sheth R.B., 2006, Chevada na gamo (Tail End Villages), Compiled by CCDU, Gujarat Jal Seve Training Institute, Gandhinagar, India

Stephen David A., 2000, Performance indicators for rural water schemes, 26th WEDC Conference on Water, sanitation and hygiene: challenges of the millennium, Dhaka, Bangladesh, pp 360-363

Still D.A. and Balfour A.F., 2006, a report on The use of Key Performance Indicators in the Benchmarking of Rural Water Supply Schemes, Project K5/1222/01

The World Bank Report, 2008, Review of effectiveness of rural water supply schemes in India, New Delhi, India

Towards Drinking Water Security in India- Lessons from the Field, Source:

http://www.mdws.gov.in/sites/upload_files/ddws/files/pdf/Towards%20Drinking%20Water%20Security.pdf

Training Manual for Trainers of CSS,2007, Gujarat Jal Seva Training Institute, Vol. 1 & 2

Tripathi S K and Lal Bharat, 2001, Community paticipation in rural water spply- Indian initiative, 27th WEDC Conference on People and systems for water, sanitation and health, Lusaka, Zambia, pp 10-14

United Nations Report: 10, 2003, http://www.undp.org/

Vasavada Shilpa, Situation analysis of women's participation in Swajaldhara, an unpublished report

Water Aid India Report, 2005, Drinking water and sanitation status in India- Coverage, financing and emerging concerns, New Delhi, India

Water and Sanitation Management Organization, http://www.wasmo.org/

Water and Sanitation Program Report, 2011, Towards drinking water security in India-Lessons from the field, New Delhi, India

ANNEXURE-I

Performance Evaluation of Regional Rural Water Supply Scheme in Gujarat State

Proforma for Users' Data Survey

General Back ground of Respondent

Instructions for filling the Form:

☐ If this mark more reply of the question to one (☐ in √ mark) shall be given.

◯ If this mark only one answer of the question (◯ in √ mark). Give full details when this is mentioned.

1. Personal Information:

- Name:-

  Surname Self name father/husband/mother name

- Village: Taluka: District:

- Male M ◯

  Female F ◯ Age:

- Religion : Caste: General 1 ◯

  Schedule caste 2 ◯

  Schedule Tribe 3 ◯

  Baxipanch 4 ◯

  Minority 5 ◯

- Education : illiterate 1 < up to 7std. 2 > up to 10 std.
  3 > 12 up to std. 4- Illiterate

- Class (Economically): 1 A.P.L ◯ 2 B.P.L. ◯

- Membership: YES 1 NO 2 (If in committee, mandali of village)
- Profession: Business man 1 ,Regular service 2, Daily wager 3, Farmer 4
- No. of family members: Female :

  Male :

  Children:

2. INFRASTRUCTURE:

1. Which water source utilized by your family from the following?

A 1.Tap (House connection) ☐

B 2.Public Tap ☐

C 3.Hand pump ☐

D 4.Bore well ☐

E 5.Well ☐

F 6. Step Well (Vav) ☐

G 7.River ☐

H 8.Pond ☐

I 9.Tanker ☐

J 10. U. G. storage Tank ☐

2. Distance of daily used water source from your house _____ Km. (If no connection in your house of the water tap)

3. For getting water

1. Government source is used? Yes ◯ 1 No ◯ 2

2. Village's source is used? Yes ◯ 1 No ◯ 2

3. Both sources are used? Yes ◯ 1 No ◯ 2

4. If you are using the government source are you satisfied with present water supply scheme?

Yes ◯ 1 No ◯ 2

5. If answer is yes give the reasons for your satisfaction from the following.

- Water available as per the requirement **A** ☐ 1
- Water available regularly **B** ☐ 2
- Clean water available **C** ☐ 3
- Water available near the house **D** ☐ 4
- Saving in time and work of the house wife **E** ☐ 5
- Positive effects on education of the children **F** ☐ 6
- Change in lifestyle **G** ☐ 7

6. If answer is NO which reasons from the following.

- No house connection available, Government tap is far away **A** 1 ☐
- Not sufficient water available from the public water tap. **B** 2 ☐
- Crowding at the time of watering. **C** 3 ☐
- Unhygienic condition surrounding public tap. **D** 4 ☐
- Socially not reachable. **E** 5 ☐
- Tap water test is not good**. F** 6 ☐
- Water is salty. **G** 7 ☐
- Water is available insufficient pressure. **H** 8 ☐
- Timing of water is less. **I** 9 ☐
- Tariff is high. **J** 10 ☐

- Frequent breakage in pipeline. **K** 11 ☐

3. Water Collection and Storage:

1. How much water needed for other than house used from the following (Litre/Balty)
    - Animal husbandry **A**
    - Dairy Industries **B**
    - Poultry Rearing **C**
    - Home Industries related water use **D**
2. Timing of water supply
    - Regular ◯ 1 irregular ◯ 2 Changeable ◯ 3
3. If water timing is not fixed mention the effect for the following.
    - Routine life **A 1** ☐
    - On business **B 2** ☐
    - Education of children **C 3** ☐
    - Others **D 4** ☐

4. Storage Practices:

1. If 'yes' then what steps have been taken up till now?

- Buying water for use F 6 ☐
- Travel long distance for getting water G 7 ☐

2. Are you spending money in days of water scarcity?

Yes ◯ 1 No ◯ 2

3. What are the average expenses for buying water in scars days?

- Daily A 1 ☐

- Weekly B 2 ☐
- Monthly C 3 ☐
- As per requirement D 4 ☐

4. For buying water in time period?

a. Days A 1 ☐
b. Month B 2 ☐
c. Whole year C 3 ☐
d. Occasionally D 4 ☐
e. Others E 5 ☐

5. What are the businesses effected due to water scarcity?

a. Agriculture A 1 ☐
b. Animal husbandry B 2 ☐
c. Home Industries C 3 ☐
d. Labour work D 4 ☐
e. Traditional profession E 5 ☐

6. Describe for effect on employment.
   a. Loss of Income

5. Water quality:

1. Is their any disease spread due to water in your area?
   Yes ◯ 1 No ◯ 2
2. If your answer in "yes" give the name of disease. _____.

3. Water born diseases are from a long period or after the use of the tap?

Yes ◯ 1 No 2 ◯

6. Water charges:

1. Are you paying any water charges for getting water on regional water supply scheme? Yes ◯ 1 No ◯ 2

2. If answer in "yes" how many Rs. are you paying per house?
_____

3. Have you paid any amount at the time of water connection?
Yes ◯ 1 No ◯ 2

4. Is this tariff bearable?

Yes ◯ 1 No ◯ 2

5. Are you satisfied by you for to get water supply and good quality?
CF ◯ 1 GF ◯ 2

7. In your village any is not agree to pay the water charges?
Yes ◯ 1 No ◯ 2

8. If not agree give the reason _____.

7. Water & Family / Social life:

1. Water is available in your house or outside. _____.
Available 1 ◯ Not available 2 ◯

2. Who is responsible for water filling in your house?

- Female A 1 ☐
- Male B 2 ☐
- Girl C 3 ☐
- Boy D 4 ☐
- Servant E 5 ☐
- Any member F 6 ☐

3. If you go outside than how many members are their filling water?
1 1 **2** 2 **3** 3

4. How much in one time is going and coming to fill water? ½ h 1
1h 2 2h 3 4h 4

5. How many times need to get water outside from the house? <1h 2
<2h 3 <4h 4

6. If girls/boys are filling the water involve this work, than mention the effect on the development of the children

- Due to irregularity in the school wick in the study. A 1 ☐
- Left the school due to continuous absent. B 2 ☐
- Girls to be left without education. C 3 ☐
- To impediment in physical development. D 4 ☐

7. You believe that your difficulties decrease after implement of Regional water supply scheme.
Yes ◯ 1 No ◯ 2

8. What changes are observed due to solution of water availability near you?

- Saving in the time for water filling A 1 ☐
- Saving in labour B 2 ☐
- Deduction in expenses to get the water C 3 ☐
- Decrease in physical labour and mental piece of house woman D 4 ☐
- To close the dispute due to water problem in family and neighbours. E 5 ☐
- Children are regular in school. F 6 ☐
- Children are giving more attention in study. G 7 ☐

- To increases the stage of kanya kelvani. H 8 ☐
- Development of agriculture and animal husbandry. I 9 ☐
- The time saved from drawing the water can be economically was used for improving financial position. J 10 ☐
- To deduct the difficulties in latrine, Toilet, Bathroom facility use to waters scarcity. K 11 ☐

9. Where will you now use the time saved because of the water?

- Agricultural A 1 ☐
- Animal Husbandry B 2 ☐
- Profession C 3 ☐
- Children education D 4 ☐
- House work E 5 ☐
- Child care F 6 ☐
- Home Industries G 7 ☐

ANNEXURE-II

NAME OF	Nos. of Vill.	Sr. no.	Name of group	Name of offtake point	cost of water	pumpig details	pumping cost of 1000 lit water	o & M Cost	Filtration Cost	Total cost
DISTRICT	Mld				Rs. / KL	disch.(lps)		Rs. / kl	Rs. / kl	Rs. / KL
		1	2	3		6	10.00			
RJT	51	1	LODHIKA	KOTHARIA	5.11	44	**0.79**	0.28		6.18
	9.1008					76				
						38				
						158				
						9.1008				
RJT	44	2	KOTADA-	KOTHARIA	5.11	60	**1.89**	0.63		7.63
	3.456		-RIBADA			12				
						60				
						3.456				
RJT	28	3	MOVIYA	MOVIYA	5.49	136	**0.83**	0.18		6.49
	7.8336					20				
						4.5				
						136				
						7.8336				
RJT	32	4	GONDAL	GONDAL	5.5	53	**0.73**	0.37		6.60
	4.2624					21				
						74				
						4.2624				
RJT	42	5	PADADHARI	NYARA	5.11	40	**1.17**	0.27		6.55
	7.6032					46				
						46				
						132				

NAME OF	Nos. of Vill.	Sr. no.	Name of group	Name of offtake point	cost of water	pumpig details	pumping cost of 1000 lit water	o & M Cost	Filtration Cost	Total cost
DISTRICT	Mld				Rs. / KL	disch.(lps)		Rs. / kl	Rs. / kl	Rs. / KL
						7.6032				
RJT	30	6	RAJKOT	KOTADA PITHA	5.84	**27**	**1.71**	0.95		8.50
	1.5552					**10**				
						27				
						1.5552				
RJT	57	7	VINCHHIYA	BOTAD	3.1	160				
			BHADLI			31				
						16				
						37				
RJT	45	8	BHADALA	KOTADA PITHA	5.84	58	**1.38**	0.24		7.46
	9.216		SANATHALI			102				
						50				
						50				
						160				
						9.216				
RJT	50	9	JETPUR	GONDAL	5.5	74	**1.51**	0.23		7.24
	10.5408					109				
						92				
						183				
						10.5408				
JND	66	10	OZAT-2	BHESAN	**5.6**		**0.64**	0.53		6.77
	6.1056					**24**				
						42				

NAME OF	Nos. of Vill.	Sr. no.	Name of group	Name of offtake point	cost of water	pumpig details	pumping cost of 1000 lit water	o & M Cost	Filtration Cost	Total cost
DISTRICT	Mld				Rs. / KL	disch.(lps)		Rs. / kl	Rs. / kl	Rs. / KL
						40				
						106				
						6.1056				
JND	42	11	VISAVADR-2	GAVADAKA	4.7	**18**	**0.72**	0.60		6.01
	3.456					**18**				
						14				
						10				
						60				
						3.456				
JND	42	12	BHESAN	BHESAN	**5.6**	129	**0.73**	0.15		6.48
	13.7664					45				
						65				
						239				
						13.7664				
JND	78	13	VISAVADAR-1	GAVADAKA	4.7	**200**	**2.15**	0.33		7.18
	11.52					**11.52**				
JND	52	14	MANGROL	AJAB						
			MALIA EMER							
JND	51	15	JUNAGADH-	BHESAN	**5.6**	**50**	**0.65**	0.51		6.77
	4.896		- VANTHALI			**35**				
						85				
						4.896				
JND	36	16	KESHOD	AJAB		**4**	**0.43**	0.44		0.87
	4.032					**45**				

NAME OF	Nos. of Vill.	Sr. no.	Name of group	Name of offtake point	cost of water	pumpig details	pumping cost of 1000 lit water	o & M Cost	Filtration Cost	Total cost
DISTRICT	Mld				Rs. / KL	disch.(lps)		Rs. / kl	Rs. / kl	Rs. / KL
						11				
						10				
						70				
						4.032				
JND	18	17	BILKHA	BHESAN	**5.6**					5.60
JMR	31	18	LALPUIR	KHATIYA	**7.11**	**59**	**0.39**	0.45		7.95
	3.3984			A NETWORK		**3.3984**				
JMR	113	19	KALAVAD	ANANDPAR	**6.56**	**92**	**0.85**	0.59		8.00
	9.4464			A NETWORK		**37**				
						35				
						164				
						9.4464				
JMR	91	20	KHIJADIA	JAMNAGAR	3.5	47	**1.06**	0.23		4.79
	19.4112			NC8		80				
						51				
						159				
						337				
						19.4112				
JMR	89	21	KHAMBHALIA	KHAMBHALIA	**7.11**	**66**	**0.80**	0.48		8.39
	9.1008			NC-21		**32**				
						19				
						41				
						158				

NAME OF	Nos. of Vill.	Sr. no.	Name of group	Name of offtake point	cost of water	pumpig details	pumping cost of 1000 lit water	o & M Cost	Filtration Cost	Total cost
DISTRICT	Mld				Rs. / KL	disch.(lps)		Rs. / kl	Rs. / kl	Rs. / KL
						9.1008				
RJT	57	22	TANKARA	HIRAPAR	2.85	19	**0.59**	0.48		3.93
	5.8176			BEDI		82				
						101				
						5.8176				
JMR	77	23	JAMJODHPUR	JAMJODHPUR	**6.56**	29.23	**0.83**	0.43		7.82
	8.846208					47.35				
						77				
						153.58				
						8.846208				
JMR	16	24	DHROL	DHROL	2.86	40	**0.77**	0.34		3.97
	2.304			NC-8		**2.304**				
RJT	107	25	WANKANER	MORBI	1.79	81	**1.32**	0.40		3.51
	13.248			NC-7		35				
						43				
						51				
						20				
						230				
						13.248				
BVN	49	26	BUDHEL	BUDHEL	3.09	80	**0.56**	0.22		3.86
	11.232					61				
						27				
						27				
						195				

NAME OF	Nos. of Vill.	Sr. no.	Name of group	Name of offtake point	cost of water	pumpig details	pumping cost of 1000 lit water	o & M Cost	Filtration Cost	Total cost
DISTRICT	Mld				Rs. / KL	disch.(lps)		Rs. / kl	Rs. / kl	Rs. / KL
						11.232				
BVN	84	27	TANSA	TANSA		**50**	**0.74**	0.32		1.06
	12.96					**14**				
						20				
						3				
						4				
						2				
						57				
						57				
						16				
						2				
						225				
						12.96				
BVN	94	28	PASVI	PASVI	3.09	**42**	**0.91**	0.40		
	11.6928			BUDHEL-BORDA		**23**				
						22				
						18				
						94				
						4				
						203				
						11.6928				
BVN	106	29	MAHUVA	MAHUVA	4.45	68	**1.10**	0.22		
	23.9616					56				
						110				
						39				

NAME OF	Nos. of Vill.	Sr. no.	Name of group	Name of offtake point	cost of water	pumpig details	pumping cost of 1000 lit water	o & M Cost	Filtration Cost	Total cost
DISTRICT	Mld				Rs. / KL	disch.(lps)		Rs. / kl	Rs. / kl	Rs. / KL
						76				
						11				
						27				
						22				
						7				
						416				
						23.9616				
BVN	21	30	PANDERIYA	VALAVAD	3.09	40	**1.16**	0.38		
	2.7072			VALLABHIPUR-		7				
				BUDHEL		4				
						3				
						2				
						47				
						2.7072				
BVN	87	31	SHIHOR	SHIHOR	3.09	63	**0.80**	0.21		
	20.0448			VALLABHIPUR-		16				
				BUDHEL		16				
						44				
						15				
						2				
						47				
						23				
						22				
						42				
						1				

NAME OF	Nos. of Vill.	Sr. no.	Name of group	Name of offtake point	cost of water	pumpig details	pumping cost of 1000 lit water	o & M Cost	Filtration Cost	Total cost
DISTRICT	Mld				Rs. / KL	disch.(lps)		Rs. / kl	Rs. / kl	Rs. / KL
						1				
						11				
						5				
						40				
						348				
						20.0448				
BVN	44	32	VALLABHIPUR-	VALLABHIPUR-	2.02	**199**	**0.45**	0.19		
	11.4624		MALPARA	NAVDA		**33**				
						16				
						16				
						5				
						0				
						199				
						11.4624				
BVN	64	33	UMRALA	VALLABHIPUR	**2.75**	52	**0.55**	0.29		
	11.0592			GADHADA		16				
						44				
						0				
						25				
						35				
						20				
						192				
						11.0592				
BVN	59	34	BOTAD	BOTAD	3.1	285	**0.53**	0.11		
	27.7056					48				

NAME OF	Nos. of Vill.	Sr. no.	Name of group	Name of offtake point	cost of water	pumpig details	pumping cost of 1000 lit water	o & M Cost	Filtration Cost	Total cost
DISTRICT	Mld				Rs. / KL	disch.(lps)		Rs. / kl	Rs. / kl	Rs. / KL
						0				
						38				
						40				
						70				
						19				
						16				
						481				
						27.7056				
BVN	65	35	GADHADA	GADHADA	**3.15**	35	**0.76**	0.23		
	14.0544					23				
						80				
						27				
						30				
						23				
						26				
						244				
						14.0544				
BVN	81	36	CHORVADALA	UMRALA	**4.04**	100	**1.57**	0.32		
	12.384			DAMNAGAR		45				
				SHIHOR		76				
						4				
						39				
						6				
						40				
						215				

NAME OF	Nos. of Vill.	Sr. no.	Name of group	Name of offtake point	cost of water	pumpig details	pumping cost of 1000 lit water	o & M Cost	Filtration Cost	Total cost
DISTRICT	Mld				Rs. / KL	disch.(lps)		Rs. / kl	Rs. / kl	Rs. / KL
						12.384				
AML	35	37	BABRA	BABRA	**4.7**	15	**0.82**	0.23		
	7.3728					27				
						67				
						19				
						15				
						128				
						7.3728				
AML	24	38	KOTADAPITHA	KOTADAPITHA	**5.84**	24	**0.59**	0.44		
	2.7072					23				
						47				
						2.7072				
AML	58	39	CHAVAND LATHI	CHAVAND	4	143	**0.98**	0.19		
	14.8032		LILIYA	LATHI-LILIYA		28				
						33				
						20				
						33				
						34				
						11				
						13				
						195				
						257				
						14.8032				
AML	82	40	SAVARKUNDALA	SAVARKUNDALA	5.8	0.3	**1.31**	0.26		
	15.71904					46				

NAME OF	Nos. of Vill.	Sr. no.	Name of group	Name of offtake point	cost of water	pumpig details	pumping cost of 1000 lit water	o & M Cost	Filtration Cost	Total cost
DISTRICT	Mld				Rs. / KL	disch.(lps)		Rs. / kl	Rs. / kl	Rs. / KL
						170				
						0.6				
						18				
						38				
						600				
						272.9				
						15.71904				
AML		41	BAGASARA	HALIYAD						

NAME OF	Nos. of Villages	Sr. no.	Name of group	Name of off take point	cost of water at off take point incl. cost of raw water	pumping cost of 1 KL water (for group)	o & m cost of pipe line of group	Filtration Cost for group	o & m OF P.M. of group	total exp. for group dist.	Grand cost for group
DISTRICT					**Rs. / KL**	**Rs. / kl**	**Rs. / kl**	**Rs. / kl**	**Rs. / kl**	**Rs. / kl**	**Rs. / KL**
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11 (7+8+9+10)**	**12 (11+6)**
RAJKOT	51	1	LODHIKA	KOTHARIA RAJKOT	5.11	0.79	0.28	0.50	0.29	1.86	6.97
RAJKOT	44	2	KOTADA-RIBADA	KOTHARIA RAJKOT	5.11	1.89	0.63	0.50	0.29	3.31	8.42
RAJKOT	28	3	MOVIYA	MOVIYA CHAMARADI-GONDAL	5.47	0.83	0.18	0.50	0.29	1.79	7.26
RAJKOT	32	4	GONDAL	GONDAL	5.47	0.73	0.37	0.50	0.29	1.89	7.36
RAJKOT	42	5	PADADHARI	NYARA NC-20 1ST	5.11	1.17	0.27	0.50	0.29	2.23	7.34
RAJKOT	30	6	RAJKOT	KOTADA PITHA	5.94	1.71	0.95	0.50	0.29	3.45	9.39
RAJKOT	57	7	VINCHHIYA-BHADLI	BOTAD	3.10	2.76	0.31	0.50	0.58	4.15	7.25
RAJKOT	44	8	BHADALA-SANATHLI	KOTADA PITHA	5.94	1.71	0.24	0.50	0.30	2.75	8.69
JUNAGADH	42	9	VISAVADAR	GAVADAKA (AMRELI)	9.85	0.13	0.21	0.50	0.29	1.13	10.98
JUNAGADH	42	10	BHESAN	BHESAN	5.47	0.73	0.15	0.50	0.29	1.67	7.14
JUNAGADH	52	11	MANGROL-MALIA	AJAB	5.47	0.69	0.21	0.50	0.29	1.69	7.16
JUNAGADH	51	12	JUNAGADH-VANTHALI	BHESAN	5.47	0.65	0.51	0.50	0.29	1.96	7.43
JUNAGADH	36	13	KESHOD	AJAB	5.47	0.43	0.44	0.50	0.29	1.66	7.13
JAMNAGAR	31	14	LALPUIR	KHATIYA NC-21	7.11	0.39	0.45	0.50	0.29	1.63	8.74

NAME OF	Nos. of Villages	Sr. no.	Name of group	Name of off take point	cost of water at off take point incl. cost of raw water	pumping cost of 1 KL water (for group)	o & m cost of pipe line of group	Filtration Cost for group	o & m OF P.M. of group	total exp. for group dist.	Grand cost for group
DISTRICT					Rs. / KL	Rs. / kl	Rs. / kl	Rs. / kl	Rs. / kl	Rs. / kl	Rs. / KL
1	2	3	4	5	6	7	8	9	10	11 (7+8+9+10)	12 (11+6)
JAMNAGAR	113	15	KALAVAD	ANANDPAR NC-20 2ND	5.80	0.85	0.59	0.50	0.29	2.23	8.03
JAMNAGAR	91	16	KHIJADIA	KHIJADIA NC-8	2.85	1.06	0.23	0.50	0.29	2.08	4.93
JAMNAGAR	89	17	KHAMBHALIA	KHAMBHALIA NC-21	7.11	0.80	0.48	0.50	0.29	2.07	9.18
RAJKOT	57	18	TANKARA	HIRAPAR & BEDI NC-12	2.85	0.59	0.48	0.50	0.29	1.87	4.72
JAMNAGAR	77	19	JAMJODHPUR	JAMJODHPUR NC-21	5.80	0.83	0.43	0.50	0.29	2.05	7.85
JAMNAGAR	16	20	DHROL	DHROL NC-8	2.85	0.77	0.34	0.50	0.29	1.90	4.75
RAJKOT	107	21	WANKANER	MORBI NC-7	1.79	1.32	0.40	0.50	0.29	2.51	4.30
BHAVNAGAR	49	22	BUDHEL	BUDHEL	3.09	0.91	0.22	0.50	0.24	1.87	4.96
BHAVNAGAR	84	23	TANSA	TANSA (BUDHEL)	4.45	0.74	0.32	0.50	0.29	1.85	6.30
BHAVNAGAR	94	24	PASVI	PASVI BUDHEL-BORDA	4.45	0.91	0.40	0.50	0.29	2.09	6.54
BHAVNAGAR	106	25	MAHUVA	MAHUVA	4.45	1.10	0.22	0.50	0.29	2.11	6.56
BHAVNAGAR	21	26	PANDERIYA	VALAVAD-VALLABHIPUR-BUDHEL	3.09	1.16	0.38	0.50	0.29	2.33	5.42
BHAVNAGAR	87	27	SHIHOR	SHIHOR-VALLABHIPUR-BUDHEL	3.09	1.21	0.21	0.50	0.38	2.30	5.39

NAME OF	Nos. of Villages	Sr. no.	Name of group	Name of off take point	cost of water at off take point incl. cost of raw water	pumping cost of 1 KL water (for group)	o & m cost of pipe line of group	Filtration Cost for group	o & m OF P.M. of group	total exp. for group dist.	Grand cost for group
DISTRICT					**Rs. / KL**	**Rs. / kl**	**Rs. / kl**	**Rs. / kl**	**Rs. / kl**	**Rs. / kl**	**Rs. / KL**
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11 (7+8+9+10)**	**12 (11+6)**
BHAVNAGAR	44	28	VALLABHIPUR-MALPARA	VALLABHIPUR & NAVDA	2.02	0.57	0.19	0.50	0.16	1.42	3.44
BHAVNAGAR	64	29	UMRALA	VALLABHIPUR & GADHADA	3.10	0.68	0.28	0.50	0.30	1.76	4.86
BHAVNAGAR	59	30	BOTAD	BOTAD	3.10	0.70	0.10	0.50	0.12	1.43	4.53
BHAVNAGAR	65	31	GADHADA	GADHADA	3.10	1.01	0.22	0.50	0.26	1.99	5.09
BHAVNAGAR	81	32	CHORVADALA	UMRALA, DAMNAGAR & SHIHOR	4.00	1.57	0.32	0.50	0.29	2.68	6.68
AMRELI	35	33	BABRA	BABRA & CHAMARADI	5.47	1.16	0.23	0.50	0.29	2.19	7.66
AMRELI	24	34	KOTADAPITHA	KOTADAPITHA	6.00	0.91	0.33	0.50	0.33	2.07	8.07
AMRELI	58	35	CHAVAND LATHI LILIYA	CHAVAND	4.00	0.98	0.19	0.50	0.08	1.75	5.75
AMRELI	82	36	SAVARKUNDALA	SAVARKUNDALA	5.94	1.31	0.26	0.50	0.29	2.36	8.30
AMRELI	48	37	ISHVARIYA	ISHVARIYA (AMRELI)	4.70	1.20	0.40	0.50	0.29	2.39	7.09
AMRELI	83	38	JUNGAR	JUNGAR CHAMARADI-BHESAN	5.47	1.82	0.57	0.50	0.23	3.12	8.59
AVERAGE COST					**4.70**	1.02	0.34	0.50	0.28	**2.15**	**6.85**

Name of group	Name of District	Nos. of Vill. in Group	Ultimate Demand in MLD	Name of offtake point	cost of water at off take point incl. cost of raw water	pumping cost of 1 KL water (for group)	o & m cost of pipe line of group	Filtration Cost for group	o & m OF P.M. of group	total exp. for group dist.	Grand cost for group
					Rs. / KL	Rs. / kl	Rs. / kl	Rs. / kl	Rs. / kl	Rs. / kl	Rs. / KL
2	3	4	5	5	6	7	8	9	10	11 (7+8+9+10)	12 (11+6)
VALLABHIPUR-MALPARA	BHAVNAGAR	44	10.53	VALLABHIPUR & NAVDA	2.02	0.57	0.29	0.33	0.16	1.35	3.37
UMRALA	BHAVNAGAR	64	16.84	VALLABHIPUR & GADHADA	3.10	0.68	0.26	0.33	0.30	1.57	4.67
SHIHOR	BHAVNAGAR	87	21.78	SHIHOR-VALLABHIPUR-BUDHEL	3.10	1.21	0.30	0.33	0.38	2.22	5.32
PANDERIYA	BHAVNAGAR	21	3.73	VALAVAD-VALLABHIPUR-BUDHEL	3.10	1.16	0.38	0.33	0.29	2.16	5.26
BUDHEL	BHAVNAGAR	49	14.74	BUDHEL	3.10	0.91	0.24	0.33	0.24	1.72	4.82
BOTAD	BHAVNAGAR	59	31.21	BOTAD	3.10	0.70	0.13	0.33	0.12	1.28	4.38
VINCHHIYA-BHADLI	RAJKOT	57	16.94	BOTAD	3.10	2.76	0.31	0.33	0.58	3.98	7.08
GADHADA	BHAVNAGAR	65	22.08	GADHADA	3.10	1.01	0.20	0.33	0.26	1.80	4.90

Name of group	Name of District	Nos. of Vill. in Group	Ultimate Demand in MLD	Name of offtake point	cost of water at off take point incl. cost of raw water	pumping cost of 1 KL water (for group)	o & m cost of pipe line of group	Filtration Cost for group	o & m OF P.M. of group	total exp. for group dist.	Grand cost for group
					Rs. / KL	Rs. / kl	Rs. / kl	Rs. / kl	Rs. / kl	Rs. / kl	Rs. / KL
2	3	4	5	5	6	7	8	9	10	11 (7+8+9+10)	12 (11+6)
CHORVADALA	BHAVNAGAR	81	16.25	UMRALA, DAMNAGAR & SHIHOR	4.00	1.57	0.34	0.33	0.29	2.53	6.53
TANSA	BHAVNAGAR	84	26.37	TANSA (BUDHEL)	4.45	0.74	0.22	0.33	0.29	1.58	6.03
PASVI	BHAVNAGAR	94	22.28	PASVI BUDHEL-BORDA	4.45	0.91	0.27	0.33	0.29	1.80	6.25
MAHUVA	BHAVNAGAR	106	29.33	MAHUVA	4.45	1.10	0.23	0.33	0.29	1.95	6.40
CHAVAND LATHI LILIYA	AMRELI	56	**21.12**	CHAVAND	4.00	0.98	0.19	0.33	0.08	1.57	5.57
ISHVARIYA	AMRELI	48	8.75	ISHVARIYA (AMRELI)	4.70	1.20	0.40	0.33	0.29	2.22	6.92
BABRA	AMRELI	34	**10.9**	BABRA & CHAMARADI	5.47	1.16	0.23	0.33	0.29	2.01	7.48
SAVARKUNDALA	AMRELI	82	**22.85**	SAVARKUNDALA	5.94	1.31	0.26	0.33	0.29	2.19	8.13
JUNGAR	AMRELI	83	**14.51**	JUNGAR CHAMARADI-BHESAN	5.47	1.82	0.38	0.33	0.23	2.76	8.23

Name of group	Name of District	Nos. of Vill. in Group	Ultimate Demand in MLD	Name of offtake point	cost of water at off take point incl. cost of raw water	pumping cost of 1 KL water (for group)	o & m cost of pipe line of group	Filtration Cost for group	o & m OF P.M. of group	total exp. for group dist.	Grand cost for group
					Rs. / KL	Rs. / kl	Rs. / kl	Rs. / kl	Rs. / kl	Rs. / kl	Rs. / KL
2	3	4	5	5	6	7	8	9	10	11 (7+8+9+10)	12 (11+6)
KOTADAPITHA	AMRELI	24	**5.12**	KOTADA PITHA	6.00	0.91	0.33	0.33	0.33	1.90	7.90
BHADALA-SANATHLI	RAJKOT	44	17.96	KOTADA PITHA	5.94	0.86	0.19	0.33	0.30	1.67	7.61
RAJKOT	RAJKOT	30	5.53	KOTADA PITHA	5.94	1.71	0.39	0.33	0.29	2.71	8.65
VISAVADAR	JUNAGADH	42	17.99	GAVADAKA (AMRELI)	9.85	0.13	0.27	0.33	0.29	1.02	10.87
BHESAN	JUNAGADH	42	9.26	BHESAN	5.47	0.73	0.27	0.33	0.29	1.62	7.09
MANGROL-MALIA	JUNAGADH	50	**19.48**	AJAB	5.47	0.69	0.15	0.33	0.29	1.46	6.93
JUNAGADH-VANTHALI	JUNAGADH	46	**34.33**	BHESAN	5.47	0.65	0.46	0.33	0.29	1.73	7.20
KESHOD	JUNAGADH	36	8.96	AJAB	5.47	0.43	0.24	0.33	0.29	1.29	6.76
WANKANER	RAJKOT	106	**22.87**	MORBI NC-7	1.79	1.32	0.39	0.33	0.29	2.33	4.12
TANKARA	RAJKOT	56	**12.61**	HIRAPAR & BEDI NC-12	2.85	0.59	0.47	0.33	0.29	1.69	4.54
DHROL	JAMNAGAR	16	1.37	DHROL NC-8	2.85	0.77	0.69	0.33	0.29	2.08	4.93
KHIJADIA	JAMNAGAR	44	19.16	KHIJADIA NC-8	2.85	1.06	0.14	0.33	0.29	1.82	4.67

Name of group	Name of District	Nos. of Vill. in Group	Ultimate Demand in MLD	Name of offtake point	cost of water at off take point incl. cost of raw water	pumping cost of 1 KL water (for group)	o & m cost of pipe line of group	Filtration Cost for group	o & m OF P.M. of group	total exp. for group dist.	Grand cost for group
					Rs. / KL	Rs. / kl	Rs. / kl	Rs. / kl	Rs. / kl	Rs. / kl	Rs. / KL
2	3	4	5	5	6	7	8	9	10	11 (7+8+9+10)	12 (11+6)
PADADHARI	RAJKOT	42	9.85	NYARA NC-20 1ST	5.11	1.17	0.30	0.33	0.29	2.10	7.21
LODHIKA	RAJKOT	51	12.47	KOTHARIA RAJKOT	5.11	0.62	0.28	0.33	0.29	1.52	6.63
KOTADA-RIBADA	RAJKOT	44	8.92	KOTHARIA RAJKOT	5.11	1.89	0.35	0.33	0.29	2.86	7.97
MOVIYA	RAJKOT	28	12.72	MOVIYA CHAMARADI-GONDAL	5.47	0.83	0.16	0.33	0.29	1.60	7.07
GONDAL	RAJKOT	32	6.97	GONDAL	5.47	0.73	0.33	0.33	0.29	1.68	7.15
JAMJODHPUR	JAMNAGAR	77	**14.52**	JAMJODHPUR NC-21	5.80	0.83	0.43	0.33	0.29	1.88	7.68
KALAVAD	JAMNAGAR	112	17.09	ANANDPAR NC-20 2ND	5.80	0.85	0.40	0.33	0.29	1.87	7.67
KHAMBHALIA	JAMNAGAR	89	16.25	KHAMBHALIA NC-21	7.11	0.80	0.32	0.33	0.29	1.74	8.85
					4.55	**0.98**	**0.30**	**0.32**	**0.28**	**1.88**	**6.43**

ANNEXURE-III

CALCULATION STATEMENT OF O & M FOR RRWSS DISTRIBUTION GROUPS in South & Central Gujarat

As on Year 2009

Sr. No.	Dist.	Name of R.W.S.S.	No. of Vills. Included	Average supply in kilo lit. Per day	Annual supply in kilo litre	Name of main head works	Cost of Raw water Rs./ KL.	Cost of Treatment Rs./KL	Pumping cost. of water Rs./KL	M & R of Distribution pipeline	M & R of Pumps Rs./ KL	Total Exp. for Distribution Rs./KL. (Col. 9+10+11+12)	Grand Cost in Rs./ KL (Col. 8+13)	Annual expendi. in Rs. lacs	Average cost Per Kilo Lit.for district
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
1	Valsad	Bigrimalvan	3	1160	423400	Malvan	3.72	0.19	0.67	1.4	0.07	2.33	6.05	**25.62**	
2		Dharasana	5	400	146000	Bamkhadi	0.00	0.00	3.32	7.08	0.17	10.57	10.57	**15.43**	
3		Dandibhagal	3	330	120450	Untadi	0.00	0.00	2.69	4.61	0.48	7.78	7.78	**9.37**	
4		Kurgam Tumbi	6	900	328500	Kurgam	0.00	0.00	4.14	1.67	0.31	6.12	6.12	**20.10**	**7.02**
5		Sutharpada Fali.	2	150	54750	Sutharpada	0.00	0.00	6.61	1.81	0.45	8.87	8.87	**4.86**	
		TOTAL	**19**	**2940**	**1073100**									**75.38**	
1	Navsari	Chingam Panar	2	360	**131400**	Panar	0.00	1.59	3.30	0.00	0.13	5.02	5.02	6.60	**5.16**
2		Dandisampor	3	480	**175200**	Matwad	1.44	1.96	4.19	0.00	0.21	6.36	7.80	13.67	

Sr. No.	Dist.	Name of R.W.S.S.	No. of Vills. Included	Average supply in kilo lit. Per day	Annual supply in kilo litre	Name of main head works	Cost of Raw water Rs./ KL.	Cost of Treatment Rs./KL	Pumping cost. of water Rs./KL	M & R of Distribution pipeline	M & R of Pumps Rs./ KL	Total Exp. for Distribution Rs./KL. (Col. 9+10+11+12)	Grand Cost in Rs./ KL (Col. 8+13)	Annual expendi. in Rs. lacs	
3		Washi Borsi	5	770	**281050**	Ubharat	1.24	1.03	5.16	0.45	0.22	6.86	8.10	22.77	
4		Chhapar	10	1860	**678900**	Chhaper	0.00	1.10	2.12	0.00	0.07	3.29	3.29	22.34	
		TOTAL	**20**	**3470**	**1266550**									**65.36**	
1	Ahwa	Bhisya	7	220.0	**80300**	Bhisya	0.00	0.00	4.62	3.36	0.18	8.16	8.16	6.55	**7.81**
2		Javtal Garmal	3	490.0	**178850**	Pandva	0.00	0.00	3.12	4.97	0.20	8.29	8.29	14.83	
3		Subir	4	170.0	**62050**	Subir	0.00	0.00	1.54	4.39	0.39	6.32	6.32	3.92	
4		Kodmal	4	140.0	**51100**	Kodmal	0.00	0.00	1.34	4.97	0.95	7.26	7.26	3.71	
5		Bhendmal	5	90.0	**32850**	Malin	0.00	0.00	2.30	6.57	0.38	9.25	9.25	3.04	
6		Galkund	8	1160.0	**423400**	Galkund	0.00	0.00	1.60	7.45	0.59	9.64	9.64	40.82	
7		Hanvatchond	4	1220.0	**445300**	Hanvatchond	0.00	0.00	2.00	5.99	0.57	8.56	8.56	38.12	
8		Kudkas	3	830.0	**302950**	Kudkas	0.00	0.00	2.02	7.30	0.57	9.89	9.89	29.96	

Sr. No.	Dist.	Name of R.W.S.S.	No. of Vills. Included	Average supply in kilo lit. Per day	Annual supply in kilo litre	Name of main head works	Cost of Raw water Rs./ KL.	Cost of Treatment Rs./KL	Pumping cost. of water Rs./KL	M & R of Distribution pipeline	M & R of Pumps Rs./ KL	Total Exp. for Distribution Rs./KL. (Col. 9+10+11+12)	Grand Cost in Rs./ KL (Col. 8+13)	Annual expendi. in Rs. lacs	
9		Lavchali	5	1280.0	**467200**	Daher	0.00	0.00	2.53	6.20	0.63	9.36	9.36	43.73	
10		Mahadar	7	1040.0	**379600**	Mahader	0.00	0.00	2.10	5.30	0.50	7.90	7.90	29.99	
11		Mahal	4	300.0	**109500**	Mahal	0.00	0.00	2.70	3.00	0.52	6.22	6.22	6.81	
12		Pipaldahad	10	1890.0	**689850**	Pipaldahad	0.00	0.00	1.50	3.29	0.75	5.54	5.54	38.22	
13		Sati.	11	1710.0	**624150**	Sati	0.00	0.00	1.39	4.69	0.45	6.53	6.53	40.76	
		TOTAL	**75**	**10540**	**3847100**									**300.45**	
1	Surat	Dumas - 1	8	2950	**1076750**	Gavier	1.02	1.82	0.88	0.84	0.1	3.64	4.66	50.18	
2		Dumas - 2	4	560	**204400**	Bhimrad	0.00	0.00	0.22	1.84	0.10	2.16	2.16	4.42	
3		Hajira	12	5420	**1978300**	Pal	1.20	1.99	0.84	0.59	0.07	3.49	4.69	92.78	4.57
4		budia	10	2980	**1087700**	Budia	1.20	1.60	1.20	2.50	0.10	5.4	6.60	71.79	
5		Gaypagla	30	9620	**3511300**	Gaypagla	0.68	1.35	1.10	0.40	0.10	2.95	3.63	127.46	

Sr. No.	Dist.	Name of R.W.S.S.	No. of Vills. Included	Average supply in kilo lit. Per day	Annual supply in kilo litre	Name of main head works	Cost of Raw water Rs./ KL.	Cost of Treatment Rs./KL	Pumping cost. of water Rs./KL	M & R of Distribution pipeline	M & R of Pumps Rs./ KL	Total Exp. for Distribution Rs./KL. (Col. 9+10+11+12)	Grand Cost in Rs./ KL (Col. 8+13)	Annual expendi. in Rs. lacs	
6		panesara	38	5270	**1923550**	**Panesara**	0.00	0.00	0.71	0.91	0.10	1.72	1.72	33.09	
7		Sandhiyer	35	4920	**1795800**	Sandhiyer	0.00	0.00	1.71	1.11	0.10	2.92	2.92	52.44	
8		South Nizar	47	7490	**2733850**	Velda	0.68	1.97	2.63	2.52	0.20	7.32	8.00	218.71	
9		Ambheta	7	990	**361350**	Ambheta	0.68	0.78	1.55	1.23	0.20	3.76	4.44	16.04	
10		Vyaval	3	200	**73000**	Vyaval	0.00	0.00	4.80	3.60	0.30	8.7	8.70	6.35	
		TOTAL	**194**	**40400**	**14746000**									**673.25**	
1	Vadodara	Sankheda	37	1136.70	414896	Rajnagar	0.69	0	2.23	2.21	0.15	4.59	5.28	21.91	
2		Waghodia	70	4290.00	1565850	Dungritekri	1.26	0.12	1.57	1.20	0.05	2.94	4.20	65.77	
3		Padra	48	7050.00	2573250	KOthiya	0.49	0.53	7.28	0.81	0.69	9.31	9.80	252.18	6.31
4		Savli	119	9077.04	3313120	Ajabpura	0.49	0.25	4.35	0.86	0.79	6.25	6.74	223.30	
5		Vadodara South Zone	13	631.02	230322	Untiya	0.00	0.00	3.94	0.00	1.10	5.04	5.04	11.61	

Sr. No.	Dist.	Name of R.W.S.S.	No. of Vills. Included	Average supply in kilo lit. Per day	Annual supply in kilo litre	Name of main head works	Cost of Raw water Rs./ KL.	Cost of Treatment Rs./KL	Pumping cost. of water Rs./KL	M & R of Distribution pipeline	M & R of Pumps Rs./ KL	Total Exp. for Distribution Rs./KL. (Col. 9+10+11+12)	Grand Cost in Rs./ KL (Col. 8+13)	Annual expendi. in Rs. lacs	
6		Fajalpur	37	5505.00	2009325	Fajalpur Main H.W.	0.00	0.00	0.50	1.69	0.44	2.63	2.63	52.85	
7		Chapad	2	141.92	51801	Chapad	0.00	0.00	0.03	4.12	0.89	5.04	5.04	2.61	
8		Khatamba	5	180.00	65700	Tatarpura& Ratanpur	0.00	0.00	0.73	12.44	2.18	15.35	15.35	10.08	
9		Ganeshpura Machlipura	5	175.00	63875	Kamrol	0.00	0.00	1.71	10.31	2.04	14.06	14.06	8.98	
		TOTAL	336	28186.68	10288138.2									649.28	