Identification of Service Performance Indicators and Development of Service Performance Index for Checking Sustainability of Regional Rural Water Supply Schemes in Indian Context

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Abstract— The concept of monitoring and evaluating the performance and sustainability of rural water supply system was considered hypothetical in past as every matter related to water supply was the liability of state government in most developing nations. However, in 21st century, the state of affairs is pole apart, the accountability has come on elected committees and therefore, the assessment of service performance is considered as need of the time. Further, the performance and design of any rural water supply scheme in India is severely affected due to several factors such as involvement of large and scattered population, non-uniformity in level of awareness, socio-economic conditions, education, poverty, practices and rituals and water availability, etc. Therefore, it is necessary to identify and develop Performance Indicators (PI's) and an Index, which help to judge the sustainability of any water supply scheme in the region. A case study comprising of several regional rural water supply schemes of Gujarat was undertaken based on specific criteria. Identified Performance Indicators can be used to judge the service (technical) performance and sustainability of any water supply scheme. A method of assessment is also developed to find out the overall service performance of any water supply scheme by assigning weights and importance factor to various PI's.

Key words: Service Performance Index, Service Performance Indicators

ABBREVIATIONS

Lpcd = litres per capita per day
PI's = Performance Indicators
SPI = Service Performance Index
GWSSB = Gujarat Water Supply and Sewerage Board
RRWSS = Regional Rural Water Supply Scheme
WASMO= Water and Sanitation Management Organization

I. INTRODUCTION

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. Nath K.J. (2002), reported that the failure to provide safe drinking water and adequate sanitation services to all people is, perhaps, the greatest development failure of 20th century. Providing safe drinking water and 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.

In India today, more than 96 percent of rural habitations - or 720 million people - have access to water infrastructure to supply them at 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. 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.

A. 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 planning and making policies for the future schemes too.

II. 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 Gujarat Water Infrastructure Limited, 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 Non-Governmental Organizations are responsible. Therefore, the present study was undertaken by data collection from above agencies, interactions with the officials and field visits in the selected RRWSS. The selection of the representative RRWSS for study was carried out based on the following points keeping in mind:

A. Hydrology of the Area:

Rainfall varies highly in the state of Gujarat. South Gujarat receive more than 1500 mm rain fall per annum, middle Gujarat receive around 1000 mm per annum, the Saurashtra

region receive less than 600 mm rain fall per annum while Kachchh region is partly a desert area and receive minimum rain fall. The prosperity of the area and quality and 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 schemes from the Saurashtra region namely RRWSS Gadhada group, Bhavnagar and RRWSS Ishwaria group, Amreli and one from the Kachchh region namely RRWSS Mandvi group, Kachchh.

B. 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.

C. 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.

D. 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 port 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.

The users' data survey was carried out covering 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 data for all RRWSS operated in South and Central Gujarat was undertaken.

III. Observations and Outcomes

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. Therefore, in the present study following four indicators are considered for the evaluation of various RRWSS.

1) Sustainability of source
2) Adequacy of water
3) Reliability of water supply and
4) Acceptable water quality amongst the users'

A. 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.

B. Adequacy for Water Supply

In June 2002, Government of India has 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 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's data survey in certain villages. The results of the user's 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).

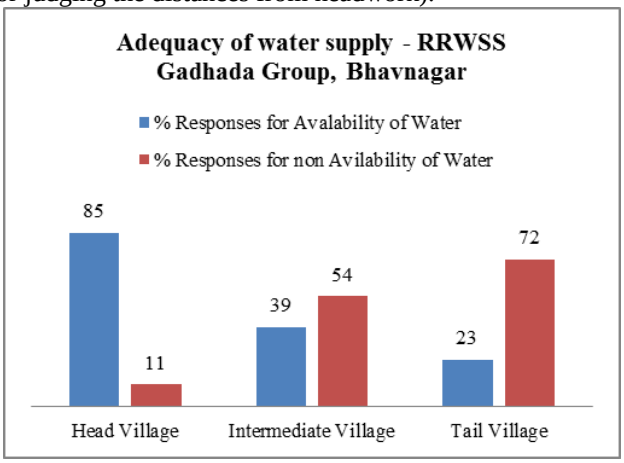

Fig. 1: Graph showing the % Responses for 'Adequacy of Water supply' in RRWSS Gadhada Group, Bhavnagar

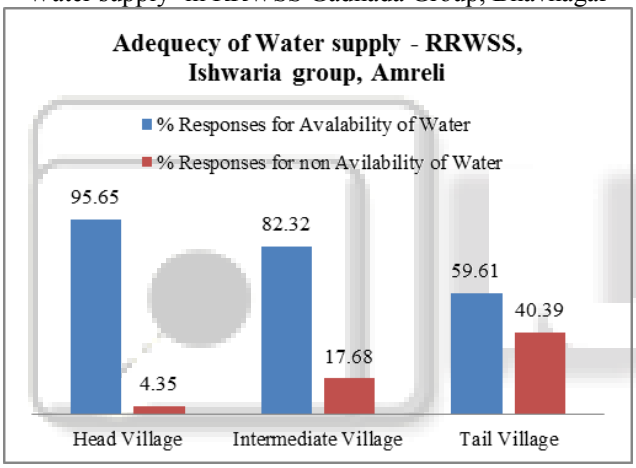

Fig. 2: Graph showing the % Responses for 'Adequacy of Water supply' in RRWSS Ishwaria Group, Amreli

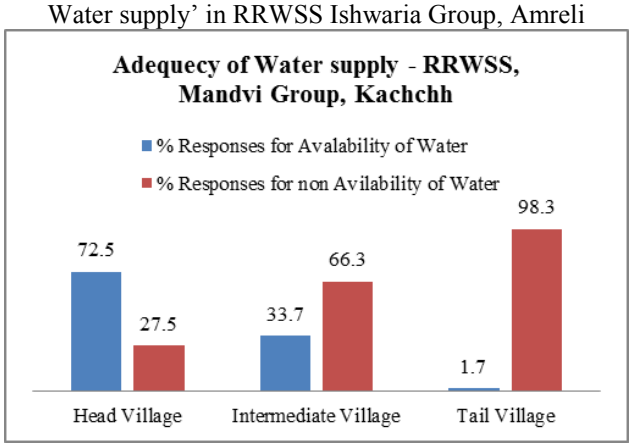

Fig. 3: Graph showing the % Responses for 'Adequacy of Water supply' in RRWSS Mandvi Group, Kachchh

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 4.0 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 in most seasons of the year.

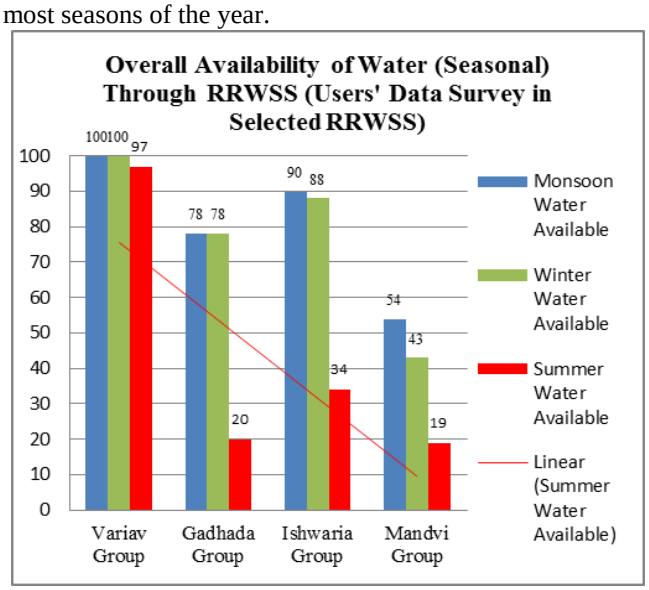

Fig. 4: Graph Showing the % Responses for 'Overall Availability of Water' Through Various Seasons in Selected RRWSS

C. 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 as the number of days of a month for which water received, especially in summer season.

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

For the evaluation of water supply reliability indicator, group of regional rural water supply schemes of whole South & Central Gujarat are selected. Figure 5.0 represents the overall scenario of reliability of water supply in the region.

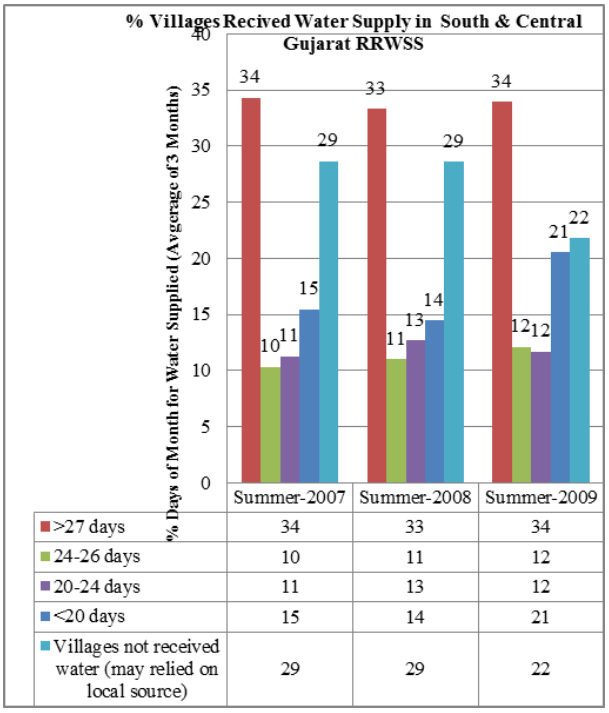

Fig. 5: Graph Showing % Villages Received water in Summer Season (Reliability of Water Supply) for South & Central Gujarat Schemes

D. Acceptable Water Quality

Even in this era of phenomenal scientific and technological developments, there are still constraints in achieving water quality assurance especially in many rural areas of developing countries. When the theoretical knowledge of treatment remains intact universally, in the practical implementation, many rural water supplies suffer 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 careless approach in dosing coagulant chemicals results in deterioration of water quality, random chlorination causes either super chlorination and consumer distaste 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 RRWSS 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 was found essential.

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. Water quality analysis data and Users' survey data are taken into consideration while summarizing the acceptable water quality in various RRWSS. Figure 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 RRWSS meet the satisfactory water quality except at certain locations.

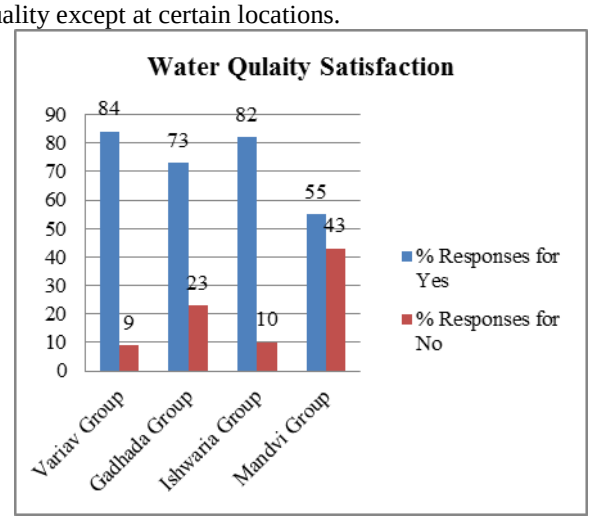

Fig. 6: Users' Data Survey Results on Water Quality Satisfaction in Selected RRWSS

IV. Development of Service Performance Index (SPI)

Service performance is dependent of four indicators as discussed above, for the assessment of overall service performance, an aggregating index is used as per the equation 1.1 and 1.2.

Service Performance Index (SPI) can be expressed as

$$SPI = \frac{\sum_{i=1}^{4} Ii\, Wi}{Wmax\, x \sum_{i=1}^{4} Ii} \; x\; 10 \qquad (1.1)$$

$$SPI = \frac{I1\,W1+I2W2+I3W3+I4W4}{Wmax\ (I1+I2+I3+I4)} \; x\; 100 \quad (1.2)$$

Where, W= Weights assigned to each of the indicators based on their ratings. 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 1.0 and I= Importance factor for each of the indicators can be selected based on their impact on overall service performance, its interrelation to other indicators and site specific conditions for example, whether RRWSS lying in the water rich area or water scarce area (such as importance of water to villagers for drinking in presence/absence of water available from an alternative source). Table 2 shows the value of *I* for various indicators in different 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, Perennial surface water source but conveyance system is sensitive, 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

Table 1: Showing Rating and Weight Assigned for the Various PI's for the Evaluation of Service Performance of RRWSS

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		

Table 2: Showing Service Performance Index value for various RRWSS under study area

SPI can be scaled from 0 to 100, 100 being the maximum index value with all factors 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 present study Table 3.0 shows the performance rating based on the overall SPI.

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 3: Showing Performance Ratings Based on SPI for the Various RRWSS

V. CONCLUSIONS

In a present case study the value of the weights and importance factor selected are as per Table 2.0 for selected four RRWSS. The values in Table 2.0 are selected by keeping following two important considerations.

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.

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