

## Study of Rainwater Harvesting Potential of Zura Village of Kutch District of Gujarat

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**ABSTRACT** Water availability is becoming acute in both urban as well as rural areas. Although large number of problem villages have been covered by the different government water supply schemes, but the number of problem villages are still growing. It's not due to new problem villages but due to lack of community sensitivity and management, which brought villages again under the problem village. Rainwater harvesting in different quantities for domestic needs is popular in some parts of India. Kutch is a desert district in Gujarat. It's scarce and precious water resources are under threat due to a number of consecutive droughts, increasing ground water salinity and falling of ground water table by over exploitation. Zura is one of the affected villages of Kutch district. Proposed study is an attempt to find out the rainwater harvesting potential (RWHP) of this village.

### INTRODUCTION

Water is one of the most important natural resource and is vital for all living organism and major ecosystems, as well as human health, food production and economic development of a nation. Due to increasing human population, use of water for various purposes such as, domestic, industrial development, hydropower generation, agriculture, recreation and environmental services has increased considerably over time. Water table in various states of India has gone down due to deforestation and unsustainable utilization of water resources. Therefore, the availability of safe drinking water for rural as well as urban habitation has become a major issue and challenge to the government.

In India, the per capita average annual freshwater availability has been reduced from 5177 cubic meters from 1951 to 1820 cubic meters in 2001 and it is estimated to further come down to 1341 cubic meters in 2025 and 1140 cubic meters in 2050 (Ministry of Water Resources, GOI, 2003). The main source of freshwater in India is the rainfall including the snowfall at the higher altitude in Himalayan region. Gujarat state of India was hit by three successive droughts from 1985-86 to 1987-88. Again in 1999 and 2000, it suffered severe droughts. The entire reservoir of Saurashtra and Kutch has undergone dry. In many regions, groundwater was the only source of water for basic survival needs. While the natural recharge to groundwater has reduced due to failure of

monsoon, excessive pumping of groundwater for irrigation and other uses had resulted in water levels dropping to alarming low levels in many areas of the state (White Paper on Water, Gujarat-2000). Due to these problems many villages of the Kutch district are categorized as no source village.

Rainwater harvesting via roof top and ground catchments is an ancient technique of providing domestic water supply (Agarwal and Narain, 1997) and it is still used, especially in tropical islands and in semi-arid rural areas. It is a best option and preferred as an alternative source of domestic water supply where the ground water is inaccessible due to certain technological & environmental problem. State Governments in India have been encouraging the people to adopt the domestic rooftop water harvesting through subsidized schemes. The water thus collected can meet the immediate domestic needs. Rainwater harvesting has assumed overriding significance all the more in view of the depleting ground water levels during the recent droughts in various parts of India (Ariyabandu, 2001).

The village Zura is one of the drought affected villages of Kutch district of Gujarat and is categorized as no source village. There is an urgent need of development and implementation of water resource management through rainwater harvesting in the village. First step in this direction would be the evaluation of the village rainwater harvesting potential through rooftop and ground catchment. Proposed study will provide us the rainwater harvesting potential of

the village, which would be very helpful in developing and implementing village level effective water resource management in the drought prone areas of Kutch district of Gujarat.

### DESCRIPTION OF STUDY SITE

Kutch district falls in the arid tracts of the country and has a unique arid-coastal climate. It forms the north western region of Gujarat state and stretches between 22° 41' 11" to 24° 41' 47" north latitude and 68° 09' 46" to 71° 54' 47" east longitude. It experiences extremes of weather condition. The winter season lasts usually from the middle of November to the end of February with January being the coldest month having an average minimum temperature of 4.6 °C. However, mercury drops down below the freezing point. Summer starts from March and continues till June end, with the maximum temperature ranging between 39-45 °C. The monsoon commences with the onset of southwest monsoon and continues between July and September. The district is characterized by the scanty rainfall with the mean annual 332 mm (1980-2002). The rainfalls are highly erratic and the average number of rainy days in a year is only 14. Winds are generally moderate to high with an annual average speed of 11.3 km/h experienced during most of the year. In July, the average wind speed goes up to 36 km/h. Due to high temperature and wind speed; the evapo-transpiration rates are very high (Gujarat Institute of Desert Ecology, GEC-Report on Kutch, 1999).

Zura village was highly rich in ground water as well as surface water. Due to over exploitation of ground water for the irrigation as well as domestic purpose the fresh water resources depleted. Due to lack of community management, the ponds of the village under gone heavy siltation, and densely as well as sparsely covered by the ganda bawal (*Prosopis juliflora*). The village has 5-6 open well, 2-3 small & large ponds and also a seasonal river, which has water during the rainy seasons only.

An extensive water resource survey of the village reveals that the local water sources is not available. So, for domestic requirement they depend only on regional water supply scheme. Survey on seasonal migration from the village shows that water is a limiting factor and play very vital role on the village economy. About 34% of total human population of Zura migrated

to other places due to water scarcity (UNICEF/IRMA, 2000).

### METHODOLOGY

A general village survey was carried out to assess the roof top area of individual houses along with the sociological survey. Some secondary informations such as population, agriculture, climate, rainfall, number of rainy days etc. were collected from the related departments. For the analysis of primary as well as secondary data, statistical methods were used according to need.

**Rainfall Data Collection:** Rainfall data (1980-2002) of all the talukas of Kutch district of Gujarat, was collected from Gandhinagar, Gujarat (Rainfall data of Kutch district 1980-2002, State Flood Control Room, Gandhinagar, Gujarat). Village Zura comes in Bhuj taluka, whose mean annual rainfall is found to be 292 mm.

**Coefficient of Runoff:** The coefficient of runoff (Cr) for any catchment is defined as the ratio of the volume of water that runs off to the volume of rain that falls on to the surface (Gould and Nissen, 1999).

$$Cr = \frac{\text{Volume of Run off}}{\text{Volume of rain water that falls on the surface}}$$

The runoff coefficient for Zura village has been taken as 0.8 which is taken as a standard for the designing of asbestos roof catchment system (Pacey and Cullis 1989).

**Potential of Rainwater Supply:** It was calculated by using the formula given below (Gould and Nissen, 1999)-

$$S = R \times A \times Cr$$

Where R = Mean Annual Rainfall in m  
A = Catchment Area in m<sup>2</sup>  
Cr = Coefficient of Run off.

### RESULTS AND DISCUSSION

(i) **Rooftop Rainwater Harvesting from Pucca Houses of Zura Village :** The rainfall data of Bhuj taluka (Table 1) reveals 292 mm mean annual rainfall as total rainwater supply. Survey revealed that the village has 1250 households and the total population is 4554. 70% of the total households i.e. 875 are pucca houses. Rooftops of these 875 houses can be used for water harvesting. Extensive survey was conducted to find out the rooftop area of these pucca houses.

**Table 1: Taluka wise rainfall data (mm) of Kutch district of Gujarat**

Years	Talukas										District Ave.
	Andasa	Anjar	Bhachau	Bhuj	Lakhapat	Mandvi	Mundra	Nakhatrana	Rapar	Gandhidham	
1980	550	541	401	<b>509</b>	330	614	838	460	263	*	501
1981	660	612	648	<b>601</b>	321	543	736	351	441	*	547
1982	308	150	179	<b>184</b>	120	162	266	267	207	*	205
1983	390	328	330	<b>276</b>	389	414	548	646	348	*	408
1984	228	288	296	<b>306</b>	255	262	372	286	376	*	297
1985	236	205	270	<b>123</b>	130	28	386	213	189	*	226
1986	222	169	115	<b>106</b>	164	193	332	150	94	*	172
1987	0	0	1	<b>2</b>	0	2	9	0	3	*	3
1988	951	458	485	<b>657</b>	676	739	672	492	278	*	600
1989	380	426	332	<b>563</b>	403	310	511	346	368	*	404
1990	182	324	306	<b>281</b>	138	191	273	291	273	*	251
1991	37	118	203	<b>82</b>	18	64	148	40	135	*	94
1992	720	456	366	<b>508</b>	937	762	842	886	390	*	652
1993	70	174	121	<b>72</b>	149	30	46	71	268	*	111
1994	633	988	1055	<b>800</b>	1262	1040	1195	1070	714	*	973
1995	368	210	245	<b>168</b>	308	178	225	198	218	*	235
1996	149	189	282	<b>87</b>	29	135	135	80	382	*	163
1997	271	677	669	<b>317</b>	233	511	861	440	829	*	534
1998	346	366	375	<b>416</b>	230	453	491	461	486	335	396
1999	187	86	273	<b>123</b>	65	84	120	100	189	103	133
2000	272	230	184	<b>217</b>	322	160	345	223	194	239	239
2001	572	331	382	<b>243</b>	294	301	411	456	339	259	359
2002	125	136	164	<b>78</b>	58	168	103	100	231	195	136
Mean	342	315	334	292	297	319	429	332	314	226	332
Annual Rainfall											

**Table 2: Rooftop area for the pucca houses and estimate of potential rainwater supply**

[Total house holds = 1250]

[Pucca houses (70% of the total houses holds) = 875]

[Total population= 4554]

S. No.	Rooftop area(m <sup>2</sup> )	Number of house holds	Total rooftop areas (m <sup>2</sup> )	Potential rainwater supply (m <sup>2</sup> ) (mean annual rainfall x catchment area x coefficient of runoff).	Stored water (lt.)	Total stored water from the Pucca houses of village (Lt.)	No. of days @ 10Lt./capita/day
1.	60 m <sup>2</sup>	148	8880	0.292 x 8880 x 0.8 = 2074.368	2074368		
2.	50 m <sup>2</sup>	52	2600	0.292 x 2600 x 0.8 = 607.36	607360		
3.	40 m <sup>2</sup>	96	3840	0.292 x 3840 x 0.8 = 897.024	897024		
4.	30 m <sup>2</sup>	183	5490	0.292 x 5490 x 0.8 = 1282.464	1282464	6309536	138days
5.	20 m <sup>2</sup>	227	4540	0.292 x 4540 x 0.8 = 1060.544	1060544		
6.	< 20 m <sup>2</sup>	166	1660	0.292 x 1660 x 0.8 = 387.776	387776		

Survey revealed maximum households i.e. 26% of the total pucca houses having rooftop area between 20 to 30 m<sup>2</sup>, 21% between 30 to 40 m<sup>2</sup>, 11% between 40 to 50 m<sup>2</sup>, 6% between 50 to 60 m<sup>2</sup>, 17% having rooftop area more than 60 m<sup>2</sup> and 19% less than 20 m<sup>2</sup>. Number of houses with different rooftop areas were calculated. Only lower limits of the rooftop area categories were

considered for eg. 26% of the total pucca houses were having rooftop area as 20 m<sup>2</sup> instead of 20-30 m<sup>2</sup>. This was done to avoid overestimation. Thus number of houses each having 60 m<sup>2</sup> rooftop area were found to be 148, 52 houses having 50 m<sup>2</sup> rooftop area each, 96 houses having 40 m<sup>2</sup> rooftop area each, 183 houses having 30 m<sup>2</sup> rooftop area each, 227 houses having 20 m<sup>2</sup>

rooftop area each and 166 houses having less than 20 m<sup>2</sup> (taken as 10 m<sup>2</sup>) rooftop area each. Total rooftop area, potential rainwater supply and stored water were calculated for each category. Total stored water from all the pucca houses of the village was estimated to be 6309536 liters (Table 2). According to United Nations, it is assumed that 20 liters/capita/day water is inevitable for the rural communities in the developing countries. The United Nation targets it as minimum water requirement for all domestic purpose including personal hygiene also. The norms were set during International Drinking Water Supply & Sanitation Decade (IDWSS). Out of this 20 liters/capita/day water, 10 liters/capita/day is only for drinking & cooking purpose. Therefore, if rooftop water harvesting is practiced in Zura village, total 6309536 liters of water can be stored and if we assume 10 liters/capita/day water is required for drinking and cooking, then the stored water can be made available for total village population (4554) for approximately 138 days (appx. 4½ months).

**(ii) Rooftop Rainwater Harvesting from Zura Primary School:** Zura Primary School has three buildings with an office building. Total roof top area of Zura primary school comes 489.767 m<sup>2</sup>. Thus rooftop rainwater harvesting potential of Zura Primary School can be evaluated as-

$$\begin{aligned} S &= R \times A \times Cr \\ &= 0.292 \times 489.767 \times 0.8 \\ &= 114.409 \text{ m}^3 \end{aligned}$$

Hence, total rainwater which can be stored through rooftop rainwater harvesting from Primary School of Zura would be = 114409 liter.

Total strength of the school is 397 along with 9 teachers, so there are 406 people in the school. If 2 liter/capita/day water allocate for their basic requirement in the school (Tapir, 1995), then per day water requirement in the school = 400 x 2 liter = 800 lit.

Hence, the total stored water available from the school can be utilized for (114409/800 = 143) 143 days. So the roof top rainwater harvesting from the school itself can fulfill the basic water requirement of the school for about 4½ months during the water scarce period. But number of water supply days may increase in the reference of student strength, as the total strength of regular students is 50% hence rooftop rainwater harvesting from school can supply water for more than 8 months.

Water stored from the house rooftop is

presumed to be pure and potable as it will not flow on the ground and come into contact with any liquid or solid materials, which can alter its quality. But the rainwater falls on the roof, passes through the gutters and finally reaches the storage tank. In this process, water comes in contact with the dust, debris and leaf litter collected on the roof and the gutters. Thus it should be disinfected before use. This can be done either by boiling the water in a vessel before consuming or by dissolving the bleaching powder to the water stored in the tank.

In domestic Rooftop Rainwater Harvesting Systems, rain water from the house roof is collected in a storage tank for domestic purpose during the periods of scarcity. Usually these systems are designed for drinking and cooking needs of a family. Such a system usually comprises a roof, a storage tank and gutters to transport the water from the roof to the storage tank. In addition to it a first flush diverter also put to prevent the entry of first monsoon shower in the storage tank. Therefore, a typical roof top Rain water Harvesting System comprise of following components:

- \* Roof catchments
- \* Gutters
- \* Down pipe and first flush chamber
- \* Filter unit
- \* Storage tank

Among the above components, storage tank is the most expensive and critical components. The capacity of the storage tank determines the cost of the system and reliability of the system for assured water supply.

**(iii) Rainwater Harvesting through Ground Catchment (Pond Management):** Although village has a number of ponds of small and large size but rainwater harvesting through ground catchment was calculated only for one pond. Surface area of this pond was found to be 1000 m<sup>2</sup> and depth appx. 30 feet. Catchment area of this pond was found to be 1 km<sup>2</sup> (10,00,000 m<sup>2</sup>), runoff coefficient was taken as 0.3 ((Pacey and Cullis 1989).

Thus potential water supply or total water available for storage is =

$$\begin{aligned} &\text{Mean annual rainfall X Catchment Area X} \\ &\text{Runoff Coefficient} \\ &= 0.292 \times 10,00,000 \times 0.3 \\ &= 87600 \text{ m}^3 \\ &= 87600000 \text{ liters} \end{aligned}$$

If the capacity of the pond is increased by

some artificial means to store 8,760,000 liters of water then this can fulfill the domestic water requirement even @ 40 liter/capita/day to a population of 4554 for 481 days.

### CONCLUSION

Kutch is an “Absolute Water Stressed” district of Gujarat, as the mean annual rainfall is less than 500 mm. Analysis of 23 year rainfall data of Bhuj Taluka of Kutch district reveals 292 mm mean annual rainfall with 70% probability. The Geomorphology of the Kutch district is just similar to “Reverse Bowl”. Hence, precipitated water immediately flows away by the rivers either in Ranns or in Arabian Sea. Thus, the management of rainwater in the area is highly needed. Effective decentralized management strategy for rainwater harvesting can be developed by community participation which will make the people self-dependent for their fundamental requirement of drinking water.

Since every village in Kutch district of Gujarat can not get Narmada Water with equity, reliability and adequacy, in that case, rainwater harvesting is the effective alternative where scientific knowledge has been integrated with the traditional one, for water resource management. Rooftop Rainwater Harvesting and effective ponds management through ground catchment harvesting will not only solve the drinking water problem in drought prone areas of Kutch district in Gujarat, but it would be highly practicable in other states of the country facing similar situation.

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### REFERENCES

- Agarwal, A. and Narain, S.: *Dying Wisdom: The Rise, fall and Potential of India's Traditional Water Harvesting System*. Centre for Science and Environment, Delhi (1997).
- Ariyabandu, R. D. S.: Varieties of water harvesting. In: *Making Water Everybody's Business: Policy and Practice of Water Harvesting*. Centre for Science and Environment, Delhi (2001).
- Current Ecological Status of Kutch district. Gujarat Ecology Commission, Baroda (1999).
- GEC Report on Kutch*. Gujarat Institute of Desert Ecology (1999).
- Gould, J. and Nissen-Petersen, E.: *Rainwater Catchment Systems for Domestic Supply*, International Technology Publications, London, United Kingdom (1999).
- Pacey, Arnold and Cullis, Adrian: *Rainwater Harvesting: The Collection of Rainfall and Runoff in Rural Area*. International Technology Publications, London, United Kingdom (1989).
- Rainfall Data of Kutch District 1980-2002*, State Flood Control Room, Gandhinagar, Gujarat.
- Sharma, P. C. and Sen., P. K.: Domestic roof (rain) water harvesting technology. In: *Proceedings of Delhi Workshop on Roof Water Harvesting*, Delhi (2001).
- Tapir, N.: *Improved Roof Rainwater Harvesting in Primary Schools*. 7th International Rainwater Catchment Systems Conference, Beijing (1995).
- UNICEF / IRMA.: *White Paper on Water*, Government of Gujarat (2000).
- Water Resources of India and World, *Newsletter on Fresh Water Year, 2003*. Ministry of Water Resources, GOI (2003).