Rain Water Harvesting – Quantification of benefits and peoples' participation is the need of the day

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ABSTRACT

More than 2000 million people in India would live under conditions of high water stress by the year 2050, according to the UNEP (United Nations Environment Programme), which warns water could prove to be a limiting factor for development in a number of regions in the world. About one-fifth of the world's population lacks access to safe drinking water and with the present consumption patterns; two out of every three persons on the earth would live in water-stressed conditions by 2025. The solution lies in the application of age-old water harvesting technology to satisfy the present day requirements. The use of rainwater-collection systems is known to have existed 4,000 years ago, in the semi-arid and arid regions of the Negev desert, in Israel, which receives less than 15 cm of rainfall a year.

In India, it has been reported that in the early Buddhist era, monks living in mountainous areas, such as the Elephanta caves in Bombay and the Udayagiri and Candagiri caves in Orissa, had laboriously hewn an intricate series of gutters and water cisterns into the rock faces to avail of domestic water supply throughout the year. Besides, the Chola and Pandya kings of the seventh and eighth centuries AD had constructed rainwater catchment tanks at the foot of a number of hills. Temples, like the famous Madurai temple, have huge water tanks; indeed, the surrounding communities depended on them for their domestic water needs.

Technically speaking, water harvesting means capturing the rain where it falls, or capturing the run-off in one's own village or town or in field. The various ways of harvesting water are normally are:

- **Capturing run off from local (Micro) catchments**
- **Capturing seasonal flood water from local streams**
- **Capturing run off from rooftops**

- **Conserving water through watershed management**

Various Government and Non Government Agencies are working in the areas of water harvesting technology. But the results have not been achieved to desired expectations. The main reason being the people who get the benefits have not been consulted or not been involved in various water harvesting measures applied in their back yards. In addition the claims of benefits have been exaggerated and always highlighted in qualitative ways rather than quantitative methods. For example, the implementers or the farmers say, "lot of water has come into the wells and water levels have risen. This is not enough. Once has to say how many people have been benefited in what way and how much water has been recharged and how many new wells can be constructed or whether, the implemented project has been economically viable. These aspects have been dealt with in this paper with a few examples. It is also proposed that an 18 ha catchment area in a village will provide drinking water for the village of 1200 population with an average requirement of 60 liters per day

1. Introduction

Water is the life-blood of the environment; without water no living being can survive; water plays a unique role in the traditional economy and culture of the native people. The same would also be true if we said that availability of an adequate and usable water supply underpins our economy; water is used for transportation, power generation, waste disposal, recreation, agriculture, and various other sectors.

However, evidence of over-exploitation and the subsequent environmental stress is there for all to see. Pollution due to human activities has nearly destroyed aquatic life, inhibited the reproductive capacity of mammals and birds, and posed a serious threat to human health. Gross misuse of water resources causes widespread degradation of soils, disrupts the supply of potable water, and generates massive economic losses.

Nearly 1.4 billion of the world's population lives in regions that would face severe water shortages in the first quarter of the new millennium. These regions do not have sufficient water resources to maintain accepted levels of food production from irrigated agriculture and also do not meet reasonable water needs for domestic, industrial, and environmental purposes.

2. The India scenario

More than 2000 million people would live under conditions of high water stress by the year 2050, according to the UNEP (United Nations Environment Programme), which warns water could prove to be a limiting factor for development in a number of regions in the world. About one-fifth of the world's population lacks access to safe drinking water and with the present consumption patterns; two out of every three persons on the earth would live in water-stressed conditions by 2025. Around one-third of the world population now lives in countries with moderate to high water stress—where water consumption is more than 10% of the renewable fresh water supply, said the GEO (Global Environment Outlook) 2000. Pollution and scarcity of water resources and climate change would be the major emerging issues in the next century. These issues would be followed by problems of desertification and deforestation, poor governance at the national and global levels, the loss of biodiversity, and population growth.

There is an urgent need for action to maintain the health of our water systems. Shortages of fresh water and its pollution threaten the quality of life of many Indians— nothing demonstrates this fact than the recent drought that had the entire country reeling under its devastating impacts. Despite being one of the wettest countries of the world, India's growing water shortage has reached alarming proportions.

3. Rain Water harvesting a probable solution

Technically speaking, water harvesting means capturing the rain where it falls, or capturing the run-off in one's own village or town or in field. The various ways of harvesting water are normally are:

- Capturing run off from local (Micro) catchments
- Capturing seasonal flood water from local streams
- Capturing run off from rooftops
- Conserving water through watershed management

Apart from increasing the availability of water, local water harvesting systems developed by local communities and households can reduce the pressure on the state to provide all the financial resources needed for water supply. Also, involving people will give them a sense of ownership and reduce the burden on government funds.

These techniques can serve the following purposes:

Provide drinking water
Provide irrigation water
Increase groundwater recharge
Reduce storm water discharges, urban floods and overloading of sewage treatment plants

Reduce seawater ingress in coastal areas.

4. History of rainwater collection

Water being essential for life, the history of the collection of rainwater is as old as the history of mankind. In fact, most ancient civilizations evolved in cities that had vast hinterlands where water was available for irrigation and navigation.

The use of rainwater-collection systems is known to have existed 4,000 years ago, in the semi-arid and arid regions of the Negev desert, in Israel, which receives less than 15 cm of rainfall a year. Hillsides were cleared to increase runoff, and contour ditches helped collect water for crop irrigation. Underground storage volumes of up to 300 cu m, enough for 10 families, and their flock, for a year, have also been reported.

In the Mediterranean region, rainwater collected from roofs and stored in cisterns constituted the principal source of water during Phoenician, Carthaginian and early Roman times, from the sixth century onwards. Right up to the 16^{th} century, rooftop collection and storage was practiced in Venice, and there is evidence to show that 177 public and 1,900 private cisterns held 665,000 cu m of water, to supply about 16 Lpcd.

In Iran, rain harvesting has gained considerable importance and high levels of technology have been attained in the spreading of flood waters. Information on this was presented at the eighth International Conference on Rainwater Catchment, in 1997.

In India, it has been reported that in the early Buddhist era, monks living in mountainous areas, such as the Elephanta caves in Bombay and the Udayagiri and Candagiri caves in Orissa, had laboriously hewn an intricate series of gutters and water cisterns into the rock faces to avail of domestic water supply throughout the year. Besides, the Chola and

Pandya kings of the seventh and eighth centuries AD had constructed rainwater catchment tanks at the foot of a number of hills. Temples, like the famous Madurai temple, have huge water tanks; indeed, the surrounding communities depended on them for their domestic water needs.

In Thailand, the existence of rainwater harvesting and storage systems goes back more than 2,000 years. There is evidence of an elaborate system of dykes built and utilised about 800 years ago. Because the surface water and groundwater are brackish in the Kalimantan region of Indonesia, rainwater has been collected over several centuries. In the Philippines, rainwater is still being used in the provinces, as it is traditionally believed to be safer than river water for household and human consumption.

In Africa, where rainwater catchment systems have been in place for at least 2,000 years, rainwater was collected from thatched roofs in open jars. In China, there are isolated instances of rainwater catchment systems being used, though by and large, rainwater here is used for irrigation purposes.

Utilising rainwater has always been a way of life in Japan, where, in most urban areas, the water is collected and stored in basements and subjected to some form of treatment. In cities that are prone to earthquakes, rainwater is collected and stored for fire-fighting purposes, should normal water supplies be disrupted.

5. Recent revival of some simple methods

In some south-east Asian countries, there seems to have been a revival of rainwater harvesting, on a small scale, around the 1960s. In fact, in the 1970s, the naming of the International Drinking Water and Sanitation Decade (1981 to 1990) led to more vigorous attempts to end the problem of poor water supply (and sanitation) throughout the world.

Large numbers of rainwater collectors were established in Kenya, Tanzania, Botswana, Uganda, Zambia, Zimbabwe , etc. Most developing countries in Asia began to tap this potential, largely with the assistance of non-governmental organisations (NGOs). Three countries in south-east Asia have made special attempts to organise these propagations, their sole target being to supply clean drinking water to the people. A few of the successful pioneering projects are detailed below.

Thailand

In the early part of this century, planners in Thailand strove for a large-scale impact and resorted to elaborate systems involving big dams and reservoirs. Such systems, however, called for substantial foreign assistance, which was not forthcoming. This led to the realisation that rainwater catchment systems, on a smaller scale, could be adopted as they were relatively simple, cheap and did not require imported material or expertise. So, in 1982, the emphasis shifted to providing clean drinking water to rural areas through shallow and deep wells, and rain-harvesting programmes. The allocated funds permitted a communal system to be executed either by village councils, foreign agencies, government or private organisations.

Indonesia

In 1979, the criteria for selecting the appropriate material to construct cisterns were that the material should be locally available, the design should be within the villagers' technical capabilities and that the activities should not conflict with the villagers' way of life. Also, construction costs should be within the government's budget. Bamboo-reinforced concrete and Ferro-cement cisterns were standardized and a method of most effective construction, involving community participation, was developed.

The general modus operandi for implementing roof water-collection systems in Indonesia, by involving the villagers, was very much like that in Thailand. Local community participation in the development of technical skills.

Consideration to local lifestyle, tradition and local opinions on water consumption.
Project schedules that matched local time constraints.
Transfer of technical skills and maintenance know-how.
In the building of the tanks, an indigenous material (instead of sand), stone and cement were initially used. Skilled labour and cement were supplied, and the local people participated fully by providing labour. Then, in 1978, ferro-cement tanks were constructed, but finding the costs prohibitive, the construction of BRC tanks was embarked upon in 1979.

In the Indonesian system, areas where such roof water collection systems were most effective and feasible were initially identified. The village head and government officials were normally requested to take part in the activities. Surveys were carried out and discussions held to determine the type of technological changes that were feasible and most appropriate for each village. A very important element in this model is that the recipients chosen were identified as being the 'poorest of the poor' in the region.

The Philippines

Having studied the establishment of collection-collection systems in both Thailand and Indonesia, the method conceived for the Philippines took all the relevant factors into consideration.

Since the proposed method to build collection-collection systems was technologically sound, and took into consideration socio-economic and cultural conditions, it was deemed a 'total approach'. The first step involved choosing the most appropriate location. This turned out to be the province of Capiz, on Panay island, in the southern half of the Philippines, where only brackish water was to be found. The province, which receives an average rainfall of 1,700 mm, supports a population of 490,000. Its total area is 2,633 km.

Three pilot locations were selected, based on earlier investigations, each experiencing different topographical conditions. Together, they represented 30 per cent of the province. In each location, 10 Ferro-cement tanks were installed, and the rainfall, water-use patterns and quality of rainwater were monitored.

Since the villagers were very poor, and had been given the basic construction material, their suggestions on the most suitable method for repayment were sought. Ultimately, they opted for the system of hog rising whereby the project authorities provided them with piglets and gave them basic training on how to care for them. This proposal was very similar to the Indonesian 'two she-goat' system, which had yielded excellent results.

India

Community based rainwater harvesting in rural areas of India - the paradigm of the past - has in it as much strength today as it ever did before. It is, in fact, only with this rudimentary technology that people are able to survive in water scarce areas. Recognizing this fact, our ancestors had learnt to harvest water in number of ways:

They harvested the raindrop directly. From rooftops, they collected water and stored it in tanks built in their courtyards. From open community lands, they collected the rain and stored it in artificial wells.

They harvested monsoon runoff by capturing water from swollen streams during the monsoon season and stored it various forms of water bodies.

How much water is required to Rural India for drinking water purposes

Large number of projects are being implemented in India in the areas of watershed development, Desert development programmes, Rainfed development programmes etc. In Gujarat alone, about 15000 check dams were constructed during the last 2 years in addition to many drinking water schemes etc.

Assuming that the average Indian population of an Indian village is approximately about 1200. Considering average requirement of 60 liters per day the total requirement would be 72000 liters per day i.e. 26.28 million liters in a year. Considering an average evaporation losses of 50 % if stored in surface tanks etc, the total requirement would be in the order of 52.56 million liters in a year. India's average rainfall is about 1170 mm. If even only 25 % this water can be captured, though with technology this can be greatly increased, an average Indian village needs 18 hectares of land to capture 52.56 million liters of water it will use in a year for drinking and other purposes. It will vary to village to village and in different meteorological divisions. These calculations show the potential of rainwater harvesting is enormous and undeniable. So let us go back and start constructing more tanks with catchment areas of at least 18 to 20 ha, which will suffice the drinking water purposes in India.

Large no of watershed and water conservation projects were being implemented in India since the first five-year plan. However, many of them are unsuccessful because of the apathy of the local population. It is the people who destroy the environment around them should undertake to revive them. Then only the watershed programmes or any other porgramme will be successful.

6. Overview of main WH systems

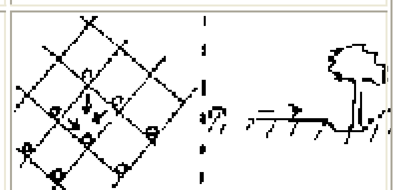
Appropriate systems should ideally evolve from the experience of traditional techniques - where these exist. They should also be based on lessons learned from the shortcomings of previous projects. Above all it is necessary that the communities appreciate the systems where they are introduced. Without popular participation and support, projects are unlikely to succeed.

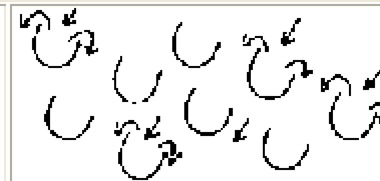
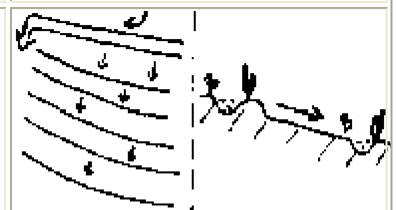
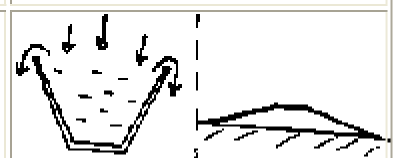
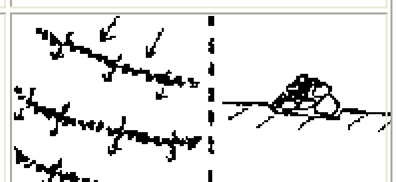
Water harvesting technology is especially relevant to the semi-arid and arid areas where the problems of environmental degradation, drought and population pressures are most evident. It is an important component of the package of remedies for these problem zones, and there is no doubt that implementation of WH techniques will expand.

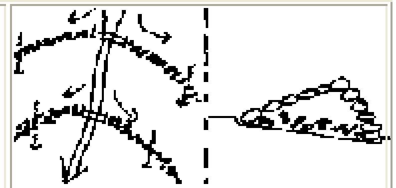
An overview of the main Water Harvesting systems are given below

The techniques presented and explained below are not the only water harvesting systems known but they do represent the major range of techniques for different situations and productive uses. In a number of cases, the system, which is described here, is the most typical example of a technique for which a number of variations exist - trapezoidal bunds are a case in point.

Table 1 - Summary chart of main WH techniques

	Classification	**Main Uses**	**Description**	**Where Appropriate**	**Limitations**	
negarim microcatchments	microcatchment (short slope catchment) technique	trees & grass	Closed grid of diamond shapes or open-ended "V" s formed by small earth ridges, with infiltration pits	For tree planting in situations where land is uneven or only a few tree are planted	Not easily mechanised therefore limited to small scale. Not easy to cultivate between tree lines	
Contour bunds	Micro catchment (short slope catchment) technique	Trees & grass	Earth bunds on contour spaced at 5-10 metres apart with furrow upslope and cross-ties	For tree planting on a large scale especially when mechanised	Not suitable for uneven terrain	

Semi circular bunds	Micro catchment (short slope catchment) technique	Rangeland & fodder (also trees)	Semi-circular shaped earth bunds with tips on contour. In a series with bunds in staggered formation	Useful for grass reseeding, fodder or tree planting in degraded rangeland	Cannot be mechanized therefore limited to areas with available hand labour	
Contour ridges	Microcatchment (short slope catchment) technique	Crops	Small earth ridges on contour at 1.5m -5m apart with furrow upslope and cross-ties Uncultivated catchment between ridges	For crop production in semi-arid areas especially where soil fertile and easy to work	Requires new technique of land preparation and planting, therefore may be problem with acceptance	
Trapezoidal bunds	External catchment (long slope catchment) technique	Crops	Trapezoidal shaped earth bunds capturing runoff from external catchment and overflowing around wingtips	Widely suitable (in a variety of designs) for crop production in arid and semi-arid areas	Labour-intensive and uneven depth of runoff within plot.	
Contour stone bunds	External catchment (long slope catchment) technique	Crops	Small stone bunds constructed on the contour at spacing of 15-35 metres apart slowing and filtering runoff	Versatile system for crop production in a wide variety of situations. Easily constructed by resouce-poor farmers	Only possible where abundant loose stone available	

Permeable rock dams	Floodwater farming technique	Crops	Long low rock dams across valleys slowing and spreading floodwater as well as healing gullies	Suitable for situation where gently sloping valleys are becoming gullies and better water spreading is required	Very site-specific and needs considerable stone as well as provision of transport	
Water spreading bunds	Floodwater farming technique	Crops & rangeland	Earth bunds set at a gradient, with a "dogleg" shape, spreading diverted floodwater	For arid areas where water is diverted from watercourse onto crop or fodder block	Does not impound much water and maintenance high in early stages after construction	

Source FAO publication

7. Ground Water Recharge

Ground water levels in some areas are falling at the rate of one meter per year while there is water logging in the canal command areas. This is mainly due to unplanned development of ground water in the country. This can be gauged by the following:

- The number of wells and bore wells for irrigation in the country has increased five fold to 175 lakhs during past fifty years.

- There are 25 to 30 lakh wells and bore wells for drinking, domestic and industrial uses.

- More than 80% of rural and 50% of urban; industrial and irrigation water requirements in the country are met from ground water.

The sustainability of groundwater will be doubtful if these overexploited aquifers are some how not recharged. This serious situation can be rectified through harvesting rainwater for the purpose of ground water recharge

More than 65000 litres of rain water in Delhi can be captured and recharged from a 100 meter size roof top and meet drinking and domestic water requirement of family of four for 160 days. Central Ground Water Board implemented the first Water Harvesting and Recharge Project in 1976 in Haryana, 1980 in Gujarat and 1988 in Kerala. Annually replenishable groundwater is assessed as 432 billion cubic meter (BCM). By adopting water harvesting, an additional 160 BCM shall be available for use.

Causes of fall in Ground Water Levels

- Over exploitation or excessive pumpage either locally or over large areas to meet increasing water demands.
- Non-availability of other sources of water. Therefore, sole dependence is on ground water.
- Unreliability of municipal water supplies both in terms of quantity and timings, driving people to there own sources,
- Disuse of ancient means of water conservation like village ponds, percolation tanks and therefore, higher pressure on ground Water development.

The Effects Over Exploitation of Ground Water Resources

- Drastic Fall in water levels in some areas.
- Drying up of wells / bore wells.
- Enhanced use of energy.
- Deterioration in ground water quality.
- Ingress of seawater in coastal areas

Objectives of Rain Water Harvesting vis vis Groundwater Recharge

- Restore supplies from the aquifers depleted due to over exploitation.
- Improve supplies from aquifers lacking adequate recharge.
- Store excess water for use at subsequent times.

- Improve physical and chemical quality of ground water.
- Reduce storm water run off and soil erosion.
- Prevent salinity ingress in coastal areas.
- Increase hydrostatic pressure to prevent / stop land subsidence.
- Recycle urban and industrial waste waters etc.
- Rehabilitate the existing traditional water harvesting structures like village ponds,
- Percolation tanks, tankas etc.
- With minor scientific modifications and redesigning, convert the traditional water harvesting structures into ground water recharge facilities.

- Use the existing defunct wells and bore wells after cleaning and also the operational wells as recharge structures.

Methods and Techniques useful for Groundwater Recharge

- Roof top rain water harvesting and its recharge to underground through existing wells or bore wells or by constructing new wells, borewells, shafts or spreading basins.
- Capturing and recharging city storm water run-off through wells, shafts, spreading basins, storm water drains.
- Harnessing run off in the catchments by constructing structures such as gabions, check dams, bhandaras, percolation trenches, Sub-surface dykes etc.
- Impounding surplus run-off in the village catchment and watersheds in village ponds and percolation tanks.
- Recharging treated urban and industrial effluents underground by using it for direct irrigation or through recharge ponds, basins or Wells, etc.

Expected benefits

Rise in ground water levels in wells.

Increased availability of water from wells.

Prevent decline in water levels.

Reduction in use of energy for pumping water and consequently the costs.

Reduction in flood hazard and soil erosion.

- Benefiting in the water quality.
- Arresting seawater ingress.
- Assuring sustainability of the ground water abstraction sources and consequently the village and town water supply systems.
- Mitigating the effects of droughts and achieving drought proofing.
- Reviving the dying traditional water harvesting structures and their rehabilitation as recharge structures.
- Effective use of lakhs of defunct wells and tube wells as recharge structures.
- Up gradation of social and environmental statuses

8. Expected Policy Measures by Govt.

For Rain water harvesting to be successful on a massive scale government should have some policy measures

- Provide at least one roof top rainwater harvesting structure for every 200 square meter plot in urban areas.
- Revive / rehabilitate all village ponds.
- Subject to technical feasibility, provide at least one check dam / KT weir / subsurface dyke in each streamlet with a catchment of 1 to 3 sq km.
- Provide all drinking water wells with a recharge structure.
- Ban construction of irrigation wells / tube wells within a distance of 200 m or less (depending on scientific criteria) of the drinking Water supply well.

9. Quantification of water harvesting

Water harvesting (WH) can be considered as a rudimentary form of irrigation. The difference is that with WH the farmer has no control over timing. Runoff can only be harvested when it rains. In regions where crops are entirely rainfed, a reduction of 50% in the seasonal rainfall, for example, may result in a total crop failure. If, however, the available rain can be concentrated on a smaller area, reasonable yields will still be received. The benefits can broadly be enumerated as indicated below

- Prevent soil erosion
- Increase soil moisture
- Increase groundwater levels
- Conserve the biomass
- Increase fodder fuel and fibre availability
- Increase yields of the crops
- Increase area in cultivation
- Increase in employment and stopping migration to towns
- Dairy production
- Drinking water
- Overall development of village both economic and social

The above benefits are suggestive and normally are quoted everywhere. If the benefits are so many, why the local population is not taking up these programmes on their own and why should they depend either on Government or NGOs. No programme can be self-sustained unless it is economically viable and tangible and quantifiable benefits accrue due to these programmes. A few examples are given below where the author worked and knows well.

Example 1

Techno Economic Appraisal of Artificial Recharge Projects- Percolation tanks

Technical Aspects

- Percolation tanks (in 66km area) in Baramati tk of Pune distrcit
- Average capacity 0.13 mcm
- Area of Influence 1.7 to 2.5 sq.km
- Additional recharge of 0.079mcm(60% of capacity of tank.
- 6 new wells can be constructed.

- Recharge from tanks is not uniform. It is mainly in the direction of fractures
- In the River bed no recharge indicating that the aquifer is full
- No recharge in tanks in constructed on hard rocks

Financial Aspects

- Cost of tank = 12.480 lakhs
- Cost of 6 wells and pumpsets = 2.076 lakhs
- Total cost = 14.556 lakhs
- Cropping pattern for 12 ha land @ 2 ha for well

–Crops (ha)	before	after
•Cotton	2	4
•Sugarcane	-	2
•Hy.maize	-	6
•Jawar	7	-
•Groundnut	3	-
•Wheat	-	4
•Gram	-	2

•S.no	details	without Subsidy	with subsidy
•1	Net Incre-Income (lakhs)	1.036	1.036
•2	BCR (@15 D.R)	0.55	1.14
•3	IRR	0.22	20.83
•4	Water rate Rs/cum	1.71	0.62

- With out subsidy the scheme is not viable
- With subsidy of 75% for the cost of percolation tank and 30% for well and pump set the scheme is viable

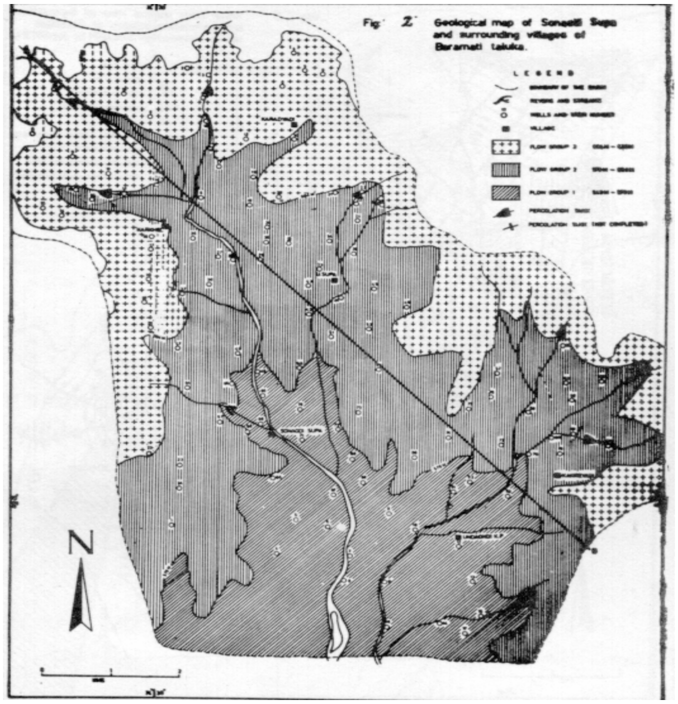


Fig. 2 Geological map of Sonaeli Sepa and surrounding villages of Baramati taluka.

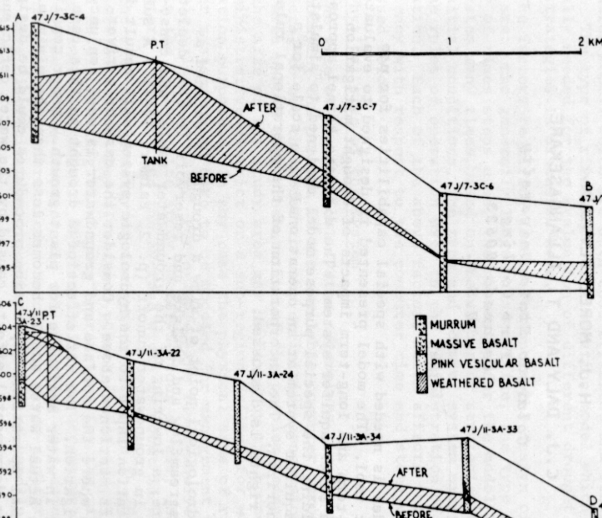


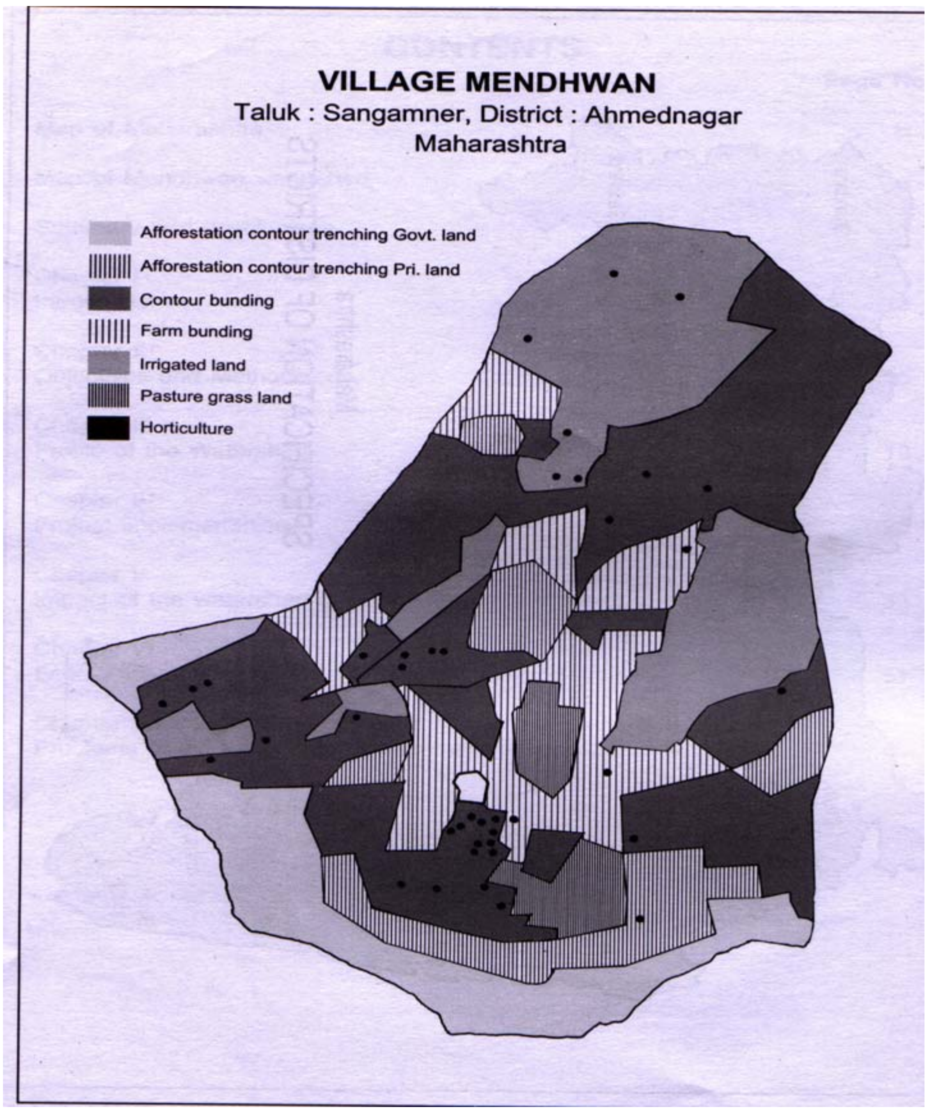
FIG.4: CROSS SECTIONS DEPICTING RISE OF WATER LEVEL DUE TO PERCOLATION TANKS IN BARAMATI TALUKA.

Example 2

Watershed Development Programme under Indo German Program Watershed Development Programme

A Watershed development programme was implemented in Mendhwan village in Sangamner taluka of Ahmednagar district By Indo German Development Programme and supported by NABARD. The WDP was started in 1992 and completed in 1996. A valuation study has been conducted by NABARD. The treatment includes Afforstation, contour trenching and contour and farm bunding, Pasture and grass land development.

The various treatments given in the watershed is shown below



The main benefits include

- The area under cultivation had increased on an average by 23 % per family due to reduction in the wastelands in the post implementation period because of various soils and water conservation measures.
- The net irrigated area has increased by 29 %. The growth in the irrigation was observed among the majority of the sample farmers irrespective of the location of their cultivated land at the upper, middle and lower levels tends to indicate that more equitable distribution of benefits were realized by the farmers across ridge to valley.
- Cropping intensity has increased from 114 % to 133 %.
- The new varieties of seeds have become common in the village and the use of chemical fertilizers to some extent.
- The cropping pattern had shifted towards cultivation of wheat and sugarcane with a decline in coarse cereals and mixed cropping.
- The net income generated from the per hectare of gross cropped area of the sample beneficiaries was Rs 2089 in the pre implementation period which has gone up to Rs 4739 in the post implementation period.
- The net income from dairy activity has gone up from Rs 538 to Rs 3935 per household. Before implementation of the programme the residents largely resorted to sheep ranching. However, due to restriction on free grazing and availability of additional fodder in the village, the stall fed dairy activity has gone up.
- The landless farmers reported to have been getting the substantial employment opportunities with in the village itself thus reducing migration.
- The sizable number of sample families who were below the poverty line in the pre development had reported to have crossed the poverty line income of Rs 17500 per family due to augmentation in their income either from the farm or non-farm business.
- The no of wells in the area has gone up from 41 to 64. As against 54 % of wells, which remained dry in the summer months, only 14 % of the wells were dry in the summer.
- Average water levels of wells in the summer months have increased from 1.2 to 2.3 m.
- The FRR is 27.6 and the ERR is 29 % of the project indicating that the project is viable financially viable.

10. Monitoring of the Programme

It is necessary that the water harvesting programmes have to be monitored and the benefits are estimated properly in addition to monitoring the same while implementing. The following methodology would be useful for estimating the benefits quantitatively.

- A programme has to be fixed for monitoring at least one observation well per sq.km on monthly basis at least for a period of 4 years.
- The pre- investment scenario has to be listed out like, human and cattle population, literacy levels, employment levels, agriculture production, Non- farm sector activities in the villages, infrastructure availability and per capita consumption of food, water etc so that the same can be monitored after the investment. It will not be sufficient if once says water levels have risen, lot of milk production etc. They have to be quantified.
- Post investment results have to be established for the above.

11.Peoples participation

Various water harvesting and watershed programmes are being implemented since first 5-year plan in India. Large amount of money has been invested in these progrmmes. But the expected gains have not been obtained due to these programme mainly because the people who are directly benefited have never been consulted and made them feel as these programmes are meant for them and they are involved in decision making process and the activities to be taken up in these programmes. This was recognized by the HanumanthRao committee and the committee has recommended that the people should be involved in any watershed programme and special emphasis is given to the participation of the beneficiaries of the programmes. The Indo German Watershed Development programme, which is funded by KFW through NABARD, has gone one step further and the implementation of watershed programme has been divided into two phases i.e. capacity building phase and the full implementation period. During the capacity building phase, both the villagers and the NGOs involved have to show their commitment to programme by completing the capacity building phase satisfactorily to get the full implementation programme sanctioned. This phase is seen as conflict resolution and training phase for preparing full implementation progamme.

12.Conclusion

Large numbers of water harvesting techniques are available for implementation for different situations to augment the existing water resources and conserve and optimize the same. Similarly, different people from various walks of life join this water harvesting technology little knowing that it is the people who matter than the methods. It is also not sufficient to indicate that these techniques have increased the ground water recharge, water levels have risen etc. It is absolutely necessary to quantify the same and indicate whether the benefits are commensurate to the cost and whether they are economically viable. A mechanism has to be set up during the implementation period itself, to monitor the projects and the benefits quantified. In addition, care should be taken that the people who destroy the environment surrounding their villages should willingly come forward to save the same. Unless people are involved, no water harvesting or watershed programme would be successful. An attempt has been made in this paper to give a broad framework of water harvesting technology over the centuries and their present scope of utilization for conserving the precious rainfall. A few examples were also shown to indicate the requirement of quantification of benefits and their economic viability of the projects.

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