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Integrated Drinking Water Resource Management: Impact Study of Watersheds in different Geohydrological and Socio-Economic Situations in India

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ABSTRACT
Increased competition for the limited ground water resource has resulted into the rapid depletion of sources. Which in turn creates unmanageable water scarcity problem during the summer almost in all the agro-climatic zones of India. A research on consequence of watershed development on drinking water supply (quality, quantity and access) has been conducted in seven different locations in five states of India. Study focuses on drinking water demand and supply status for consumptive and productive uses, type of infrastructure in place, operation and maintenance arrangements, and institutional roles in development and management of infrastructure. The impact of a watershed development programme on drinking water sources in watershed villages and peripheral villages is a complex phenomenon. A study of a watershed development model from differing physical and socio-economic frameworks reveals the variability in the nature and degrees of impacts of watershed development on drinking water regimes from various agro-climatic regimes of India. The drinking water supply in rural India cannot be looked at in isolation. There are vital and multifaceted links of water resources with the socio-economic situation of community, ecosystem health including the crucial role of agriculture, political, institutional and administrative environments and most significantly in the changes in water utilization over a period of time. In most of present watershed development programmes and drinking water supply projects in India, there is absence of proper assessment of this extremely critical issue. It is essential to follow the systems approach in an integrated manner for sustainable rural drinking water supply.

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I. BACKGROUND

Watershed development and management is evolving as a useful mechanism to address the two most common water resource problems in India. Firstly, it aims to address the problem of water availability resulting from an increased demand on a resource rendered fragile due to irregular and erratic rainfall. However, in addition to addressing water resources issues, the watershed development model also offers an effective medium to tackle larger natural resources management problems arising out of a competition for the limited resources that often results in conflicts at various levels.

Repeated water scarcities leading to large-scale droughts have severely affected the livelihoods of the rural poor in India. Three types of reactions to such situations can be broadly observed:

(a) Short term, relief measures to mitigate water shortages by developing water sources that are often not sustainable.
(b) Highly expensive measures involving relief measures like supplying water through tankers (as relief measure) and development of regional piped water supply schemes that require high costs of O & M.
(c) Local solutions through participatory approaches that have increasingly resorted to the integrated watershed management model to identify, assess and address the larger problem of rural systems management.

In India 5.58% out of 623 million rural population (74% of total population as per 1991 census) has been covered by safe drinking water facility. Contaminated drinking water is the main cause of high mortality in India (80/1000). The depleting ground water levels, recurring droughts and political solutions to the problems related to water supply add the intensity of problem of drinking water availability. (Kakade, 2000) Each of the seven study watersheds cover about three to four villages of about 500ha to 1500 ha area. Sixteen villages and their respective 10 hamlets have been covered in these seven watersheds. The total geographical area of the watersheds studied is 7000 ha and about 2500 households with population of 14769 reside in the area.

II. RESEARCH OBJECTIVES

The central objective of this study was to describe the impacts of a watershed development programme that includes different models in different locations on the water demand and supply scenarios for all types of uses, but with special emphasis on drinking water supplies and access to the rural poor (backward communities).

III. METHODOLOGY

The study involved integration of various data obtained from three sources namely from local community through participatory, questionnaire and transects methods (including villages from within and from outside the watershed), from BAIF offices (Pune, Cluster/Regional centers and Field centers) and Government sources. Household level socio-economic information was obtained from a sample size of 25% in watershed villages and 10% each from a downstream village up to the area of influence and a village outside the area of influence of the watershed. Downstream village was selected to understand the area of influence of micro watersheds while study of the nearby village (out of watershed influence) provided a basis for comparing the overall changes and the net effect of project interventions. Fieldwork of the study was best optimized during March-April-May to experience the extreme situation during pre-monsoon summer and understand the changes due to the programme.

Drinking water, sanitation, ecosystem dimensions and socio-economic situation were the focus areas of study. Specific issues and indicators have been identified under each of the focus areas to assess the watershed system as a whole keeping WSS at centroid.

After the study of seven cases with above methodology, the data gathered was synthesized through a simple matrix based analysis. The case studies revealed interesting facts and data on similarities and differences in the implementation of the watershed projects by BAIF under various programmes each with its own objectives, approach, time frame and budget. Some projects such as a project funded by India Canada Environment Facility or Commission of European Communities were found very comprehensive and integrated while the others supported by National Watershed Development Programme were with narrow focus. The findings of the study are given below.

IV. STUDY AREA

BAIF Development Research Foundation has been working in several parts of the India for upliftment of rural poor. Watershed development is one of its major programmes covering 6 states, 27 districts, 264 micro-watersheds and 128167 ha area. Seven watersheds have been selected from among such programmes for the present study **(figure 1).** Most of the selected watersheds are between 4^{th} to 5^{th} year of implementation and represent different agro-climatic conditions, problems pertaining to natural resources, social & economic factors and the mitigation mechanisms practiced through watershed models. The watersheds studied include, Govardhanpura-Gokulpura Watershed, Bundi District, Rajasthan, Adihalli-Mylanhalli Watershed, Hassan District, Karnataka, Karaondia-Sengur-Yamuna Watershed, Kanpur District, Uttar Pradesh, Kelghar-Ranjanpada Watershed, Thane District, Maharashtra, Titoi Watershed, Surat District, Gujarat, Manhere watershed Ahmednagar Dist. Maharashtra and Kharachiya and Kharachiya jam watersheds, Rajkot District Gujarat. **Annexure 1** gives the summary of physical characteristics of seven watersheds. The projects studied were funded by different funding agencies, which had their respective objectives and activities. This is given in detail in **Annexure 2.**

V. FINDINGS

5.1. Problems/ Issues

The WSS situation in all the watersheds studied was very pathetic especially during the scarcity period of summer. Certain commonalities and differences have been observed in the study of seven representative watersheds in six regions.

The commonalities among 7 projects studied are as given below:

- All the seven watersheds have the ground water as the source of drinking water supply.
- After the drying up of the surface water sources, the supply source for drinking, other domestic purposes and cattle is common.
- Drying up of the dug wells tapping the shallow aquifer in summer.
- Limited number of perennial sources particularly the recently introduced hand pumps by government authorities.
- Water scarcity period in the summer season from the end of February upto the end of June.
- Severe water scarcity in the upper catchment villages.
- Close link between water supply sanitation and health and hygiene.
- Water contamination leading to water borne diseases.

The scarcity period is about 4 months of summer when the water table depletes creating tremendous stress on the local population and cattle. Scarcity leads to traveling distances by women mainly (mostly all areas), standing in long queues waiting to get a pot of water from government tankers (Rajkot, Manhere), searching the seepage

points in early morning hours and sometimes half a day (Manhere). The adverse situation forces the communities to drink non-potable water to quench their thirst leading to water borne diseases. This is also due to the lack of awareness about drinking the clean drinking water.

The factors responsible for the water related problems are associated with varying degrees in different areas. These factors are both natural as well as anthropogenic.

5.1.1 Natural causes

All the watersheds except two in Western Ghats (Manhere and Kelghar) fall under low rainfall zones. The rainfall in these areas ranges just between 350mm to 650mm that too is very erratic. In absence of surface storages, there has been very limited ground water recharge in monsoons. Natural recharge is very limited due to the fact that all the studied watersheds are located on the upper most parts of the region or valleys. Except UP area no other area has access to the river water coming from other regions. Although there is good rainfall in the watersheds at Western Ghats (Manhere and Kelghar) the topography and geology is not favourable for ground water storage and also the yields.

Being a common aquifer for both domestic and irrigation use in Rajkot and Govardhanpura area, the irrigation use for kharif and rabi season depletes all the water sources. So overall depletion of the ground water leads to drinking water problem in the summer season in these areas. The water use for coconut throughout the year in Adihalli area dries up the drinking water dug wells in summer and reduces the yield of bore wells.

5.1.2. Anthropogenic causes

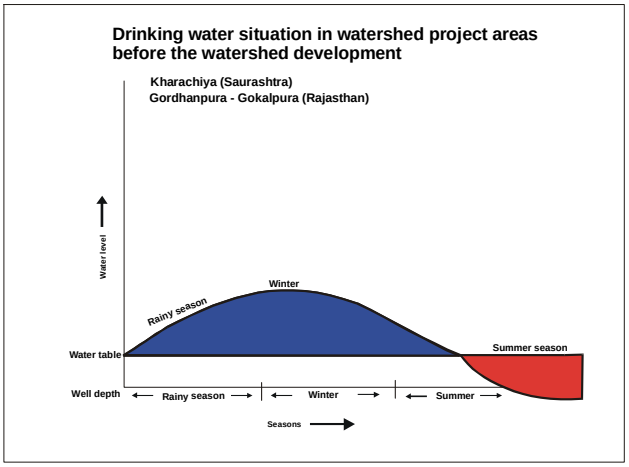
The presence of individual bore wells and dug wells for irrigation without proper management in Rajkot watersheds lead over exploitation of groundwater. The exploitation rate is more than available recharge rate. The dependence on the Rabi crops has encouraged the individual to over use the only source both for drinking and irrigation. The absence of awareness among the community about harvesting of rainwater and proper utilization of both surface and ground water creates imbalance due to low recharge and high exploitation.

The coping mechanisms in most of the watersheds were very short cited. They are short cited because of following reasons:

- Provision of limited HPs
- New HP if earlier one goes dry or becomes permanently defunct
- Water supply through water tankers (Guj & Mah) in a very limited quantity

The government water supply departments have installed the hand pumps in all areas except Kelghar where dug wells form the only source. The hand pumps installed are very limited in number to meet the needs of the population. Many times locations are not appropriate for access to the majority of community. It has been observed that out of 60 HPs only 24 were functional at baseline. This problem is due to absence of local management and maintenance mechanisms and ignorance by the authorities to follow proper maintenance and management criterion.

Out of these seven watersheds, Govardhanpura- Gokulpura (Rajasthan) and Kharachiya (Saurashtra) watershed area witness frequent droughts. There is drinking water scarcity in both the areas. The Graph given below illustrates the drinking water situation in both the watersheds. As the rainy season begin in the area the wells get recharged and yield ample amount of water for drinking as well as irrigation till the end of monsoon. As the winter season begins, maximum amount of water available is utilized for the irrigation of rabbi crops. This withdrawal causes depletation of water level in the wells. This causes water scarcity during the summer season.



5.2. Activity for WS

The projects study show that although the projects were implemented by BAIF the project design has influence of the broad project objectives and the project-funding agency. Hence the WS issues although found one of the top priority of locals in all the baseline reports, the solutions or the approach of tackling the problem vary from programme to programme. The direct interventions for addressing WS issues include:

a) Intervention through Entry Point Activity

- Drilling of bore wells and installation of electric pump on it.

- Construction of overhead tank and inflow and supply pipeline connected to a stand post with taps
- Drilling of new bore wells

b) Core Project Activities

- Installation of hand pumps on the dug wells and newly drilled bore wells.
- Deepening of the existing dug wells.
- Enhance recharge to groundwater
- Development of springs
- Train locals in hand pump repairs.

It is also important to note that the above activities in isolation cannot solve the drinking water problem. The perenniality of the sources can be ensured only if the other water requirements also taken into consideration. Then all the demands may be together addressed taking up an integrated approach of source development and management. In all the projects the user Groups have been developed to maintain, manage and share the water for both irrigation and drinking. Thus the main project activities for soil and water conservation indirectly benefited the drinking water supply situation in all the watersheds.

5.3. Effects of Watershed Development on WS

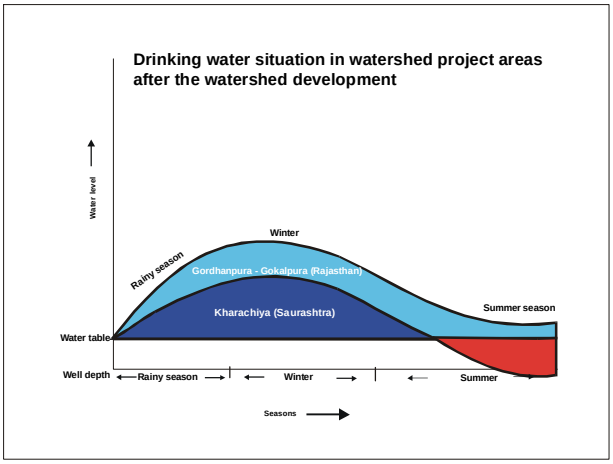
In the earlier section we saw the different initiatives and activities taken up under different watershed projects specifically for addressing the issues related to WS. In this section the effects of these specific inputs for WS and other activities under watershed projects are analyzed. Analysis of this breaks the boundaries of the focus areas (Drinking water, Sanitation, Ecosystem and Socio-economic) as it becomes a complex system to synthesize and hence cuts across all the issues of a watershed system.

The outcomes related to the WS reveal that the water supply problem has been completely solved in except in the two watersheds of Rajkot district. Rajkot area has been facing severe droughts during last two years resulting the drinking water problem even after watershed project implementation. While the Govardhanpura-Gokulpura project has overcome the drought situation due to watershed project implemented with more integrated approach In Jawhar although the drinking water is available throughout the year, the access is still a problem.

The drinking water problem of most of the watershed areas has been solved due to the combined effect of the development of supply sources (HP, bore and dug wells, etc.) and improved ground water table as a result of recharge measures under watershed development projects. In addition, the community initiatives in Titoi and Adihalli helped receive the support from forest department and government respectively. While in Manhere the piped water supply scheme by government has completely solved the problem in main villages and the watershed measures augmented the traditional sources in hamlets. So the tankered supply is no more required there in Manhere. Watershed communities in all the seven areas enjoy the safe drinking water facility. The improved quality is the outcome of improved hygienic conditions around sources, main source being the bore well deeper aquifers, and regular chlorination to the open wells.

Formation of user group for the utilization of ground water has been of great help in reducing pressure on the only source for drinking and agriculture i.e. the ground water. The sustainability of the sources will be ensured through proper management by the local user groups and the maintenance skills acquired by the village youths.

The following representative graph illustrates the situation of drinking water in both the watershed areas after watershed development programme. After the implementation of watershed development programme in both the watersheds, it reveals that Kharachiya project area is still facing water scarcity problem; people in the area are going deeper and deeper in search of water. The needs of drinking water are satisfied by the single source, which is 1100 ft. deep. On the other hand in the Govardhanpura – Gokulpura watershed there is ample amount of water available for drinking in the sources during the summer of the drought year.



VI. CONCLUSIONS

Learnings or the conclusions of the study are based on the representative watersheds selected from different working areas of BAIF. These represent the respective broader regions of the rural India. Below are the salient findings of the research study.

1) Despite the location of study areas in different topographic, geo-hydrological and climatic situations, all the rural areas had problem of water

scarcity in summer. The scarcity problems were mainly due to:

- Natural causes like adverse topography, unfavorable geohydrology or common aquifer for both drinking water sources and irrigation sources.
- Anthropogenic causes such as overexploitation of ground water, absence of recharge measures, very limited reach or no government support for WSS, emphasis of government on relief measures than long term solutions (e.g. tanker water supply).
- Failure of government water supply schemes due to absence or very poorly established management and maintenance of water supply sources/ schemes in villages resulting into wastage of investment, dependency of locals on government authorities and lack feeling of ownership on the schemes provided by government.
- Water quality tests at baseline show contamination in most of the sources. Awareness on drinking potable water had been missing in most of the rural villages.

2) All the watershed projects implemented by BAIF tried to address the drinking water problem on priority. Even though some programmes had no funding, BAIF organized funds from other sources to ensure adequate water supply to watershed population. It brings out important observation that some watershed programmes provide support only for soil and water conservation leaving drinking water issue untouched. Such watershed project can only augment some existing sources but cannot solve the drinking water problem completely.

3) Availability of drinking water throughout the year has been ensured in all the watersheds. This was possible only due to the combined effect of development of drinking water supply sources within the village and hamlet and improvement of ground water table or the yield of the sources due to water conservation measures. This has been also validated with the prevalence of scarcity situation during the survey in the peripheral villages.

4) All the water supply sources (mainly Hand Pumps and village level piped water supply systems) developed through the project were found in working condition (as against only 40 % sources were functional at baseline). This was possible due to the presence of local Water User Groups developed by project, local contribution for source development and development of local skills for repair and maintenance.

5) Due to improved availability of irrigation water, agriculture practices are drastically being changed. Cropping intensity as well as cropping area under irrigation has increased. This has resulted into increased crop production up to double than the earlier. More sustainable agricultural practices are also seen (e.g. tree based farming, horticulture).

6) In all the projects, Water User Groups (WUG) and Village Watershed Committees (VWC) have been developed for management, maintenance and sharing the benefits of resources. However, their understanding of responsibility and capacity to manage (mainly irrigation sources) appears to be very limited. Thrust of watershed projects has been more on development of sources and less on proper utilization.

7) There is no state legislation (being enforced) for regulating water use for irrigation. There is no control on use of water and it is still a “free for all” source.

8) The study reveals that at least one downstream village has been benefited due to watershed development mainly due to improved ground water. A detailed study will be required to find out precise extent of the effects on downstream.

9) Comparison between two drought affected areas (Rajkot, Gujarat and Govardhanpura, Rajasthan) reveals that Govardhanpura had sufficient water for drinking during the summer of drought year while Rajkot area had to face scarcity problem, in fact, villagers received tanker-water during the summer. This has happened due to the fact that Govardhanpura project is more integrated and includes comprehensive activities for watershed development. On the other hand the project under NWDPRA/DPAP had focused only on water harvesting structures in drainage lines due to the limitation of funds.

VII. RECOMMENDATIONS

Study revealed some tangible as well as intangible trends of development. Such trends imply quite obvious learnings. Based on learnings below are few recommendations.

- Water supply, sanitation and watershed development should be linked together to solve the problems of drinking water supply, sanitation and irrigation.
- Controlled utilization of water for irrigation needs to be incorporated in projects to avoid potential conflicts in the areas such as irrigation vs. drinking water, aquifer vs. aquifer or among well owners.

- The responsible local management of sources can certainly ensure the balance of ground water system. So it is very important to develop strong local user groups who can regulate the water utilization. These groups should actually initiate the water management during project implementation. Responsibilities of the group should be:

- ✓ *Look after maintenance of sources, collection of water use charges.*
- ✓ *Ensure equitable sharing of water among the farmers in command areas (there is need to redefine the command area as well. The area, which is on upstream side, should also get benefit of surface as well as ground water reserve).*
- ✓ *Assess the stock and utilize the portion of water quantity for irrigation during rabi season leaving sufficient stock for summer. It will also require appropriate crop planning during every season.*
- ✓ *Mechanism to solve conflicts.*

Unless the balanced water utilization is ensured, any positive impacts of watershed project will be short term. So the watershed development plan or design itself should have sustainable water utilization as mainstream project objective.

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