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Some Water Management Options and Challenges in Micro & Water sheds of N-W Tract of India

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ABSTRACT: *Water management in the micro-watersheds suffers from management decisions rarely made keeping in view the needs of people, variations in rain, land, soil and vegetation parameters. Some studies conducted in N-W tract of India pointed out about the serious issues affecting the water management and limiting their success and sustainability in upper watersheds. Opportunities and challenges to research this goal can be grouped in five major areas viz overcoming constraints to technology adoption managing conflict, balancing local economic and environmental services and strengthening organizational and learning processes. Recently conducted study demonstrated that the construction of series of small water harvesting structures in the form of earthen dams across the seasonal streams for managing runoff during the monsoon season could help in improving water availability in lower shivaliks of northern India. Some evidences showed that the recharge is merely 20-50 per cent of existing level in Hoshiarpur and Gurdaspur districts of N-W tract of India in the state of Punjab, which mean that even the rainwater is not able to compensate the extraction. It is thus important to involve stakeholders in seeking their partnership at addressing the local and other serious problems from water management point of view in the upper watersheds. It is a matter of concern to follow the integrated water management options and their sustainable combinations will be the key to future agricultural economic growth and social wealth etc. the constraints reported in the adoption of rain water management practices are topographical problem, followed by lack of technical knowledge and ignorance of rain water management practices are topographical problem, followed by lack of technical knowledge and ignorance of rainwater management practices etc. in rain fed submontane region of Punjab. However managing resources at local levels requires ability to negotiate solutions and to resolve conflicts among stake holders ranging from contractors to landless laborers should be viewed seriously. It is also important to refine the existing indigenous technical knowledge systems in a scientific way in rain fed submontane region from moisture conservation point of view. The lessons learnt from the successful projects can be replicated following participatory approach of the people. understanding the importance of collective action of farmers communities and of jointly framing the rules for resource access and use, improved institutional arrangement of land and water resources in upper watersheds is of immediate concern.*

Key words : *Hydrological parameters: Rain water management practices; Integrated water management*

INTRODUCTION

People in reality rarely manage watersheds deliberately but they manage different components of watersheds in isolation viz, land, water or vegetation or live stocks. However the management decisions are rarely made keeping in view needs of the people, variations in rain land soil and vegetation parameters and with different objectives in mind. Also the combined outcomes of these independent decisions with their often highly dependent economic and ecological consequences determine the overall watershed function. For varied reasons top down watershed management strategies ignored multiple uses and users of watershed resources have not been successful. However in order to improve watershed management and services including the availability and quality of water, the benefits of which could be accrued by the farming community by flowing participatory approach. It may also require encouraging people to think beyond individual resources or plot/ community level to consider the implications of their actions at the watershed scale. For example the integrated watershed management options have been quite successful in the kandi area

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of Punjab (sur and toor, 2002). Also in an on farm applied research projects, monitoring evaluation and geographic information system experts were involved. Jain (1995) reviewed and highlighted experiences from some of these projects. It was felt that there are still serious issues affecting these programmes and limiting their success and sustainability.

TEMPORAL AND SPATIAL DIMENSIONS OF TECHNOLOGY ADOPTION

Technology adoption decisions are often perceived or modeled as being individual decisions, where benefits and cost are assessed and actions taken on the basis of net expected impacts. This model is appropriate where the benefits and costs of an action are well understood and where they are mainly felt by decision maker himself/herself where internalities are significant, the sum of individual decisions may not lead to optimal social outcomes. It is likely to be the case for management of upper watersheds.

For technologies, such as improved varieties, temporal and spatial scales are not likely to influence adoption sense the benefits can be realized at the plot level in short period of time, by adoption by individual. Other technologies such as land and soil management, may only yield benefits in the medium to long term, which means the farmer must consider temporal dimensions in making adoption among farmers is effective if group of farmers agree to adopt them on contiguous plots. It can be visualized that on an average 4 cm of more soil water storage can be achieved by treating the land with conservation measures in kandi area of Punjab. (Table; Hadda and sur, 1987).

Table 1
Soil Water Storage in 180 cm Soil Profile in Untreated and Treated Fields at Boothgarh, Hoshiarpur

Day	*Soil water storage (cm)*	
	Untreated	*Treated*
0	30.5 ±1.4	34.3 ± 1.5
2	20.7 ± 1.3	23.2 ± 1.1
4	19.6 ± 1.4	22.0 ± 1.0
17	28.0 ± 1.4	32.0 ± 2.0
19	19.1 ± 1.6	26.1 ± 2.0
Mean	23.5	27.5

Source: Hadda and sur (1987)

- Treated with conservation measures viz, minor land leveling, bunding, terracing and provisions of outlets for safe disposal of runoff water.

It is thus imperative that the watershed management technologies and practices generally yield benefits over the long term and to be effective, they must be adopted on a large scale through community participation or in small groups. For example, an irrigation dam built at karoran district ropar in a participatory mode during the year 1984 have the following features as listed in table 2. The catchments area of the dam is 17.3 ha, however the command area is 20 ha. The earth fill core wall dam is expected to generate runoff volume of capacity 5.7 ha m. It involved total cost of 2.50 lakh of rupees. The underground irrigation pipeline (950 m length of 250 mm size and 132 m length of 150 mm size) system was laid in the command area. The suitable outlets were provided to ensure equal distribution of water. The studies (jindal et al., 1990) conducted on rainfall – runoff (during the years 1985-89) indicated that the rainfall becomes runoff to the tune of 36.4 per cent. The reduction in seepage to the tune of 60 per cent occurred due to deposition of silt on the bed and sealing of soil pores. The average (1984-87) silt load was observed to be 48 t/ha/yr and the availability of the water in the dam was observed to vary from 208 mm to 253 mm (average of 1985 – 1989 years) in the beginnings of months of November and December respectively. This quantity was sufficient to apply one pre-sowing irrigation of 5 cm depth in whole of the 20 ha command area.

Table 2
Some Salient Features of the Dam at Village Karoran District Ropar, Punjab

Attributes	*Values*
Average rainfall for the monsoon	935mm
Catchments area	17.3 ha
Runoff	35 per cent
Expected runoff volume during monsoon	5.7 ha-m
Designed storage capacity	5.7 ha-m
Dead storage capacity	0.4 ha-m
Type of Dam	Earth fill, core wall
Height of Dam	11.0 m
Top width of Dam	5.0 m
Side slope on the u/s and d/s sides	3:1, 2:1
Estimated runoff for spillway	225 m
Slope on spillway on sides	1.5:1
Cost of Dam	Rs 1.50 lakh
	Total cost
Cost of irrigation system	Rs. 1.00 lakh
	2.5 lakh
Cost of storage, per m^3	Rs. 2.70
Total command area	20 ha

Source: Jindal *et al.* (1990)

Similarly the watershed treatment resulted in significant reduction of sediment loss from 140t/ha to18t/ha in the sukhna lake of 4207 ha catchment area over a period of ten years (Samra, 2002; Table 3).

Table 3
Effect of Watershed Measures and Social Protection in Sukhna Lake Catchments (4207 ha) on Sediment and Water Yield

Particulars	*Pre–treatment (Avg. 1970-79)*	*Post- treatment (Avg. 1979-89)*
Average Annual		
Monsoon rainfall (mm)	1003	953
Monsoon water yield (mm)	295	63(4.7*)
Runoff (% of monsoon rain)	29	7
Monsoon sediment yield(t/ha)	140	18
	Avg. 1958 -78	(7.8)

Source: Samra (2002)
*value in parenthesis indicates time reduction.

CHALLENGES TO IMPROVE WATER MANAGEMENT IN WATERSHEDS

The agriculture sector is by far the largest user of water in the world. About 80-90 per cent of all the water is used in agriculture. Unfortunately, water use efficiency in agriculture sector is very poor not exceeding 45 per cent. Thus more than 50 per cent is being utilized. Enormous water saving could be achieved in the agricultural sector comparable with the other sectoral using water (IWMI, 2002).

According to experts, water is being exploited more than the normal threshold level. Hydro-geologists from groundwater board of the state of Punjab opine that Punjab might be desert by 2025 if the groundwater table is exploited in the ongoing rampant manner (Hadda and Arora, 2003). The same reports indicate, reckless installation of tubewells by the private and government agencies, incentives to the farmers in the form of free power, discharge of effluents by industrials houses, faulty cropping pattern, lack of will to harness rainwater and above all empty government coffers. Thus, each factor is adversely affecting the groundwater table.

In the 300 km long and 30 km wide kandi area of Punjab state, which more or less meets the boundary of the Shiwalik range, the water level fluctuation is immense. Some reports indicated that from 1995 to 1996, the water table has gone down by more than 7m in the Balachaur block located in district Nawanshahr. However, the recharge is merely 20-5-per cent of existing level in Hoshiarpur and Gurdaspur districts, which mean that even the rainwater is not able to compensate the extraction(Hadda and Arora, 2003). It is apprehended that the people of Punjab are sure to face an acute scarcity of drinking water, leaving aside water for irrigation purposes and Punjab, the land of five rivers is likely to turn in to a desert like conditions.

Therefore, keeping these points in view, some drastic corrective measures need to be taken up. The percentage of the area irrigated by tube wells increased from 23to 60 per cent in 1995 to 1998(in plains). It is thus imperative to use the canal water in conjunction with the tube well water where ever possible as indicated by irrigation engineers of Punjab agricultural university, Ludhiana. Nearly, 75 per cent of the cultivated land in Punjab is under water intensive cropping pattern of wheat – rice monoculture. There is need to educate the farmers about the effect of over withdrawal of water. The early transplanting of paddy should be discouraged and there is need to look for other means of not only harvesting roof top water but also adopting artificial recharging technologies, harvesting the rainwater either in impounding or excavating of Makkhowal type of water harvesting tanks in the foothills of Shiwaliks depending upon catchments area, probable rainfall, cultivated area, cropping sequences and type of soils, etc.

Qadir *et al.* (2003) indicated that because of uneven distribution of water resources and population densities worldwide, water demands already exceed supplies in nearly 80 countries with more than 40 per cent population of the world. Consequent to further increase in these countries supplies of agricultural and non-agricultural uses. These facts reveal that the time has come for the sustainable management of available water resources based on global, regional and site specific strategic options. The integrated water management approaches can be followed and their sustainable combination will be the key to future agricultural and economic growth, social wealth, particularly in the region that are deficient in fresh water supplies and are expected to become more deficient. Sur et al (1999) advocated the construction of a series of small water harvesting structures (WHS) in the form of earthen dams across the seasonal streams for managing runoff during the monsoon season that could improve the water availability in the lower Shiwaliks of the Northern India. Three water harvesting structures (core wall type of earthen dams) having catchement's areas of 77.2, 6.6 and 17.3 ha were constructed: one at village Ballowal Saunkahari and Takarla each in district of Nawanshahr and one at Karoran in district of Ropar, Punjab in 1983-84. The study showed that 73, 77 and 85 per cent of the total summer monsoon rains could produce runoff with runoff coefficients of 0.22 ± 0.03, 0.37+0.04 and 0.35 ± 0.05 at the respective sites. On an average, 1211, 2712 and 2769 m3 of water was harvested per hectare in these structures. The major mode of water loss was through seepage which varied from 61 to 86 per cent at these structures. The water harvesting structures lost their gross storage capacity by 1.3, 1.1 and 1.2 per cent with siltation rate of 31, 37 and 47 t/ha of catchments area at Ballowal Saunkhari, Takarla and Karoran respectively.

Options and challenges for water management in watersheds can be grouped in five major areas: overcoming constraints to technology adoption, managing conflict; balancing local economic and environmental services; and strengthening organizational and learning processes.

OVERCOMING CONSTRAINTS TO TECHNOLOGY ADOPTION

Many appropriate technologies have been developed for supplemental irrigations and waterharvesting. However, developed technologies are not being adopted to variety of constraints. While the causes of lack of adoption may be similar across different area, site specific may be required based on solutions, social, economic, biophysical parameters. A survey of two districts of **submontane** Punjab indicated that the constraints in adoption of rainwater management practices included topographical problem (90%) lack of technical knowledge (78%) ignorance's of rainwater management practices (58%) non availability of agricultural machinery and implements for water harvesting (51%) and non availability of labour (32% (Table 4: Sidhu, 2002).

Table 4
Constraints in Adoption of Rainwater Management Practices

Sr No	*Constraints in adoption of rain water management practices*	*Farmers*	*Per cent*
1	Non availability of labour	48	32.0
2	Non-availability of agricultural machinery and implements used for rainwater harvesting	77	51.3
3	Lack of technical knowledge	117	78.0
4	Topographical problems	135	90.0
5	Ignorance of rainwater management practice	88	58.7

Source: Sidhu (2002)

In an on-farm experiments conducted in foothills of shiwaliks there was 13.2 per cent increase in grain yield of maize in T4 treatment as compared T1 (Farmers practice). The grain yields other treatments viz. T2 and T3 was 3.2 and 7.3 per cent higher over control (Table 5; Hadda *et al.*, 2002).

Table 5
Effect of Different Treatments on Grain Yield of Maize Following Participatory Approach at Kokowal Majari-Jhunewal watershed, Hoshiarpur, Punjab during the year 2002

Treatments	*Grain yield(kg ha^{-1})*
Farmers practice (T_1)	2270.5
Improved variety+ recommended dose of fertilizer (RDF) + minor land shaping (T_2)	2344.4
T_2+25% N replacement through farm yard manure (FYM) (T_3)	2435.6
T_3+ addition of Zn as per recommendation+ herbicides (T_4)	2570.2
LSD<0.05	87.4

Source: Hadda *et al.* (2002)

MANAGING CONFLICTS

In the absence of clear and widely accepted rules for access and norms for use, multiple uses and users of resources can often lead to conflict. For example in N-W tract of India the residents of watersheds are resource poor, have small land holdings and suffer from vagaries of nature. Since time immemorial land clearing and farming by those farmers is seen as a threat to the integrity of the watershed functions produced by these forest lands. Often conflicts occur and it is a matter of concern and cause to reduce conflicts between upland farm communities and state forest departments and other public agencies concerned with water and watershed management. (Tomich *et al.*, 1998; swallow *et al.*, 2002).

Decentralization of government services, NGOs and devolution of responsibilities with field functionaries for natural resources management is creating new opportunities for resources management as per requirements and needs of local people. However managing resources at the local level requires the ability to negotiate solutions and to resolve conflicts among stakeholders ranging from contractors to landless laborers should be viewed seriously and not underestimated. (sur and Toor, 2002)

BALANCING LOCAL ECONOMIC AND ENVIRONMENTAL OBJECTIVES

In many developing countries there are clear tradeoffs between the revenues generated by those enterprises and deterioration of quality and quantity of water for downstream users of water. The affected users are often the poor who are least able to defend their right to clear water. an important question needs to be addressed is that how the rights of the poor can be safe guarded in the processes of demographic, economic, political and global changes that are shaping the de eloping regions. The adoption of indigenous technologies and their refinement in a scientific way is a need of the hour in rain fed submontane region of Punjab.

The perusal of data in table 6 indicates that there was considerable reduction in soil loss from 11.2t/ ha/yr to 2t/ha/yr following the participatory integrated watershed management approach at Fakot, UP Hills. Also there was tremendous reduction in heavily grazing to stall feeding after managing the watershed. It has generated the income source at a place where participatory watershed approach has been adopted as evidenced by reduction in male migration from 26.6 to 0.7 per cent in the area. (samra, 2002).

Table 6
Environmental and Productive Impacts of Participatory Integrated Watershed Management at Fakot in UP hills

Attributes	*Pre-project (1974 -75)*	*During Project (1975 – 86)*	*Post–Project (1987-95)*
Total foodgrain production (qtls)	86.6	421	515
Average family income at constant price ('000 Rs.)	3.7	20.5	24.5
Male migration (%)	26.6	9.3	0.7
Runoff (%)	42	18	13
Soil Loss (t/ha/yr)	11.2	4.9	2.0
Role of women in decision making (%)	10	25	45
Animal grazing	Heavy	Partial	Stall Feeding

Source: Samra (2002)

SUSTAINABILITY AND REPLICABILITY

It is now recognized that in any discussion on sustainability, it is important to clarify what is being sustained for how long for whose benefit at whose cost over what area and measured by what criteria. in the world Bank aided Project (IWDP) in Punjab, Haryana, Himachal Pradesh and J & K, the issue of sustainability received a good attention. The major concern was on the sustainability of resources created during the project like water harvested, fodder, fuel, crops and milk produced. It was emphasized that project area should work as demonstration to be simulated and replicated beyond the project area. Major lesson learnt from this project was that the task of replicability and sustainability is huge and cannot be solved without peoples participation (Sur and Toor, 2002). The study further showed that the runoff was reduced from 45 to 22 per cent in arable watersheds compared to non-arable watershed where it reduced from 45 to 18 per cent due to adoption of soil conservation treatment. the reduction in runoff observed was more in non-arable compared to arable because of better vegetation status and less disturbances caused by human, and livestock's, etc. (Table 7)

Table 7
Runoff as Affected by Soil and Water Conservation Treatment in Kandi Area

	Rainfall (mm)	*Untreated (mm)*	*Treated (mm)*
Arable	3160	1438(0.45)	693(0.22)
Non-Arable	10597	4733(0.45)	1889(0.18)

Figures in parenthesis represents runoff coefficient
Source : Sur and Toor (2002)

PEOPLE'S PARTICIPATION

People's participation holds the key to sustainable management of water resources in the watershed by proper and purposeful execution, replicability and sustainability. Lessons learnt during the implementation of IWDP (Hills) project (Sur and Toor, 2002) showed that the peoples participation can be ensured through a) adoption of need based, scientifically sound technology, b) involving people during various phases of project implementation like planning, decision making and execution, c) proper training and extension efforts, d) changing and adjusting approaches which infuse in people the confidence and reliance in the project works and workers both, e) transparency of accounts, f) getting more and more works executed through beneficiary, g) including a good portion of works with quick returns, h) encouragement to contribute in term of labor and/or money in various activities of the project, and evaluation of the technical practices in terms of cost-benefit ratio. Thus moral and ethical commitment on the part of those directly involved in execution of works is vital for the successful implementation of project.

STRENGTHENING ORGANIZATIONAL AND LEARNING PROCESSES

Understanding the importance of collective action of farmer's communities and of jointly framing rules for resource access and use, improved institutional arrangements for better management of land and water resources in upper watersheds are urgently needed. Collective action and institutional arrangements at different scales do not generally emerge spontaneously. Kerr et al (1996) analyzed some watershed projects in India and those watersheds which were implemented through partnerships between NGO's and government organizations had the highest rate of success.

Also it is needed to assess the advantages and disadvantages of catchments management entities from community user group to large scale NGO's or centralized organizations for basin management. However, some of the questions addressed by challenge programme document on food and water (IWMI, 2002) of realizing increased potential for sustainable water management in upland watersheds are:

(i) What types of organizations are most effective in which circumstances?

(ii) What are the transaction costs of different organizational mechanisms?

(iii) What is the best way to facilitate the emergence and sustainability of these organizations, or to support existing organizations to take new function ?

(iv) How can it be ensured that the poor participate and the powerful vested interests do not dominate ?

(v) How can biophysical research best support collective decision making, especially in the context of a participatory adaptive learning process?

CONCLUSION

Where the potential for improved water use exists, how can it be realized? Often, actual benefit is obstructed by complex problems such as uncertainty of gain, lack of institutions to implement changes and possible conflicts between diverse groups of people. This will require identification of factors that influence people to engage in long term, adaptive process of water resource management. People organize themselves in response to a variety of influences, including social, economic, political, technological and biophysical influences. In upper catchments, biophysical implications of individual decisions may not be considered due to high degree of uncertainty, externalities or overriding economic or social pressures. As a result, many of the institutions and policies that influence how people use resources in upper catchments/watersheds are not designed to maximize benefits from water. Yet, top-down, engineering approaches to watersheds management have generally not been effective precisely because they do not take into account he multiple uses and users of resources in the upper watersheds.

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