

Watershed Management Challenges

Improving Productivity, Resources and Livelihoods

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Upstream-Downstream Complementarities and Tradeoffs: Opportunities and Constraints in Watershed Development in Water Scarce Regions

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Abstract

In India watershed management is largely focused on local level micro-watershed (typical watershed area between 500-1000 ha) for improved soil and water management. The key underlying assumption in many watershed development programmes is that good land management will lead to increased availability of water resources, especially groundwater resources for productive and domestic uses.

Watershed development projects implemented over the last two decades have some important positive and negative aspects. On the positive side, it has increased net agricultural production on arable and non-arable land. There is development of village level institutions and substantial improvement in the livelihood of some social groups. The less positive aspects of the programme include emphasis on development of land and to a lesser extent on water resources (i.e., emphasis is on increasing water supplies by constructing check dams, rehabilitating tanks, etc). As the planning takes place at the village level, a whole range of wider issues, such as upstream-downstream equity, allocation of water among and within watersheds, flood protection, drought preparedness, pollution of water courses, biodiversity and protection of rare habitats are not considered in the planning process and not included in the development proposals.

This paper presents a conceptual framework wherein it argues that water resources management should play a vital role to improve the sustainable productivity of the watershed. The paper looks at the upstream-downstream conflict created at basin scale due to micro-level planning and implementation of watershed programme through a case study. The paper also presents some research results of an on-going collaborative project of IWMI with Catholic Relief Services (CRS) on four pilot watersheds in the tribal belt of central India. The importance of hydrologic analysis of watershed is brought out for ameliorating upstream-downstream conflicts.

Introduction

There is a great deal of hope bestowed on watershed management and development to meet a variety of needs in regions like south Asia and Africa. Following the recognition that Green Revolution advances were limited to a handful of its better resource-endowed districts, India has made significant investments in 'watersheds' (estimated at Rs. 14,000 crore and Rs. 18,000 crore in

the 1996-2001, 9th Plan and 2002-07, 10th Plan periods, or US\$ 2.9 and 3.7 billion, respectively)¹. The most important lessons from the Indian experience is that greater water availability made through watershed development is quickly nullified by the increased use of water by conventional inefficient methods for irrigation and other purposes. The implication is that watershed management as practised now alone cannot satisfy increasing needs and that at some point allocation and demand management of water must be dealt with as well. In this regard, an issue that needs immediate attention is in water allocation and water rights to stakeholders. For example, while successful capture of rainfall in one part of the watershed can lead to improved local availability, this can also lead to problems further downstream if proper water rights are not stipulated. Even at the scale of small watershed itself, there are problems linked to capture by land holders in the valley bottom of improved water resources created by investments in good land management on the hill slopes.

In countries around the world including India, 'watersheds' are seen as the silver bullet of environmental management, water resources improvement, poverty alleviation and a long wish list of rural development of governments and NGOs. By contrast, we support the notion that watersheds are water and land resource assessment and management units. Physical watershed development alone is not sufficient. This must be followed with the critical phase of management practices by the stakeholders for sustainability of the developed system. Special focus is given in this paper and the case studies it summarizes to the spatial and temporal distributions—shortage and abundance—of water. When linked with land resource parameters (soil quality, slope, holding size, etc.), management by users at different scales generates watershed outputs and benefits. There are no doubt that these outputs and benefits have considerable linkages with other aspects of the rural development enterprise—health care, education, markets, etc.; however, we insist that water (and land) management need to be positioned at the centre of watershed management. Water allocation and demand management alongwith water conservation should play the central role in watershed development and management paradigm.

A brief recap of water management in India may provide a useful context in which to consider the growing importance of the watershed approach. India's massive investments in irrigation infrastructure in the post-independence and Green Revolution periods are getting plateauing and reducing year by year. The heyday of big dams and river valley projects has been replaced by a quiet but highly dynamic and equitable groundwater revolution (Shah, 2001). The groundwater boom since the early 1970s parallels another political trend in the country towards decentralization of services and investment, but has largely been driven by farmers' own investments and sheer determination. Yet there are signs that groundwater too will plateau, constrained by aquifer depletion, water quality problems, and competition with rural and urban water needs. This leaves watersheds and upper catchments as the 'ultimate frontier' for development and the closest

¹Watersheds are operationally considered to be village-level catchments, roughly 500 ha in size. An estimated 10,000 'micro-watersheds' in India have received some form of external assistance for soil and water conservation, agricultural land improvement, etc. This does not include untold numbers of watersheds managed and improved through farmers and land users' own interventions and investments.

point on land to where the water falls as rain. It is not without its tradeoffs, particularly in semi-arid and arid watersheds, where watershed development has resulted in decreased inflows to important reservoirs, many increasingly used for urban water supplies. The case study presented illustrates the impact of upstream development on downstream reservoir inflow and inequity in water use within villages where development of watershed work was undertaken.

Impact of Upstream Watershed Development on Downstream Reservoir Inflow

Aji 1 reservoir is a water supply reservoir to the city of Rajkot in Saurashtra, Gujarat, and is located at the downstream end of Aji 1 catchment. Of late, the flow to the reservoir was on decline although the rainfall was not. There has been large-scale development of small water harvesting structures within the watershed for artificial groundwater recharging.

Aji 1 inflow during 1968-1999 was considered for the analysis. The flow to the reservoir is hypothesized to be governed by two factors: one is rainfall and the other is upstream development with massive implementation of water conservation structures resulting in abstraction of large quantity of water by water harvesting structures. To separate these two effects, a linear regression between rainfall and reservoir inflow was attempted (Fig. 1).

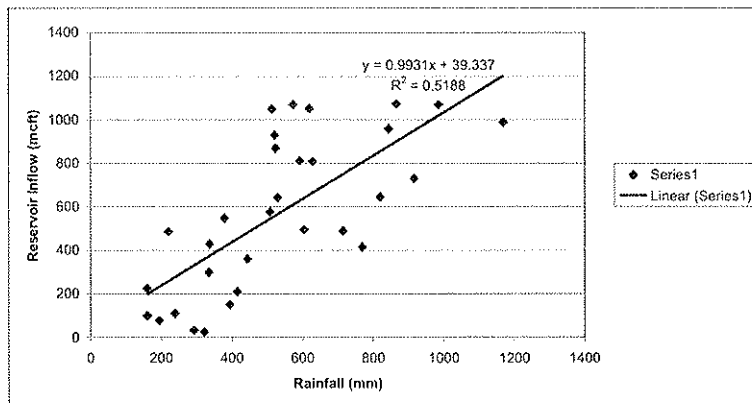


Figure 1. Linear regression between rainfall and reservoir inflow

From the regression equation, the contribution by rainfall is determined and subtracted from the annual inflow to Aji 1 reservoir to get the impact on downstream flow due to upstream development and retention by water harvesting structures. This component is plotted in Fig. 2.

As seen in Fig. 2, the contribution to the reservoir storage was significantly reduced after 1985. During this time an estimated 100 check dams started to come up within the catchment. Definitely there is a downstream impact on reservoir inflow due to upstream development of water harvesting structures. This can also be seen in run-off coefficient variation along with rainfall variation from 1968 to

1999 (Fig. 3). As can be seen that run-off coefficient was fairly high up to 1985 and thereafter it has reduced considerably although the rainfall remained more or less the same during the two periods. The average reduction in run-off coefficient is almost 100 percent indicating the impact of upstream water harvesting structures on downstream flow. The Rajkot city has to now look for another source for its water supply.

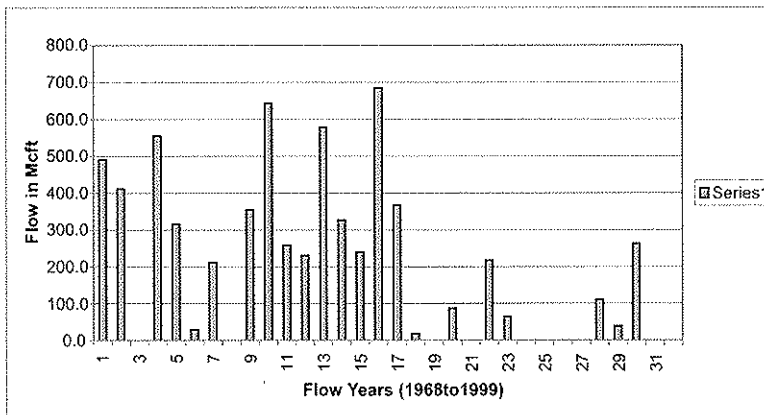


Figure 2. AJI 1 Inflow after accounting for rainfall

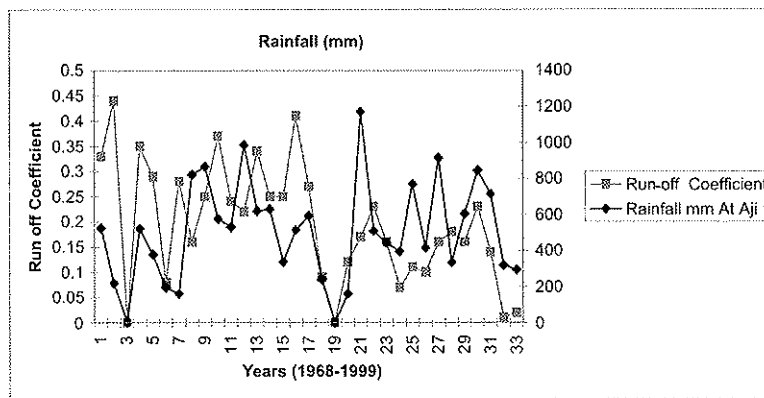
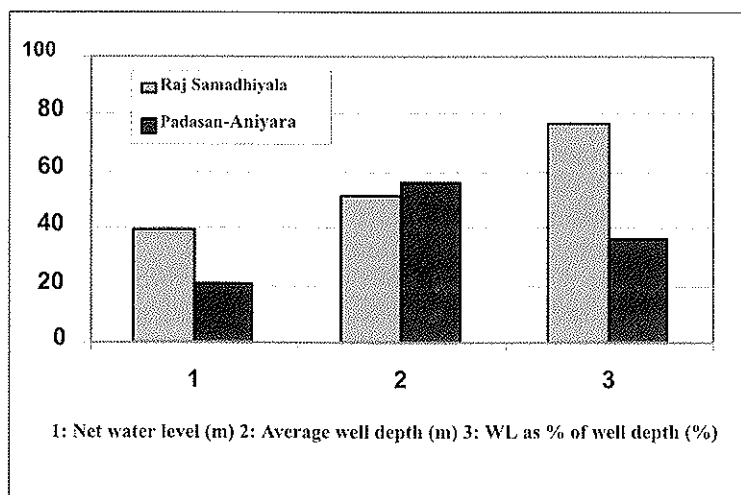


Figure 3. Run-off coefficient and rainfall in Aji 1 catchment

Impact of Watershed Development Within and Without Water Recharge Structures

Raj Samadhiyala (RS) and Padasen (PA) are two neighboring villages located within Aji 1 catchment with one difference. Raj Samadhiyala has more than 12 water harvesting structures such as percolation ponds, and check dams which holds not only run-off generated from its own catchment but also a part of run-off generated from upper catchment flowing through Aji river whereas Padasen gets only natural recharge from rainfall. The artificial recharge through watershed development has made the following differences to the two villages as shown in Fig. 4.



Pumping hours	RS	PA
Average (till Dec)	477	81
Till September	153	81
Till Sept as % of total	31	100

Figure 4. Water level in sample wells - 30th September 2001

Present Status of Watershed Management

It appears that in India the art and science of watershed development and management has gone through major change. Initially, in certain water-scarce regions, the 'anarchy model' of watershed development-indiscriminate management of scarce water and land resources-has come to the fore. Institutional and physical (spatial) scale linkages, which are critical to ensure equity and minimize conflicts, have largely been ignored. It has long been acknowledged that technological innovation alone is insufficient to address environmental sustainability concerns. Best watershed practices must be integrated with sound management and governance in order to be viable over the medium to long term. The goals and objectives vary considerably by project and region as well. However, it has been difficult to assess the real outcomes of watershed development of the past decade's massive efforts (Kerr *et al.*, 2002). And land degradation driven by mounting population and other pressures on resources continues apace, suggesting that at best a 'holding pattern' has been reached. In other, more critical conditions, the battle is being lost, resulting in irreversible resource exploitation, abject poverty, out-migration to cities and better endowed regions, and ultimately, collapse of the environmental underpinnings of agrarian societies.

This reads like a doomsday litany of unbridled resource appropriation and exploitation but does it has to be so? There is evidence to suggest that in India over the past decade and a half, since the 1987 drought, a subtle shift has been occurring in natural resource use centered on watershed management. The equity implications

of intensification on agricultural and non-agricultural lands alike are important and looked into. Institutional strengthening of community during pre-watershed development phase is given due recognition (Bhattacharya, 2002). What are the key elements of success or failure of these decentralized approaches envisaged to natural resource management? What are the management principles on which future development should take place? Finally, what is the appropriate mix of initiative and investment on the part of government, non-governmental organizations, community groups, and individual users?

This paper seeks to address some of these concerns through the presentation and assessment of a series of case studies² on watershed-based land and water management primarily in central India. We develop a conceptual approach that static, historical levels of watershed resource productivity are inadequate to confront today and tomorrow's realities, and that management is the critical variable in ensuring sustainability at various levels including biophysical resource use, local social and economic relations, and the macro institutional and policy contexts. We propose (the outlines of) a series of watershed indicators that will continue to be developed, but which have the aim of establishing reliable assessments of the interactions between management approaches, resource use and livelihoods. An explicit attempt is made to address scale issues - physical, spatial, institutional, social and economic. There is growing agreement that "scale out" means to replicate, i.e., adopt the village-level watershed approach in x number of villages in a state or region, etc. but without explicit attempts to capture the benefits, tradeoffs, or negative outcomes of one watershed project on another particularly in an upstream-downstream relationship. On the other hand, "scale up" means to implement multiple watershed projects in nested scales, particularly village or micro watershed projects concentrated from upstream to downstream in the larger basin of a river or (or large tributary) with explicit recognition that omitting one or more contiguous (sub-) watersheds will not allow the full impacts of scaling-up to be achieved.

The central premise of the paper is that with growing livelihood dependence on water and land resources in a watershed context, there is a need to rise above the individual, household and even village community levels in order to address equity, productivity, and competition for resources. Institutions that function quite well at subsidiary levels are not easily scaled up. Part of the constraint is the policy environment in which line agencies and investments are stove-piped and not integrated to the same degree to which their outcomes are felt by resource users.

Conceptual Framework for Watershed Development

A conceptual framework for watershed development over a period of time is presented in Fig. 5. Initially when the population in the watershed is less than its carrying capacity, the actual production in the watershed is less than its potential

²Catholic Relief Services and the International Water Management Institute have developed collaboration in India in 2002 at four watershed sites across a transect of resource endowment and tradition of water harvesting, stretching from Ajmer (Rajasthan) in the west to Dundlu (West Bengal) in the east. This paper draws heavily on the lessons learnt during the process and also brings in and incorporates relevant material from both CRS and IWMI's own institutional experience.

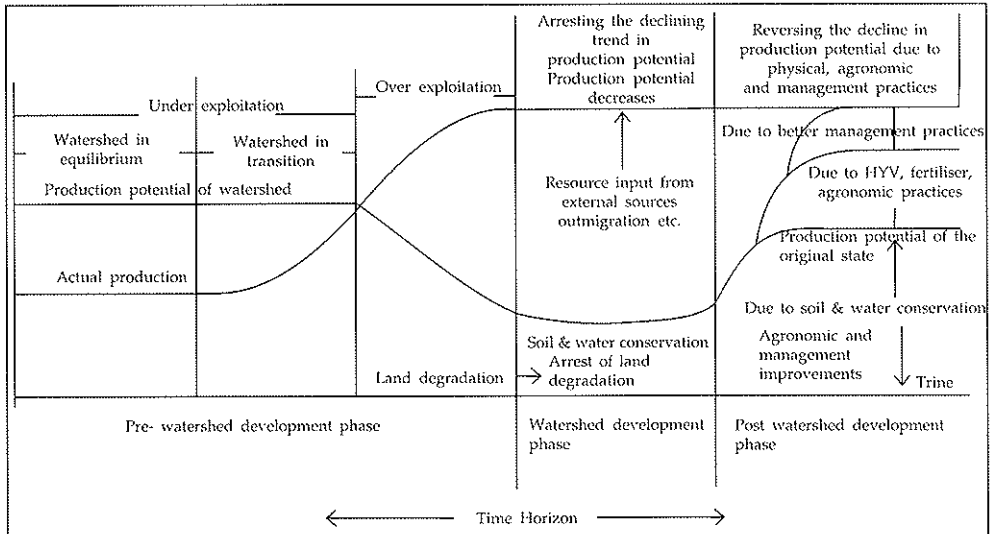


Figure 5. A conceptual framework for watershed development

production and the watershed is said to be in equilibrium condition from the point of bio-mass and sustainability considerations. In other words, the watershed is in its virgin condition. As the population increases and agricultural production takes place, actual production goes on increasing to reach the potential level of production. This is what we call as transition phase. Soon, the actual production level surpasses the potential production, which happens at the expense of over-exploitation and degradation of vital natural resources such as land, forest and water. This over-exploitation and degradation of watershed leads to progressive reduction in potential production of a watershed. At this juncture, the watershed development focuses primarily to arrest and reverse watershed degradation through land and water conservation. During this stage, very little management factors form part of watershed development project. This stage is called watershed development phase. In the post-watershed development phase, it is not only sufficient to raise the production level to its original production but also we need to go beyond that to the existing level of actual production so that sustainability of developed watershed can be maintained. Herein comes the need for improved agricultural practices such as introduction of high yielding varieties and application of chemical fertilizers etc; and land and water management practices to increase agricultural productivity through farming system approaches. Therefore, in the post-development phase attention has to be shifted to the efficient use of natural resource and increasing production potential by: (a) proper estimation and augmentation of available and sustainable natural resource base, (b) improving agronomic practices by farming system approaches, and (c) demand management of water.

Indicators

The following are the broad areas in which we develop indicators to monitor the process and outcome of the watershed development projects:

- Baseline
 - (b) Biophysical
 - (c) Livestock
 - (d) Social, and
 - (e) Economic
- Process
 - (g) Implementation
 - (h) Equity
 - (i) Productivity, and
 - (j) Watershed potential
- Outcome/Impact
 - (l) Livelihoods
 - (m) Environmental quality, and
 - (n) Sustainability
- Scale Linkages
 - (p) Water resources (conjunctive surface-groundwater, upstream-downstream, rainfed irrigated, domestic agriculture...), and
 - (q) Multipliers (the up-spiral).

Scales

There are multiple scales at which watershed interventions are implemented and their benefits are derived. Retaining the focus on water and land-based resources in a watershed context, the scales of management are:

- Household (including intra-household gender concerns, particularly important in the context of migration).
- Community (in large villages, there may be differential approaches by hamlets or caste-based groupings).
- Watershed (this usually brings in government resources, e.g., forest lands, in addition to private and village resources).
- Meso-watershed (groupings of watersheds).
- River basin.

Among the five scales of analysis and development, focus is now on the first three aspects of Indian watershed development projects with limited emphasis on the remaining two aspects. It is hypothesized that the last two aspects are equally important for equitable and sustainable water resources development, use and management in the long run especially when the basin turns from open to closing and closed basins.

Case study

The Catholic Relief Services (CRS), a non-governmental organization is implementing about 200 watershed project in the central Indian tribal belt. Among the 200 and odd projects to be implemented by Catholic Relief Services (CRS), four pilot watershed projects (Nakna in Chhattisgarh, Nayagaon in Rajasthan, Karaighat in UP and Dundlu in West Bengal) were selected in association with International

Water Management Institute (IWMI), Colombo for learning watershed development process and forming guidelines relating to institutional arrangement and technical requirement with needed information base for sustainable watershed development. In selecting these pilot projects, considerable time and energy were spent to select those projects representing the geographic, agro-climatic and socio-economic situation of the watershed projects being implemented by the CRS. The pilot projects started in 2002 are in different stages of planning, development, and implementation. This paper summarizes the process adopted and lessons learnt so far in implementing these pilot projects. The process adopted and the lessons learned will be valuable not only for implementing CRS projects but for similar projects being implemented in the Asian region.

Presently, the whole exercise of watershed development is being undertaken without really estimating how much water that we receive in the watershed, how much of it is stored where and how much of it can be used in a drought year, in a normal and in a surplus year. What we really do not know is the flow paths taken by the various components of the hydrological cycle both spatially and temporally. We would like to know these flow paths before and after the watershed development to match the supply and demand situation. A hypothetical situation of flow paths before and after the watershed development is depicted in Fig. 6a and 6b by taking watershed as a unit of analysis for a time period of one year. This figure is called a finger diagram since it is similar to a hand with five fingers. The width of the finger is an indication of how much water is stored or used in different components of the hydrological cycle. For example, after the watershed development, one would expect that evapo-transpiration will go up and run-off from the watershed will decrease compared to what it were before watershed development. There is a need to continuously monitor the magnitude of the flow paths in the finger diagram to know how much water we are utilizing now in this watershed; how much water we will be using when it is fully developed and what will be the impact of such development on the downstream cluster of watersheds? In the pilot watersheds, arrangements have been made to collect requisite hydro-meteorological and other relevant data to track down the flow paths of watershed water.

River basin in essence will consist of a number of watersheds, the management of which will have impact on the basin management and vice versa. Similarly, the alteration of flow paths in a particular watershed will not only affect the neighbouring downstream watersheds but it will also have impact on the whole basin. Both institutions and hydrological variables, particularly quantity and quality of flow are inter-related as one moves from watershed level to basin level.

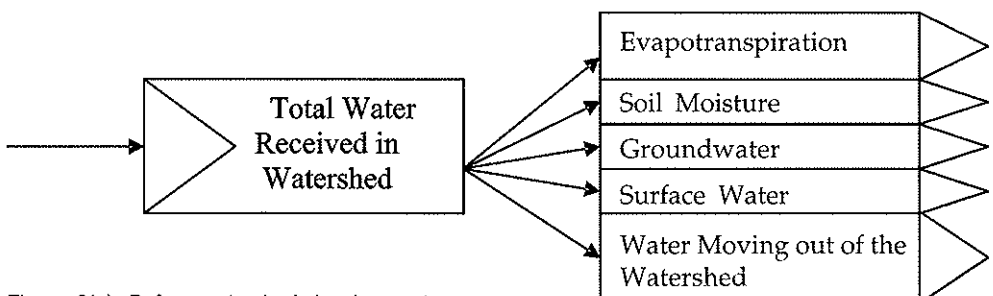


Figure 6(a). Before watershed development

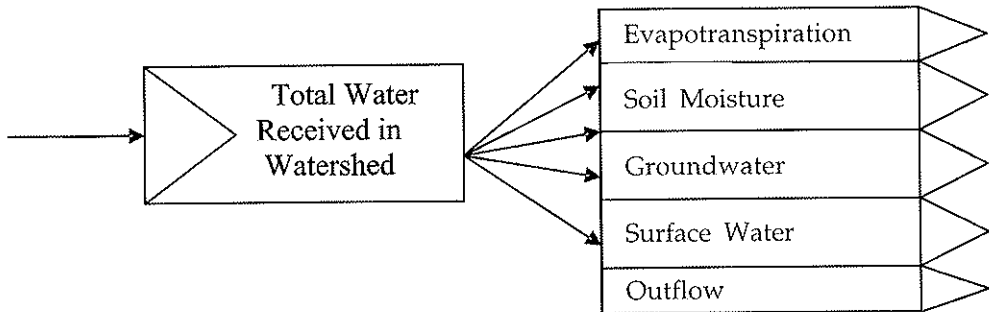


Figure 6(b). After watershed development

Hydrological analysis for managing natural resource base especially water become complex as one moves from watershed to basin scale. The basic problem encountered in watershed management is the complexity of institutional arrangement needed to manage a large watershed such as a river basin which consists of large number of small micro watersheds. Since watershed institutions are hierarchical and embedded within one another, crafting of smooth and co-operating institutional arrangements with forward and backward linkages assumes greater significance. There are attempts to develop institutional mechanisms to manage the river basin in a top down approach. There are also attempts to develop institutions at micro level. However, there are not very many studies to connect these two approaches for managing a large watershed with a number of clustered micro watersheds. This type of study would allow us to test a set of hypotheses on institutional arrangements from which to select the one that would be easy to implement and effective in managing upscaled watersheds.

The bigger problem in managing clustered watersheds will come not from hydrological issues (although they are important) but from institutional issues due to inclusion of extended administrative boundaries. If the institutional interface is not smooth and co-operative, managing the watershed becomes difficult. Therefore, crafting institutions for collective choice decision making and institutional arrangement needed for effective management are the areas for action and adaptive research. As a result of understanding and commitment to institutional issues, IWMI and CRS can play a crucial role in taking forward the clustered watershed approach to upscaling.

Lessons learnt from the On-going Study

The four pilot project studies undertaken by IWMI-CRS collaboration are under different stages of development. Two of the pilot studies are progressing well while the other two are not doing so well. In those that are progressing well the following processes were adopted.

For setting the stage for participatory planning during the pre-watershed phase, the following activities were carried out in an intensive and systematic way.

- Awareness creation (meetings, street play, video presentation, etc.).
- Rapport building through entry point activities.
- Creating program for women and landless.

- Creation of SHGs and mobilizing community for watershed development works.
- Formation of village institutions (Watershed Committee; Core Committee; Hamlet Committee).
- Understanding the existing:
 - indigenous knowledge use,
 - ability for community to make decisions,
 - willingness to share cost of watershed development,
 - status of managing common property resource,
 - equity among all (poor, women, landless), and
 - mechanism for conflict management.
- Identifying the core problems faced by the community through brain storming and prioritizing.
- Hydrologic and socio-economic data collection.
- Preparation of watershed maps.
- Identifying livelihood coping mechanisms.
- Preparation of detailed watershed development proposal and getting it approved by the village institutions and CRS.
- Developing skills and knowledge of PIAs to promote participatory planning.
- Capacity building of village institutions for taking up implementation programme.
- Implementation and monitoring.

From the results of this study, it is seen that for efficient watershed development, the following are important factors.

Community Participation: It is necessary to bring all the communities within a watershed under one fold and make them feel that they all will get benefitted both in the short-term as well as in the long-term; this activity may need a flexible time period (not fixed period as envisaged now) to create awareness, convince all the community to work together and show the benefit through entry point activities. In addition, the Project Management Team should be recruited mostly from the locals within watershed hamlets and implemented through village institutions. They must speak the same language as the locals and must be well versed with their local customs and norms.

Institution Building: A systematic procedure in creating hamlet and watershed committees should be followed using grassroot organization such as SHGs to select committee members giving representation to all. This broad based representation in the committee will have a good impact in bringing the community together. Great care should be bestowed in establishing smooth and cooperative institutions for collective choice decision-making. It is also necessary to rope up the government and other institutions working within the watershed to be part and parcel of this activity.

Data/Information Collection and Collation: Socio-economic, physical and hydrologic information base needs to be developed to the extent possible by the stakeholders

and presented in the easily readable forms of charts and maps to the watershed community to make rational decisions. Water should play the centre stage in all development process. Hydrologic measurement of important parameters such as rainfall, groundwater level and outflow hydrograph of flow from the watershed should start simultaneously or even before the start of the watershed project.

Watershed Development Plan: Preparation of a detailed watershed development proposal through intense community involvement is a must detailing the activities envisaged, resources required, present status of that activity and expected benefits. While preparing such plan upstream-downstream impact of developing the watershed and demand management of the water conserved must be given due consideration. Preparation of such a detailed proposal makes implementation of the project much more simpler, monitoring easy and allow corrective steps to be taken in time.

Transparency: Displaying through pasting on each hamlet notice board (wall), the sanctioned work, the cost estimate and expected contribution from the community has a marked effect on the community on the transparency of the project implementation. This has to be followed.

Allocation and Accountability: For each intervention such as nursery raising, pond construction, a user group is identified and they are involved from the very beginning of the project. They maintain and manage the whole activity and share the benefits with Watershed Committee.

Communication: During the implementation phase, it is very essential that the community and others involved in implementation be kept informed of the progress. Achievement and the work that lie ahead for which what should be the community contribution. For this, conduct of Annual General Body meeting with accounts and achievements is a must.

Capacity Building: Capacity building of the village institutions is an important activity for sustaining the assets created and to get the benefit out of it. Presently, this component is not given due importance either in allocation of funds or in the time allocated by the Project Management Committee. This aspect needs to be given utmost importance while formulating the detailed watershed development proposal.

Monitoring: Monitoring the changes in hydrological flow paths and livelihood changes of the communities during and post-implementation phases is important.

Scaling up: Institutional analysis becomes complex as watersheds are scaled up. It is time that we take up a few studies on clustering of watersheds with different institutional arrangement to learn lessons and to arrive at certain guidelines for scaling up of watersheds.

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