Watershed Management Concept and Principles

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Abstract

Watershed is not simply the hydrological unit but also socio-political-ecological entity which plays crucial role in determining food, social, and economical security and provides life support services to rural people. The criteria for selecting watershed size also depend on the objectives of the development and terrain slope. A large watershed can be managed in plain valley areas or where forest or pasture development is the main objective. In hilly areas or where intensive agriculture development is planned, the size of watershed relatively preferred is small.

Keywords: Watershed, consortium, community, water, livelihood.

Introduction

The rain-fed agriculture contributes 58 per cent to world's food basket from 80 per cent agriculture lands (Raju et al. 2008). As a consequence of global population increase, water for food production is becoming an increasingly scarce resource, and the situation is further aggravated by climate change (Molden, 2007). The rain-fed areas are the hotspots of poverty, malnutrition, food insecurity, prone to severe land degradation, water security and poor social and institutional infrastructure (Rockstorm et al. 2007; Wani et al. 2007). Watershed development program is, therefore, considered as an effective tool for addressing many of these problems and recognized as potential engine for agriculture growth and development in fragile and marginal rain-fed areas (Joshi et al. 2005; Ahluwalia and Wani et al. 2006). Management of natural resources at watershed scale produces multiple benefits in terms of increasing food production, improving livelihoods, protecting environment, addressing gender and equity issues along with biodiversity concerns (Sharma, 2002; Wani et al. 2003a,b; Joshi et al. 2005; and Rockstorm et al. 2007).

History of Watershed Development Program in India

About 60 per cent of total arable land (142 million ha) in India is rain-fed, characterized by low productivity, low income, low employment with high incidence of poverty and a bulk of fragile and marginal land (Joshi et al. 2008). Rainfall pattern in these areas are highly variable both in terms of total amount and its distribution, which lead to moisture stress during critical stages of crop production and makes agriculture production vulnerable to pre and post production risk. Watershed development projects in the country has been sponsored and implemented by Government of India from early 1970s onwards. The journey through the evolution of watershed approach evolved in India is shown in Figure-1 (Wani et al. 2005 and 2006). Various watershed development programs like Drought Prone Area Program (DPAP), Desert Development Program (DDP), River Valley Project (RVP), National Watershed Development Project for Rain-fed Areas (NWDPRA) and Integrated Wasteland Development Program (IWDP) were launched subsequently in various hydro-ecological regions, those were consistently being affected by water stress and draught like situations. Entire watershed development program was primarily focused on structural-driven compartmental approach of soil conservation and rainwater harvesting during 1980s and before. In spite of putting efforts for maintaining soil conservation practices (example, contour bunding, pits excavations etc.), farmers used to plow out these practices from their fields. It was felt that a straightjacket top-down approach can not make desired impact in watersheds and mix up of individual and community based interventions are essential.

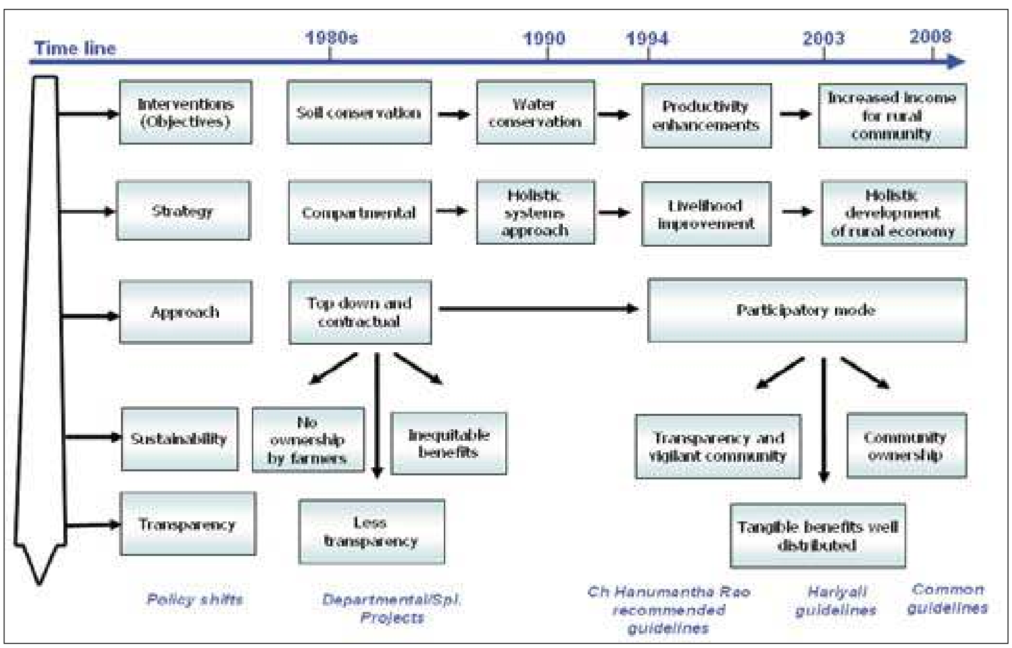

Figure 1. Journey through watershed approach in India (Wani et al. 2005 and 2006).

The integrated watershed development program with participatory approach was emphasized during mid 1980s and in early 1990s. This approach had focused on raising crop productivity and livelihood improvement in watersheds (Wani et al. 2006) along with soil and water conservation measures. The Government of India appointed a committee in 1994 under the chairmanship of Prof. CH Hanumantha Rao. The committee thoroughly reviewed existing strategies of watershed program and strongly felt a need for moving away from the conventional approach of the government department to the bureaucratic planning without involving local communities (Raju et al. 2008). The new guideline was recommended in year 1995, which emphasized on collective action and community participation, including participation of primary stakeholders through community-based orgnizations, non-governmental organizations and *Panchayati Raj* Institutions (PRI) (GoI, 1994, 2008; Hanumantha Rao et al. 2000; DOLR, 2003; and GoI, 2008; Joshi et al. 2008). Watershed development guidelines were again revised in year 2001 (called Hariyali guidelines) to make further simplification and involvement of PRIs more meaningful in planning, implementation and evaluation and community empowerment (Raju et al. 2008) and guidelines were issued in year 2003 (DOLR, 2003). Subsequently, Neeranchal Committee (in year 2005) evaluated the entire government-sponsored, NGO and donor implemented watershed development programs in India and suggested a shift in focus "away from a purely engineering and structural focus to a deeper concern with livelihood issues" (Raju et al. 2008). Major objectives of the watershed management program are: 1) conservation, up-gradation and utilization of natural endowments such as land, water, plant, animal and human resources in a harmonious and integrated manner with low-cost, simple, effective and replicable technology; 2) generation of massive employment; 3) reduction of inequalities between irrigated and rain-fed areas and poverty alleviation.

What is Watershed

Definition of Watershed

A watershed, also called a drainage basin or catchment area, is defined as an area in which all water flowing into it goes to a common outlet. People and livestock are the integral part of watershed and their activities affect the productive status of watersheds and vice versa. From the hydrological point of view, the different phases of hydrological cycle in a watershed are dependent on the various natural features and human activities. Watershed is not simply the hydrological unit but also socio-political-ecological entity which plays crucial role in determining food, social, and economical security and provides life support services to rural people (Wani et al. 2008).

Delineation of Watershed

Hydrologically, watershed is an area from which the runoff flows to a common point on the drainage system. Every stream, tributary, or river has an associated watershed, and small watersheds aggregate together to become larger watersheds. Water travels from headwater to the downward location and meets with similar strength of stream, then it forms one order higher stream as shown in Figure-2.

The stream order is a measure of the degree of stream branching within a watershed. Each length of stream is indicated by its order (for example, first-order, second-order, etc.). The start or headwaters of a stream, with no other streams flowing into it, is called the first-order stream. First-order streams flow together to form a second-order stream. Second-order streams flow into a third-order stream and so on. Stream order describes the relative location of the reach in the watershed. Identifying stream order is useful to understand amount of water availability in reach and its quality; and also used as criteria to divide larger watershed into smaller unit. Moreover, criteria for selecting watershed size also depend on the objectives of the development and terrain slope. A large watershed can be managed in plain valley areas or where forest or pasture development is the main objective (Singh, 2000). In hilly areas or where intensive agriculture development is planned, the size of watershed relatively preferred is small.

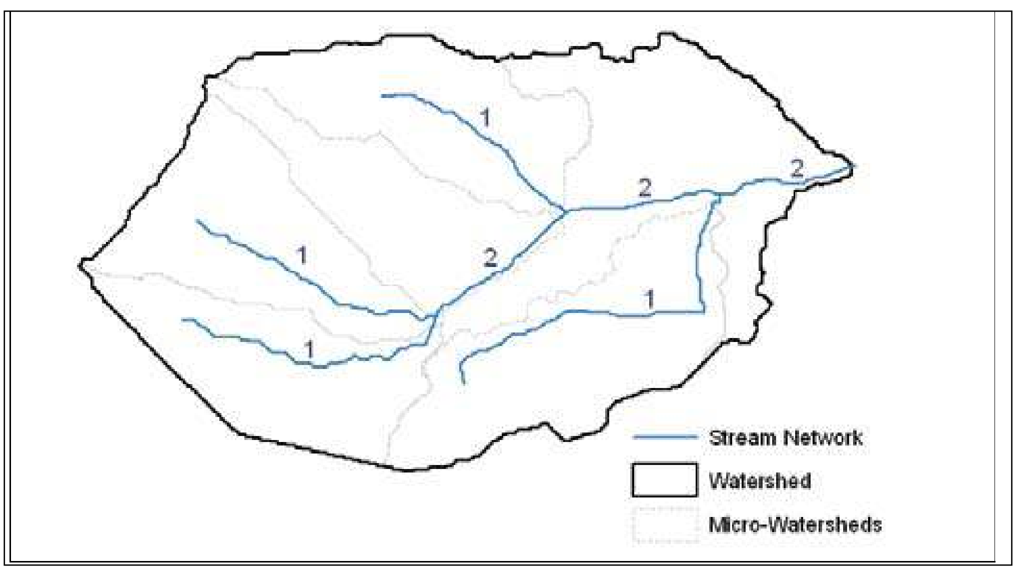

Figure 2. Stream network, micro-watersheds and watershed large watershed has divided into six micro-watershed based on stream order. Numbers on the stream network shows the stream order of respective stream.

Components of Watershed Management

Entry Point Activity (EPA)

Entry Point Activity is the first formal project intervention which is undertaken after the transect walk, selection and finalization of the watershed. It is highly recommended to use knowledge-based entry point activity to build the rapport with the community. Direct cash-based EPA must be avoided as such activities give a wrong signal to the community at the beginning for various interventions. Details of the knowledge-based EPA to build rapport with the community ensuring tangible economic benefits to the community members are described here.

Land and Water Conservation Practices

Soil and water conservation practices are the primary step of watershed management program. Conservation practices can be divided into two main categories: 1) *in-situ* and 2) *ex-situ* management. Land and water conservation practices, those made within agricultural fields like construction of contour bunds, graded bunds, field bunds, terraces building, broad bed and furrow practice and other soil-moisture conservation practices, are known as in-situ management (Figure 3). These practices protect land degradation, improve soil health, and increase soil-moisture availability and groundwater recharge. Moreover, construction of check dam,

Figure 3. Broad band and furrow practices (in-situ management). Photo: (BW7 watershed) at ICRISAT, Patancheru.

farm pond, gully control structures, pits excavation across the stream channel is known as *ex-situ* management (Figure 4). *Ex-situ* watershed management practices reduce peak discharge in order to reclaim gully formation and harvest substantial amount of runoff, which increases groundwater recharge and irrigation potential in watersheds.

Figure 4. Water stored in check dam built across the stream channel (ex-situ management); Photo: Kothapally watershed.

Integrated Pest and Nutrient Management

Water only cannot increase crop productivity to its potential level without other interventions. A balanced nutrient diet along with adequate moisture availability and pest and disease free environment can turn agricultural production several folds higher compared to unmanaged land. Integrated nutrient management (INM) involves the integral use of organic manure, crop straw, and other plant and tree biomass material along with little application of chemical fertilizer (both macro and micro-nutrients). Integrated pest management (IPM) involves use of different crop pest control practices like cultural, biological and chemical methods in a combined and compatible way to suppress pest infestations. Thus, the main goals of INM and IPM are to maintain soil fertility, manage pest and the environment so as to balance costs, benefits, public health, and environmental quality.

Crop Diversification and Intensification

The crop diversification refers to bringing about a desirable change in the existing cropping patterns towards a more balanced cropping system to reduce the risk of crop failure; and crop intensification is the increasing cropping intensity and production to meet the ever increasing demand for food in a given landscape. Watershed management puts emphasis on crop diversification and intensification through the use of advanced technologies, especially good variety of seeds, balanced fertilizer application and by providing supplemental irrigation.

Use of Multiple Resources

Farmers those solely dependent on agriculture, hold high uncertainty and risk of failure due to various extreme events, pest and disease attack, and market shocks. Therefore, integration of agriculture (on-farm) and non-agriculture (off-farm) activities is required at various scales for generating consistent source of income and support for their livelihood. For example, agriculture, livestock production and dairy farming, together can make more resilient and sustainable system compared to adopting agriculture practice alone. Product or by-product of one system could be utilized for other and vice-versa. In this example, biomass production (crop straw) after crop harvesting could be utilized for livestock feeding and manure obtained from livestock could be applied in field to maintain soil fertility. It includes horticulture plantation, aquaculture, and animal husbandry at indivisible farm, household or community scale.

Capacity Building

Watershed development requires multiple interventions that jointly enhance the resource base and livelihoods of the rural people. This requires capacity building of all the stakeholders from farmer to policy makers. Capacity building is a process to strengthen the abilities of people to make effective and efficient use of resources in order to achieve their own goals on a sustained basis (Wani et al. 2008). Unawareness and ignorance of the stakeholders about the objectives, approaches, and activities are the reasons that affect the performance of the watersheds (Joshi et al. 2008). Capacity building program focuses on construction of low cost soil and water conservation methods, production and use of bio-fertilizers and bio-pesticides, income generating activities, livestock based activities, waste land development, market linkage for primary stakeholders. Clear understanding of strategic planning, monitoring and evaluation mechanism and other expertise in field of science and management is essential for government officials and policy makers. The stakeholders should be aware about the importance of various activities, their benefits in terms of economics, social and environmental factors. Therefore, organizing various training at different scales are important for watershed development.

Watershed Management Approaches

Integrated Approach

This approach suggest the integration of technologies within the natural boundaries of a drainage area for optimum development of land, water, and plant resources to meet the basic needs of people and animals in a sustainable manner. This approach aims to improve the standard of living of common people by increasing his earning capacity by offering all facilities required for optimum production (Singh, 2000). In order to achieve its objective, integrated watershed management suggests to adopt land and water conservation practices, water harvesting in ponds and recharging of groundwater for increasing water resources potential and stress on crop diversification, use of improved variety of seeds, integrated nutrient management and integrated pest management practices, etc.

Consortium Approach

Consortium approach emphasizes on collective action and community participation including of primary stakeholders, government and non-government organizations, and other institutions. Watershed management requires multidisciplinary skills and competencies. Easy access and timely advice to farmers are important drivers for the observed impressive impacts in the watershed. These lead to enhance awareness of the farmers and their ability to consult with the right people when problems arise. It requires multidisciplinary proficiency in field of engineering, agronomy, forestry, horticulture, animal husbandry, entomology, social science, economics and marketing. It is not always possible to get all the required support and skills-set in one organization. Thus, consortium approach brings together the expertise of different areas to expand the effectiveness of the various watershed initiatives and interventions.

Recommendations for Practioners

- Select watershed sites where dire need exists in terms of improving soil and water conservation, enhancing productivity and improving livelihoods.
- Adopt holistic and participatory consortium approach from the beginning ie, from selection of watershed.

- Ensure that ground rules for operation are made clear to the community as well as consortium partners.
- Adopt knowledge-based entry point approach to build rapport with the community and ensure tangible economic benefits for the community.

Kothapally Watershed in Andhra Pradesh, Southern India

Kothapally watershed is located at 17^0 22' N latitude, 78^0 07' E longitude and about 550 meters AMSL altitude in Ranga Reddy district, Andhra Pradesh, India. This watershed is part of the Musi sub-basin of the Krishna river basin, and situated approximately at 25 km upstream of Osman Sagar reservoir. Soil has been classified as Vertisols with shallow soil depth (10 to 90 cm ranges) and has medium to low water holding capacity. The average landholding per household is about 1.4 ha. Average crop yield was less than 1 ton/ha therefore Kothapally was characterized by low productivity, low income, and low employment with high incidence of poverty in year 1999 and before. ICRISAT, consortium with local partners (government agencies and NGOs) started watershed development program in Kothapally village from year 1999 onwards. Integrated watershed management approach was used. Soil and water conservation, both *in-situ* and *ex-situ* practices were made in watershed. Integrated nutrient and pest management approach adopted. Efforts were put in direction of increasing crop productivity. Good variety of seeds and fertilizer were made available in village and helped farmers in selecting right cropping pattern according to their soils. Water balance of Kothapally watershed shows that after doing such interventions, groundwater recharge has increased from 7 to 32 %, outflow reduced from 37 to 9 % of total rainfall. Crop yields increased by 2 to 5 times in monsoon season and irrigation potential increased from 13 % to 31 % compared to pre-development stage. Survey suggest that average household income in Kothapally watershed is greater than 50 % compare to adjoining locations where watershed interventions were not been made. This program has significantly increased crop productivity, reduced poverty and increased employment opportunity and has become the site for learning to the farmers, researchers and policy makers.

Box 1: A Case Study of Kothapally Watershed.

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