

CHAPTER 2

Catchment management to basin management: International perspectives and overview of global experience

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2.1 Introduction

Watershed development is an approach to raise agricultural productivity, conserve natural resources, and improve rural livelihoods in the regions suffering land degradation, which are often characterized by high levels of food insecurity and income poverty (Hope, 2007; Farrington et al., 1999). Watershed development has emerged as an important policy instrument for rural development in many developing countries, including India (Hope, 2007). Since the 1970s, India has invested significantly in watershed development as a driver of rural development (Joshi et al., 2005), partly in an attempt to scale up successes from a handful of well-known village-level watershed projects, such as Pani Panchayat, Ralegaon Siddhi, and Sukho-majri (Turton et al., 1997). But, the focus of watershed development in India has evolved over the last 25 years from soil conservation to water conservation to now include a more participatory planning approach (Hope, 2007). In fact, the importance of institutions of collective action for implementing and managing watershed programs was recognized in the GOI guidelines formulated in 1994–95 (Reddy et al., 2004).

A principal assumption underlying watershed development and management project is that there is sufficient amount of un-utilized water flowing out of the agricultural watersheds (Kumar et al., 2006, 2008), which, if can be captured during the wet season, may be made available in dry periods

offering several potential benefits (Farrington et al., 1999). Socioeconomic benefits commonly associated with watershed development include improved agricultural yields and farmer returns, increased access to domestic water, and new employment opportunities (Kerr et al., 2002). However, these benefits will vary for different resource user groups located across watersheds. However, emerging global evidence suggests that there are limits and tradeoffs to modifying watersheds due to complex hydrological and social systems' interactions (Calder, 2005). This is partly because watershed development interventions modify land use impacts on water resources, which in turn may alter downstream water access, while augmenting upstream water supplies (Batchelor et al., 2003; Gosain et al., 2006).

Evident are dramatic changes in the hydrology of many dry areas of India in recent years as a result of increased groundwater-based irrigation, watershed development, water harvesting, and land use change. Although current watershed development programs bring a range of benefits, they may also change the temporal and spatial pattern of water availability and use at the scale of large catchment in which these watersheds fall (Batchelor et al., 2003; Calder, 2005; Kumar et al., 2008). This can result in significant negative tradeoffs such as more unreliable lean season flows, particularly during low rainfall or drought years, drying up of tanks and large reservoirs, and damage to riverine ecology.

But, the political preference for watershed development remains high in India, generally for supply-side interventions. Given the fact that nearly Rs. 2200 crore (US\$340 million) per year is allocated to watershed projects in India at present (Reddy, 2012), there is a need to ensure enhanced performance of the watersheds from social, economic, and environmental perspectives and to identify and mitigate perverse outcomes and negative externalities (Batchelor et al., 2003; Calder et al., 2008). There is increasing recognition among scholars of the need to take a look at the hydrology and land use in the larger catchment, in order to decide on the degree /scale of agricultural intensification and rainwater harvesting in order to avoid undesirable effects of watershed management (Calder et al., 2008). But, while doing this, water managers should recognize that hydrological characteristics of catchment are not necessarily stationary, and instead are constantly altered by changes in regional land use and hydrological structures (Moench and Dixit, 2004).

This chapter provides a review and puts together catchment assessment and planning aspects of watershed management, that are practiced under international programs and projects; the catchment/watershed management

programs undertaken by different countries of the world; and, the integrated watershed management program of government of India, and other donor-supported projects.

2.2 Catchment assessment and planning for WSM: Theoretical and conceptual aspects

Watershed management professionals generally view that increasing the thickness of vegetative cover in the upper catchments would reduce erosion and sediment load in the runoff, and increase the base flows, irrespective of the agroecology. Often international agencies and scholars, aggressively promoting small-scale rainwater harvesting in catchments, view rainwater as separate from groundwater and surface water (COMMANS, 2005; Stockholm Environment Institute, 2009). Such views ignore the following: (1) how the type of catchment land use influences the impact of increased vegetation cover on stream flows (including water quality), in different agroecologies; (2) how the nature of vegetation (whether shallow-rooted grasses and shrubs or deep-rooted trees) determines the impact of increased vegetation cover on the consumptive use of water from the soil profile and groundwater system of the catchment (Oliveira et al., 2005) and the stream flows (Bosch and Hewett, 1982), and how these impacts can change across agroecologies; (3) the hydraulic interdependence between groundwater and surface water in a catchment and therefore the impact of change in groundwater withdrawal on stream flows downstream (Leblanc et al., 2012); and, (4) rainwater (precipitation) is the source of surface water, soil moisture, and groundwater in the catchment. But, this knowledge is extremely important for catchment management measures.

2.3 International literature on catchment assessment and planning

2.3.1 Catchment assessment

2.3.1.1 State-of-the-art knowledge of relationship between changes in land use/land cover and catchment yield and soil erosion

The traditional perception that forests increase water resources has long been questioned by the results of scientific forest hydrology since the early 20th century (e.g., Calder, 2002). A large number of catchment experiments conducted all over the world clearly demonstrated that the deforestation of a catchment implies an increase of water yield from it and, conversely,

the establishment of a forest cover implies a decrease of water yield (Sahin and Hall, 1996). The application of this knowledge to designing sustainable water management practices, although necessary in water-stressed regions, has been largely delayed because of difficulties inherent to the change of any scientific paradigm, the limited experience on the hydrological consequences of land cover changes in large territories, and the disconnection between policy and science (Falkenmark et al., 2004; Calder, 2002).

Most of the microcatchment management programs in India are grounded on inadequate knowledge of the relationship between changes in land use/land cover and catchment yield and soil erosion and wide misconceptions concerning their functions in different agroecologies. Therefore, scientific understanding of the relationship between catchment land use and land changes and hydrological and ecological processes is essential for effective catchment planning.

Such scientific understanding is developed elsewhere through experimental field monitoring of data on soil erosion, sediment yield and catchment runoff, and the use of simulation models. Some of the most fascinating ones, including those available from modeling studies, are relative effectiveness of field-scale soil conservation measures taken in reducing both soil loss and sediment yield over grass buffer strips and retention ponds (Verstraeten et al., 2002); negative impact of increase in forest cover in dry areas of Spain on river flows in Spain (Gallart and Llorens, 2003); rising groundwater levels and increase in soil salinity as a result of clearance of native vegetation for agricultural use in Murray Darling basin (Leblanc et al., 2012); combined effects of a combination of socioeconomic developments and land use changes occurring historically on river water quality in Scotland (Pollard et al., 2001); the importance of analyzing the spatial and temporal patterns in rainfall and land use in the catchments over and above the aggregate scenarios, in explaining the spatial and temporal variations in runoff occurring in the catchment in North West England (Orr and Carling, 2006); the negative impact of replacing paddy fields by forests on catchment yield, with just an opposite impact from replacement of forests by crop land, and positive impact of irrigated paddy on watershed hydrology in terms of quantum of flow in Chi river basin of Thailand (Homdee et al., 2011); and distinction between notional water saving and real water saving through efficient irrigation technologies, and importance of scale in deciding the water-saving impact of water use efficiency improvements in agriculture (Wallace and Batchelor, 1997).

2.3.1.2 Knowledge use in catchment management decisions

As mentioned in [Chapter 1](#), simple knowledge about the nature of impacts that land use and land cover can cause on hydrology of the catchment and water quality parameters will not be sufficient for taking catchment management decisions. Rather, a quantitative understanding of the impacts of these impacts, which finally decide whether the social, economic, and environmental outcomes at the catchment level are optimal or not, is needed. This can only be obtained using complex mathematical models, which simulate the hydrological and biophysical processes.

What is important to note is that while changing land use and land cover and construction of vegetative bunds in the upper parts of the catchment as part of the ICM approaches could change the catchment yield along with soil loss, withdrawal of either surface water or groundwater in the catchment to affect such changes could also cause variations in water yield received in the lower parts of the catchment. This in turn can bring about drastic ecological changes in those areas in terms of changes in nature and extent of vegetation that the river plains support. Hence, these models have to be used in an integrated way to understand the cumulative effects.

As indicated by [Verstraeten et al. \(2002\)](#), when soil conservation measures such as changing the crop rotation sequence or terracing or contour bunds are taken up at catchment scale, the effect of sediment control measures such as grass buffer strips or retention ponds on sediment yield from the catchment would be less visible. Hence, there is an optimum level of treatment, which needs to be carried out in the catchment beyond which intensifying the treatment would not produce additional benefits. In certain situations, such activities can also lead to negative social or environmental outcomes. Integrated catchment models could help identify the optimum level of various interventions to maximize the overall benefits^a in physical terms at catchment scale.

In the case of water use efficiency (WUE) improvement measures, the knowledge about the difference between notional water saving and real water saving from efficient irrigation systems is crucial, while applying knowledge derived from farms to the catchments for planning. Sufficient insights into the likely impact of using efficient irrigation systems in terms

^a The overall benefits in physical terms could be sum of the individual benefits of reduction in soil loss reduction and sediment yield, flood control, increased water availability of drinking, irrigation and other competitive uses, and water availability for ecological flows during lean season.

of real water saving would help avoid unintended consequences of depleting more water rather than freeing water from agriculture (Wallace and Batchelor, 1997; Kumar and van Dam, 2013; Howell, 2001; Molle and Turrall, 2004; Perry et al., 2009). Since the hydrological process involved is quite complex and dynamic, in order to get an empirical understanding of the catchment scale impacts of farm-level WUE improvement measures, modeling is required. The model used for catchment assessment and management planning should be such that it is able to simulate the dynamic hydraulic interaction between surface irrigation and groundwater.

The fundamental question is how the knowledge, which has been in existence for several decades in the public domain, gets ignored in policy formulation. The key issue is with regard to the ability to convert this knowledge into “proper evidence” to convince the policy makers and counter the reductionist and misinformed view of “what constitutes evidence” (Whitty and Dercon, 2013).

2.3.2 Main components of integrated catchment management in major international programs/projects

2.3.2.1 Physical/technological aspects

There are a wide range of technologies used in catchment management worldwide, depending on the agroecology. Ideally, the type of intervention should vary from humid, high-rainfall regions to arid low-rainfall regions; it should also vary from temperate climates to more tropical climates; the interventions for an area with mild slopes would be vastly different from those used in a hilly watershed.

The treatment technologies adopted in catchment management programs are terracing; contour bunding for preventing erosion and soil & water conservation; contour trenching for moisture conservation; grass plantation for soil conservation; gully plugs for preventing gully erosion due to runoff; gabien structures; check walls for reducing erosive force of the runoff and to retain sediments; check dams for reducing erosive force of water and to impound some water; vegetative barriers on stream banks for preventing bank erosion; earthen dams for sediment control; sediment retention ponds; mulching for moisture conservation; and afforestation (Buhl and Sen, 2006).

In addition, there are several regulatory measures, which can be used to bring about changes in the performance of the catchment, in terms of yield, runoff quality, condition of the wetlands, etc. For instance, reducing area under rain-fed crops might help increase the runoff. Similarly, reduction

in area under irrigated cropland and size of livestock might help reduce the nitrate load in the runoff, occurring as a result of leaching of fertilizers and organic waste from dairy farms in areas (McDonald et al., 1995). It can also prevent nitrate contamination of groundwater in humid high-rainfall areas with shallow water table conditions (Kraft and Stites, 2003). Augmenting river flows during low flows and high temperature through increased release of water from reservoirs in the upper catchment is another widely practiced regulatory measure for catchment management, particularly for reducing algal growth, protecting birdlife, and increasing fish breeding (Collins et al., 2007).

But over the last two decades, several new technologies and practices were added to the watershed treatment technology package activities in India to address the local needs. Most notable among them is structures for groundwater recharge, adopted in response to depletion and degradation of groundwater in the semiarid and arid areas. The recharge restructures try to create the saturated conditions in the unsaturated zone whereby the hydraulic conductivity of the formation increases sharply. Most of them are aimed at augmenting groundwater resources in the watersheds (COMMANS, 2005).

2.3.2.2 Institutional, legal/regulatory measures

For successful implementation of integrated catchment management programs, institutional structures that facilitate the involvement of stakeholders in the development and implementation of appropriate natural resource management strategies and policies need to be developed (Batchelor, 1999). There are some instances where developed countries have implemented integrated catchment management programs through legal, institutional, and policy approaches. The fundamental change brought about in water management in these countries through the adoption of ICM approach has been organizing water resource management around hydrological boundaries. Examples are Australia, Britain, South Africa, and France (based on Johnson et al., 1996; Bellamy et al., 2002; Buller, 1996; Batchelor, 1999; Connell, 2012; European Environmental Bureau (EEB), 2010; Herrfahrdt-Pähle, 2010; Mitchell and Hollick, 1993; Schreiner and Van Koppen, 2002).

However, many ICM strategies have not been able to bring about improvements in resource management at the catchment scale mainly due to lack of delivery mechanisms and enabling policies that generate the interest and trigger the participation of local institutions and communities (Batchelor, 1999). In certain cases, catchment management programs were also implemented effectively without legislative support. But, in such

cases, the success of the initiatives is very much dependent on involvement of community leaders and resource agencies (Johnson et al., 1996). Several institutional models are tried in ICM around the World with varying degrees of success, beginning in Europe (Britain and France in the early 90s, though the most common among them being tried in developing countries is decentralized, community-based institutions for implementing watershed management program at the level of microcatchment (Darghouth et al., 2008).

The nature and functions of these institutions vary from country to country and in a few instances from province to province. They range from: (1) the Catchment Management Plans in Britain, which form the basis for the actions of its National River Authority (NRA) in the respective basins; (2) the two-tier tradition of water management with SAGE (*Schemas d'aménagement et de gestion des eaux*) and SADGE (*Schémas directeurs d'aménagement et de gestion des eaux*), implemented through local management commissions and a higher-order River Committees, respectively, in France; (3) the River Basin Management Plans (BMPs) developed by the member states of European Union under its flagship legislation of European Water Framework Directive; (4) the Basin Plan, which provides a new management framework for a transboundary, river-catchment-level management of water resources in the Murray Darling Basin, encompassing four basin states, being implemented by the newly constituted MDB authority; (5) Integrated Catchment Management program of western Australia, which enjoys, legislative, policy, administrative, and financial support since the early 90s; and (6) Catchment Management Agencies (CMAs) in South Africa that are created for ensuring poor people's access to water for domestic and productive purposes, being facilitated the DWAF under the National Water Act.

While the CMPs of Britain remain wholly consultative with respect to the planning process, with no binding force on land users, developers, and local planning authorities, the NRA, which is the higher-level institution, possesses a wide range of regulatory powers over the private and public bodies that directly impact on the water environment. While SDAGE has statutory obligations, SAGE is discretionary. With the passing of the European Water Framework Directive in 2000, more than 10 years of planning and consultation went into development of River Basin Management Plans (RBMPs) by member countries. These plans are meant to be the main instruments for realizing the environmental objectives of protection of water bodies from nutrient pollution. 14 out of the 27 member countries have come out with RBMPs for the basin districts in their respective countries. In Australia, the Basin Plan, which is legally enforceable, defines sustainable

limits for groundwater and surface water; basin-wide environmental objectives; roles for a basin-wide water trading system; requirement of subplans for each one of the four states to implement the Basin Plan objectives; measures to improve the security of water entitlement holders. In South Africa, the process of establishment of Catchment Management Agencies began with the passing of the National Water Act in 1998, but only two out of the nine proposed CMAs are fully established and operational so far.

Table 2.1 summarizes the institutional arrangements for catchment management and the management instrument administered by them in selected countries worldwide.

2.3.3 Catchment planning tools and processes

2.3.3.1 Integrated crop, rainfall runoff, soil erosion, and economic models

There are multiple social, economic, and environmental objectives underlying catchment management approaches, and the interventions needed for achieving one of them could work at cross purposes with the other two.

As a result, value of the marginal returns from ICM interventions owing to incremental benefits to some sectors may not be higher than the marginal costs, which will be the sum of the incremental cost of the interventions and the reduction in benefits to some other sectors, at every scale of intervention. The net marginal returns can become negative at some scale of a given management activity. Therefore, it is important to analyze the tradeoffs. This would involve quantification of each one of the impacts from the selected ICM interventions, and assessment of the economic value of the net benefits accrued, for various scales of interventions, and choosing the one which gives highest overall benefits. Only such integrated assessments of resource use and resource management can provide good guidance to resource managers on decision making with respect to catchments.

But, planning for catchment or watershed management in India is not driven by considerations of the costs and benefits associated with the economic, social, and environmental outcomes. This is partly because of the lack of scientific data defining the physical relationship between catchment interventions on land use and land cover, and their hydrological outcomes, and the economic imperatives (Kumar et al., 2006). Another reason is the drive to address the concerns of equity in distribution of benefits of agricultural productivity enhancement programs to rain-fed areas where large number of poor people live (Kerr, 2002). Ultimately, what gets implemented as a catchment management plan has more to do with the current political economy rather than what is optimal from social, economic, and environmental angles.

Table 2.1 Institutions for catchment management and management instruments.

Name of institution	Year of establishment-continued till	Nature	Characteristics	Objective functions	Outcomes
River Basin Organizations, France	1970–1992	Water financial investment institutions with no statutory powers	Intermediary institution between central and local government; and, between water consumers and water industry	Water resource management in major river basin, by promoting efficient water use and pollution reduction through financial incentives to local agencies and private players	(i) Introduced charges for water abstraction and discharge, by various users in the basin, under the 1964 Water Act, and became financially powerful (ii) Effective in case of larger & identifiable point polluters, but not for widespread non-point source pollution (iii) Unsuccessful in implementing “polluter pays principle”
Regional Water Authorities (RWA), England and Wales	1973–1989	Regulatory and management functions	Centralized body	(i) Flood control (ii) Organized water supplies (iii) Water resources management	(i) No active community participation in catchment management (ii) Distortion in catchment development pattern due to inconsistency between local land-use planning authorities and RWAs in their goals (iii) Had a dual role both in policing water pollution (regulatory function) and being polluters themselves

Integrated Catchment Management Coordinating Group (ICMCG) and Community Catchment Groups (CCG), Western Australia	1987	ICMCG is to plan for ICM, its implementation, and advice CCG CCG is expected to participate in planning process	ICMCG is a centralized body with representation from various State government agencies responsible for land and water management CCG is a community-based institution formed under guidance of ICMCG	(i) ICMCG provides forum for interagency coordination of policies and activities (ii) CCG was expected to involve local people in defining problems and developing strategies for catchment management	(i) ICMCG played a key role in developing a draft state wetlands policy and provided a platform to develop coordinated action on the Swan River coastal plain (ii) Reporting structure of ICMCG created resentment in some senior officers who thought it to be questioning their judgment and activities (iii) Formation of ICMCG led to uncertainty about the role of other agencies such as the WA Water Resources Council and the Soil and Land Conservation Council, land care groups, etc.
National Rivers Authority (NRA) and Catchment Management Plans (CMP), England and Wales	1989	NRA is a regulatory institution CMP forms the basis for NRA action within each catchment	NRA is a centralized agency with range of regulatory powers on private and public bodies CMPs are consultative with respect to the planning process, with no ability to enforce on land-users, developers or local planning authorities	(i) Protection of water environment (ii) Establish management protocols and monitoring programs (iii) Facilitate better coordination between land use and water policy makers	(i) Highlighted the divergence between water management and land-use planning functions (ii) However, NRA did little to incorporate water management decisions in land-use planning as it had limited formal authority to restrict land use development (iii) CMP had no immediate impact on statutory authorities

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Table 2.1 Institutions for catchment management and management instruments.—cont'd

Name of institution	Year of establishment-continued till	Nature	Characteristics	Objective functions	Outcomes
Catchment Co-ordinating Groups (CCG) and Catchment Care Committees (CCC), Queensland, Northern Australia	1991	CCG and CCC were formed to provide forum for public discussion on catchment management	No legislative basis, voluntary involvement of stakeholders	(i) Promote stakeholders participation in catchment management (ii) CCC identifies and prioritizes natural resource issues; and develops, promotes, and facilitates implementation of CM strategies (iii) CCG take part in local action and planning	(i) ICM in Queensland has fostered co-ordination between landholders, community action groups, and government agencies (ii) Under this institutional arrangement, ICM is dependent on the support of prominent community leaders and resource agencies (iii) ICM is not successful in solving the land use conflicts (iv) Financing remains a major issue for effective functioning of CCC
SAGE and SDAGE in France	1992	SAGE is a precise planning document for small local catchments SDAGE is a forward planning document for	SDAGE has statutory obligation SAGE is discretionary Local Management Commission to	(i) SAGE is to influence land-based activities that have direct impact on water resources and aquatic environment	(i) A step toward involving all possible stakeholders in catchment management (ii) Spatial and institutional fragmentation of local water responsibility continues in France

Catchment Management Agencies (CMA), South Africa	1998	major river basins Both draw on elaborate participation of water users, consumers, regulators, and policy makers Implementing National Water Act and management of water at local level	implement SAGE and a higher-level institution of River Committees to implement SDAGE Participatory; but are statutory bodies Governing Board of CMA to have representation from present and potential future water users, local and provincial government, & environmental interest groups	(i) Planning of WRM at catchment scale (ii) Registration of water users (iii) Water charges collection (iv) Water authorization and licensing (v) Ensure poor communities' access to water for domestic and productive needs	(iii) This institutional set up was driven more by political rather than environmental considerations, and is not suitable to achieve sustainable water management objectives (i) Shift from a centralized management approach to a decentralized participatory approach based on equity (ii) Water users from poor communities got opportunity to discuss directly with the concerned agency on WRM (iii) Only two CMAs became fully operation in 12 years (iv) Delegation of water management functions to the CMAs has only been partially implemented (v) Poor cooperation between the CMAs and the water supply agencies, due to the misfit between catchment boundaries and local administrative boundaries
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Table 2.1 Institutions for catchment management and management instruments.—cont'd

Name of institution	Year of establishment-continued till	Nature	Characteristics	Objective functions	Outcomes
River Basin Management Plans (RBMPs) under the European Water Framework Directive	EWFD was adopted in 2000 by EU members States	EWFD is a legislative framework RBMPs are instruments for realizing the new environmental objectives	Preparation of RBMPs is a consultative process which each EU member State has to follow for realizing the ecological objectives set under EWFD	(i) Water quality protection (both surface and groundwater), especially to control nutrient pollution (ii) To assess environmental quality (iii) RBMPs is for water management based on river basins	(i) Till 2010, only 14 member States had adopted RBMPs (ii) Lack of transparency and robustness in assessment of environmental quality by the member States (iii) Measures suggested in the RBMPs to restore specific water quality elements such as nutrient conditions were useless (iv) Only 1/3rd of water bodies were targeted for restoration in next few years (v) Limited progress in dealing with negative impacts of nutrient pollution on aquatic ecosystem

Murray Darling Basin Authority (MDBA), Australia	2007	Authority for developing and implementing Basin Plans Basin plan has legislative backing and is an enforceable document	Centralized body with community participation through basin community committee	(i) To limit surface and groundwater diversions from the basin for environmental sustainability (ii) Ensure that sub-plans for each state are in line with the basin plan (iii) To promote water trading to maximize the social and economic benefits, while ensuring hydrological integrity of the basin	(i) MDBA replaced the existing institutional arrangements at the state level, which were unable to achieve environmental sustainability and resource security targets (ii) Shift in responsibility for high-level policy making for basin management from the states to the national government (iii) Creation of environmental water holder at the basin level (iv) Provision of water entitlements for environment created resentment among irrigation stakeholders as it was bound to reduce the overall size of allocation for that sector
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Table 2.1 Institutions for catchment management and management instruments.—cont’d

Name of institution	Year of establishment-continued till	Nature	Characteristics	Objective functions	Outcomes
Catchment Management Authorities in New South Wales (NSW), Australia	2003	They replaced the existing Regional Catchment Coordination Committees & Catchment Management Boards, Trust, and local land-care groups	Legal entities set up after the enactment of Native Vegetation Act-2003; Catchment Management Authorities Act-2003 and Natural Resource Commission Act-2003 13 CMAs exist in NSW	(i) Responsible for implementing integrated approach to catchment management, with community participation (ii) Develops Catchment Action Plans	(i) Effective mechanism for supporting land owners to voluntarily manage their land for public and private benefit (ii) Gives regional communities a direct say in the complex task of reconciling their needs with ecosystem health (iii) Very good, well-designed projects were delivered throughout NSW; the activities had strong links with the expected outcomes; over 90% achieved expected short-term outputs (as per the Audit carried out in 2010)

Source: Based on Johnson et al. (1996), Bellamy et al. (2002), Buller (1996), Connell (2012), European Environmental Bureau (EEB) (2010), Herrfahrtd-Pähle (2010), Mitchell and Hollick (1993), Schreiner and Van Koppen (2002).

Internationally, in many cases, water resource management projects have concentrated only on “physical control of water.” In other cases, economic aspects were attended to, but, environmental and social effects were at best given token consideration (Jakeman and Letcher, 2003).

The reason for this is that the decision on how much water is needed for meeting environmental flows demands answering questions like when, how often, and for how long river flows are needed to protect various river ecosystem goods and services. But, the concepts, theories, and methods of assessment of environmental flow and their practical applications are largely new in most developing countries. Moreover, environmental flow is a relatively new concept for the water sector and there is lack of awareness among the general public on the concept and its application (Kashaigili et al., 2005). Integrated assessment tools try to address these concerns by allowing efficient scenario generation for different catchment management choices, in particular assessment of the resultant tradeoffs among indicators of environmental, economic, and social outcomes (Jakeman and Letcher, 2003).

2.3.3.2 Planning processes in catchment management

Catchment management is about managing the multiple perspectives and stakeholder interests, and the conflicts emerging out of it (Prato and Herath, 2007). But to begin with, planning for integrated catchment management requires scientific understanding of the interaction between the catchment flows (both surface water and groundwater) and the human systems, which depend on it; and the catchment flows and water dependent ecosystems such as wetlands, swamps, and biodiversity reserves. It is really important to understand two things: (1) The hydrological processes that determine flows and fluxes with respect to space and time; and, (2) how the hydrological gain in one location in the catchment would mean a loss for a downstream location. It is also important to base decisions on empirical evidence, rather than expert opinions and anecdotes (Whitty and Dercon, 2013). When such evidence does not exist in ample measure, it will have to be generated, sometimes through complex modeling tools, which are also referred to as Decision Support Tools (DST), which are used to decide on ICM interventions to enhance the catchment functions. As seen earlier, catchment-wide management of land and water resources has to be based on multiple objectives and criteria (Prato and Herath, 2007), and therefore involve tradeoffs (Prato and Herath, 2007). For the tradeoffs to be socially acceptable, multistakeholder dialogues is an essential component (Falkenmark, 2004; Warner, 2006).

There are a variety of tools and techniques for facilitating informed decision making for improved catchment management, in situations of multiple

values and objectives that exist among stakeholders. [Prato and Herath \(2007\)](#) discussed Multicriteria decision making in catchment management. [Collins et al. \(2007\)](#), using case studies of three catchment management projects in the United Kingdom, illustrated on the extent to which a systemic approach to understanding multiple perspectives and stakeholder interests could improve policy and practice. [Ewing et al. \(2000\)](#) illustrated the potential of a decision support system called Adaptive Environmental Assessment and Management (AEAM) in facilitating Integrated Catchment Management (ICM) processes in the context of Western Australia, through a case study of Blackwood River Catchment.

Besides the scientific and technical aspects of catchment planning process, there are other important aspects in the planning process, and which precede the former. They concern identifying community desires and objectives with respect to development of catchment; developing strategies to meet the objectives; and carrying out audits. This requires institutional platforms like the CMPs in England and Wales, SAGE in France, CMAs in Western Australia.

Institutional development process, which is often long drawn, is integral to the planning process, as illustrated by the experience of setting up Catchment Management Agencies in South African river catchments ([Schreiner and Van Koppen, 2002](#)).

Community participation in the management of river basin areas is explicitly stipulated in Article 14 of the European Water Framework Directive (EWD) ([European Environmental Bureau \(EEB\), 2010](#)), which states that the general public should be consulted in the formulation of basin management plans. However, there are indications that the “Directive” accepts public involvement, which is reduced to mere “consultation” and “information provision” rather than meaningful participation. Again, if such consultation processes are dominated by the powerful groups like the State water agencies, the communities will not have much influence on the process ([Mostertman, 2005](#)), communities can easily get frustrated into thinking that “nothing ever changes” and therefore will find the entire exercise meaningless. Since participation involves considerable opportunity cost for the stakeholder groups, the benefits have to outweigh these costs ([Warner, 2006](#)).

2.3.4 Outcomes of implementing CM plans: Experience from select countries

A few countries or territories have implemented the concept of ICM programs and projects in terms of management instruments called “catchment

management plans,” and also created institutional arrangements for their implementation. Australia has been a pioneer in implementing ICM, often basin wide, using formal institutional structures or otherwise, covering large geographical areas. Many countries in the European Union had implemented ICM, sometimes within the country’s territories or at the scale of international river basins. But, studies that scientifically documented the outcomes and impacts of such initiatives on water resources are extremely limited. Limited evidence seems to suggest a mixed experience.

The United Kingdom had implemented environmental management policies and institutional structures for achieving the goals of ICM in early 1990s. But, as per the recent monitoring data across England and Wales, percentage of rivers that have nitrate levels exceeding 30 mg/L changed from 29.9% in 1995 to 28.3% in 2005 and the percentage of rivers with phosphate levels exceeding 0.1 mg/L increased from 50.3% to 51.5%, during the same period. Such unexpected outcomes are the result of failure to apply “systems perspective” while using the well-established scientific knowledge about physical processes in policy formulation. What this suggests is that catchment management requires natural and social scientists to work more closely, to provide robust analysis of water management outcomes of environmental policies that fully considers the biophysical, social, political, and economic settings (Macleod et al., 2007).

But, there are notable positive experiences with catchment-wide water trading and reallocation of water for environment in the case of Murray Darling Basin and integrated catchment management in New South Wales in Australia, even prior to the implementation of the National Water Act of 2007. Water trading has been progressively introduced in the southern MDB since the late 1980s, along with further reforms in the mid-1990s and again in the mid-2000s. It was based on the premise that trading provides economic benefits to buyers and sellers, and to society as a whole. Trading of water rights enabled increased water use efficiency in irrigated production, through the movement of water from low-valued uses to high-valued uses (National Water Commission, 2010).

In South Africa, through the implementation of the NWA-1998, attempt was made to improve government and management of water resources by organizing them around hydrological boundaries under the institution called CMAs. But, several issues still need to be sorted out. Water-related services such as drinking water and industrial water supply are being managed by Water Service Agencies, which are within the administrative control of local governments such as municipalities. The Water

Services Development Plans being developed by the WSAs within the local governments are based on information provided by the CMAs on water availability within the basin. But, these plans do not take into water demands in agriculture, and concern only water supply and sanitation and urban and industrial water supply (Herrfahrdt-Pähle, 2010).

There are problems of poor cooperation between the newly established CMAs and the WSAs, due to the misfit between catchment boundaries and administrative boundaries of local governments under which the line agencies of water supply work. There are also problems of lack of coordination within the DWA between the divisions dealing with water resources management and water-related services, and between DWA and the water service agencies (Herrfahrdt-Pähle, 2010). There are currently no specified procedures and rules that guide cooperation between CMAs and the local governance institutions. Cooperation is based on capacity and levels of understanding of legislation and strategies by individuals within these institutions (Mazibuko and Pegram, 2006).

Whereas in the NSW, the 13 catchment management authorities created under the ICMP have become effective mechanism for supporting land owners to voluntarily manage their land better for both public and private benefits. It has given the regional communities a more direct say in the complex task of reconciling community needs with ecosystem health. The audits of the CMAs done, during the recent droughts, showed improvement in resource condition in half of the cases (source: Report of the Commissioner, New South Wales Natural Resources Commission, Level 10/15 Castlereagh Street, Sydney, NSW 2000, Australia. John.Williams@nrc.nsw.gov.au).

2.4 Catchment planning for watershed management programs in India

2.4.1 State of knowledge about catchment hydrology for WSM programs in India

In India, the current state of knowledge about the catchment processes is extremely inadequate. One major issue is that the other key factors, which determine the impact of land use and land cover on catchment hydrology, viz., rainfall regime, geohydrology, climate, soils and topography, vary remarkably from region to region, making it difficult to apply the limited knowledge available for select catchments from other parts of the world, for the hundreds of thousands of country's catchments, which have varying

environmental conditions. This means, in the Indian context, such scientific data need to be generated for typical catchments.

A major lacuna arises from the lack of adequate scientific knowledge of catchment characteristics, hydrology, hydrogeology, stream flows, and groundwater-surface water interactions. To start with, hydrological data are not available for many catchments. Many small basins in India are ungauged for stream flows, and some do not even have adequate number of rain gauges to capture the spatial variation in rainfall across the basin. Also, the data from non-IMD stations such as those managed by agricultural universities, state irrigation department, and forest department are of poor quality. While rainfall-runoff relationship can be established with known values of daily rainfall, data on soil type, land use, and land cover, such datasets are also not available for small catchments on spatial scale. This makes it practically impossible to analyze how changes in land use and land cover in the past had affected the catchment hydrology and the likely future changes in the same.

Improved access to online terrestrial data on rainfall, soil moisture, etc. acquired using wireless sensors and properly calibrated, is making it a lot easier to understand catchment hydrology, especially rainfall-runoff relationships, when supported by field evidence of catchment outflows and inflows into tanks and other wetlands ([Campbell and Newfoundland, 2010](#)).

Groundwater-surface water interactions are important, but more significant for hilly and mountainous catchments, wherein groundwater outflows contribute to stream flows not only during monsoon but also during lean season ([Kumar et al., 2005](#)). By the very nature, these hilly and mountainous become priority areas for catchment management initiatives. But, water resource assessment, especially groundwater resource assessments, does not provide any separate data on groundwater outflows into surface streams (base flow) in such regions.

2.4.2 Planning for catchment management in the IWMP

The planning for watershed management activities in India under the IWMP is highly decentralized, while the funds for undertaking the program is from the central plan allocation, administered by the Ministry of Rural Development, Government of India. The plan allocation is driven by the consideration of the number of districts and the total land area falling under rain-fed category in each state. The underlying rationale is that areas that are rain-fed—areas where the total net irrigated area is less than 25% of the cultivable area—attract much less government investment in agriculture as

compared to irrigated areas. Also, since most rain-fed areas in the semiarid and arid parts of the country face problem of groundwater overexploitation (Kumar, 2007), the program is viewed as a tool for arresting it through resource augmentation.

In developed countries, the primary focus of integrated catchment management was of reallocating water from agriculture to other sectors and to make agricultural land use more ecologically sustainable. But, in India, the primary objective has been to improve the productivity of agricultural land by making more water or soil moisture available to the farming communities, and arrest degradation of common land (Farrington et al., 1999; Hope, 2007). The key concern is improving soil moisture regime in the agricultural and nonagriculture land and augmenting groundwater recharge. The unit for planning catchment management interventions is a small microwatershed of 500–1000 ha size, which makes it difficult for communities within the watershed to foresee other potential uses of water, which flows out of their catchments.

The central funds, which are allocated to the states, are routed through the district rural development agencies, which in turn allocate the funds to a wide range of agencies, to finally reach the watershed communities. The project implementing agencies (PIA), which receive the funds from against the proposals that specify the watersheds and the area to be treated, carry out watershed planning in their respective areas with the involvement of the stakeholder communities, through an institution of the communities, which are promoted by them, called Village Watershed Committees.

Watershed planning in India under IWMP generally does not involve any scientific considerations of the catchment hydrology, including available runoff and uncommitted runoff from the catchment (Batchelor et al., 2003). The program focus is on soil and water conservation measures and water resources development. Since the unit for planning is very small, for which hydrological data are not available (except for experimental watersheds), hydrological planning is hardly attempted. The KAWAD project is a clear illustration of this poor planning.

It also does not consider the demand for water in the watershed (from irrigation, livestock drinking, domestic uses, and water for environment) against the utilizable surface and groundwater. While water demand far exceeds the supplies in most semiarid and arid regions of India (Biggs et al., 2007; Batchelor et al., 2003; Kumar et al., 2008), with increasing number of basins either closed or on the verge of “closure” (Biggs et al., 2007; Kumar et al., 2008), the program by design does not involve components, which address demand management issues (Batchelor et al., 2003).

Instead, the accent is on building more water-harvesting structures, on the premise that it would increase the local water supplies, an idea supported by most researchers and academicians. While environmental flow considerations are gaining greater acceptance in water resource decision making, this is hardly visible in watershed management programs and policies in India (Smakhtin and Anputhas, 2006).

While the approach is participatory planning at the microwatershed level (James, 2000), the Village Watershed Committees are not supported by any scientific data on the catchment slopes, soil types, the drainage lines, land use, and land cover, which are very crucial for scientific planning for effectiveness from both physical and economic perspectives. Generally, the implementing agency does not have resources available for generating such information in the project funds. Nearly 85%–90% of the funds allocated for are to be used for physical interventions. The remaining funds are used for covering the overheads of the PIA to support social engineering. The knowledge about how various land uses affect catchment hydrology is very tentative and hence the impact of the proposed interventions.

Very often, conflicting claims are made about the potential impact of the interventions. No doubt, a well-designed and executed watershed development intervention works in terms of improved recharge in the treated watershed and reduced soil erosion. But these benefits accrued often come at the cost of undesirable hydrological changes like reduced stream flows downstream. While one of the socioeconomic indicators of success of IWMP has been increase in area under cultivation and irrigation in the treated watershed, which meant increased consumptive use of water, the claim of “increased base flow during lean season” is also used simultaneously to defend extensive WH work carried out under the program by the PIA. But, the point is that increased consumptive use of water in the watershed has to come with a reduction in runoff from the watershed or base flow or both.

Several misconceptions drive the choice of technologies and practices under watershed management. It is widely believed by the planners as well as PIAs that tree planting is very good for improving the flow regime of the catchment if not augmenting the flow itself, irrespective of the climate. The application of scientific knowledge of forest hydrology is hardly visible. Similarly, it is believed that adoption of microirrigation technologies would eventually lead to reduction in water use in agriculture.

In India, the agroecology of the rain-fed area ranges from hot and arid tropical areas with very low rainfall and flat topography to cold and humid subtropical areas with excessively high rainfall and mountainous topography.

Interestingly, rain-fed areas exist under both the conditions. While in the first case, the crops remain largely rain-fed due to lack of sufficient water for irrigation, whereas in the second case, the crops do not require irrigation water for most parts of the year due to excessive rainfall over long time periods and soil moisture. The kind of issues relating to catchment management in the former would be drastically different from that in the latter. While in the former, the focus should be on introducing limits on water diversion for biomass production and improving the efficiency of use of the water allocated to that sector, in the latter plenty of scope for regulating the monsoon flows, reducing soil erosion, controlling sediment load in runoff and augmenting local surface water storage might exist.

Hence, the ICM interventions will have to change as we move from one agroecology to another. But, the uniform guidelines for watershed management and the standard norms on financing based on area treated do not encourage development of innovative approaches that would make hydrological and economic sense.

2.4.3 Physical and socioeconomic impacts of watershed management programs in India

The focus of watershed development in India has modified over the last 25 years from soil conservation to water conservation to now include a more participatory planning approach, evaluation studies estimating the distribution or magnitude of social impacts from watershed development are often unclear or disputed (Hope, 2007; Kerr et al., 2002; World Bank, 2004).

Very few studies, based on catchment monitoring and research, are available to help evaluate the impact of catchment management interventions on their environmental conditions. They pertain to the following: the hydrological and biophysical impacts of the interventions at the level of microcatchments in terms of changes in runoff collection efficiency; increase in vegetation cover; soil loss from the catchment (Panwar et al., 2012; Garg et al., 2012); and groundwater recharge (Garg et al., 2012). They all show positive impacts at the local level (Panwar et al., 2012; Pathak et al., 2013). But, these microlevel studies are not representative of the hydrological conditions such as rainfall, slope, geohydrology, soil type, land use, and land cover, of the large catchments they are part of. In nutshell, the impact assessments do not factor in the “scale effects.” In other words, the hydrological processes that matter for microwatersheds or the mathematical relationships representing the hydrological processes will not be same as that for the large catchment in which these microwatersheds fall. This makes it difficult to

draw useful inferences of catchment-wide interventions for the large catchment in question.

Several researchers have provided empirical evidence to illustrate the “scale effects” in small water harvesting (Batchelor et al., 2002; Gupta, 2011; Kumar et al., 2008; Ray and Bijarnia, 2006; Talati et al., 2005) and watershed development (Batchelor et al., 2002; Syme et al., 2012).

Economic valuation of watershed management programs also suffers on many counts: they fail to link the measurable indicators of watershed impacts to planned interventions (Hope, 2007); and they are not able to capture the negative externalities (World Bank, 2004), which are very significant as shown by several empirical studies across the country (Batchelor et al., 2003; Calder, 2005; Hope, 2007; Kumar et al., 2006, 2008). Over and above, there is failure to capture the lasting effects of project interventions on the social and natural systems (Barron and Noel, 2011). Failure to quantify the hydrological gains from the structures to compute the economic value created from the use of the additional water stored in the catchment is another pressing problem. Findings of studies on socioeconomic impact of watershed development programs from different authors, particularly those relating to poverty impacts, often contradict (source: based on Hope, 2007; Buhl and Sen, 2006; Kerr, 2003), while the skewed distribution of benefits from projects, which achieved resource conservation productivity gains, toward large land holders, is visible (Kerr, 2003).

2.4.4 Sustainability of watershed management institutions at the microlevel

In the countries where catchment-wide management of land and water resources has been attempted, the need for the same has been felt by the community groups living within the catchment. Such needs have arisen due to conflicts arising out of excessive diversion of water for agriculture or excessive use of nitrogenous fertilizers in the farm land or disposal of effluents in the rivers by users who constituted a small share of the watershed population. Such uses had impacted several of the downstream users of water, including environmental uses, fisheries, and recreation and quality of drinking water for a large section of the population (Prato and Herath, 2007; Collins et al., 2007).

The relationship between the nature of land use and the resultant impact on the ecological and economic services provided by the catchment was quite visible. More importantly, the communities could value enhanced ecological services such as increased hot weather flows and reducing coastal

salinity, high-quality water for drinking water supplies and management of aquatic ecosystem including protection of rare species of fish, which could be derived from such initiatives (Collins et al., 2007; Connell, 2012; Johnson et al., 1996; Prato and Herath, 2007). In certain other cases, it came out of the realization that there is high degree of fragmentation of water management institutions as found in Britain and France (Buller, 1996) or the policies and activities carried out by various agencies in the catchments need to be coordinated and communities need to be involved in the program as in Western Australia (Mitchell and Hollick, 1993), or as the aftermath of a legislation to ensure poor communities' access to water for domestic and productive needs as in South Africa (Schreiner and Van Koppen, 2002).

But, the situation in most of the treated watersheds in India differs drastically from what is illustrated here. In general, the opportunity cost of participation outweighs the benefits, creating a tendency to self-exclude. First: there are clear winners of an effectively implemented watershed program, while there are losers (Johnson et al., 2001). Second: the opportunity cost of nonparticipation in the program does not exist for the individual members of the communities, including those who are likely to be adversely affected. The reason is that the program mostly produces nontangible public goods and the newly created institutions do not perform any role for distribution of benefits accrued from enhanced watershed performance, either for improving the poor's access to groundwater or ensuring sufficient water in the local aquifer for domestic uses during the lean season (Shiferaw et al., 2006). Third: the local institutions are not internally driven, but instead are driven by external support, and receive too little support for their own capacity building (Singh et al., 2012), fall in the capability trap, and ultimately collapse once the donor withdraws from an area (Sinha and Sinha, 1996).

2.5 Major findings

1. The science of catchment hydrology is well developed internationally, with sufficient knowledge and understanding of the manner in which the hydrology changes in response to changes in land use and land cover in the catchment. But, there is also sufficient evidence of delayed use of this knowledge in catchment management programs, particularly in developing countries like India.

2. Modeling tools exist for simulating the complex hydrological processes in catchments, which, if used correctly, have the potential to predict hydrological outcomes for projected changes in land use and land cover in terms of runoff, soil loss, and sediment transport. Models, which incorporate economic outcomes of catchment management interventions into the hydrological and biophysical models, also exist.
3. But, given the variety of uses and users of land and water in the catchments, catchment management decisions will be based on multiple objectives and criteria, which are social, economic, environmental, and political. Often, there could be strong tradeoff between maximizing economic outcomes and meeting environmental and social goals, and vice versa. Making the right management choice is about minimizing the tradeoffs. But to what extent this tradeoff could be minimized depends on which stakeholder has the political influence or is powerful. The challenge is to ascertain the weightage to be given to each one of the criteria.
4. Catchment management plans should offer a vision for the catchment and its communities for the future. Therefore, it is important that that they accept the rules and framework of actions broadly defined by such plans. Often, the communities are not really convinced about the influence of individual actions on catchment functions.
5. Hence, catchments cannot be managed merely on the basis of scientific knowledge of hydrological and ecological processes. There is a need to recognize the fact that individual actions of the community members are not governed by scientific practices that promote good catchment functioning, but other considerations. This recognition only can foster the awareness of interdependencies between individual actions and catchment functioning and optimize the individual actions. Facilitating the dialog among the stakeholder groups in the catchment, the scientists and policy makers would help the latter understand the rationale behind the individual actions. Awareness of the interdependencies can be created through appropriate practical initiatives that provide a systemic awareness of the context in which the individual actions and catchment functions are positioned.
6. In countries where ICM practices are attempted, the need for catchment-wide management of land and water resources had mostly arisen in response to the prevailing or perceived future conflicts over land and water use so as to ensure water for environmental flows to prevent coastal salinity, augmenting lean season flows for ecology, and preservation of aquatic life and protection of water quality for drinking. The objectives for catchment management varied across countries and situations though.

7. Catchment management planning is a process, outcomes of which would be determined by who initiates and facilitates the process. Different countries follow different processes. While in the MDB of Australia, which has a long history of catchment management, the activities of various catchment management agencies are to be now regulated through a Basin Plan, which is a legally enforceable document. In South Africa, under the National Water Act, the DWAF is to facilitate the process of setting up CMAs within each basin, statutory bodies for basin-wide management of water resources. The CMAs are expected to come out with their own technical proposals for managing their catchments with the larger goal of participatory basin management.
8. In Britain, the CMPs form the basis for the NRA's actions within each catchment. The French SAGE and the SDAGE follow a two-tier tradition in catchment management. SDAGE is a forward planning document at the regional level, concerning major drainage basins, whereas SAGE is a more precise planning document at the local level for small local catchments (around 100–200 km²). In Western Australia, the Community Catchment Groups are formed to define the principles and rules for management of their own catchments, under political, administrative, and financial support from the Office of Catchment Management.
9. In India, watershed management has evolved as a participatory approach for managing both private and common degraded lands for enhancing agricultural productivity in rain-fed areas using watershed as the unit for treatment of land, with the “ridge to valley” concept. The entire focus is on soil and water conservation and water resources development at the microcatchment level. The “scale effects” are not considered in the planning.
10. There is little evidence of hydrological considerations in catchment planning. Given the fact that scientific data on stream flows, groundwater resource availability, groundwater-surface water interactions in the catchment, and the catchment characteristics are largely absent for microwatersheds chosen for implementation, the tendency is to overestimate the resource availability so as to enhance the scope for water resource development interventions.
11. The program is implemented using a decentralized approach, through village watershed committees. They are financially supported by the Ministry of Rural Development through the dept. of rural development of the respective states and their district-level arms. The physical interventions are planned by the VWCs with the help of the PIAs, which

are in turn supported by state-level resource agencies. The monitoring and evaluation of the watershed activities are carried out by the State line departments. The DOLR undertakes periodic monitoring of the projects, midterm evaluations, and special impact assessment studies.

12. The program by design promotes resource development and exploitation and does not envisage any mechanism either for sharing the augmented resources equitably or for promoting sustainable and efficient use of water and land. Intensive water-harvesting activities carried out under the program supported by groundwater overexploitation help improve economic returns for the farmers. But, they also simultaneously cause negative effects downstream in terms of reduced flows into tanks and other wetlands and drinking water shortage.
13. Though there are multiple uses and users of water, biomass and land in the treated watersheds, the evidence to the effect of involving them in designing management strategies is absent. The heavy emphasis on water harvesting means that the program is primarily targeted at benefiting the agricultural communities in terms of improved land productivity and water access, while the cost is being borne by the landless, who are denied access to the forest land and pastures due to ban on grazing and tree cutting.
14. Watershed management programs across the country follow the same norms and guidelines vis-à-vis the technical strategy and the expenditure for treatment activities. However, the agroecology of rain-fed areas varies drastically from hot and arid semiarid tropical climate with plains to cold and humid, subtropical climate in the mountainous areas. Accordingly, the land and water-related problems also vary. While in the former, the problem is of excessive use of water for agriculture with resource depletion, in the latter the problem is of poor soils, and excessive soil erosion and sediment load in water along with poor utilization of the available renewable water resources. But the focus everywhere is on one type of solutions, i.e., soil and water conservation and water resources development, indicating a lack of clarity of purpose.
15. There is some evidence available from scientific research and monitoring on the positive hydrological impacts of watershed management interventions at the local level in terms of improved runoff collection efficiency, soil loss reduction, sediment control, and augmentation of groundwater recharge when interventions are designed on the basis of scientific data. But, the schemes do not appear to be economically viable at catchment scale. Evidence available from studies in watersheds

of Karnataka, Andhra Pradesh, Gujarat, and Madhya Pradesh shows negative impacts on areas outside the watersheds in terms of reduced inflows into reservoirs.

16. Social impact assessment is fraught with many methodological challenges, owing to the difficulty in establishing ideal “controls,” and the practical issues in nullifying the effect of larger socioeconomic changes. The available independent studies involving robust research designs and methodologies do not show very encouraging outcomes in terms of agricultural productivity growth, improvement in drinking water supply situation, and reduction in rural poverty, though evaluation studies of some of the widely acclaimed watershed programs do show some positive changes in terms of poverty reduction and environmental sustainability.
17. Even in situations where projects were successful in achieving resource conservation and productivity enhancement objectives, skewed distribution of benefits toward large land owners is apparent. In any case, there is no evidence of watershed management programs contributing toward addressing the concerns of inequity in access to groundwater.
18. The projects that followed proper microplanning taking into consideration of the existing resource condition both for private land and common land, using scientific as well as participatory assessment tools seem to be doing good in terms of realizing the intended outcomes and impacts. Also, such projects are also found to have made special provisions in their design for landless communities to derive benefits out of the project.

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