8 Rainwater Harvesting for Irrigation in India

Potential, Action, and Performance

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Introduction

Rapid expansion of groundwater use in India in the last three decades has resulted in a steep decline in the groundwater table in vast areas of the country. This has led to drying up of a huge number of wells, low well productivity, rapid rise in well and pumping depths, deteriorating groundwater quality, and also salinity ingressin many areas, see discussion in Chapter 7 of this *Report*. Shallow wells are running dry and the depth of tube wells is increasing every year. Some estimates indicate that the withdrawal rate of groundwater in India is twice the recharge rate (International Water Management Institute 2002).

In response to this situation, rainwater harvesting offers a critical and promising solution to replenish and recharge the groundwater (in areas where geologic conditions are conducive). In a typical setting, much of the rainwater is lost to surface flows. Rainwater harvesting for agriculture generally involves the creation of structures such as check dams, ponds, and percolation tanks to slow the flow of water, and to collect and hold limited quantities at a planned set of places along the flow path. The primary objective is to increase the percolation of the rainwater into the ground to recharge the groundwater table. This leads to a rise in the water table levels, increased supply of water in wells, and a longer period of availability of water. In this chapter, we outline the case for small decentralized water harvesting structures and institutions in contrast with the conventional, centralized river basin wide planning and development model of water resource management. We review policy initiatives on watershed development (WSD). We also present the results of a survey where respondents were beneficiaries of check dams in the Saurashtra region of Gujarat and draw policy implications from the same.

Background

What is the amount of water available through rainwater in India annually? The normal annual rainfall precipitation in the country is estimated to be 400 million hectare-metres (Mha-m) of water (Majumdar 2002) (see Figure 8.1). Out of this, 115 Mha-m enters surface flows, 215 Mha-m enters the ground, and 70 Mha-m is lost to evaporation. Only 25 Mha-m is finally used

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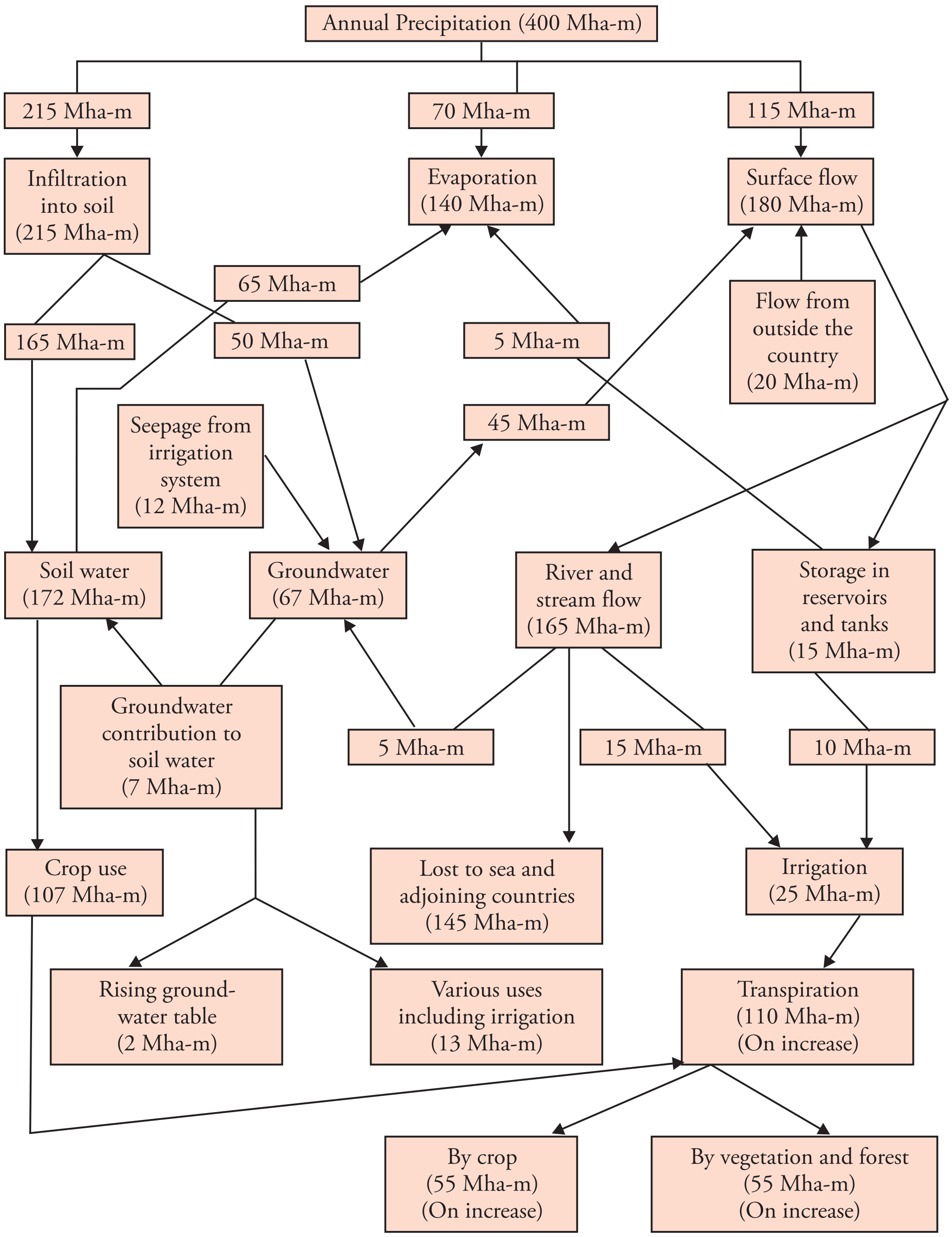

FIGURE 8.1 Water Resource Wealth of India

Source: Majumdar (2002).

through surface irrigation which constitutes a mere 6 per cent of the total water available through rain and from flows from outside the country (20 Mha-m). The figure also indicates that out of the 215 Mha-m infiltrating into the soil, only 13 Mha-m is utilized for groundwater irrigation and other uses. This again constitutes a mere 6 per cent of the annual precipitation infiltrating into the soil, indicating the substantial potential for rainwater harvesting.

One of the reasons for the poor utilization of rainwater in India is the high concentration of rainfall over a few months. As Table 8.1 shows, about 74 per cent of the rainfall is received during the south-west monsoon period of June to September. Even this does not fully reveal the concentration of big spells of rains. As a result, the soil saturates, and much of the water flows away if no structures are made to check this flow. The uneven distribution also creates a situation of long dry periods when cropping is difficult if water is not retained or made available in some other way.

Besides this, the distribution of rainfall is also geographically highly uneven (see Table 8.2). Only 8 per cent of the country receives very high/assured rainfall of above 2000 mm, and another 20 per cent receives high rainfall of 1150 to 2000 mm. The rest of the country, that is, 72 per cent, is in the low, dry, or medium rainfall range of less than 1150 mm, with 30 per cent area particularly dry at below 750 mm. Thus, in vast areas, unless wells are present, groundwater is not available with adequate rainwater recharge. In the absence of a proper surface irrigation scheme, crop production becomes difficult. Athavale (2003) indicates that about 50 per cent of irrigation water, 85 per cent of the drinking water, and about 33 per cent of the domestic water in cities comes from tapping of groundwater through dug wells or tube wells. By 2008–9, groundwater accounted for about 61 per cent of the irrigated area in the country (Ministry of Agriculture 2010).

Table 8.1 Distribution of Annual Rainfall by Seasons in India

Rainfall	*Duration*	*Approx. percentage of annual rainfall*
Pre-monsoon	March–May	10.4
South-west monsoon	June–September	73.7
Post-monsoon	October–December	13.3
Winter or north-east monsoon	January–February	2.6
Total	Annual	100.0

Source: Meteorological Department of India, Pune, cited in Fertilizer Association of India (2007).

Table 8.2 Distribution of Area by Annual Rainfall in India

Rainfall classification	*Amount of rainfall (mm)*	*Approx. percentage of area receiving rainfall*
Low/Dry	Less than 750	30.0
Medium	750 to 1150	42.0
High	1150 to 2000	20.0
Very high/Assured	Above 2000	8.0
Total		100.0

Source: Meteorological Department of India, Pune, cited in Fertilizer Association of India (2007).

The situation of acute drops in the water tables is highlighted by Table 8.3. Water table falls of over four metres per year are seen in a large number of districts. The situation seems to be particularly acute in the states of Madhya Pradesh, Rajasthan, Gujarat, Maharashtra, Uttar Pradesh, Andhra Pradesh, and Tamil Nadu where sharp drops are common. There appears to be a widespread need to explore the possibilities of rainwater harvesting to alleviate the decline in water tables.

As pointed out in Chapter 7, 'Groundwater Irrigation in India: Growth, Challenges, and Risks' in this *Report*, the level of groundwater development is already as high as 141 per cent in Punjab, 111 per cent in Rajasthan, and 105 per cent in Haryana. This is followed by Tamil Nadu at 81 per cent, Gujarat at 70 per cent, and Uttar Pradesh/Uttarakhand at 65 per cent. Further, these figures hide the highly skewed intra-state distribution.

Importance of Rainwater Harvesting

Verma et al. (2008) indicate that decentralized small water harvesting structures present a major alternative to the conventional river basin water resource development models. An excellent example is the decentralized, large-scale, check dam rainwater harvesting movement in Saurashtra, Gujarat. This is also brought out by studies conducted by the Central Soil and Water Conservation Research and Training Institute, Dehradun (reported by Khurana 2003).The studies show a clear relationship between the size of catchment and amount of run-off that can be captured. Increasing

Table 8.3 Observed Annual Fall in Water Table Levels, District Frequency, May 1999 to May 2001

States	*May 1999 to May 2000*		*May 2000 to May 2001*	
	Fall in water table level			
	2 to 4 metres	*More than 4 metres*	*2 to 4 metres*	*More than 4 metres*
	Number of Districts			
Andhra Pradesh	8	6	5	3
Maharashtra	11	6	12	3
Madhya Pradesh	3	2	23	11
Rajasthan	All except 5	14	NA	NA
Punjab	2	1	6	0
Haryana	3	2	3	1
Uttar Pradesh	6	4	11	6
Bihar	4	–	NA	NA
West Bengal	3	2	NA	NA
Orissa	2	1	NA	NA
Assam	4	–	5	1
Gujarat	All except 4	9	NA	NA
Karnataka	8	3	4	2
Tamil Nadu	13	6	16	10

Source: Ministry of Water Resources (2001).
Note: NA–data not available.

the size of the catchment from 1 hectare (ha) to about 2 ha reduces the water yield per hectare by as much as 20 per cent. Thus, in a drought prone area where water is scarce, 10 tiny dams with a catchment of 1 ha each will collect more water than one larger dam with a catchment of 10 ha. Khurana (2003) indicates that the drought proofing benefits from small rainwater harvesting structures can very effectively distribute the available water when there is no drought or a limited drought. Moench and Kumar (1993) say that smaller structures help in conditions of high inter-year rainfall variability and low reliability.

Rockstrom et al. (2009) discuss that rainwater harvesting structures can be very useful for semi-arid and dry, sub-humid regions especially as water scarcity is caused by extreme variability of rainfall rather than the amount of rainfall. Under such conditions, with high rainfall intensities, few rain events, and poor spatial and temporal distribution of rainfall, even if total rainfall is adequate, water losses are very high, thus leading to scarcity. Given that the frequency of dry spells and droughts is expected to increase with climate change (Intergovernmental Panel on Climate Change 2007), they suggest rainwater harvesting structures as extremely important for mitigating the impact on agriculture and increasing agricultural productivity. Rockstrom et al. (2009) argue for the need to downscale water resource management from the river basin scale to the catchment scale (about 1000 km^3). Indicating these important benefits, Oweis (1997) finds that bridging critical dry spells through supplemental irrigation of about 50 to 200 mm through groundwater and rainwater harvesting can stabilize yields in dry, sub-humid regions; and up to 400 per cent increase in yields have been reported in the arid regions of Syria.

Kateja (2003) discusses the importance of groundwater in arid states such as Rajasthan and the need for different techniques of groundwater recharge. Seventy per cent of the population in Rajasthan depends on groundwater for drinking and irrigation purposes and the scanty rainfall cannot recharge the groundwater without the adoption of water harvesting techniques. The techniques may include recharge structures such as *Talabs, Nadi, Tanka, Bawari, Jhalara,* and *Khadin* to suit the local geological and climate conditions. Groundwater extraction is also leading to significant water quality problems and health hazards and over 16,000 habitations (that is, about 13 per cent of the total habitations in the state) may be fluoride affected.

With respect to the usefulness of tanks for collecting rainwater and recharging groundwater, Shah and Raju (2001)—who studied the socio-ecology of tanks and water harvesting in Rajasthan—report that there are multiple benefits from tanks. Tanks lead to substantial rainwater harvesting at the local level, and the associated distribution system leads to water availability in large areas and to larger numbers of farmers. A significant benefit of percolation of rainwater is groundwater recharge and higher water table in the area. Other benefits include low cost flow irrigation, reduction in intensity of flash floods, concentration of silt and minerals to fertilize the soil in the command area, and reduction in soil erosion.

Kishore et al. (2005) find that even when the rainfall shows no decline, there are growing scarcities at many locations, as use is increasingly exceeding the availability. They say that the only recourse in such locations is to close the demand–supply gap by conserving water through rainwater harvesting. This may include building a core wall on the upstream side of ponds to prevent them from pulling out groundwater from upstream lands.

Tilala and Shiyani (2005) undertook a study of the impact of water harvesting structures on the Raj Samadhiyala village of Saurashtra near Rajkot. This is a highly admired rainwater harvesting experiment and the study sought to evaluate the impacts through a comparison of beneficiaries and non-beneficiaries (see Table 8.4). The authors found that the water harvesting structures had a substantial positive impact on the cropping patterns of farmers (for example, could grow vegetables in summer), crop yields (42 per cent , 45 per cent, and 31 per cent increase for groundnut, cotton and wheat, respectively comparing beneficiary and non-beneficiary farmers) and farmer incomes (76 per cent, 95 per cent, and 77 per cent higher farm business income for beneficiaries vis-à-vis non-beneficiaries in these crops). They also report benefits of higher water use efficiency, reduction in cost of production, and higher labour productivity.

Sikarwar et al. (2005), evaluated the impact of 5 small check dams and 5 marginal check dams constructed in Saurashtra, Gujarat in the Ladudi Watershed between 2002 and 2004 by the Gujarat State Land Development Corporation (GSLDC). They found that the total hours of irrigation from the wells increased by 32 per cent and that there was a rise of 6 to 7 metres in the water table depth observed in the wells. There was also improvement in the cropping pattern, net revenues, as well as the socio-economic status of farmers as a result of the check dams.

The National Water Policy 2002 recommends the development of water harvesting systems to increase the utilizable water resources. In line with this, the Tenth Five Year Plan set targets and budgets for artificial recharge of groundwater and rainwater harvesting (see Table 8.5).

Table 8.4 Yield and Returns per Hectare of Different Crops

Items	*Unit*	*Groundnut*			*Cotton*			*Wheat*		
		Beneficiaries	*Non-beneficiaries*	*per cent change*	*Beneficiaries*	*Non-beneficiaries*	*per cent change*	*Beneficiaries*	*Non-beneficiaries*	*per cent change*
Yield	Q	21.01	14.75	42.44	14.50	10.03	44.56	33.97	25.91	31.11
Gross Return	Rs	28610	20370	40.45	28086	19318	45.38	27642	21097	31.02
Farm Business Income	Rs	12810	7248	76.74	8335	4267	95.33	16138	11242	43.55

Source: Tilala and Shiyani (2005).

TABLE 8.5 Targets and Budget for Recharge Structures Under the Scheme 'Artificial Recharge of Groundwater and Rainwater Harvesting' of the Tenth Plan

States/UTs	*Number of recharge structures*	*Cost (Rs in Lakh)*
Andhra Pradesh	185	1350
Bihar & Jharkhand	205	750
Chhattisgarh	104	500
Delhi	235	300
Goa	30	150
Gujarat	240	1350
Haryana	260	350
Himachal Pradesh	64	350
Jammu & Kashmir	40	350
Karnataka	373	1350
Kerala	95	350
Madhya Pradesh	232	1100
Maharashtra	212	1100
North-Eastern States	165	600
Orissa	100	800
Punjab	425	500
Rajasthan	196	1350
Sikkim	170	150
Tamil Nadu	184	1350
Uttar Pradesh & Uttaranchal	770	1500
West Bengal	236	900
Andaman & Nicobar Islands	77	100
Chandigarh	100	100
Lakshadweep	100	100
Dadra & Nagar Haveli	140	100
Daman & Diu	110	100
Puducherry	38	100
Eastern Coastal States	1	200
Western Coastal States	1	200
India	5088	17500

Source: Ministry of Water Resources (2002).

WSD Programmes

A major national initiative in India in which rainwater harvesting is a significant component is the WSD programme, taken up under different schemes/programmes of the Government of India and the state governments (See Table 8.6). Raising productivity and incomes in rain-fed areas is a major challenge in India and a key to achieving this is to improve the use of natural resources—particularly land and water which are major constraints in these areas. Since about 50–60 per cent of the country's population depends directly or indirectly on agriculture for income and livelihood (including the majority of the poor), and poverty is particularly acute in the rain-fed areas, WSD programmes are given huge importance. They are seen as a significant measure for mitigating drought impact and reducing the vulnerability of the large poor populations in dry regions.

For WSD programmes, scientists and engineers have developed a variety of technologies which offer solutions to difficult watershed conditions. The solutions include interventions ranging from simple check dams to large percolation and irrigation tanks, from vegetative barriers to contour bunds, and changes in agricultural practices for example, in-situ soil and moisture conservation, agro-forestry, pasture development, horticulture, and silvipasture. A hierarchy of institutional arrangements of the government and other agencies undertakes the planning and implementation of WSD. An example of an institutional arrangement is shown in Figure 8.2. A watershed is considered a geo-hydrological unit or an area that drains to a common point. Practical definitions have varied over the years but for government projects and budgeting purposes, a watershed has been typically identified as an area of approximate 500 ha in a village. This is being expanded in the recent years.

The history and concept of WSD in India can be traced back to the Famine Commission of 1880 in British India which first indicated its importance. It was identified again in 1928 by the Royal Commission of Agriculture. After independence, Government of India-supported WSD programmes started during the 1950s. The first step towards a systematic effort to tackle the problem of drought and desertification through WSD was the establishment of a special centre at Jodhpur in 1952 with the major focus of carrying out research on core needs of desert area development. In 1959, the entire responsibility for research on dry land/desert

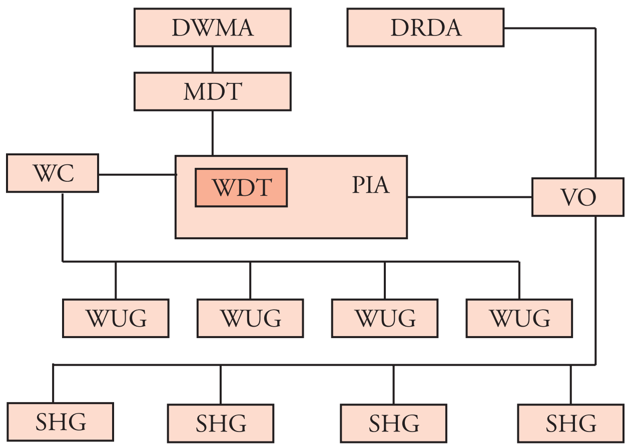

Figure 8.2 An Example of the Institutional Arrangement for Water Development

Source: Authors' own.
Note: DWMA—District Water Management Agency; DRDA—District Rural Development Agency; MDT—Multi Disciplinary Team; PIA—Program Implementation Agency; SHG—Self-help group; VO—Village Organization; WC—Watershed Committee; WUG—Water User Group; WDT—Watershed Development Team.

areas was entrusted to the above centre which was then designated the Central Arid Zone Research Institute (CAZRI). The first large-scale government supported watershed programme was launched in 1962–3; a major purpose was to check siltation of multi-purpose reservoirs through soil conservation works in the catchments of river valley projects.

During the Second and Third Five Year Plans, the problems of drought-affected areas were mainly sought to be solved by launching Dry Farming Projects, which were initially taken up in a few areas and emphasized moisture and water conservation measures. The Fourth Plan continued to place major emphasis on dryland farming technology, and for this purpose, the All India Coordinated Research Project for Dryland Agriculture was started, later based at the Central Research Institute for Dryland Agriculture (CRIDA). Under its aegis, 24 pilot projects were started to serve as training-cum-demonstration centres for application of technology relating to soil management, water harvesting, improved agronomic practices, drought resistant crops, and more.

The origin of the Drought Prone Areas Programme (DPAP) can be traced to the Rural Works Programme launched in 1970–1 with the objective of creating assets designed to reduce the severity of drought in the affected areas. The programme spelt out a long-term strategy in the context of the conditions and potentials of identified drought prone districts. In all, 54 districts as well as parts of 18 other districts contiguous to them were identified in the country as drought-prone for purposes of the programme (See Table 8.7). The programme grew to cover 12 per cent of the country's population and nearly one-fifth of the area. Labour-intensive activities such as medium and minor irrigation projects, road construction, soil conservation, and afforestation projects were taken up under the programme. The success of these activities prompted the government to take up a mega sized project named the Drought Prone Areas Programme in 1972–3, with the principal objective of mitigating the impact of droughts in vulnerable areas.

In the Fifth Five Year Plan, the DPAP adopted the strategy and approach of integrated area development laid down by the Task Force constituted by the Planning Commission. On the suggestion of the National Commission on Agriculture, 1974, a specific programme was initiated in 1977–8 for hot desert areas, consisting mainly of afforestation and livestock development—the Desert Development Programme (DDP) (See Table 8.8). The DPAP and DDP were reviewed periodically by the Ministry of Rural Development, which recommended modifications in the nature and coverage of these programmes from time to time. The major emphasis was on productive agriculture, dryland as well as irrigated, and vegetation cover. In 1980, the Ministry of Agriculture also started a new scheme called the Integrated Watershed Management in the Catchments of Flood Prone Rivers (FPR).

The DPAP was withdrawn from areas covered under DDP as both programmes had similar objectives. The main thrust of DPAP/DDP was on activities relating to soil conservation, land shaping and development, water resource conservation and development, afforestation, and pasture development.

With experience gained from the different approaches, the concept of integrated WSD was first formalized in the early 1990s, and in 1990, the National Watershed Project for Rain-fed Areas (NWDPRA) was launched in 99 selected watersheds to enhance crop productivity in arable rain-fed areas. By 1994, it covered 2554 micro watersheds. In 1993, the Government of India constituted a technical committee headed by C.H. Hanumantha Rao to review these programmes. The committee indicated that:

> the programmes have been implemented in a fragmented manner by different departments through rigid guidelines without any well-designed plans prepared on watershed basis by involving the inhabitants. In many areas the achievements have been dismal. Ecological degradation has been proceeding unabated in many of these areas with reduced forest cover, reducing water table and a shortage of drinking water, fuel and fodder (Ministry of Rural Development 1994 and 2006.)

The Committee, therefore, proposed a revamp of the strategy of implementation of these programmes, drawing upon the 'the outstanding successes' of some

Table 8.6 Number of WSD Projects, Area Covered, and Funds Released under Different WSD Programmes in India, 1995–6 to 2007–8

Name of programme	*Number of projects sanctioned*	*Area covered in lakh ha*	*Total funds released by the central government (Rs Million)*
DPAP	27,439 (60.9)	130.20 (41.2)	28,378 (36.7)
DDP	15,746 (34.9)	78.73 (24.9)	21,032 (27.2)
IWDP	1877 (33.9)	107.00 (33.9)	27,976 (36.1)
Total	45,062 (100.0)	322.93 (100.0)	77,386 (100.0)

Source: Ministry of Rural Development (2010).
Note: Figures in parenthesis are percentages.

Table 8.7 Area Treated Under DPAP

Year	*Area treated in lakh hectares*
1995–6	5.95
1996–7	5.50
1997–8	4.54
1998–9	3.65
1999–2000	3.66
2000–1	7.50
2001–2	5.44
2002–3	6.56
2003–4	7.35
2004–5	7.49
2005–6	8.10
Total	65.74

Source: Ministry of Rural Development (2010).

Table 8.8 Area Treated Under DDP Since its Inception

Year	*Area treated in lakh hectares*
From inception till 31 March 1995	5.15
1995–6	2.02
1996–7	1.31
1997–8	1.40
1998–9	1.60
1999–2000	2.00
2000–1	3.41
2001–2	3.56
2002–3	4.39
2003–4	4.72
2004–5	4.89
2005–6	6.01
Total	40.46

Source: Ministry of Rural Development (2010).

ongoing watershed projects. It recommended that sanctioning of works should be on the basis of action plans prepared on a watershed basis instead of a fixed amount being allocated per block as was the practice at the time. It called for the introduction of participatory modes of implementation, through involvement of beneficiaries of the programme and non-government organizations (NGOs). Based on its recommendations a new set of guidelines was formulated and came into effect from 1 April 1995 and applied to all the watershed projects of the Ministry of Rural Development. At the time, the Department of Land Resources of the Ministry of Rural Development administered three area-based watershed programmes for development of dry, rain-fed wastelands and degraded lands namely DPAP, DDP, and Integrated Wastelands Development Programme (IWDP). The Common Guidelines of 1994 were revised by the Ministry of Rural Development in 2001 and then again modified and reissued as 'Guidelines for *Hariyali*' in April 2003.

The watershed programme has become the centrepiece of rural development in India. The Ministry of Environment and Forests and bilateral funding agencies are involved in implementation of watershed projects in India. The new initiative of the Department of Land Resources called 'Hariyali' had the objective of empowering *Panchayati Raj* Institutions (PRIs) both financially and administratively in the implementation of WSD Programmes. Under this initiative, all new area development programmes under IWDP, DPAP, and DDP were to be implemented through the PRIs in accordance with the guidelines for Hariyali from 1 April 2003. In November 2006, an apex body called the National Rain-fed Area Authority (NRAA) was set up. It brought out new 'Common Guidelines for Watershed Development Projects' in 2008 in order to have a unified approach by all ministries, leading to the Integrated Watershed Management Programme (IWMP). These guidelines are now applicable to all WSD projects of all departments/ministries of the Government of India concerned with WSD projects.

Rainwater Harvesting: Institutional Effectiveness in Gujarat

Community based rainwater harvesting is perhaps more important today than ever before. An outstanding grassroots level initiative for rainwater harvesting is seen in the check dam movement in the dry Saurashtra region of Gujarat state. This was a grassroots level movement that witnessed the formation of hundreds of village level institutions for organizing rainwater harvesting through planning, funding, and construction of a series of check dams as well as other rainwater harvesting structures in and around each village (see Gandhi and Sharma 2009). The purpose was to collect and hold rainwater for a short time and recharge the underground aquifers, thereby bringing water to the open wells, most of which had run dry. From the late 1990s, such institutions have been formed in hundreds of villages in the region and the movement is reported to have had a significant impact on water availability and agricultural incomes.

Check dams are small low barriers built across the pathways of rainwater surface flows. The pathways could be natural or manmade, small or large, and may include gullies, old village roads, streams, and shallow rivers. In the rainy season, the check dams help retain surface water overflows so that water percolates and recharges the water table below (Gandhi and Sharma 2009). A series of check dams is usually planned along a water flow path so that water overflowing one structure is captured by the next, and so on. In this manner, the benefits of groundwater recharge are spread over a large area and potentially impact a large number of wells. Check dams do not require much technical know-how to construct and the capital investment is generally modest. Construction is often labour intensive which facilitates participation by most of the villagers. The involvement of the local people in planning and implementation, through these institutions, is reported to be crucial in making these interventions possible and successful.

The rainwater harvesting movement in the Saurashtra area of Gujarat was inspired primarily by the success in a village called Raj Samadhiyala near Rajkot. Commencing initially as a local initiative, the check dam concept and development has benefited substantially from private voluntary support organized through several organizations such as the Jal Dhara Trust. The Trust pooled funds from expatriate village residents who had migrated to the city of Surat, and done well in diamond cutting businesses and who were willing to offer help/philanthropy to their community of origin. The Trust not only helped organize funds but also supported the initiative with technical know-how and, in some cases, earth-moving equipment. The movement also benefited from active government support. During the year 2000, the Government of Gujarat launched the Sardar Patel Participatory Water Conservation Programme to aid in the construction of check dams. As part of this programme a scheme was devised whereby 60 per cent of the cost of a check dam would be met by the state on the proviso that villagers contributed the remaining 40 per cent, primarily in the form of labour. However, the village institutions eager for speedy implementation before the rainy season often did not always wait for government paperwork clearance and went ahead through their own contributions and those sourced from private/trust sources; the government funds often followed. According to some reports, 15,000 check dams had been constructed in the state by year 2002 (*Times of India* 2002), and according to government statistics given in Table 8.9, over 90,000 check dams had been completed by 2007 (Government of Gujarat 2007).

Of 5600 villages in Saurashtra, 3000 have small and medium check dams while there are 300 large check dams in the region (*DNA Newspaper* 2008). The outcome has been profound as evidenced by this comment from Maldebhai Bodar, a farmer from Sevantara village with 35 check dams: 'Earlier it was very difficult getting water for even one crop in a year. Now we have three crops' (Ibid.).

The research described below has examined the performance of a sample of village institutions which were organized for rainwater harvesting work and which were critical to its successful implementation. The examination uses the framework of features based on new institutional economics and management theories of governance developed in Gandhi et al. (2009).

Sample and Respondent Profile

A Study of Rainwater Harvesting in Gujarat

Seven village rainwater harvesting institutions were selected from three districts in the Saurashtra region of Gujarat, namely Amreli, Bhavnagar, and Rajkot. A total sample of 100 beneficiaries affiliated with check dam institutions was surveyed. The study used both institutional questionnaires and household questionnaires to collect information (Gandhi and Sharma 2009).

Table 8.9 Number of Check Dams Constructed in Various Districts in Gujarat, June 2007

	District	*Number of check dams*
1	Ahmedabad	629
2	Amreli	4822
3	Anand/Kheda	367
4	Banaskantha	2766
5	Bharuch	685
6	Bhavnagar	7290
7	Dahod	5468
8	Dang	1678
9	Gandhinagar	328
10	Jamnagar	7871
11	Junagadh	5080
12	Kuchchh	5804
13	Mehsana	832
14	Narmada	1302
15	Navsari	1234
16	Panchmahal	7856
17	Patan	1587
18	Porbandar	902
19	Rajkot	14192
20	Sabarkantha	8228
21	Surat	2174
22	Surendranagar	2493
23	Vadodara	2684
24	Valsad	4477
	Total	90648

Source: Government of Gujarat (2007).

Table 8.10 Respondent Profile

Education	
Education	Per cent
Illiterate	7
Std1–4	36
Std5–9	51
Std10–12	6
Below graduation	0
Graduation	0
Above graduation	0
Total	100
Sources of irrigation	
Sources	Per cent
River	0
Open well	100
Tube well	0
Canal	0
Tank	0
Lift from tank	0
Total	100
Reliance on the institution	
Reliance	Per cent
Very substantial	19
Substantial	81
Some	0
Very little	0
None	0
Total	100

Source: Gandhi and Sharma (2009).

The educational profile of respondents (see Table 8.10) shows that education was limited: 93 per cent of households had some education, but very few had education beyond the 9th grade, and none had college education. The only source of irrigation for the households was open wells and reliance on the water institution for water access was reported as very high, with 81 per cent indicating it as substantial and 19 per cent as very substantial.

Governance

The data in Table 8.11 show that the Chairman, Managing Committee, and the Secretary are reported to be active by about half the respondents and very active by the other half, indicating some variation. Government officials are also indicated as having an active part in the institutional arrangements. The local government, including the panchayat and sarpanch, shows active involvement but not as much as some others.

Table 8.11 Role in Running the Institutions

Role of:	*Very active*	*Active*	*Passive*	*None*
1. Chairman	48	52	0	0
2. Managing committee	53	46	0	1
3. Members	7	8	85	0
4. Secretary	48	52	0	0
5. Government officials	38	62	0	0
6. Panchayat	14	86	0	0
7. Sarpanch	7	93	0	0
8. Other local institutions	0	0	0	100

Source: Gandhi and Sharma (2009).

Measuring Institutional Performance

The overall performance rating for check dam institutions is reported in Table 8.12. About 56 per cent of the respondents considered the institution to be very successful whereas 44 per cent considered it to be successful. Thus, the satisfaction with the institution and its results seems very high.

Table 8.12 Performance of the Institution

Performance	*Rating*	*No. of farmers*
Very successful	4	56
Successful	3	44
Satisfactory	2	0
Poor	1	0
Total		100

Source: Gandhi and Sharma (2009).

Table 8.13 presents results on the broader perceived impacts of the institution, including the effects on equity. The data indicate that the institution was perceived as having facilitated empowerment and a sense of ownership among the farmers. Moreover, active involvement of all classes was reported. The institution was also perceived as having a substantial positive impact on the whole village, including small/marginal farmers and labourers. Even the impact on the environment was reported to be positive, presumably because local groundwater recharge was conceptualized as benefiting the environment.

Multivariate Analysis

The TOBIT regression model is used and the caveats of potential multicollinearity apply. The results on overall institutional performance are given in Table 8.14. The model indicates that if the objectives are clear to the

Table 8.13 Impact of the Institution on the Village, Different Communities, and the Environment

	Highly positive	*Positive*	*No impact*	*Negative*	*Highly negative*
Empowerment of farmers to manage irrigation	42	58	0	0	0
Beginning of a sense of ownership by farmers	61	39	0	0	0
Active involvement of all classes	30	70	0	0	0
Impact on:					
Village as a whole	91	9	0	0	0
Women	71	29	0	0	0
Large/medium farmers	61	38	1	0	0
Small/marginal farmers	67	33	0	0	0
Labour/wage earners	25	74	0	0	1
Environment and natural resources	83	17	0	0	0

members, management has sound expertise, and management has the authority to adapt the rules and systems, institutional performance is better. In addition, superior performance is promoted when the institution uses its powers to bring about compliance. Where the government has played an active part in the derivation of rules there would appear to be better performance. In addition, good interaction between the members and capable leadership to facilitate interaction helped improve the performance. Thus, many factors are associated with good performance, particularly objectives being clear to members, management's expertise, management adapting the rules, and compliance.

Conclusions and Policy Implications

Extraction of groundwater has resulted in large declines in the groundwater tables in many areas of the country. This has resulted in low productivity of wells, deterioration of groundwater quality, and intrusion of sea water in coastal areas. In response to this, rainwater harvesting offers a very promising solution. Estimates indicate that there is a huge potential and only about 6 per cent of the available surface and groundwater is being used. Most of the rainwater which falls, is lost to surface flows. Rainwater harvesting for agriculture generally involves creation of structures such as check-dams, ponds, and percolation tanks at a planned set of places along the flow path. This increases the percolation of the water into the ground and recharges the groundwater table. It increases the supply of water in the wells and the duration of availability.

Decentralized small harvesting structures present a major alternative to conventional river basin water resource development. Decentralized water harvesting can capture five times more water. The drought proofing benefits from small rainwater harvesting structures can be well distributed especially when the drought is limited and not severe. Rainwater harvesting can be very useful in semi-arid and dry sub-humid regions where the problem is not the amount of rain but the extreme variability. Given that with climate change the frequency of dry spells and droughts are expected to increase, rainwater harvesting can be extremely important to mitigate the impact on agriculture and increase agricultural productivity. Bridging critical dry spells by irrigation through rainwater harvesting can stabilise and increase yields.

The National Water Policy and the Tenth Five Year Plan set targets and budgets for artificial recharge

Table 8.14 TOBIT Regression: Dependent Variable–Overall Performance/Success

Parameter	*Estimate*	*t value*	*Approx Pr > |t|*
Intercept	–4.68	–1.04	0.3001
Managing committee active	–0.08	–0.44	0.6598
Secretary active	–0.22	–1.07	0.2831
Management has the expertise	0.20***	2.72	0.0066
Government helped determine the rules	1.06***	4.24	<.0001
The objectives are clear to the members	0.76***	3.10	0.0019
The institution regularly plans for achievement of objectives	0.01	0.07	0.9469
There is good interaction between the members	0.46**	2.19	0.0282
There is good leadership to facilitate interaction	0.41*	1.78	0.0746
There are clear mechanisms for changing the rules	0.21	1.14	0.2545
The management has authority to adapt the rules and systems	0.60***	2.77	0.0056
The institution uses its powers to bring compliance	0.78***	2.91	0.0036

Notes: *significant at 10 per cent; ** significant at 5 per cent; *** significant at 1 per cent.

of groundwater and rainwater harvesting. Besides, rainwater harvesting is pursued in India through WSD programme of the Government of India and the state governments. Since poverty is particularly acute in the rain-fed areas, WSD programmes are given huge support by the government, and are looked upon for mitigating drought impact and reducing vulnerability of the large poor populations in the dry regions. Under the DPAP, DDP, and IWDP watershed development programmes of the government, huge funds of over Rs 77300 million have been released, and an area of 32.29 million hectares has been treated between 1995–6 and 2007–8.

A huge grassroots initiative on rainwater harvesting has taken place in the Saurashtra region of Gujarat and has received substantial support from the state government. The movement works through the formation of local village institutions for organizing the planning, finance, and implementation of village-wide rainwater harvesting through construction of check dams and other water conservation structures. It is reported that since the late 1990s, over 90,000 such structures have been created in the state and evidence indicates that these initiatives have had a huge impact on water availability and agricultural incomes. Study and multivariate analysis of the performance of these rainwater harvesting institutions indicates that success is determined by a number of factors including appropriate scale, clarity of objectives, good interaction, management having expertise, adaptiveness, and compliance.

There is an urgent need for strong policies and programmes to promote rainwater harvesting in India. These should target areas that are water scarce, those that have become highly dependent on groundwater, and where rapid declines in groundwater levels are taking place. Substantial funding is required for the creation of rainwater harvesting structures and given the costs and externalities involved, it calls for public support. However, it is very important that this is accompanied by the development/creation of appropriate institutional structures for planning and implementation. Experience indicates that given the substantial variation in the geologic, hydrological, and social settings, bringing together the formal/scientific with the local and informal is a major challenge and clearly requires a participative approach for success. Conditions of institutional success such as clear objectives, good interaction, adaptiveness, appropriate scale, and compliance need to be addressed by the policies and programmes to ensure good performance. The activities need to be preceded by area based planning and formulation of regular action plans. The check dam movement in Gujarat shows that community involvement in rainwater harvesting projects and activities is extremely important for success. It also shows that creating effective village institutions with active participation can go a long way in improving results. The potential for raising donation support and other funding is also demonstrated in such an approach.

Other experiences indicate that to improve the impact of rainwater harvesting, it is necessary to go beyond natural resource management to add productivity enhancement activities. These may include measures to improve water use efficiency such as drip and sprinkler irrigation, and promotion of appropriate crops, varieties, and modern inputs to enhance physical productivity and economic returns. Further, to extend the benefits to landless and weaker sections in rain-fed areas, it is important to include an enterprise promotion component. This would assist in the development of small business enterprises of these people with the involvement of women and SHGs. This would help the landless and weaker sections to capture some benefits from the rise in incomes and demand of the farming community. Rainwater harvesting and WSD undertaken with such a comprehensive policy approach would lead to more inclusive and sustainable water resource development and management in water scarce areas.

References

Agarwal, Anil (2001), 'Drought: Try Capturing the Rain', Briefing Paper prepared for Members of Parliament.

Athavale, R.N. (2003), *Water Harvesting and Sustainable Supply in India*, *Environment Development Series*, Centre for Environment Education, Rawat Publications, Jaipur and New Delhi.

Central Ground Water Board [CGWB] (2006), *Dynamic Ground Water Resources of India*, (as on March 2004), Ministry of Water Resources, Government of India, Faridabad.

Crase, Lin and Vasant P. Gandhi (2009), *Reforming Institutions in Water Resource Management: Policy and Performance for Sustainable Development*, Earthscan, London.

Department of Land Resources (1994), *Report of the Technical Committee on Drought prone Areas Programme and Desert Development Programme*, (Hanumantha Rao Committee Report), April Department of Land Resources, Ministry of Rural Development, Government of India.

———— (2006), *Report of the Technical Committee on Watershed Programmes in India, (From Hariyali to Neeranchal)*, Department of Land Resources, Ministry of Rural Development, Government of India, January.

DNA Newspaper (2008), 'Water Returns to Saurashtra Farmers', 8 November 2008, Ahmedabad, available at http://www.dnaindia.com/india/report_water-returns-to-saurashtra-farmers-follow_1204607 last accessed on 28 September 2011.

Fertilizer Association of India (2007), *Fertilizer Statistics 2006–07*, The Fertilizer Association of India, New Delhi.

Gandhi, Vasant P. and N.V. Namboodiri (2002), 'Investment and Institutions for Water Management in India's Agriculture: Profile and Behaviour', in D. Brennan (ed.) *Water Policy Reform: Lessons from Asia and Australia*, Australian Centre for International Agricultural Research (ACIAR), Canberra

———— (2009), 'Water Resource Development and Institutions in India: Overview and Profile', in Lin Crase and Vasant P. Gandhi (eds)*Reforming Institutions in Water Resource Management: Policy and Performance for Sustainable Development*, Earthscan, London.

Gandhi, Vasant, Lin Crase, and Ashutosh Roy (2009), Institutional Analysis of the Performance of Water Institutions in Three Major States of India in Lin Crase and Vasant P. Gandhi (eds), *Reforming Institutions in Water Resource Management: Policy and Performance for Sustainable Development*, Earthscan, London.

Gandhi, Vasant and Suresh Sharma (2009), 'The Performance of Rain-water Harvesting Institutions in India: Empirical Study', in Lin Crase and Vasant P. Gandhi (eds) *Reforming Institutions in Water Resource Management: Policy and Performance for Sustainable Development*, Earthscan, London.

Government of Gujarat (2007), 'Details of Checkdams Completed in Gujarat State', Gujarat, Narmada Water Resources, Water Supply and Kalpsar Department, Government of Gujarat, Gandhinagar, available at http://guj-nwrws.gujarat.gov.in/ pdf/checkdam_01.pdf

International Water Management Institute [IWMI] (2002), *Socio-ecology of Groundwater in India*, Water Policy Briefing, IWMI-Tata Water Policy Program, IWMI.

Intergovernmental Panel on Climate Change [IPCC] (2007), *Climate Change 2007*, Fourth Assessment Report, Cambridge University Press, Cambridge, UK.

Kateja, Alpana (2003), 'Groundwater Recharge: Need of the Day', in Kanchan Chopra, C.H. Hanumantha Rao, and Ramprasad Sengupta(eds) *Water Resources, Sustainable Livelihoods and Eco-System Services*, Concept Publishing Company, New Delhi, pp. 194–203.

Kerr, J., G. Pangare, and V.L. Pangare (2002), *Watershed Development Projects in India: An Evaluation*, International Food Policy Research Institute (IFPRI), Washington, DC.

Khurana, Indira (2003), 'Water Scarcity? Try Capturing the Rain' in Kamta Prasad (ed.) *Water Resources and Sustainable Development*, Shipra Publications, Delhi, pp. 137–47.

Kishore, Ravi, D.K. Singh, R.M. Singh, R. Singh, and D.M. Bhandarkar (2005), 'Restructuring of Water Harvesting Ponds and Ground Water Recharge', in N.C. Patel, R. Subbaiah, P.M. Chauhan, K.C. Patel, and J.N. Nandasana(eds) *Sustainable Management of Water Resources*, Himanshu Publications, Udaipur, pp. 208–14.

Majumdar, Dilip Kumar (2002), *Irrigation Water Management: Principles and Practice*, Prentice-Hall of India Pvt. Ltd, New Delhi.

Ministry of Agriculture (2010), *Agricultural Statistics at a Glance 2010*, Directorate of Economics and Statistics, Ministry of Agriculture, Government of India, New Delhi.

Ministry of Water Resources (2001), *State-wise Water Fall Statistics,* Government of India, New Delhi.

———— (2002), *Xth Plan Documents for Water Resources*, Government of India, New Delhi.

Ministry of Rural Development (1994), *Report of the Technical Committee on Drought Prone Areas Programme and Desert Development Programme*, (Hanumantha Rao Committee Report), Department of Land Resources, Ministry of Rural Development, Government of India, New Delhi.

———— (2006), *Report of the Technical Committee on Watershed Programmes in India* (From Hariyali to Neeranchal), (Parthasarathy Committee Report), Department of Land Resources, Ministry of Rural Development, Government of India, New Delhi.

———— (2010), *Annual Report 2009–10*, Ministry of Rural Development, Government of India, New Delhi.
Moench, Marcus (2003), 'Groundwater and Food Security in India', in Kamta Prasad (ed.) *Water Resources and Sustainable Development: Challenges of 21st Century*, Shipra Publications, Delhi, pp. 148–67.
Moench, M. and M.D. Kumar (1993), 'Local Water Management Initiatives: NGO activities in Gujarat', VIKSAT–Pacific Institute Monograph, VIKSAT, Ahmedabad.
Oweis, T. (1997), 'Supplemental Irrigation: A Highly Efficient Water Use Practice', International Centre for Agriculture Research in the Dry Areas, Aleppo, Syria.
Rockstrom, Johan, Louise Karlberg, Suhas P. Wani, Jennie Barron, Nuhu Hatibu, Theib Oweis, Adriana Bruggeman, Jalali Farahani, and Zhu Qiang (2009), 'Managing Water in Rainfed Agriculture: The Need for a Paradigm Shift', *Agriculture Water Management,* Vol. 97, pp. 543–50, available at http://dspace.icrisat.ac.in/bitstream/10731/ 2920/1/AgrWatManag97_4_543-550_2010.pdf journal published by Elsevier BV and journal home page at: http://www.elsevier.ocm/locate/agwat)
Shah, Tushaar and K.V. Raju (2001), 'Rethinking Rehabilitation: Socio-Ecology of Tanks and Water Harvesting in Rajasthan, North West India', CAPRi Working Paper No. 18, CGIAR System-wide Project on Collective Action and Property Rights. International Food Policy Research Institute (IFPRI), Washington DC.
Shah, A. 'Who Benefits from Participatory Watershed Development? Lessons from Gujarat, India', *Gatekeeper series*, No.97, International Institute for Economic Development (IIED), London.
Sikarwar, R.S., H.D. Rank, and R. Subbaiah (2005), 'Impact Assessment of Water Harvesting Structures in Ladudi Watershed', in N.C. Patel, R. Subbaiah, P.M. Chauhan, K.C. Patel, and J.N. Nandasana (eds) *Sustainable Management of Water Resources*, Himanshu Publications, Udaipur.
Tilala, Hiren and R.L. Shiyani (2005), 'Economic Impact of Water Harvesting Structures on Farmers of North Saurashtra Agro-Climatic Zone', in N.C. Patel, R. Subbaiah, P.M. Chauhan, K.C. Patel, and J.N. Nandasana (eds) *Sustainable Management of Water Resources*, Himanshu Publications, Udaipur.
Times of India (2002), 'Big Increase in Water Table Due to 15000 Check-Dams', 8 February 2002, Ahmedabad.
Verma, S., P. Van Der Zaag, and S. Uhlenbrook (2008), 'Small Reservoirs, Big Impacts? Exploring Alternate Models of River Basin Development', Draft Paper for discussion presented at the 2nd International Forum on Water and Food, Addis Ababa, Ethiopia, November 10–14, 2008.