AgWater Solutions Project
Case Study

An Assessment of Decentralized Rain Water Harvesting Systems in Madhya Pradesh, India

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The AWM Project
The AgWater Solutions project was implemented in five countries in Africa and two states in India between 2008 and 2012. The objective of the project was to identify investment options and opportunities in agricultural water management with the greatest potential to improve incomes and food security for poor farmers, and to develop tools and recommendations for stakeholders in the sector including policymakers, investors, NGOs and small-scale farmers.

The leading implementing institutions were the International Water Management Institute (IWMI), the Stockholm Environment Institute (SEI), the Food and Agriculture Organization of the United Nations (FAO), the International Food Policy Research Institute (IFPRI), International Development Enterprises (iDE) and CH2MHill.

For more information on the project or detailed reports please visit the project website http://awm-solutions.iwmi.org/home-page.aspx.

Disclaimers

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EXEXCUTIVE SUMMARY

India has a long tradition of rainwater harvesting. Most of the efforts in harvesting rainwater have been initiated by the government, though communities and Non-Governmental Organizations (NGOs) have been important stakeholders in these efforts. The rainwater harvesting structures are generally built on community land and collectively managed through the formation of local water user groups. The available evidence shows that the community management of natural resources does not always produce the desired results of greater participation or empowerment of stakeholders, nor has such institutional arrangement always led to better management, more equitable access to water resources, or improved sustainability of the structures or the resource itself. As a result, communities often have little interest in operating and maintaining such projects in the long run.

To avoid some of the problems associated with community management of natural resources systems, a private, in contrast to communal, approach to rainwater harvesting has been attempted in certain parts of India. One such example is in Dewas District, in the state of Madhya Pradesh, where farmers faced several water scarcity issues following rapid decline in the region's groundwater tables due to over extraction. To address the situation a movement was started in 2006 emphasizing *decentralized* rainwater harvesting through the construction of water storage structures built on farmers' own land with farmer's own resources. As a rule of thumb, farmers have allocated $1/10^{th}$ to $1/15^{th}$ part of their cultivable land for the structures. To date, more than 4000 farmers in Dewas District, Madhya Pradesh have adopted this approach to revive the region's agricultural economy.

Individual control over available water can enable farmers to better plan agricultural operations, more efficiently and productively use the available water, and to maintain the structures for long-term use. To examine the impact of the Dewas District model, we undertook a structured questionnaire survey drawing from a random sample of 90 adopter and 30 non -adopter farmers. The objective of the survey was to analyze the experiences of farmers who have invested in decentralized rainwater harvesting structures; quantify the associated socio-economic benefits and costs of adopting this approach; and examine opportunities for further up scaling the approach in other parts of India and elsewhere.

The results show that *decentralized* rainwater harvesting structures have led to significant improvements in availability of irrigation water, a reprieve from dependence on groundwater and uncertainties over electricity supply for groundwater pumping, a revival of the agricultural economy of the region, and substantial increases in farmer incomes and improvements in livelihoods. The investments in these structures are highly cost effective and farmers are able to recover their initial investment in approximately three years. While further assessment is needed on the downstream impacts of these structures, the model is a promising private small irrigation option with several investment opportunities to support its further up scaling in other similar regions in India and elsewhere.

1. INTRODUCTION

Irrigation has been at the center of agricultural development strategy in India. Huge investments have been made by the government and the private sector in extending irrigated area in the country. All forms of irrigation infrastructure have been tapped - large, medium and small-scale surface irrigation infrastructure, groundwater development, rehabilitation of defunct irrigation systems and more recently through country wide initiation of Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS). Despite all these efforts, almost 60% of net sown area in the country still remains unirrigated.

Dependence on groundwater for irrigation has been increasing. More than 60% of the net irrigated area in the country is irrigated by groundwater. Despite substantial investments in surface irrigation, no new additions to area irrigated by surface sources have been reported. All new additions to net irrigated area have been made by groundwater, pointing clearly to the increasing role groundwater plays in sustaining the current level of irrigation and in adding to the future irrigated area in the country.

In the absence of any effective regulations or monitoring of groundwater extraction, coupled with subsidies on electricity for irrigation pumping, groundwater tables in several parts of the country have been falling and a number of blocks in the country have been declared “dark” where no further exploitation of groundwater is permitted. Groundwater tables in several areas have been falling at the rate of more than one meter per year. In several parts of the country a number of tubewells have gone dry and new investments in either deepening these tubewells or installing new tubewells have often yielded no water or water for a short time or water unfit for irrigation. This scenario is coupled with rising demand of electricity for drawing water from greater depths and increasingly unreliable supply of electricity for irrigation pumping in some of these regions. This makes reliance on groundwater for irrigation uncertain. Farmers have suffered huge financial losses due to unproductive investments in groundwater and losses in agricultural production.

The present case study was undertaken in Dewas District in the State of Madhya Pradesh in India. Dewas has seen groundwater deterioration as described above. The present study demonstrates how farmers in the region have managed to move away from over dependence on groundwater and revived not only the agricultural economy of the region but their own fortunes as well. This has been made possible by carefully harvesting rain water, but with a difference.

The study region

The State of Madhya Pradesh is located in the center of India (Figure 1). Spread over a geographical area of 30.8 million hectares, Madhya Pradesh constitutes 9.4% of the geographical area of the country. With a population of 60.38 million (2001 census) the state supports 5.87% of the country’s population. More than 73% of the states’ population live in rural areas. Administratively the state is divided in to 50 districts while agro-climatically the state can be been divided in to 11 agroclimatic zones.

Agriculture accounts for about 21% of gross domestic product of state. Wheat, paddy, oilseeds (notably soybean), maize and pulses (notably gram) are the important crops. The state produces 10% of India's wheat, 23% of its pulses (40% gram) and, 25% of its oilseeds (55% of soybean). The state ranks first in terms of production of total pulses, gram and soybean, while it ranks second in terms of total oilseeds production. The state has 7.36 million operational holdings which operate 16.37 million hectares of land. The proportion of marginal (0-1 hectares) and small (1-2 hectares) holdings constitute more than 65% of the total holdings but their combined share in the total operated area is just 25.8%. Of the 15 million hectares of net sown area about 38% is irrigated while the proportion of gross irrigated area to gross cropped area is about 30%. Surface water sources account for less than 20% of the net irrigated area and the remaining is by groundwater.

Poverty levels in the state are quite high. Depending on the measure used, the percentage of the population below the poverty line varied between 28% and 38% in 2004-05.

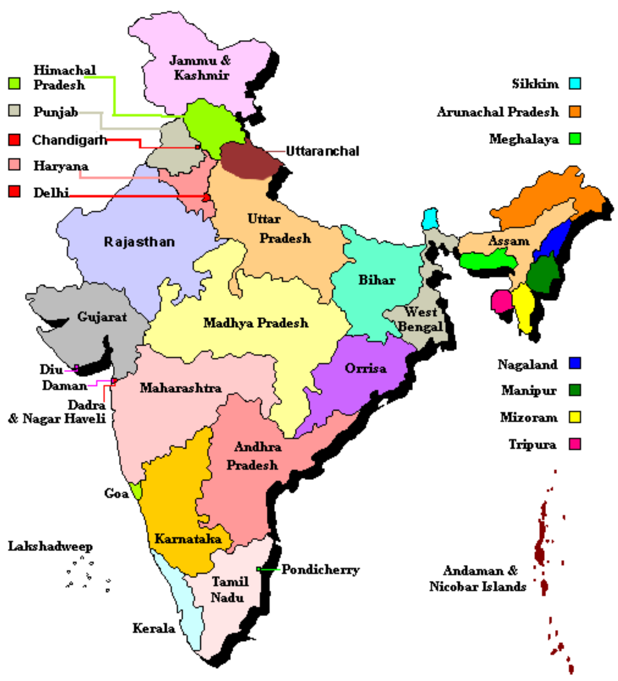

Figure 1. India and the State of Madhya Pradesh

The western part of Madhya Pradesh, especially the Malwa region[1], lacks adequate access to surface water for irrigation. The farmers in the region have traditionally relied on groundwater for meeting their irrigation water requirements. In the absence of any significant consideration to recharge, the groundwater tables in the region started to decline first gradually and then steeply. The water tables in some parts of the region have declined to almost 200-300 feet below ground level. As a result, the failure rate of existing tubewells has surged significantly and fresh investments in tubewells either do not yield any water or yield water for a short time and then stop working. Quite often the water is of poor quality and unfit for irrigation. Coupled with problems relating to water quantity and quality, even those farmers whose tubewells yielded water faced severe constraints in using

[1] Malwa region of Madhya Pradesh covers districts of Dewas, Dhar, Indore, Jhabua, Mandsaur, Neemuch, Rajgarh, Ratlam, Shajapur, Ujjain, and parts of Guna and Sehore

the water due to frequent electric power cuts. As a result, the region has been suffering from severe water challenges since the 1980s, posing a serious threat to the agriculture based livelihoods of the region.

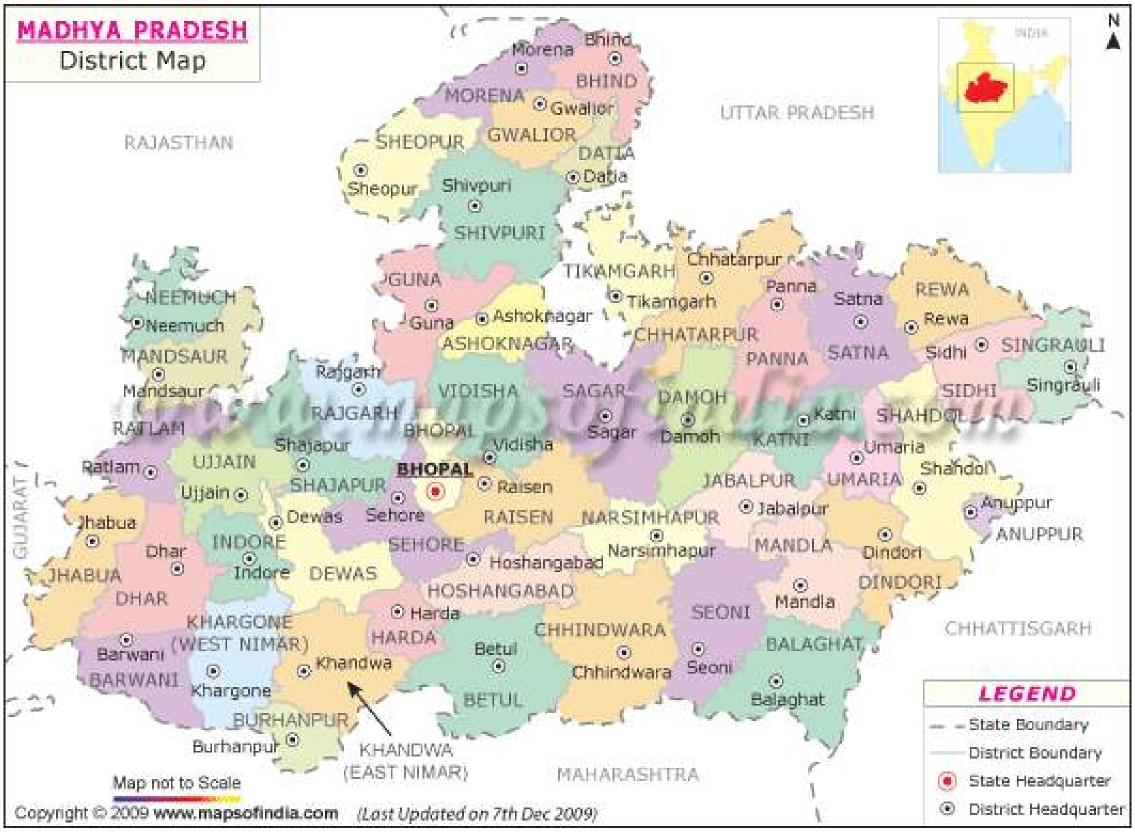

Figure 2. ……

Farmers in the region were used to decent incomes from agriculture and in leading a comfortable lifestyle in the past. They started to feel the pinch of water shortages as their incomes declined and lifestyles were affected. Crop cultivation in the region generally became restricted to taking one rainfed crop during the wet (kharif) season leaving major part of the land uncultivated during the dry (rabi) season. The lack of fodder for livestock also restricted investment in livestock as a means of agricultural diversification. Overcoming water shortages in the region became a major challenge both for farmers and the administration.

Efforts at overcoming water shortages: an idea can change life

Dewas District is one of the 12 districts of Madhya Pradesh facing acute water scarcity problems. It has annual average precipitation of between 1100-1300 mm. Conscious of the problems of farmers in the region, the district administration led by an energetic official Mr. Umakant Umrao, who was posted as District Collector[2] of Dewas in 2006, stressed harvesting of rain water as possibly the only solution to overcome the water woes of the

[2] District Collector, usually a young officer belonging to Indian Administrative Service (IAS), is the highest administrative official of a District.

district. The administration emphasized construction of locally managed rain water harvesting structures. Aware of the problems often associated with building, maintaining and managing community water harvesting structures and frequent conflicts over distribution of available water in these structures, the proposed approach emphasized construction of decentralized rain water harvesting structures on the lands of individual farmers. It was argued that such an approach, while helping avoid the problems associated with community water harvesting structures, would give the owner farmers complete control over the available water and lead to a more efficient use of water. This approach to water harvesting was given the title “Rewa Sagar”.

The process

Translating the concept into action posed a great challenge for the administration. One, the farmers have always strongly resisted giving away even a small part of their cultivable land for non-cultivation purposes. Two, the administration did not want to give subsidies to farmers. Rather than launching the approach in a “big-bang” way, the program started in 2006 with the district administration approaching initially the relatively bigger farmers (with more than 10 acres of agricultural land) and persuaded them to allocate one-tenth to one-fifteenth of their land for construction of a pond which could store runoff water during the monsoons and thereby assure the availability of required water for irrigating during the dry season. The farmers could also use part of the stored water for providing crop-saving irrigation to even wet season crops during the occasional long gaps between rainy days.

The implementation of the program by district administration was mooted in public-private partnership with public agencies providing the technical and logistical support and individual farmers contributing their land and personal (including financial) resources for construction. The district administration ensured a smooth flow of technological support with the help of line department personnel, while the *zila panchayat* officials were entrusted with the responsibility of arranging digging machines and specialized tractors[3] from Rajasthan to execute the work. The district administration intervened to negotiate construction charges and ensure that the farmers were not cheated. To develop the confidence of the farmers, the District Collector personally attended all the “ground breaking” religious ceremonies held at individual farmers’ land and also contributed token labor at the start of each construction site. He personally attended to all the problems and complaints of the investing farmers and took on-the-spot decisions to rectify them. In the following monsoon season, these structures filled up with the water and justified the efforts of the administration. The farmers who had built water harvesting structures were celebrated at a function held by the district administration. These farmers were honored with the title of “*Bhagirath Krishaks*”.

Having savored some initial success, the administration decided to scale up the program. Considering that a district administration with limited resources may not on its own be able to put in the required efforts, they decided to engage with enthusiastic and willing *Bhagirath Krishaks.* Another factor that weighed with district administration in involving

[3] There were several reasons for getting these specialized services from professionals in the neighboring state of Rajasthan. One, since the number of tractors locally available was small the hiring rates were much higher than that charged by tractor owners of Rajasthan. Two, these tractor owners had experience in digging deep structures with tractors

Bhagirath Krishaks was that the potential investing farmers would have more confidence when they talked to their fellow farmers. The district officials identified some *Bhagirath Krishaks* as trainers to convince fellow farmers about the benefits of this approach.

Realizing that constraints on availability of personal finances to meet the upfront cost of construction might hinder adoption by such farmers who might otherwise be convinced on technical and economic considerations to invest, the district officials convinced the District Cooperative Bank to provide loans to at least a few farmers for pond construction. An important factor in convincing an initially reluctant bank over which the District Collector wields considerable influence[4], was the District Collector's personal guarantee for some of the initial loans.

As a result of these efforts, an initiative which started on a small scale over a very short period of time took the form of a movement known as "Rewa Sagar Bhagirath Farmers Movement". Although the scheme initially targeted large farmers, small and medium farmers also came forward to construct ponds in their fields. Taking note of the popularity and technical feasibility of the program, the state administration also jumped in to help scale up the program in the entire state through implementation of first the *Khet Talab* scheme and subsequently the *Balram Talab* scheme. Following the traditional government approach to scaling up, the state announced a subsidy of up to INR 50,000 for farmers building water harvesting structures. Subsequently the maximum subsidy was raised to INR 80,000. This resulted in slowing down the program. Since the total amount of the subsidy allocated by the government to a district in a year is fixed, the administration can distribute subsidies to a limited number of farmers. The farmers who are not able to get a subsidy in a given year wait for their turn in the next year and postpone their investment in the water harvesting structure. According to the available estimates, as at July 2010, more than 4,000 ponds varying between 0.5 - 10.0 acres with a depth ranging between 6 and 25 feet had been constructed by the farmers of Dewas District without any financial assistance from the government.

Several promising interventions were shortlisted for detailed investigation at the Agricultural Water Management (AWM) Solutions project stakeholders meeting organized by International Water Management Institute (IWMI) in Bhopal January 2010 and subsequent discussions with other officials, academics and NGOs. The selection of this intervention on decentralized rain water harvesting for detailed study was made during this process.

Study objectives

The approach adopted by the district administration is not like the general approaches that have often been applied in other parts of the country. Citing the popularity of the program, the district administration has asserted that the movement has led to a significant increase in the total irrigated area, increases in cropping intensity, resulted in increased agricultural production and productivity, a reduction in electricity consumption, increases in livestock production, and a marked increase in flora and fauna of the region. In addition, it has led to reduced dependence of farmers on groundwater for irrigation. More importantly, the

[4] District Collector is also the Chairman of the District Cooperative Bank

farmers are reverting to surface water harvesting from ground water, which is good for ecological conservation. Investing in rain water harvesting structures is also seen as a good coping strategy for minimizing the impacts of variability in rainfall due to climate change.

No attempt seems to have been made to make an assessment of the experiences of the farmers who have invested in these structures, quantify the benefits and costs associated with adoption of this approach to water harvesting, ascertain the concerns of non-adopters and understand the reasons for their non-adoption. Before endeavoring to upscale this intervention it is essential to make a careful assessment of this intervention.

The study addresses the following issues:

1. What have been the farm level impacts of investing in rain water harvesting structures by adopter farmers in terms of changes in cropping pattern, level of input use, pattern of use and sources of irrigation, crop yields, livestock rearing, and income. Do the benefits commensurate with the costs incurred?

2. Why have a large number of farmers not invested in these structures? What constraints do non-adopters face? What are the perceptions of the adopters and non-adopters to the usefulness of the approach and its likely sustainability?

3. If this approach to rain water harvesting and sustainable use of water area holds promise, how can the approach be scaled up? What are the prerequisites and requirements, both financial and institutional, for scaling up and replicating the approach in other areas?

Salient Features of Dewas District

Dewas District is situated on the Malwa plateau in the west-central part of Madhya Pradesh. The district is divided in to six *tehsils* (sub-districts): Sonkatch, Dewas, Bagli, Kannod, Tonkkhurd and Khategaon. Three rivers, the Narmada, Kali Sindh and Kshipra, pass through the district. The soils are of deep medium black type.

The district contributed 2.1 per cent to the states' GDP in 2008-09. Soybeans are the most important crop. Other important crops are wheat, gram and cotton.

Methodology and Data

This assessment is based on primary data collected from a random sample of 90 adopter and 30 non-adopter farming households from Khategaon and Tonkkhurd Blocks of Dewas District (Figure 3 and Table 1). While Tonkkhurd generally has hard rock aquifers, Khategaon has soft rock aquifers interspersed with areas of hard rock. The impact assessment has been made by comparing a select number of impact indicators before and after the project intervention. Since the intervening period, between the project intervention and this assessment, has been very short (varying between 1 to 3 years) it is fair to assume that the influence of non- project related factors, if any, in confounding the identified project impact parameters has been non-significant and therefore can be disregarded.

In addition to the primary data, the assessment draws on information collected through discussions with various officials at the state, district and block level; several NGOs; private sector entrepreneurs undertaking the construction work of water harvesting structures; and a number of other knowledgeable persons engaged in agricultural marketing, input supply, and equipment supply.

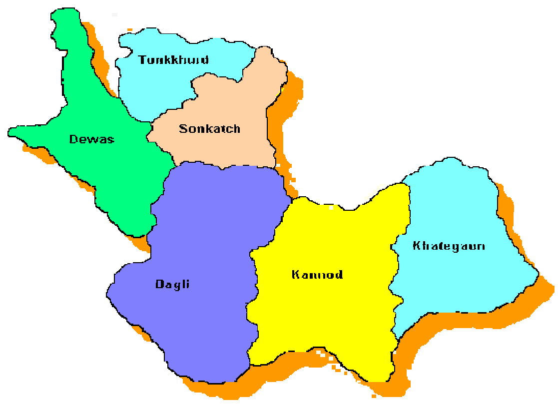

Figure 3. Tehsil demarcated map of Dewas District showing the selected study regions.

Table 1. Sample size and distribution of farming households

Block	Adopter households	Non-adopter households	Total sample size
Khategaon	45	14	59
Tonk Khurd	45	16	61
Total	90	30	120

Some salient features of rain water harvesting structures of sampled households

Size and depth of structures

Construction started in 2006 and with the active role played by the district administration and the adopting farmers the pace of construction picked up quickly. About 87% of the sampled adopter farming households in Khategaon and 98% in Tonkkhurd had constructed their structures by 2008 (Table 3). The average area assigned for water harvesting structure by sampled farmers varied between 10% (one-tenth) of the operated area in Khategaon to 8.8% (one-eleventh) in Tonkkhurd.

Taking a restrained approach to minimize the risks associated with investing in a new intervention, most of the adopting farmers invested in not very deep structures. However, after seeing the benefits, new investing farmers went in for much deeper structures. Innovative farmers also started investing in further deepening their existing structures. At the time of construction of the initial structures, the depth varied between 5 to 25 feet with an average depth between 11.38 feet in Khategaon to 7.22 feet in Tonkkhurd. The current average depth of these structures varies between 12.29 to 8.77 feet respectively in the two study locations. There are a few farmers in the region who have invested in structures as deep as 25 feet. There is an increasing tendency to go in for deeper structures rather than allocating more land for wider structures.

Siting rain water Harvesting structures

Farmers are sensitive to parting with even a small area of cultivable land for non-cultivation purpose and prefer to build on a piece of land which is not suitable for cultivation or is relatively less productive. Land allocated for construction of water harvesting structure goes out of cultivation permanently and therefore the farmer has to forego the crop production that would have otherwise been produced on that piece of land. In our sample, about 58% of the farmers in Khategaon have built such structures on the that piece of land on which they had been previously cultivating, while in Tonkkhurd the proportion is 64% (Table 2). The remaining farmers have built structures on that part of their operational holding which was either not being cultivated or on an adjoining piece of wasteland.

Table 2. Characteristics of water harvesting structures

Characteristic	Khategaon	Tonkkhurd
% of water harvesting structures built during		
- 2006	16	33
- 2007	20	20
- 2008	47	45
- 2009	13	2
- 2010	4	0
% of operated area allocated to water harvesting structure	10.04	8.79
Average depth of water harvesting structure when constructed (feet)	11.38	7.22
Average depth of water harvesting structure currently (feet)	12.29	8.77
% Distribution of water harvesting structures according to their current depths (feet)		
5- 7	22	36
8-10	36	47
11-15	26	13
>15	16	4
% of farmers who built structures on		
- Cultivable land	58	64
- Waste land	42	36
% of farmers who paid the entire cost of construction		
- Upfront	23	77
- In two installments	44	56
% of farmers according to sources of funds for construction		
- Owned funds	62	73
- Borrowed funds	13	2
- Partly owned partly borrowed	25	25
% of Farmers who got some financial subsidy from the government either before or after the construction of structure	87	89
Average amount of subsidy received by farmers	66,282	64,660

Sources of funds for building the structures

Building water harvesting structures is a capital intensive activity. An important consideration is arranging for the finances required to meet the upfront cost of construction. Being a relatively new activity with unclear financial viability, the banks were unwilling to advance construction loans, nor were farmers enthusiastic about taking loans from money lenders or from other private sources. To begin with, farmers with adequate financial resources were encouraged by the district administration to invest in this activity. Realizing that non-availability of finances would hamper investment, the district administration used its influence over the District Cooperative Bank (DCB) to advance loans to a few farmers. The district administration also impressed upon the construction groups to be flexible on payment terms and rather than demanding the entire construction cost at one go they should permit payments to be made in at least two installments, one immediately after construction and the other immediately after the first harvest following completion of the construction. These interventions by the administration proved extremely helpful.

A majority of our sampled farmers (62% in Khategaon and 73% in Tonkkhurd) reported having built these structures from their own private financial resources (Table 2). About 25% farmers in both locations financed construction partly from their own resources and partly from funds borrowed either from financial institutions or family. While 23% of the farmers in Khategaon and 44% in Tonkkhurd paid the entire cost upfront, the remaining paid in two installments.

Government subsidy

The government intervened to scale up the program and rechristened the scheme as Balram Talab Yojana in 2007. Under this scheme, the Government of Madhya Pradesh offered a cash subsidy to farmers willing to invest in water harvesting structures. The government provided a subsidy equivalent to 50% of the cost of structure subject to a maximum of INR 50,000 per structure. The subsidy scheme was meant for all categories of farmers both large and small. The maximum amount of subsidy was subsequently increased to INR 80,000. The government has fixed a target of providing subsidies for construction of 25,000 structures during its XI Five Year Plan (2007-12). For the year 2010-11, the government has made a budgetary provision of INR 250 million.

A majority of the sampled farmers who constructed structures could also manage to get the government subsidy (Table 2). While some had got the subsidy approved before they initiated construction, others got it afterwards. Since the maximum amount of subsidy that can be made available has differed over the years and also according to the size of the farm and structure, the average amount of subsidy works out to INR 66,282 in Khategaon and INR 64,660 in Tonkkhurd.

Multiple uses

While more than 60% of the farmers in both the study locations are using these structures for irrigation only, almost 36% in Khategaon and 16% in Tonkkhurd are using them for both irrigation and livestock (Table 3). The remaining 20% reported having used these structures for more than two uses including drinking water, bathing/swimming and sanitation/hygiene. A small number of farmers are also using or intend to use their structures for fish cultivation**.**

Table 3. Multiple uses

Uses of the Structure	Khategaon	Tonkkhurd
Irrigation only	29	28
Irrigation + livestock	16	7
Irrigation + livestock + other uses (drinking, bathing, sanitation, fish cultivation etc)	0	10
Total	45	45

Storage Capacity

To ensure optimal use of their investment, farmers follow a rule of thumb in allocating a portion of their land for construction. A large majority of farmers (87% in Khategaon and 96% in Tonkkhurd) reported that their size of water harvesting structure was just sufficient to meet their own crop water requirements (Table 4). These farmers also reported that they are able to use the entire water stored in their structures and do not have any spare water left.

Table 4. Adequacy of storage capacity: farmers' perceptions

Indicators	Khategaon		Tonkkhurd	
	Yes	No	Yes	No
Capacity of structure adequate to meet your water requirements?	39	6	43	2
Able to use the entire water stored in the structure?	39	6	42	3

Construction of water harvesting structures and growth of water markets

Investment in private irrigation water development by a few individual farmers who can afford to do so often leads to development of informal water markets whereby farmers who either do not or cannot access or invest in their own irrigation infrastructure buy their surplus water. The investing farmers have so far built water harvesting structures of sizes which are just sufficient to meet their own farm water requirements and do not have surplus water to share or sell. As a result, no water markets have so far developed, although there appears to be enough scope for this. A large majority of investing farmers (more than 95% in both the study regions) however reported that even if they had surplus water they have no intention of selling to neighboring farmers. At this early stage of development, farmers have not yet explored the possibility of developing water markets.

In this context it will be useful to monitor (i) the relative economics of investing in storage of water by those farmers who can afford to do so, for sale of water to intending buyers who cannot afford to invest in their own structures, and (ii) even at the current level of water storage availability with the owner farmers, the option to use the available water for crop cultivation on their own farms versus selling part of the water to water buyers and leaving part of their own land unirrigated or uncultivated. Much will depend on the number of intending sellers and buyers of water and the price of water as determined by the forces of demand and supply.

Energy Use for Water Withdrawal

Farmers like to build structures upstream so that the water stored can be applied for irrigation with gravity flow. An upstream location may not always be consistent with technical requirements for harvesting the maximum volume of rain water. Since the level of water in the structure when full is generally close to ground level, farmers often use only small diesel pump set to draw water from the structure. Although using an electric motor is more economical, access to electricity at the point of withdrawal may not always be possible and electricity at the required time cannot be guaranteed.

Almost all the sampled farmers in Khategaon and 80% in Tonkkhurd have been using diesel pumping sets for withdrawing water (Table 5). Switching over to diesel engines has enabled farmers to apply irrigation water at a time and in as much quantity as required by the crop, set the farmers free from the regime of an unreliable and inadequate electricity supply, and has helped the State Electricity Board use the saved electricity for other sectors. Since electricity in Madhya Pradesh is in short supply, the opportunity cost of electricity allocated to agriculture is high. Diversion of electricity from the agricultural sector would allow the State Electricity Board to supply it to more remunerative sectors.

Table 5. Form of energy used for water withdrawal (number of farmers)

Method Used	Khategaon	Tonkkhurd
Gravity	0	0
Diesel pumping set	44	36
Electric motor	1	9
Total	45	45

2. IMPACT OF DECENTRALIZED RAIN WATER HARVESTING STRUCTURES

The main reason for investing in water harvesting structures is to store rain water available during the wet season and use it for irrigation in the dry season. The water stored can also be used for 'protective' irrigation to wet crops in case of long spells between rainy days. These structures also provide a hedge against unreliable rainfall. Though built initially for providing irrigation water, these structures are also becoming multiple use structure and have significant externalities in terms of recharge of groundwater, rise in water tables leading to improved drinking water availability, improved flora and fauna, and possibly improved wild life. The multiplier effects could be substantial.

In what follows we make an assessment of the direct impacts these structures have made on the economy of the sampled households.

Impact on the agricultural sector

Decline in fallow land and increase in cropping intensity

The most important impact of investments in water harvesting structures is to enable crop cultivation during dry season. Before the construction of water harvesting structures farmers could cultivate almost their entire operated area during wet season. Due to lack of access to irrigation water, more than 75% of the cultivable area during dry season was left fallow. Only a few farmers who had access to some source of irrigation could cultivate part of their land during dry season. After the construction of water harvesting structures, the available water in the structures has enabled farmers overcome this constraint and the proportion of area kept fallow in the dry season has declined sharply to between 4% and 7% (Table 6). As a result, the annual cropping intensity[5] on adopting farmers' fields has increased from 122% prior to construction to 196%.

[5] Cropping intensity is defined as ratio of gross cropped area to net sown area expressed as a percentage.

Table 6. Shifts in operated area cultivated and changes in cropping patterns

Season	Indicator (All figures in %)	Khategaon		Tonkkhurd	
		Before	After	Before	After
Dry	Operated area cultivated	97.8	98.4	97.2	97.8
	Operated area allocated to				
	- Soya	67.9	91.4	97.2	97.8
	- Cotton	29.9	7.0	0	0
	- Fallow	2.2	1.6	2.8	2.2
dry	Operated area cultivated	21.8	92.7	24.1	95.9
	Operated area allocated to				
	- Wheat	17.6	46.8	9.3	52.5
	- Gram	4.2	45.9	14.8	43.3
	- Fallow	78.2	7.3	75.9	4.1
Annual	Cropping intensity	122.3	194.1	124.8	198

Changes in cropping pattern

We discuss separately the changes in cropping pattern during wet and dry seasons.

Wet season

The study region specializes in the cultivation of soybeans during the wet season. A majority of the sampled farmers, for the last several years, have been cultivating soybeans during the wet season, generally as a rainfed crop. Some farmers in Khategaon have also been allocating a part of their land for cultivation of cotton. Since soybeans do not require any supplementary irrigation, the construction of water harvesting structures was not expected to make any significant changes in either the nature of crops cultivated or the intensity of cultivation.

Although not intended for use during wet season, the water stored immediately after the onset of the monsoons offers scope for use during the early wet season as well as for cultivating irrigated crops and thereby diverting at least a part of wet season cropping pattern away from soybeans. The water can be recouped before the monsoons weaken towards the end of season and the filled structure can again be used for providing irrigation in the dry season. We ascertained if our sampled farmers have used the stored water for cultivating any irrigated crops during the wet season and if not what have been the constraining factors.

The results suggest that none of the farmers (with a sole exception) made any attempt at diversification of their wet season cropping (Table 6). While farmers advanced several reasons, the more common reasons included non-availability/ high cost of labor and lack of access to markets for sale of irrigated crops. Lack of processing facilities (such as a rice seller, sugar factory etc.) in Khategaon and lack of access to technology for cultivating irrigated crops in Tonkkhurd were the other important factors (Table 7).

Table 7. Reasons for not changing cropping patterns in the dry season

	Percent of sampled farmers for each reason	
	Khategaon	Tonkkhurd
Started cultivating any new irrigated crop during dry season	2	0
Reasons for not cultivating		
Lack of skills in cultivating these crops	24	56
Lack of access to technology	56	62
Lack of access to markets for such crop outputs	62	42
Lack of transport facilities/ high cost of transportation	2	9
Less remunerative than the existing crop	2	9
Lack of processing facilities (e.g. rice sellers, sugar mills etc)	78	13
Water available is not sufficient to grow irrigated crops	22	2
Non-availability/high cost of labor	91	53

Dry season

Wheat and gram are the two most important crops in the dry season. With the availability of irrigation water from water harvesting structures, farmers have started cultivation of wheat and gram during dry season. Wheat and gram have different irrigation water requirements. Depending on the amount of water available, farmers decide on how much area to cultivate during dry season as also on an optimal combination of the area to be allocated to wheat and gram. Irrigation for 'saving' a crop is more important than meeting full crop water requirements. Farmers generally seek to give 2-3 irrigations to wheat and just one irrigation to gram.

The availability of irrigation water has changed the agricultural scenario of the study region. The proportion of cultivable area kept fallow during dry has declined from 76% before the construction of water harvesting structures to as low as 4-7% (Table 6), and the proportion of area cultivated has increased from 23% to 95%. Wheat and gram are now being cultivated in almost equal proportions.

Changes in cultivation practices

In addition to extending crop cultivation to the dry season, there has been a significant shift in crop cultivation practices. With availability of irrigation and intensification of farming activity, the pressure on timely completion of various crop operations has become more important. This requirement coupled with a severe shortage of agricultural labor and high wage rates, has encouraged the farmers to switch to mechanized farming. A majority of the farmers in both the study locations reported switching their method for land preparation and sowing operations from bullocks to tractors (owned or hired). Crop harvesting is also increasingly mechanized with combine harvesters being hired in for harvesting and threshing operations.

Adoption of water conserving practices

Given the high cost of harvesting rain water, one would expect that farmers would try to use the available water to maximize crop water productivity. Adoption of water conserving technologies such as sprinklers and drip could help make more efficient use of water. The results obtained however show that the farmers are using traditional furrow irrigation. Adoption of water conserving technologies is still low. Only three of the 45 farmers in Khategaon and none of the 45 farmers in Tonkkhurd reported using any water conserving practices. The reasons for non-use are lack of awareness, high cost of technology, lack of access to finances for investment, and too many impediments associated with the use of such technologies. Another reason is that irrigation has improved the farmers income to such an extent that farmers think that it is still too early to think of saving water or using it more efficiently to increase their incomes still further. It is, however not known how the economics of investing in further increasing the size of the water storage structures compares with investing in water conservation technology.

Impact on crop yields

The availability of irrigation water coupled with adoption of improved farming practices, more intensive use of material inputs, and use of better crop varieties has lead to increases in crop yields (Table 8). The yields of all the irrigated crops were higher under “after” conditions as compared to those under “before” conditions. In the case of a major part of the irrigated area during dry season, the realized yield was actually a net addition to crop yield as most of the now cultivated area during dry was kept fallow under the “before” conditions.

Table 8. Changes in crop yields (quintals/acre)

	Crop	Before		After	
		Irrigated	Rainfed	Irrigated	Rainfed
Khategaon	Soybeans	5.3	5.1	5.5	5.3
	Cotton	3.6	2.9	3.8	3.1
	Wheat	8.4	-	10	-
	Gram	5.1	-	5.4	4
Tonk Khurd	Soybeans	-	5.4	-	4.9
	Cotton	-	-	-	-
	Wheat	8	7.4	9.4	-
	Gram	5.1	3.5	5.4	-

Impact on livestock

Availability of fodder is an important factor influencing investment in livestock. Lack of access to irrigation in the study region constrained availability of fodder and therefore investment by farmers. Availability of irrigation in the dry season leading to cultivation of wheat has increased fodder availability. Availability of wheat straw has encouraged farmers to pay attention to improving and expanding their livestock activity. Since livestock is also capital intensive, the progress on this front has been relatively slow. Rather than increasing herd size, farmers are initially investing in improving the quality of their herd. Farmers are gradually replacing the existing low milk yielding stock with improved breeds. Some farmers have brought in high milk yielding cows and buffaloes from Punjab and Haryana.

The results obtained confirm that while the total number of animals with our sampled farmers has either remained constant or declined somewhat, there has been some shift in the mix of animals and change in breeds (Table 9). The net result has been an increase in milk production by 34% in Khategaon and by 11% in Tonk Khurd.

Table 9. Livestock numbers and milk production in sampled households

	Khategaon			Tonk Khurd		
	Before	After	% Change	Before	After	% Change
Buffaloes	67	77	15	49	39	-20
Cows	27	17	-37	20	26	30
Oxen	4	4	0	8	2	-75
Milk production	122510	164330	34	102150	103300	11

Impact on fish cultivation

Standing water in ponds provides a good environment for fish cultivation. In our study region, water harvesting structures are not being used for fish. Only one farmer in Khategaon and two in Tonkkhurd reported practicing fish farming on a limited scale in constructed ponds. The most important factor limiting fish cultivation has been non-availability of standing water in the structures for a long enough period of time. The water stored in the structures gets used up in about 4-5 months. Some farmers indicated that they could manage to leave a minimum amount of water standing in the structure for a longer period of time for the fish to survive but they do not have much technical knowledge. Even if the farmers were provided with this knowledge, most might still not cultivate fish because fish are a non-vegetarian food and most farmers, being vegetarian themselves, do not want to cultivate fish.

3. EXTERNALITIES OF WATER HARVESTING STRUCTURES

Ecological and Environmental Impacts

The availability of water in ponds for several months in areas where standing water has not been seen for the last several years is bound to influence the local ecology. The greater the density of ponds in a region, the higher is the likely impact on the ecology. Since the density of ponds in the surveyed villages differed, the likely impact on the ecology is also likely to differ. As there was no way of assessing the impact of water availability on the ecology, we gathered information on a select number of identified ecological parameters.

The results show that there has either been a positive change in several of these parameters. Almost 85% of the respondents in both study locations said that wildlife such as deer, wolves and other large animals has increased substantially as a result of construction of a large number of water harvesting structures (Table 10). Other ecological changes include a perceptible increase in the visibility of birds, including the return of migratory birds, and a significant increase in the number of peacocks, ducks and fowls.

Table 10. Impact on ecology: Percent of farmers reporting increased incidence in identified ecological parameters

Increased Incidence of	Khategaon	Tonkkhurd
Birds (including migratory birds)	56	40
Peacocks	40	73
Ducks and fowls	53	38
Wildlife (deer, fox and other large animals)	82	84

The impact of small ponds in providing a breeding ground for mosquitoes and impact on malaria has been studied by IWMI scientists and other researchers. The available findings generally indicate increased mosquito breeding and generally higher incidence of malaria where there are standing bodies of water.

We assessed if the construction of water harvesting structures in our study region have in any way contributed to increased incidence of mosquito breeding or increased incidence of malaria and other mosquito borne diseases (Table 11). The data indicate that construction of water harvesting structures has no so far led to any increased incidence of mosquitoes.

Table 11. Impact on mosquitoes

Observed increase in incidence of mosquitoes	Khategaon (n=45)	Tonkkhurd (n=45)
Yes	5	3
No	40	42

Impact on groundwater

Standing water also has the potential to improve the availability of groundwater through recharge. The extent of improvement in groundwater availability through recharge will depend on several factors including the soil characteristics, baseline conditions and the period elapsed between the time the structures started storing water and the time impact is measured. We did not have access to any official data on groundwater before and after the construction of these structures, but based on farmers' perceptions, there has been some improvement in groundwater availability. In fact, 40% of the farmers in both study locations said that the seepage losses from the structures have led to some rise in groundwater tables as reflected in the relative ease in availability of drinking water from open wells (Table 12).

Table 12. Impact on groundwater: Percent of farmers reporting impact on drinking water availability in open wells

Observed impact on availability of drinking water	Khategaon (n=45)	Tonkkhurd (n=45)
Led to improvement	38	42
No improvement	62	58

4. CONFLICTS AMONGST ADOPTERS AND BETWEEN ADOPTERS AND NON-ADOPTERS

Unchecked construction of decentralized water harvesting structures by individual farmers could lead to increased social conflict both within the group of adopting farmers and between the groups of adopting and non-adopting farmers. The nature of the conflicts could be with respect to the location (siting) and size of the structures, with neighboring farmers wanting to channel the maximum amount of rain water into their structure. The nature of conflict between adopting and non-adopting farmers could be similar to conflicts observed in upstream-downstream, early adopter and late adopter, or head and tail farmers in an irrigation system. If the stream of rain water passing through a non-adopter's field is blocked by the action of the adopting farmer, it could lead to a conflict.

We ascertained the nature and extent of such conflicts, if any, in accessing rain water. None of the sampled adopter and non-adopter households (with the exception of one household) reported any such conflict. Just four of the 30 non-adopter households reported some impact on their water availability as a result of a neighboring farmer having built a water harvesting structure.

There could be several reasons for the absence of conflict. The number of harvesting structures built in most villages is not large enough and therefore farmers would not have possibly noticed any change in their rain water availability. The technical advice on siting the structure is given by district officials after carefully studying the topography of the area. The Rajasthani tractor owners who have been doing the construction work have enough experience in this and provide their inputs on siting to minimize any negative externalities. Third, since the crop water requirement of soybeans is moderate, the normal rainfall in the region is large enough (> 1000 mm) to meet everyone's crop water requirements. In fact, the harvesting structures get filled up if there are just one or two heavy downpours in a season. That there is unlikely to be any serious conflicts on sharing of rainwater when large number of farmers within a small geographical area build such structures is best demonstrated by the experience of two villages Dhaturia and Harnawada in Tonkkhurd block of the region, where almost 100 percent farmers have built their rainwater harvesting structures and each is getting enough water to fill up his structure.

5. PATTERN OF SPENDING OF INCREASED INCOME

As a result of increases in cropping intensity and improved livestock activity, the incomes of farmers who have invested in water harvesting structures have increased significantly. To ascertain the nature of economic and social multiplier impacts these increases have fostered, we determined the pattern of spending of their increased incomes. While the farmers were not willing to give specific amounts of money spent on different consumption and savings activities, they were quite forthcoming on their priorities in the use of income. Sampled farmers show striking similarities in both the study areas in some of their responses. Most farmers have been spending a relatively large part of their increased income on consumption and only a part is used for retiring the outstanding loans and savings. A large part of the consumption expenditure is being spent on creating or improving assets (Table 13).

Almost 80% of the adopting farming households in both the study locations reported spending at least a part of their increased income on improving their children's' education. More than 70% of the households in both the study locations spent part of their increased earnings on acquiring a new vehicle, such as a tractor, car or motorcycle for increased mobility. In addition to their usefulness, these assets have high visibility and portray affluence in their social circle. Some other important items of spending have been improving family food consumption, and repair and construction of brick houses. Investing in improving livestock has been a low priority especially among Tonkkhurd farmers. Investing in improving farm water availability, such as investing in improving or building a new structure, has also been on a somewhat low priority, especially in Tonkkhurd.

Table 13. Pattern of spending of increased income: Percent of farmers reporting use of increased incomes for different activities

Activity	Khategaon	Tonkkhurd
Improving family food consumption	47	67
Acquiring new farm/non-farm assets (tractor, car, motorcycle)	76	71
Repairing/building house	42	36
Improving education of children	82	78
Improving the savings/repaying old debts	71	31
Improving farm water availability	42	13
Investing in livestock	33	9
Other	18	2

6. BENEFIT –COST ANALYSIS OF INVESTING IN WATER HARVESTING STRUCTURES

We present in Table 14 estimates of annual increases in benefits and costs on an average farm. The benefits estimated do not include the non-quantifiable benefits attributable to changes in environment and ecology or other externalities.

Table 14. Farm level estimates of benefits and costs of investment in water harvesting structures

Parameter	Characteristics	Khategaon	Tonkkhurd
Farm and structure	Average size of farm (acres)	20	25
	Average size of water harvesting structure (acre)	2.08	2.2
	Average depth of water harvesting structure (feet)	11.38	7.22
Benefits	Net annual increase in income from crop production (INR)	135041	154673
	Net annual increase in income from livestock production (INR)	11122	2720
	Total annual increase in income (INR)	146163	157393
Scenario 1 No government subsidy	Capital cost of structure (INR)	361330	484675
	Life of structure (assumed) (years)	15	15
	Annual depreciation (INR)	24089	32312
	Annual interest cost (at 10% of capital cost) (INR)	36133	48468
	Annual maintenance cost (at 2% of capital cost) (INR)	7227	9694
	Annual loss of net value of crop production on land where harvesting structure built (INR)	8597	16064
	Total annual cost (INR)	76046	106537
	Benefit -Cost ratio	1.92	1.48
	Payback period (years)	2.5	3.1
Scenario 2 Government subsidy of INR 80,000	Capital cost of structure (INR)	281330	4.0o4675
	Total annual cost (INR)	61112	91604
	Benefit-Cos ratio	2.39	1.72
	Payback period (years)	1.9	2.6

The results obtained under two scenarios: (i) assuming non-availability of government subsidy and (ii) assuming government subsidy of INR 80,000 per structure to partially offset the capital cost of investment are presented in Table 15. Due to differences in capital cost of structures in Khategaon and Tonkkhurd, the benefit cost ratios differ. Without government subsidy the benefit cost ratio works out to between 1.9 in Khategaon to 1.5 in Tonkkhurd. The estimated payback period in the two cases works out to 2.5 and 3.1 years.

With a government subsidy of INR 80,000, the capital cost of investment goes down. The benefit cost ratio improves to between 2.4 and 1.7 in the case of Khategaon and Tonkkhurd respectively. The payback period also declines to 1.9 and 2.6 years respectively at the two locations.

7. SCALING UP THE WATER HARVESTING MODEL

The data strongly suggest that financial benefits from rainwater harvesting structures far outweigh the financial costs. Given the initial positive outcomes of this investment, efforts need to be made towards scaling up. There are a large number of farmers and regions which are similarly placed. We need to assess what constrains them from adopting this approach to water harvesting and what interventions can help encourage adoption of this model.

Based on observations and discussions we have had with officials of district administration who engineered the initial success, and other knowledgeable persons in the study area, we venture to suggest an approach to scaling up.

The perceptions of the adopter farmers

The farmers who have not so far invested in these structures can broadly be divided into two groups (i) those located in the same region and in the vicinity of the adopter farmers and (ii) those located further away. The two groups of farmers are likely to differ in respect of their awareness and about the value of the program. While the first group of farmers may have chosen not to invest despite their awareness of the program, the second group of non-adopters may not have adopted primarily because they lack information about the program.

We asked farmers who have already invested and experienced the gains, what, in their opinion, might have prevented some of their neighbors from investing. They indicated three possible reasons:

- Small size of land holding and large family to support,
- Lack of access to either own or borrowed capital for investment,
- Waiting their turn to get a government subsidy.

Neither technical feasibility nor financial viability were cited as possible reasons for non-investment.

On how the program can be extended to second group of non-adopters, the sampled farmers suggested adoption of a mix of interventions for up scaling. The suggested package should include:

- Identification of an appropriate suitability domain. The intervention is likely to be more successful in those regions where similar biophysical conditions exist. Efforts need to be invested in mapping an appropriate "suitability domain" where all initial efforts at scaling up should be directed;
- Knowledge and awareness building. The best approach is to follow the principle of "seeing is believing". Facilitate visits of farmer groups from potential areas so they can see for themselves and discuss face to face with the fellow farmers the benefits of investing;
- Administrative support. Based on their own experience the adopting farmers were of the view that support of district administration in scaling up the program is indispensable. A responsive, understanding, and supportive local level bureaucracy is absolutely essential for any large scale uptake of the program by the farmers;
- Access to capital. Since construction of water harvesting structures is a capital intensive activity and most farmers do not have enough resources, efforts aimed at making capital available on easy terms would go a long way towards encouraging farmers to borrow money and invest in water harvesting structures;
- Provision of subsidy. To partially compensate farmers for the high cost of building water harvesting structures, the government subsidy should be

increased and made available more easily. At the time of initiation, there was no government subsidy and the entire cost was met by farmers. But the farmers who initially built these structures were generally large farmers who had financial resources of their own, could afford to take a risk even if such structures failed to deliver the intended benefits, and had the ability to understand the relevance of this investment.

Given the crucial role the government bureaucracy played in the study region and is expected to play in the efforts aimed at scaling up, we asked the adopting farmers what, in their view, are the specific activities on which the government should be focusing its attention. The results indicate three important roles for the government:

- Providing technical support such as siting structures, shape and size of the structure, construction activity etc;
- Facilitating access to financial resources by impressing upon the financial institutions to treat building of water harvesting structures as an activity eligible for loans under priority sector advances category and charging reasonable rates of interest
- Making the subsidy available to farmers as and when requested by enhancing the annual subsidy budget for supporting construction of rain water harvesting structures.

Farmers believe that private sector players who specialize in construction of rainwater harvesting structures will develop in response to the demand and that the government need not spend its efforts and resources on this activity. They also feel that the government agencies no longer need to play the supervisory role they successfully played in the initial phase of construction in settling with the private players a rate contract ensuring that the private did not cheat the farmers. The farmers feel that competition amongst the service providers will take care of this aspect. On the role of government in awareness raising, the responses of farmers from the two study areas differed (Table 15). While a relatively large proportion of farmers in Tonkkhurd believe that government has a role to play in awareness creation, the proportion of such farmers in Khategaon is much less.

Table 15. Suggested role of government in up scaling: adopting farmer's perception

Role of Government	Percent of farmers suggesting in	
	Khategaon	Kot Khurd
Providing technical support	49	69
Facilitating access to financial resources	76	82
Providing subsidy to offset high cost of construction	67	89
Providing logistic support	11	27
Creating awareness	16	53

The perceptions of non-adopters

If the investment in decentralized water harvesting structures has been so profitable, why is it that a large number of farmers have not invested in this activity? Do they lack awareness or information? In addition to ascertaining the perceptions of the adopting farmers as to what might have constrained the non-adopter farmers located in their neighborhood from investing, it is important to ascertain directly from some of the non-adopting farmers what prevented them from investing and would they be willing to consider investing. The results show that lack of awareness did not constrain these farmers from investing. About 90% of the non-adopting respondents reported awareness about this intervention. Almost every farmer who reported awareness also reported that someone known to them has already invested. These farmers have also seen or visited some of these structures to get first-hand information and knowledge and discuss their doubts with the adopting farmers.

Given such high awareness amongst non-adopting farmers, why is it they have not so far invested? Are they planning to invest in the near future or are they unenthusiastic about investing? Our discussions indicate that a majority of our sampled farmers are not willing to invest. What constrains them? Are these farmers unsure about the availability of enough water to fill their ponds if a large number of farmers were to construct ponds? Are they uncertain about the technical feasibility of ponds, unclear about economics of investment, or unconvinced about long-term implications of investments? The results from our survey show that none of these factors guided their decisions (Table 16). Due to substantial rainfall in the region, the farmers are convinced there is sufficient rain water to fill their water harvesting ponds even if most other farmers in the neighborhood were to construct ponds. Neither are the farmers unconvinced about either the technical feasibility or financial viability or long-term implications of their investment. The two most important factors constraining construction of ponds are: 1) the lack of access to financial resources to pay for the upfront cost of construction and 2) reluctance of farmers, especially very small farmers, to set aside even a small part of their already small cultivable area for construction.

Table 16. Awareness of and willingness to invest in water harvesting structures by non-adopter sampled farmers

Characteristic	Khategaon (n=16)	Tonkkhurd (n=14)	Total (n=30)
Awareness about water harvesting ponds	13	13	26
Does anyone known to you have constructed ponds	12	13	25
Ever seen / visited ponds	12	13	25
Number of respondents who would not like to invest in similar ponds on their farm	11	14	25
Reasons for unwillingness to construct ponds			
No money to invest	11	10	21
Small farm size. Difficult to part with land for the purpose	10	11	21
Have access to alternative irrigation sources	6	2	8
Unsure about economics of investment	0	2	2
Unsure about sufficient water availability to fill my structure	2	3	5
Unconvinced about long-term implication of such investment	0	2	2
Unsure about technical feasibility of ponds	2	0	2

The government has been providing limited financial subsidies to encourage farmers invest in ponds. Because of the limited funds available, the subsidy cannot be made available to all farmers willing to invest in a given year. Since an important factor constraining construction by non-adopter farmers is the high cost and lack of financial resources to invest, we enquired from these non-adopting farmers about awareness of availability of government subsidy and if the subsidy were available would they invest? To what extent does availability of the subsidy affect their decision to invest?

The results suggest that level of awareness about availability of government subsidy is very high (Table 17). More than two-thirds of farmers who have not so far invested are aware of government subsidy. Of these, about 60% reported that they would consider investing if a subsidy could be made available to them. But 60% of such farmers who are aware of the availability of subsidy responded that availability or otherwise of subsidy is not a necessary precondition for their decision to invest in a water harvesting structure.

Table 17. Government subsidy: Awareness and motivating factor

	Khategaon (n=16)	Tonkkhurd (n=14)	Total (n=30)
Awareness of government subsidy	9	12	21
If subsidy is made available will you consider constructing harvesting structure?	9	3	12
Is subsidy a necessary pre condition for your decision to invest in such structures?	8	1	9

The path to scaling up: Action points

We suggest a three-step approach to scaling up decentralized rain water harvesting structures as an important agricultural water management solution.

Step 1: Identifying a suitability domain

Replicating and scaling up requires identification of a suitability domain. Some of the underlying factors that can help narrow identification of such a domain include:

Bio Physical factors

1. No or inadequate access to surface water irrigation,
2. Depth to ground water table high; regions which have been declared "dark",
3. Inadequate, unreliable or non-availability of electricity for irrigation pumping,
4. Water extraction expensive or uneconomic,
5. Purely rainfed areas,
6. Areas where farmers have had sufficient water for irrigation in the past but over the years water has substantially reduced posing threats to their livelihoods,
7. Areas where community based water harvesting structures were built (such as under watershed program) but had to be abandoned due to community conflicts over water sharing or maintenance of structure,
8. Adequate rainfall and sufficient surface runoff available, infrequent extreme rainfall, year-to-year variability,
9. No upstream-downstream conflicts,.

Institutional factors

1. A responsive and adaptive bureaucracy at the district level; or a reputable NGO with significant influence in the region,
2. An agency which could help provide technical know how about the structures siting, size, and construction,
3. Agencies for undertaking the digging works,
4. Easy availability of agricultural inputs,
5. Financial institutions (NABARD, commercial banks, cooperative banks, micro finance institutes) willing to provide loans,
6. Markets for selling irrigated crop output,
7. Agricultural research and extension support (desirable but not essential).

Social Factors

1. Good inter-personal relations amongst households, not many communal issues,
2. A strong community/panchayat leader who commands respect,
3. Good gender relations.

Step 2: Creating awareness

1. Seeing is believing: Arrange visits of groups of potential adopters to the farms where ponds have already been built.
2. Discussing with peers is convincing: Recognizing that adopting farmers are the best messengers, encourage farmers to take the message of their success to other potential areas by organizing group meetings,
3. Exploiting the potential of mass media is effective: Prepare well argued documentary films and exhibit these films through TV or arrange public viewings in potential areas,
4. Inspiring the establishment can be productive: Sensitize water/ irrigation/ rural development bureaucracy in potential areas to this concept,
5. Politics can provide enthusiasm: Educate political leaders on the political pay-offs of the approach,
6. Resounding the skeptical helps: assure reluctant farmers that loss of agricultural production as a result of parting with a portion of land for construction of a water harvesting structure is more than compensated for by increased agricultural production from the remaining land.

Step 3: Providing access to investment capital

1. Convince state planners of the need to treat construction of water harvesting structures as an agricultural activity and include this activity in the category of priority sector advances[6]. Make loans for this activity eligible at the same terms of lending as for other agricultural inputs. This loan however should be over and above the limit of loan that a farmer is entitled to take for inputs.
2. Convince NABARD to provide a refinance facility to the lending banks for this activity.
3. Encourage micro finance institutions/ cooperative banks to finance these activities.
4. Since limited funds for subsidies can actually slow down the pace of adoption, the government can consider providing more funds for the annual subsidy. To illustrate, in 2010-11 the Government of Madhya Pradesh budgeted INR 250 million for subsidies for this program. At INR 80,000 per structure, the allocated amount can provide support for only 3,125 structures in a year. Given the vast area to be covered this amount is very small compared to the requirement.
5. If the government cannot substantially raise the annual subsidy outgo on the program it could consider reengineering the subsidy instrument to reach a much larger number of

[6] Under the priority sector advance scheme, the farmers in India are entitled to get a certain amount of crop loan each season from public sector financial institutions at a concessional rate of interest for purchase of farm inputs such as seed, fertilizers etc. The farmers can also get loans for farm modernization such as for investing in a tractor, pumping equipment, agricultural equipment etc. Investment in a water harvesting structure however does not qualify as a priority sector investment from a bank's perspective and banks have either refused or are unwilling to advance loans for construction. Money lenders who are flexible about the purpose for which a loan is taken however charge exorbitant rates of interest. Some of the financial institutions willing to advance loans treat this as a loan for commercial activity which does not qualify for concessional credit and carries a much higher rate of interest (12-14% per annum).

farmers. This could include doing away with cash subsidies and providing an interest cost subsidy.

6. Encourage donors, lenders, and venture capitalists with social and environmental commitments to assist farmers in pursuing this activity.

Impact: likely reach of the program

To what level can the program be scaled up? How much area and how many people can be reached? At this stage it is difficult to provide a definitive answer to this question. The underlying solution to agricultural water management and the approach suggested to scaling up is quite broad and applicable under a wide range of prevailing conditions. Depending on the time frame envisaged and the geographical area covered, the number of farmers impacted could vary from a few to several thousand.

Financial requirements for scaling up: An illustrative

Since access to finance has been flagged as the most important constraining factor in scaling up the program, we provide a hypothetical case based on an order of magnitude estimate of the scale of finances required. Assuming that medium and large groups of farmers can manage to raise their own finances for investment, we focus on marginal and small farmers. To begin, we focus on Dewas District. Table 18 provides an estimate of the magnitude of the task. There are about 63 thousand farmers in Dewas District with operational holdings between 1 to 3 hectares. These holdings combined come to about 110 thousand hectares of land with an average holding size of 1.74 hectares. While some holdings have access to irrigation, others are wholly unirrigated or partly irrigated. The number of unirrigated or partly irrigated holdings is 58 thousand and these combined cover an area of 80 thousand hectares. At this stage we assume that the program is targeting only this sub-group of holdings.

Table 18. Scaling up the program in Dewas District: Identifying the number of Potential Beneficiaries

Category	Unit	Value
Farmers with holdings between 1 to 3 hectares	Number	62946 (1731)
Total area operated by these holdings	Hectares	109316 (2829)
Average size of holding	Hectares	1.74 (1.64)
Wholly unirrigated or partly irrigated holdings	Number	58061[92.2]
Area of holdings belonging to wholly unirrigated or partly irrigated farms but receiving no irrigation	Hectares	80375[73.5]

Note: Figures in () parentheses denote information about female holdings. Figures in [] denote percentages. Source: Agricultural Census 2001

In the first phase we envisage targeting only 10% of the holdings which are either wholly unirrigated or partly irrigated. The total number of holdings thus intended to be covered in the first phase is 5,800, of which about 160 are female headed households. Taking the average size of holding of this group to be 5 acres (approximately) we demonstrate the investment requirements and the likely impact of this investment on the small farm economy.

Since in Dewas the awareness level about the program is quite high and farmers are generally convinced extending the program to these neighborhood farmers will not have financial implications for awareness creation. With an average size of farm at 5 acres, the size of water harvesting structure works out to 0.44 acres. With an average cost of building one harvesting structure of this size at INR 135,000, the total cost of 5,800 water harvesting structures works out to INR 786 million.

This investment leads to an annual increase in production of wheat by 122 tonnes and that of gram by 46 tonnes (Table 19). In monetary terms, the increase in annual gross value of crops and livestock output works out to INR 364 million, while the net increase in output (net of paid out costs) works out to INR 211 million. After accounting for the loss in agricultural production because of 0.44 acres of land going out of cultivation for building the water harvesting structure, the net value of output increases by INR 192 million. Taking average family size of 5, this translates into an increase in annual per capita income of INR 6,629.

Table 19. Economic impact of targeting 10% of identified potential holdings for investments

	Unit	Value/ Farm	Total for 5800 Farms
Size of operated land	Acres	5	
Size of harvesting structure (8.8%)	Acres	0.44	
Depth of structure	Feet	7.22	
Quantum of water harvested	Cum	3920	22.74 Million Cum
Cost of one structure (without subsidy)	INR	135580	786 Million INR
Increase in per year production of (Quintals)	Per Farm		
-Soybean	-2.38	-4360	-14 Tonnes
-Wheat	21	30616	122 Tonnes
-Gram	7.92	22259	46 Tonnes
Increase in gross value of crop production (main + by product)	INR per Farm	51426	298.3 Million INR
Increase in net value of crop output (main+ by)	INR per Farm	30646	177.5 Million INR
Increase in gross value of milk production per year	INR Per household	11422	66.2 Million INR
Increase in net value of milk per year	INR Per household	5711	33.1 Million INR
Increase in gross value of crop and milk output	INR Per household	62848	364.5 Million INR
Increase in net value of crop and milk output	Per household	36357	210.9 Million INR
Loss in annual value of crop production because of land going of cultivation for building water harvesting structure	Per household	3213	18.6 Million INR
Net increase in income	Per Household	33144	INR 192.3 Million INR
Increase in per capita income(family size=5)	Per person	6629	

Note: In the calculations we have used the values of parameters relating to size, depth, cost, increases in production etc. at par with those in Tonkkhurd sampled farms.

Investment requirements and sources of funds

We next provide an estimate of the finances required to make this happen. Table 20 below provides some estimates. The total investment requirement for 5,800 structures works out to INR 786 million. Assuming that farmers must pay at least 20% of the investment requirement from their own personal resources, the remaining investment requirement works out to INR 629 million.

The government has been providing a subsidy to farmers to partly meet the high cost of investment. The amount is limited to 50% of the cost of construction subject to a maximum of INR 80,000. The amount of subsidy also varies according to size of the farm and the structure. Assuming the maximum amount of government subsidy is INR 50,000 per structure, the total subsidy outgo from government works out to INR 290 million. This still leaves a gap of INR 339 million to be bridged. If the government can persuade financial institutions to treat lending for investment in water harvesting structures as a priority sector and make small farmers eligible to take INR 50,000 as a loan for this purpose, then the financial gap remaining to be filled reduces substantially to INR 49 million.

Table 20. Investment requirements under three alternative assumptions (in million INR)

Cost of one structure	INR 135,580		
Number of structures	5,800		
Total investment requirement	INR 786.36 Million		
	Model 1 No subsidy	Model 2 With Subsidy	Model 3 Subsidy + Loans from financial institutions
Total investment requirement (million INR)	786.36	786.36	786.36
Farmer's contribution (20%)	157.27	157.27	157.27
Government subsidy (INR 50,000 per structure)		290	290
Loans from financial institutions (INR 50,000 per structure)			290
Financial requirements from donors (million INR)	629.09	339.09	49.09
In million USE	13.98	7.54	1.10

Bridging the financial gap: possible role of donors

Depending upon whether the government provides a subsidy or not and depending upon whether financial institutions provide credit to farmers or not, the residual financial requirements can vary over a wide range - from about 630 million INR in a no-support scenario to just INR 49 million in a full-support scenario. Depending on the extent of government and financial institution support available. donors and venture capitalists can help bridge this gap by providing bridge finances.

If a donor is willing to provide bridge financing, an appropriate business model can be worked out. We envisage that donor money can be managed by a reputable micro credit institution, a privately managed financial institution or a an NGO. Since financing water resource development is not a normal lending activity of such institutions, they can be encouraged to start a new line of credit which may be called "rain water harvesting loans" with donors providing the initial funds. These loans can be provided at zero cost to farmers who are willing to invest in building rain water harvesting structures. Depending upon whether the government subsidy and financial institution support to farmers is available or not, the duration of these loans can vary from one to three years since that is the maximum payback period required to recover the entire cost of construction.

Farmers taking loan can start repayment within one year of taking the loan. The amount recovered can be loaned to the next group of farmers. In lieu of the services provided for managing the donor money, the donor can annually reimburse the institution for its cost involved in managing the fund. At the end of say 10 years, the rotating donor money would have helped investing farmers and donors can get back their money without earning any interest. The cost to the donor is the opportunity cost of the capital invested plus the administrative costs it pays to the managing institution for managing the funds.

A detailed business model including the cash flow statements and the number of farmers can be worked out. The approach requires working in partnership with the government and financial institutions as they are stakeholders in the same venture.