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Research Article

UTILITY OF SMALL WATER HARVESTING STRUCTURES FOR AGRICULTURE

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ABSTRACT
The significance of traditional water harvesting structures is very well realized in the current context of increasing competition and conflict over water for multiple uses in India. The emphasis since the British rule in the country has been on the expansion of big and medium irrigation based on the principles of modern science and centralized management and administration. As a result the traditional systems of small water harvesting structures (SWHSs) have deteriorated sharply. This has accentuated the water crisis in the country. There is not much data and information available about the traditional SWHSs which existed in different parts of the country. Having noted the fact that the SWHSs could make a very significant contribution in resolving the water crisis, it is essential that some concrete efforts were made to understand the conditions and important issues related to these structures. Keeping this in view, a project was given to the Institute of Rural Management, Anand (IRMA) by the Society for Promotion of Wastelands Development (SPWD), New Delhi in 1998 to prepare a status paper on the traditional SWHSs in India, in which also shows importance and utility of SWHSs. The scope for installation of large and medium irrigation projects is limited due to lack of availability of proper sites, paucity of funds, equity issues and other social factors in many regions of the country. Therefore the installation of 'small but decentralized structures' for water harvesting has a great potential in the times to come. A recent initiative in Chhattisgarh, India to promote government funded, rainwater harvesting structures (Percolation Tank, Stop Dams, Gabions and Subsurface Dams) in villages has shown substantial economic and livelihood benefits. In contrast to the many poorly functioning, community managed rainwater harvesting programs, the individual or decentralized rainwater harvesting structures have led to significant improvements in availability of irrigation water, a revival of the agricultural economy of the region, and substantial increases in farmer incomes and lively hoods. The impact of small water harvesting structures on study area i.e. village and village community in Patan Block is positive and significant. The small water harvesting structures are prove that only the large water harvesting structures like masonry dams, structures of major irrigation projects are not fulfill the water requirement of human community of any village or block for irrigation as well as for domestic purpose. Crop productivity increases significantly and ground water level rise effectively by establishing the small water harvesting structures in water scarce areas of the Patan block. It was found that about 60 percent runoff conserved by the cascade of different small water harvesting structures and utilize the stored water for supplemental irrigation to *kharif* crops.

Keywords: *Percolation Tank, Stop Dams, Gabions, Subsurface Dams*

INTRODUCTION
India has a long tradition of harvesting rainwater, dating back more than two millennia. Evidence of this tradition has been found in ancient texts, inscriptions and archeological remains (http://www.gits4u.com/water/water6.htm). While the tradition diminished considerably in the early part of the 20th century due, in part, to an emphasis on large scale irrigation projects, the practice has experienced a revival recently for a variety of reasons (Agarwal and Narian, 1997). In a country with more than 86 million ha of rainfed agriculture (Sharma *et al.*, 2008), rainwater harvesting offers supplementary irrigation as well as protection against climate variability. It also offers additional options for farmers, who were previously dependent on groundwater resources and now are experiencing fast

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declining water tables due to overexploitation. Rainwater harvesting is gaining favor as a positive alternative to costly large-scale irrigation infrastructure projects, particularly in light of growing opposition to the impacts of these large structures on India's environmental, ecological and social landscapes (Rangachari *et al.,* 2000; Briscoe and Malik, 2006; Shah, 2013). As a result, the last two decades have witnessed a significant increase in rainwater harvesting efforts, albeit in ways that are markedly different from their traditional prototypes, in terms of the context and purpose (Kumar *et al*., 2008). Most past efforts in rainwater harvesting have been initiated by the government, although communities and non-governmental organizations (NGOs) have been important stakeholders. Government support for the structures has come through direct rainwater harvesting programs or through complementary investments in watershed development (e.g., India's Integrated Watershed Development Program), micro-watersheds, check dams, small tank revival, and groundwater recharge. With the support of national and state governments, rainwater harvesting structures are generally built on communal land, and, ultimately, are collectively managed through the formation of local water user groups in an effort to promote efficient management of the structures and equitable allocation of the resource. While community management is often promoted as a means to improve resource productivity, the model has been a source of many failed institutional interventions in India, including participatory irrigation management (PIM) and irrigation management transfer (IMT) (Shah, 2007). A review of the IMT/PIM literature suggests that community management of natural resources does not always produce the desired results of greater participation or empowerment of stakeholders, nor has such devolution always led to better management, more equitable access to water resources, or improved sustainability of the structures or the resource itself (FAO, 2007; Vermillion *et al.,* 1999; Meinzen-Dick, 1997). Mukherji *et al.*, (2009) examine 108 cases of IMT/PIM in public irrigation systems in India and other parts of Asia. The authors find that successful cases of IMT/PIM occur only under a set of context specific factors, which are either impossible to replicate, or very costly and there-fore, impractical to replicate elsewhere. The authors conclude that transferring irrigation systems to communities does not necessarily ensure better management of such systems (Mukherji *et al.,* 2009).

Outcomes from watershed development programs in India, and community managed rainwater harvesting in particular, show similarly mixed results with unsuccessful projects significantly outnumbering successful ones (Sharma, 2009). One of the most intractable problems in watershed development has been the lack of sustainability. Many projects fail to include strategies to maintain communal assets once project support ends (Sharma, 2009), and farmers often view the benefits as short term, through paid labor for construction (Joy, 2003).

As a result, communities often have little interest in the longer-term operation and maintenance of project assets. This approach emphasizes decentralized water harvesting structures built on village level as a micro watershed basis.

In this paper, we analyze the experience in Patan block, Durg district, Chhattisgarh, where there has been significant government investment in small water harvesting structures since 2006, following precipitous declines in groundwater levels and, consequently, agricultural production. We examine the impacts of the ponds on crop production and other farmer-reported changes to the region's agricultural and environmental landscape.

The scope for installation of large and medium irrigation projects is limited due to lack of availability of proper sites, paucity of funds, equity issues and other social factors in many regions of the country. Therefore the installation of 'small but decentralized structures' for water harvesting has a great potential in the times to come. Small water harvesting systems are environmentally sound and apart from increasing biomass production, they have the additional benefits of flood and drought moderation, ground water augmentation, employment generation and improvement in socio-economic conditions of the people. The term "Utility of Small Water Harvesting Structures" implies collection of inevitable runoff by small water harvesting structures like Check Dams, Percolation Tanks, Stop Dams, Subsurface Dams and Gully Plugs for efficient storage of harvested water, its application and optimum utilization for maximizing production.

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MATERIALS AND METHODS

We formulated this case study following an initial scoping study and stakeholder survey in Chhattisgarh to identify promising, existing small scale agricultural water management practices. Several practices were highlighted through this process, including the significant government investment in small water harvesting structures in Patan block, Durg district, Chhattisgarh. Following initial interviews with district officials, non-governmental agencies and farmers, we selected this case study as one of several for further analysis. We collected detailed primary data through personal interviews in August 2012 using a customized, structured questionnaire administered based on a random sample of many farmers who have takes benefits in decentralized rainwater harvesting structures (beneficiaries farmers) and non beneficiaries farmers who have not benefited in such. We assessed the impacts on cropping intensity, cropping patterns and yield, and the benefit-cost ratio by comparing a selected number of indicators before and after establishment of small water harvesting structures.

Other impacts on the agricultural and environmental landscape, including livestock and fisheries cultivation, groundwater recharge and changes to the surrounding environment, are reported based on information obtained during the survey. Since the intervening period between the project intervention and this assessment has been very short (varying between 2 and 5 years), we believe it is reasonable to assume that the influence of non-project related factors, if any, has been insignificant. In addition to the primary data, we gathered information also through structured discussions with officials at the district, block and village level.

We interviewed NGO representatives, private sector entrepreneurs undertaking the construction work of water harvesting structures, and several other individuals engaged in complementary services, such as agricultural marketing, input supply, and equipment supply.

This section covers the description of methods applied materials used, instruments and equipments used and systems adopted to perform the operation involved to achieve the objectives of our study. The study about utility of small water harvesting structures was carried out at twelve villages of PATAN Block, DURG C.G. under Integrated Watershed Development Programs (IWDP). The study was divided into various parts; survey of small water harvesting structures and assessment of that structures.

The Study Area

After scrutiny of various small water harvesting structures in Chhattisgarh, Patan block in Durg districts was chosen for the study because most of the data including meteorological, hydrological and hydro geological data are available for this district. Durg District is situated in Chattisgarh state of India. Until 2000 it formed part of Chhattisgarh. District headquarters is Durg. The district covers an area of 8,537 km². Patan is located at 21°02′N 81°32′E 21.03°N 81.53°E. It has an average elevation of 280 meters (918 feet). Patan is 32.5 km far from its district main city Durg. It is 24 km far from its state capital city Raipur.

Meteorological Data

The Patan Block experiences sub-tropical climate and is characterized by extreme summer and winter seasons. The summer months are from March to May and the months of April and May are the hottest. The rainy season extends from the months of July and August. Winter season is marked by dry and cold weather with intermittent showers during the months of December and January. The month of June to September with well distributed rainfall through southwest monsoon. Monsoon generally breaks in the third week of June and is maximize in the months of July and August. Winter season is marked by dry and cold weather with intermittent showers during the months of December and January.

Agro Climate

Patan generally has a dry tropical weather which is moderate but on a warmer side in summer season. The peak temperatures are usually reached in May/June and can be as high as 45°C. The onset of monsoon is usually in the month of July and the season extends up to September, with monsoon peaking during July and August. The maximum, average and minimum rainfall of Patan Block are 2126 mm, 1138.12 and 571 mm respectively. The monthly normal of meteorological parameters at study site is shown in Table 3.1.

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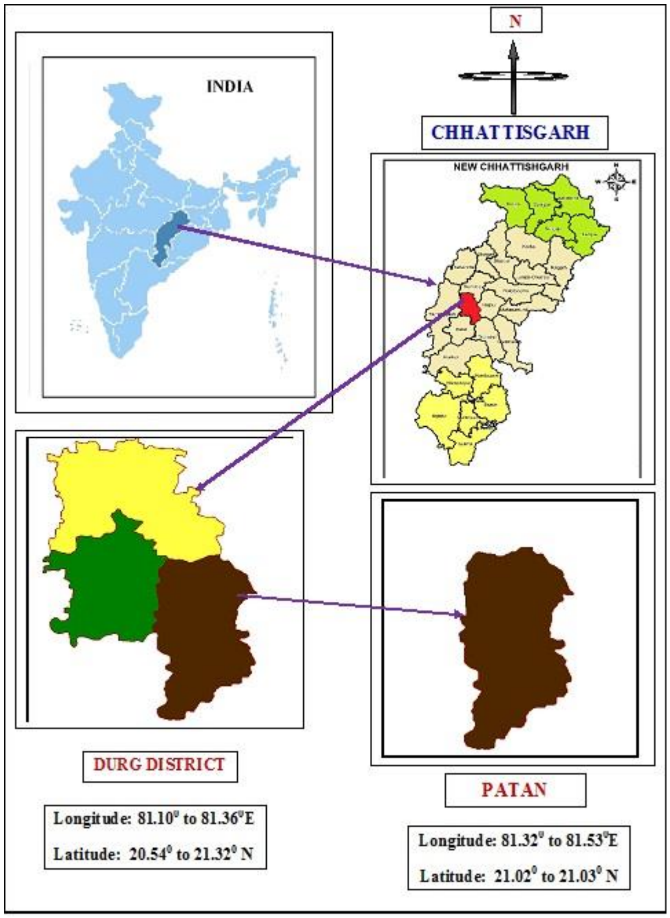

Figure 3.1: Location of study area

Table 3.1: Monthly average values of meteorological data (1993-2010)

Month	Mean air temperature, (°C)				R.H. %	Mean wind speed, km h^{-1}
	Daily max.	Daily min.	Highest	Lowest		
Jan.	27.9	12.5	30.8	7.6	66.0	2.6
Feb.	30.9	15.5	34.2	10.2	60.0	3.7
Mar.	34.7	19.6	38.1	14.2	49.0	5.3
Apr.	38.1	24.4	41.1	19.4	46.0	7.1
May	40.2	27.6	43.2	22.6	45.0	8.6
June	35.5	26.1	41.6	21.8	66.0	10.2
July	29.8	23.8	33.6	21.6	81.0	9.6
Aug.	29.2	23.5	32.2	21.6	84.0	8.6
Sept.	30.2	23.1	32.8	21.0	81.0	5.9
Oct.	30.6	20.3	32.9	15.6	76.0	3.2
Nov.	29.0	15.1	31.1	10.9	70.0	2.7
Dec.	27.3	12.1	29.7	8.1	69.0	1.0

Rainfall

The Patan Block receives rainfall mainly from south-west monsoon. It sets in third/fourth week of June and continues till mid August/September with heaviest showers in the months of July and August. The mean annual rainfall for the past 21 years is 1094.86 mm, out of which 97% (1094.86 mm) occurred during the monsoon period, in Table 3.2.

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Table 3.2: Pattern of rainfall - Average monsoon and annual rainfall

	Patan block Avg.										
Year	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	
Monsoon	1478.4	866	1520	1230	749	803	998	1344	1065.3	1224.5	1078.38
Annual	1478.4	895.4	1608	1230	749	803	998	1385	1094.8	1250	1097.88

Temperature
The temperature in the Block changes continuously with the season and even in day and night. The temperature decreases progressively after October. The winter season lasts till February. January is the coldest month with mean daily maximum temperature at 30°C and the minimum is around 10°C. During winter season, the night temperature sometimes may drop below 10°C. The temperature increases rapidly from mid February till May and sometimes up to mid-June (summer season). The mean daily maximum temperature in summer season goes up to 46°C and nights are slightly warmer during May and mid-June. The monsoon period is generally pleasant. With the withdrawal of the monsoon by the end of September, day temperature rises a little and then both day and night temperatures begin to drop rapidly.
Humidity
The atmospheric humidity is usually low during summer months around 25%. However humidity slowly starts building up from third week of May and it reaches maximum around 85% during monsoon period. The humidity again decreases in winter season and it varies between 30 to 40% during winter season.
Wind Velocity
The wind flows easterly or westerly during the south-west monsoon period. During Post-monsoon and winter seasons the wind directions are between north and east and sometimes westerly. The wind speed of more than 10 km/hr is recorded during the monsoon months (from June to September). In the post-monsoon and winter months (from October to February), the wind speed is less than 5 km/hr and in the summer months (March to May) the wind speed is more than 7 km/hr.
Soil Resource Data
Generally soils are classified on the basis of texture, mineral content and presence of salts and alkalis. However in present context the classification and distribution is adopted as per the soil orders in US soil taxonomy and their Indian equivalents. There are 12 orders in US soil taxonomy but only three orders are found in Patan Block. They are described in brief below and given in Table 3.3 and Table 3.4.

Table 3.3: Soil Classification

S. No.	**US Soil Taxonomy**	**Indian Equivalents**
1	Ultisols	Lateritic soil
2	Vertisols	Medium black soil

Table 3.4 Area under different soil texture prevailing in the Patan Block

Soil type	**Local name**	**Area (ha)**	**Percent of total area**
Deep black soils	Kanhar	39302	59.18
Medium Black soils	Dorsa	21763	19.69
Lateritic soils	Matasi	15135	21.13

RESULTS AND DISCUSSION
Small decentralized rainwater harvesting structures have played a positive role in alleviating severe water scarcity challenges in Patan block, Durg district, Chhattisgarh. However, farmers who have benefited by the small water harvesting structures have experienced improved water availability through rainwater harvesting, which in turn has directly and indirectly improved the socio-economic conditions of rural population and environmental landscape of the region. Furthermore, the decentralized nature of the

structures has avoided many of the management and sustainability issues faced in community approaches to rainwater harvesting, including the allocation of shared resources and the maintenance of the supporting assets. Further up scaling this option, however, requires consideration of two key issues. The first relates to resource sustainability.

As noted above, positive environmental impacts were noted by farmers in the block following the implementation of small scale rainwater harvesting structures, related to the surrounding ecology as well as, and importantly for the region, groundwater recharge.

The potential downstream impacts need to be further studied, however, before implementing the model on a larger scale. An assessment in a semi-arid watershed in Andhra Pradesh, for example, found that while rainwater harvesting improved crop yields and groundwater recharge locally, water outflows from the developed area declined significantly resulting in potentially large negative impacts for downstream users (Garg *et al.*, 2011).

Moreover, within the study region itself, increased cropping intensity following the introduction of small scale rainwater harvesting, may in fact result in more water being available to recharge groundwater supplies. The second issue relates to equity.

MGNREGA now covers the entire country with the exception of districts that have 100% urban populations.

The majority of the permissible works being carried out under MGNREGA relate to building small scale water harvesting structures to enhance water security in rural areas. It is applicable to regions of Patan, Durg and elsewhere that receives moderately high rainfall, and offers a potentially more sustainable option to groundwater irrigation.

The impact of small water harvesting structures on village and village community in Patan Block is positive and significant. The small water harvesting structures are prove that only the large water harvesting structures like masonry dams, structures of major irrigation projects are not fulfill the water requirement of human community of any village or block for irrigation as well as domestic purpose.

Impact Assessment of SWHSs on Village Community in Patan Block, Durg District

Increase in Ground Water Level

This is clear that the ground water level rise positively by establishing the small water harvesting structures in water scarce areas of the Patan block. Effect of SWHSs on ground water level is shown in table 4.1.

Table 4.1: Effect of SWHSs on ground water level of different villages in Patan, Durg

S. No.	Name of Micro Watershed	Name of Zone	Before establishment of SWHSs, GWL (m)		After establishment of SWHSs, GWL (m)		Rise of GWL (m)	
			Pre Mon-soon	Post Mon-soon	Pre Mon-soon	Post Mon-soon	Pre Mon-soon	Post Mon-soon
1	Marra	Upper	8.50	2.20	8.10	1.80	0.40	0.40
2	Semri	Middle	7.00	1.50	6.65	1.05	0.35	0.45
3	Sipkona	Discharge	8.55	6.65	8.20	6.15	0.35	0.50
		Average	8.02	3.45	7.65	3.00	0.37	0.45

Increase Crop Productivity

Small water harvesting structures shows a positive effect for crop production because it fulfill proper requirement of irrigation water by many different path like lifting water, temporary channel service and through seepage. It provides supplemental water for paddy after rainy season and maintains proper moisture in soil for *Rabi* crop (Gram, Wheat).

Table 4.2: Effect of SWHSs on crop productivity in different villages of Patan, Durg

S. No.	Name of Village	Crop productivity before establishment of SWHSs (qtl/ha)			Crop productivity after establishment of SWHSs (qtl/ha)		
		Paddy	**Wheat**	**Gram**	**Paddy**	**Wheat**	**Gram**
1.	Bodal	30	-	-	57	29	17
2.	Dangniya	35	17	11	60	27	19
3.	Gujra	13	19	7	30	60	18
4.	Khamaria	34	-	-	58	30	19
5.	Marra	26	12	8	65	29	20
6.	Matang	29	15	5	57	23	14
7.	Matia	31	13	9	56	28	16
8.	Santra	32	11	-	53	23	17
9.	Semri	34	14	-	60	30	18
10.	Sipkona	33	-	-	58	22	17
11.	Sonpur	28	-	7	59	23	17
12.	Soram	32	10	6	55	25	15

Amount of Water Conserved by SWHSs in Patan, Durg

Small water harvesting structures are conserved water maximum as compare to other large structures in any village and utilize the stored water for the purpose of agriculture as well as for domestic purpose. Due to SWHSs are interconnected by artificial channels which catch maximum runoff in rainy season. Amount of conserved water by small water harvesting structures are shown in Figure 4.1. Percolation tank, stop dams, check dams and farm ponds are conserved more than 50% of runoff water and rest of structures are employing mainly reducing soil erosion. By figure it shows that the one third of the rainfall water not conserved by any water harvesting structures in villages of Patan Block.

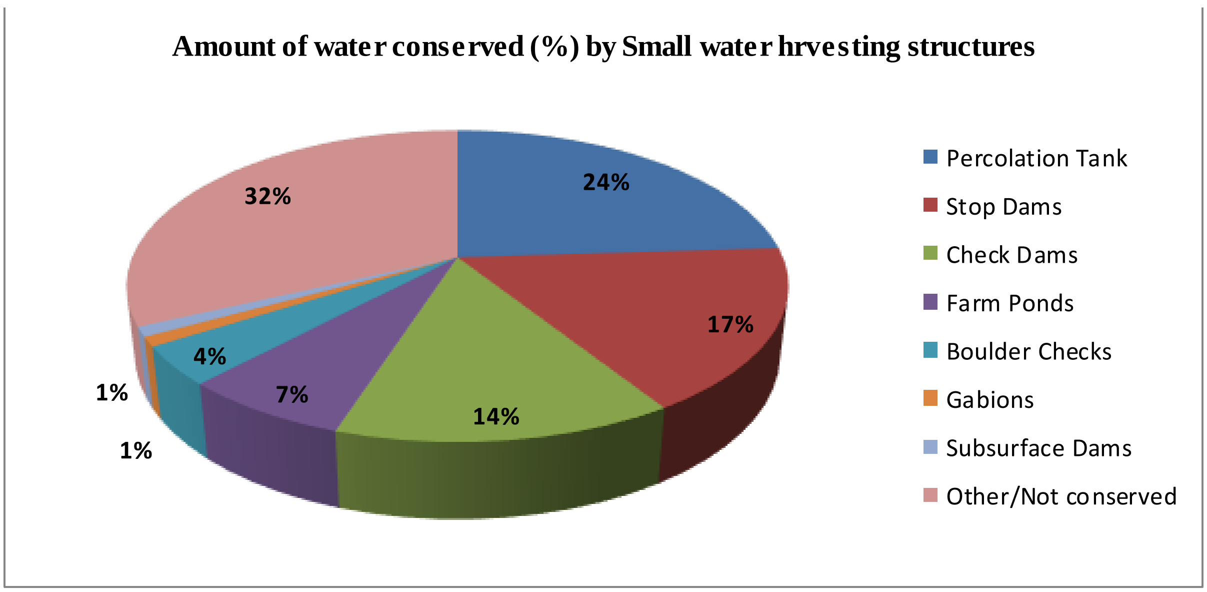

Figure 4.1: Amount of conserved water by small water harvesting structures

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