Int.J.Curr.Microbiol.App.Sci (2020) *9*(10): 2938-2947

International Journal of Current Microbiology and Applied Sciences
***ISSN: 2319-7706* Volume 9 Number 10 (2020)**
Journal homepage: http://www.ijcmas.com

Case Study https://doi.org/10.20546/ijcmas.2020.910.354

On-Farm Water Harvesting: Promising Intervention towards Crop Diversification and Doubling Farmers Income in Drought Prone Central Province of India

D. S. Tomar[1*], Ishwar Singh[2] and Rekha Tiwari[1]

[1]Krishi Vigyan Kendra, Ujjain (M.P), Rajmata Vijaya Raje Scindia Krishi Vishwa Vidyalaya (Gwalior), India
[2]Krishi Vigyan Kendra, Gariaband (C.G), India

**Corresponding author*

Keywords

On-farm water harvesting, Crop diversification

Article Info

Accepted:
24 September 2020
Available Online:
10 October 2020

A B S T R A C T

On farm water harvesting and reuse of rain water will be a critical intervention in rainfed farming will remain the main stay for the livelihood support of millions of small and marginal farmers across the country even after realizing the complete irrigation potential. Rainwater management is the most critical component of rainfed farming. The successful production of rainfed crops largely depends on how efficiently soil moisture is conserved in situ or the surplus runoff is harvested, stored and recycled for supplemental irrigation. Diversification of crops from the existing cropping system and adoption of related enterprise fetches more income to the farmer. System productivity can be made more than four times by increasing the cropping intensity of any farm. Despite these experiences, the adoption of farm ponds at the individual farm level has been very low, particularly for drought proofing through life saving irrigation of kharif crops. A number of technological and socio-economic constraints are cited for this poor adoption and up-scaling. With climate change posing a major challenge for rainfed agriculture and the constraints in further expansion of irrigated area in the country, rainwater harvesting and efficient water use are inevitable options to sustain rainfed agriculture in future.

Introduction

Indian economy is largely agriculture driven with nearly 55% of the population depending on it and allied sectors for their livelihoods while it contributes only 15% to the nation's GVA. Marginal and small land holdings (under 2 ha) comprise 85% of the total operational land holdings both in terms of number and area. Of 193.7 million ha, around 45% (87.7 million ha) is irrigated while the rest is rain fed. Groundwater and surface water sources irrigate about 31% and 68% of the irrigated area respectively (GOI 2017a). In addition to water scarcity and increasing land degradation, Indian farmers are vulnerable to impacts of climate change as their livelihood largely depends on monsoon, markets and intermediaries who are integral part of their lives but are unpredictable and play havoc on

rural livelihoods. With the agricultural growth rate stagnant around 3 to 3.5 % annually, farmers are in economic distress despite huge subsidies being pumped to farm sector. The brighter side of the economy is that, Indian agriculture has many advantages, which includes robust demand (domestic and international), largest agricultural land (> 157 million ha) with 15 agro-ecologies and 46 different global soil types uniquely positions India to design, develop and deliver solutions for smallholder farmers in India.

Popularizing innovative technologies and achieving larger impacts on the ground requires the involvement of various stake holders. Further, Mechanism and models of delivery will require focused funding, institutional incentives, behavioral change, and rethinking on the role of public extension systems (World Bank, 2013). For strengthening the technology delivery system, 706 plus KVKs across the country have played a larger role in skill development and participatory technology demonstration to address location-specific constraints. These solutions can then be scaled through targeted dissemination that will empower farmers to act on ecologically sound and marketable options to increase their incomes. Besides, Agricultural Technology Management Agency (ATMA) has given an institutional identity to extension, strengthen linkages with other line departments and *Krishi Vigyan Kendras* (KVKs).

Water Harvesting

Water is one of the most critical inputs in agriculture having a determining effect on the eventual yield. Good seeds and fertilizers or any other innovative technology fail to achieve their full potential if plants are not optimally watered. India accounts for about 17% of the world's population but only 4% of the world fresh water resources. Distribution of these water resources across the vast expanse of the country is also uneven. Indian agriculture is a gamble of monsoon rains received during the four months of the year i.e., from June to September. Since more than 54 percent of the arable land is dependent on rains, hence water harvesting is the only viable option to carry out the agricultural activities so as to feed the ever burgeoning population on one hand and on the other owing to fast industrialization and urbanization there is a huge pressure on arable land as more and more area is being put into non-agricultural work, thus demanding more production per unit area and more crop per drop of water. For scientific and meaningful water harvesting the total annual precipitation received plays a crucial role particularly when climate change and global warming has made its presence felt more consistently over the last few decades.

Distribution of Annual Rainfall in India

Distribution of rainfall in the Indian Sub-continent is mostly influenced by the relief features on the surface of the Earth and the direction of the rain-bearing winds in that region. Apart from the above factor, the path followed by the cyclonic depressions decide the amount of rain at any place.. The region located on the windward side of mountains, hills or plateaus receives comparatively more rainfall than the leeward side, Majumdar (2002). The normal annual rainfall precipitation in the country is estimated to be 400 million hectare-metres (Mha-m) of water. India's water budget has been estimated and reported by Gupta and Deshpande (2004), Kumar et al (2005), and Garg and Hassan (2007). These analyses are based on estimates of water budget components presented in a report by the National Commission for Integrated Water Resources Development Plan (Ministry of Water Resources 1999).

Importance of Rainwater Harvesting

Rainwater harvesting is defined as a method for inducing, collecting, storing and conserving local surface runoff for agriculture in arid and semi-arid regions (Boers and Ben-Asher, 1982). Rainfall has four facets. Rainfall induces surface flow on the runoff area. At the lower end of the slope, runoff collects in the basin area, where a major portion infiltrates and is stored in the root zone. After infiltration has ceased, then follows the conservation of the stored soil water. Verma *et al.,* (2008) indicate that decentralized small water harvesting structures are very good alternative to the conventional river basin irrigation infrastructures which requires high initial investment and hence not affordable by individual farmer. Several studies have reflected that a clear relationship between the size of catchment and amount of run-off that can be captured exists. Increasing the size of the catchment from 1 hectare (ha) to about 2 ha reduces the water collection per hectare by as much as 20 to 25 per cent. Thus, in a drought prone area where water is scarce, tiny dams with a catchment of 1 ha each will collect more water than one larger dam with huge catchment. Similar inferences have been drawn by Moench and Kumar 1993, Khurana 2003, and Rockstrom *et al.,* 2009. Shah and Raju (2001) studied the socio-ecology of tanks and water harvesting in Rajasthan reported that there are multiple benefits from tanks. Tanks lead to substantial rainwater harvesting at the local level, and the associated distribution system leads to water availability in large areas and to larger numbers of farmers.

Most significant effect of percolation of rainwater is groundwater recharge along with higher water table in the area. Other benefits include low cost flow irrigation, reduction in intensity of flash floods, concentration of silt and minerals to fertilize the soil in the command area, and reduction in soil erosion.

Why Double Farmers' Income. ?

The major dilemma of more than 138 million Indian farmer's is that they are facing a decline in their farm income on one hand and the increasing cost of inputs on the other, both of which are parallel in nature and have no chances to intersect at a common point. A recent study by the National Institute of Agricultural Economics and Policy Research (NIAP) has shown that around 70% farmers in the country have annual per capita income less than Rs.15, 000. NIAP have further analyzed the situation geographically and finds that, the problem is precarious in Uttar Pradesh (27.4%), Bihar (11.4%), West Bengal (9.9%), Odisha (6.3%), Rajasthan (5.8%), Madhya Pradesh (5.3%), Maharashtra (4.9%), Assam (3.9%) and Jharkhand (3.2%) as, these states lack the required infrastructure for agricultural income growth. NITI *Ayog* (Formerly Planning Commission of India) concluded that, the post Independence strategy for the development of agriculture was dependent on the following factors.

a. Increase in productivity through the drivers of Green Revolution.
b. Incentive structures I the form of remunerative prices for some crops or subsidies for the other.
c. Public investment in the sector and
d. Facilitating the Institutions.

The above strategy fell short in realizing the increase in farmers' income. Under actual production scenario, increase in production should have also led to increase in farmers' income. But the real fact is that instead of increase in income, there was a steep down fall so much so that the income of farmers was below the poverty line leading to mass suicide in some states of the country between

1994 to 2004. Situation in states like Jharkhand was so precarious that more than 45 per cent farmers were below the poverty line. There was also a disparity between the incomes of different sectors of economy. Those engaged in farm related activities, the income was far less than the non-agriculture sector by more than four times. The low and fluctuating farm income led to loss of interest in agriculture and particularly the youth started leaving this profession and migrating to urban areas for search of bread and butter. All the above factors forced the Government to pay special attention to the farming community of the country and hence the year 2015-16 was selected as base year and the target was fixed that the income of farmers' would be doubled by 2022 based on the economic parameters prevailing during the base year. This means that Indian agriculture needs to grow by more than 14.86 per cent annually to meet the target, Gulati 2016.

Materials and Methods

Case study

Rapid expansion of groundwater use in *Malwa* plateau of Madhya Pradesh in the last three decades has resulted in a steep decline in the groundwater table. This has led to drying up of a huge number of wells, low well productivity, and rapid rise in well and pumping depths, deteriorating groundwater quality, and also salinity / alkalinity problem in many areas. Rain-fed agriculture is practiced on 80 % of the world's agricultural land area, and generates 65-70 % of the world's staple foods, but it also produces most of the food for the poor communities in developing countries and least favored areas. Rain-fed areas in India are highly diverse, ranging from resource-rich areas with good agricultural potential to resource-constrained areas with much more constrained potential. It is in the rain-fed regions where cultivation of nutritious (coarse) cereals (91 %), pulses (91 %), oilseeds (80 %) and cotton (65 %) predominates. Rainfall is a truly random factor in the rain-fed production system, and its variation and uncertainty is high in areas of low rainfall. Supplemental irrigation is a key strategy, so far underutilized, to unlock rain-fed yield potentials. Since time immemorial, water conservation and harvesting have been practiced in India and other parts of world. The production process depends on the timely water conservation in Talab, pokhar, johad, khet talab, and bandhan which will provide the supplemental or life saving irrigation. The objective of supplemental irrigation is not to provide stress-free conditions through the crop growth for maximum yields, but to provide just enough water to tide over moisture scarcity at critical growth stages to produce optimal yields per unit of water (Oweiss *et al.*, 1999; Sharma and Smakhtin 2004). In this precarious situation integration of different agriculturally related enterprises with crop activity as base, provide ways to recycle the products and by-products of one component as input to another serves to realize the best use of available natural and manmade resources.

Ujjain district of *Malwa* Agro-climatic zone in central India is a drought prone area with unsustainable production systems. Krishi Vigyan Kendra working here as a developmental agency for the transfer of technology to the farmers conducted On-Farm trials from 2014 to 2017 in five different agro-ecological situations by emphasizing on the harvesting of run-off water in suitable storage structures. Water harvesting tanks with a capacity of 6000 to 7500 cubic meter constructed at the lower end of the catchment in five different villages, served as the base for increasing the cropping intensity, change in the cropping sequences, incorporation of market driven cash crops and increase in the overall system productivity.

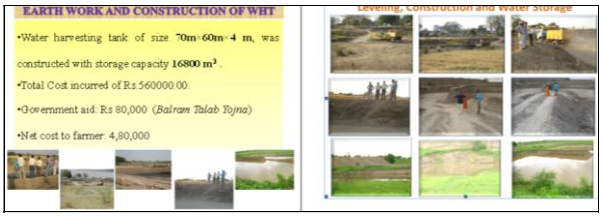
Intervention

To assess the impact of rain water harvesting structures at the farm level, On Farm trial was planned based upon the Participatory Research Appraisal with the help of the beneficiaries of the village and the most critical problem i.e. the shortage of irrigation water was taken up. This problem was the basic hindrance in diversification of crops and in adoption of new technologies or cropping system. For this, five independent sites under two different agro-ecological situations were selected and the interventions were implemented in three different phases as described below.

At the first instance water harvesting tanks measuring 70*60*4 m^3 was dug out at the lowest elevation having not less than 2.0 ha of catchment area. Thus a pond of size 16,800 m^3 was available to the farmer for rainfall storage. The entire expenditure was subsidized by the state government @ Rs 80,000 per tank to promote the farmers. After the rainy season the tanks were loaded with full capacity and then the plan for the diversification was given to farmers providing new varieties and complete package of practice.

The plan was executed continuously for three consecutive years and the emphasis was paid in increasing the grossed cropped area with the help of supplemental irrigation from the tamk. Simultaneously, high yielding crop varieties and inclusion of cash crop like potato was also introduced. A separate unit to recycle the farm waste was prepared and vermin-compost was prepared and used in the fields to maintain the soil physical conditions and to increase the water use efficiency.

At the end of fourth year the farm produce was subjected to Seed Certification process so that the entire production received could be sold out as seed and a higher remunerative could be fetched by the farmer. The yearly progress on diversification, sequential change in various economic parameters, change in family income and finally the change in enterprise reflected is presented below through different tables 1–6 and figures 1–3. The events of intervention are shown as pictorial graphics below.



Results and Discussion

The results of four years study revealed that during the base year the cropping intensity of all the farmers ranged between 135 to 143 percent under the conventional soybean based cropping system, in which soybean was followed by wheat and or chickpea and the total system productivity was 6.4 kg/ha /day. After full storage of water tanks the total water stored was 2 to 3 irrigation was made possible at critical stages and the farmers shifted from the conventional cropping sequences to soybean-potato-wheat, soybean-potato-onion, and soybean –green peas-wheat-fodder. Crops were also substituted with additional enterprise taking 5 to 6 milch animals for better utilization of farm wastes and the by-products of the animals was utilized to prepare sight specific nutrient options to take care of decreasing soil health mainly due to loss of organic carbon. The cropping intensity increased to more than 262 and the system productivity in terms of soybean equivalent yield increased to 64.8 kg/ha/day. This was reflected in terms of increase in yield per unit area due to higher water use efficiency, increased nutrient use efficiency, increase in milk yield due

availability of green fodder, etc. This was a quantum leap in the net income from mere Rs 4224 per month to Rs 38400 per month per family through the system approach, which is far more than doubling of income of farm families. The increase in family income led to change in the life style particularly in the field of food, hygiene, children education and affording the luxurious amenities Thus the results are clear indicative of the facts that the above model of integration of resources is capable to combat the vagaries associated with the changing climatic scenario and the above model is resilient to climatic aberrations.

Data in table 6 pertain to a new intervention when the farm families were asked to change the enterprise and sell their entire agriculture produce as seed after due certification process. As a result of that the total produce of 1670 qt was certified as seed and the income rose from Rs 48638 / ha to Rs 64240 / ha. This is a rise in income by 32.1 percent and the Incremental Cost benefit Ratio was 4.49 i.e. almost the double from the conventional farming. Thus the case study clearly reflects the possibility, means and measures of doubling the farm income with assured irrigation and diversifying the crops and enterprise.

Table.1 Principal annual components of India's water budget

Component	Volume (km^3)	Precipitation (%)
Precipitation	3838	100
Potential flow in rivers	1869	48.7
Natural recharge	432	11.3
Available water	1869 + 432 = 2301	60
Evapo-transpiration	3838 − (1869 + 432) = 1537	100 − (48.7 + 11.3) = 40.0

Source: Gupta and Deshpande (2004); Planning Commission (2007)

Table.2 Productivity and Economics of Crop Production in the Base Year

Year	Season	Crops	Area	Production	Gross Income	Cost of Cultivation	Net Income
2014-15	**Kharif**	**Soybean**	**16.5**	**206.25**	**371250**	**156750**	**214500**
	Rabi	**Wheat**	**4**	**128**	**147200**	**30000**	**117200**
		Gram	**5.5**	**52.25**	**104500**	**52250**	**52250**
		Gross Area	**26**	**386.5**	**622950**	**239000**	**383950**
		Cropping Intensity	**159.4**	**System Productivity = 4.07 kg/ha/day**			
		Prod./day (Kg/day)	**106**				
		Gross Income./day (Rs/day)	**1707**				
		Net Income./day (Rs/day)	**1052**				
		B:C ratio	**2.61**				

Table.3 Productivity and economics of crop production in the second year as affected by crop diversification

Year	Season	Crops	Area	Production	Gross Income	Cost of Cultivation	Net Income
2015-16	Kharif	Soybean	20	270	486000	190000	296000
	Rabi	Wheat	8	280	322000	60000	262000
		Gram	4	44	88000	38000	50000
		Potato	3	525	262500	135000	127500
		Onion	2	500	250000	96000	154000
		Gross Area	37	1619	1408500	519000	889500
		Cropping Intensity	185	System Productivity = 11.98 kg/ha/day			
		Prod./day (Kg/day)	444				
		Gross Income./day (Rs/day)	3859				
		Net Income./day (Rs/day)	2437				
		B:C ratio	2.7				

Table.4 Productivity and economics of crop production in the third year as affected by crop diversification

Year	Season	Crops	Area ha	Production (Qt)	Gross Income Rs	Cost of Cultivation	Net Income Rs
2016-17	Kharif	Soybean	20	270	486000	190000	296000
	Rabi	Wheat	8	304	349600	60000	289600
		Gram	4	46	92000	38000	54000
		Potato	5	1050	525000	225000	300000
		Green Pea	3	150	120000	25500	94500
	Summer	Onion	8	2000	1000000	384000	616000
		Fodder	2	300	45000	8000	37000
		Gross Area	50	4120	2617600	930500	1687100
		Cropping Intensity	250	System Productivity = 22.57 kg/ha/day			
		Prod./day (Kg/day)	1129				
		Gross Income./day (Rs/day)	7172				
		Net Income./day (Rs/day)	4622				
		B:C ratio	2.8				

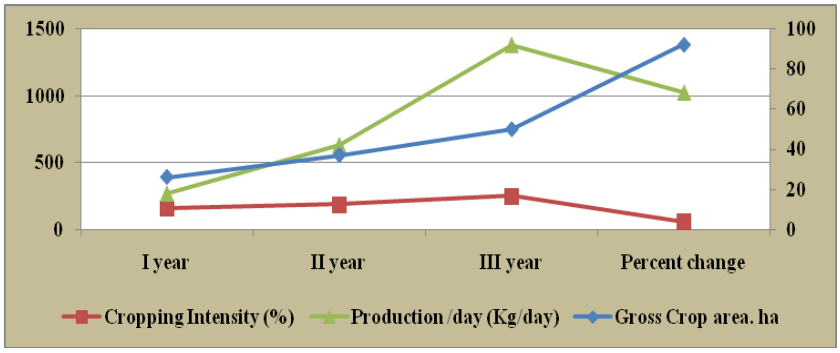
Table.5 Effect of converting to seed enterprise on farm income

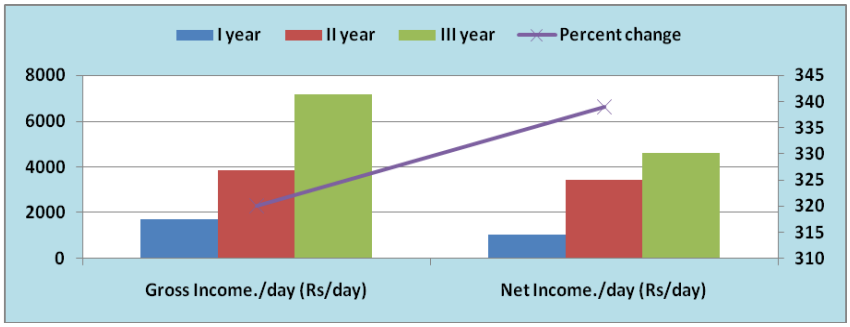
Crops	Area (ha) Under seed production	Raw Seed Produced (qt)	Total Cost of production (Rs)	Market Value of Seed (Rs)	Net Income Seed (Rs)	Net income/Ha in seeds (Rs)	Net income/Ha in Conventional Farming (Rs)	ICBR Seed
Soybean	20.00	270	325600	665280	339680	16984	7750	4.49
Wheat	8.00	304	173120	548416	375296	46912	36500	4.41
Gram	4.00	46	50880	129536	78656	19664	27300	6.11
Potato	5.00	1050	519000	1386000	867000	173400	123000	2.95
TOTAL	37.00	1670	1068600	2729232	1660632	64240	48638	4.49

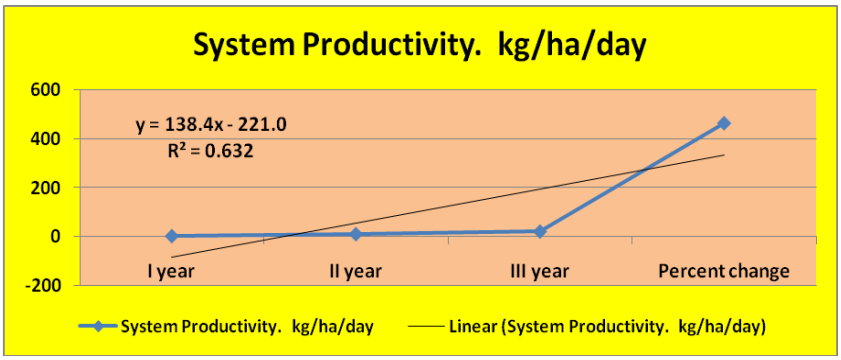
Table.6 Effect of intervention on family income

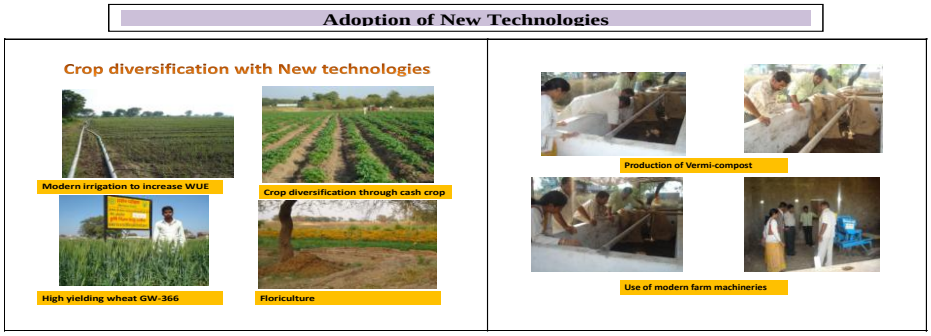
Year	Gross Area (ha)	Total Annual Production (Quintal)	Annual Gross Income (Rs)	Cost of Cultivation (Rs)	Annual Net Income (Rs)	Percent change in Income
First	26	387	622950	239000	383950	*
Second	37	1619	1408500	519000	889500	131.7
Third	50	4120	2617600	930500	1687100	89.7
Mean	37.7	2042.0	1549683	562833	986850	110.7

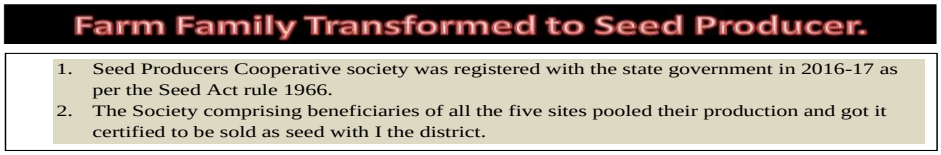
Fig.1 to 3 Sequential changes due to Interventions and crop diversification











In conclusion with assured irrigation in arid and semi arid tropics the crop intensity can be increased with appropriate diversification of crop and enterprise. Adoption of timely and sequential interventions leads to almost doubling the farm income. By adoption of new enterprise related to agricultural activity the income can be further doubled or can be made four times from the base line or the conventional approach. The system productivity is the key to doubling of farm income. On farm water harvesting is the only option under the changing climatic scenario and hence this study clearly focuses upon the adoption al viable option for the farmers of the tropics.

References

Gupta S K and Deshpande R D 2004 Water for India in 2050: first order assessment of available options; Curr. Sci. 86 1216–1224.

Garg N K and Hassan Q 2007 Alarming scarcity of water in India; Curr. Sci. 93 932–941.

Gulati Ashok and Shweta Saini 2016. From plate to plough. Raising farmers' income by 2022, March 28.

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

Kumar R, Singh R D and Sharma K D 2005 Water resources of India; Curr. Sci. 89 794–811. Planning Commission 2007 Report of the Expert Group on Ground Water Management and Ownership, Government of India, New Delhi, September 2007

Majumdar, Dilip Kumar 2002, *Irrigation*

Water Management: Principles and Practice, Prentice-Hall of India Pvt.Ltd, New Delhi.

Moench, M. and M.D. Kumar (1993), 'Local Water Management Initiatives: NGO activities in Gujarat', VIKSAT– Pacific Institute Monograph, VIKSAT, Ahmedabad.

Rockstrom, Johan, Louise Karlberg, Suhas P. Wani, Jennie Barron, Nuhu Hatibu, Th eib Oweis, Adriana Bruggeman, Jalali Farahani, and Zhu Qiang (2009), 'Managing Water in Rainfed Agriculture: Th e Need for a Paradigm Shift', *Agriculture Water Management*, Vol. 97, pp. 543–50, available at http://dspace.icrisat. ac.in/bitstream/10731/ 2920/1/AgrWatManag97_4_ 543-550_2010.pdf journal published by Elsevier BV and journal home page at: http://www.elsevier.ocm/ locate/agwat).

Shah, Tushaar and K.V. Raju (2001), 'Rethinking Rehabilitation: Socio-Ecology of Tanks and Water Harvesting in Rajasthan, North West India', CAPRi Working Paper No. 18, CGIAR System-wide Project on Collective Action and Property Rights. International Food Policy Research Institute (IFPRI), Washington DC.

Verma, S., P. Van Der Zaag, and S. Uhlenbrook (2008), 'Small Reservoirs, Big Impacts? Exploring Alternate Models of River Basin Development', Draft Paper for discussion presented at the 2nd International Forum on Water and Food, Addis Ababa, Ethiopia, November 10–14, 2008.

How to cite this article:

Tomar, D. S., Ishwar Singh and Rekha Tiwari 2020. On-Farm Water Harvesting: Promising Intervention towards Crop Diversification and Doubling Farmers Income in Drought Prone Central Province of India. *Int.J.Curr.Microbiol.App.Sci.* 9(10): 2938-2947.
doi: https://doi.org/10.20546/ijcmas.2020.910.354