Evolving Watershed Clusters into Drought-Proof, Climate-Resilient Areas: An Impact Evaluation Study in Maharashtra, India

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Key words: India; Maharashtra; drought; watershed; impact evaluation; resilience

1. Introduction

Watershed development programs started in early 1970s in India as a measure to augment agricultural productivity, reduce poverty and food insecurity. Since, India is an agrarian economy with high reliance on rainfall for agricultural water requirement, soil and water conservation programs are imperative to growth of agricultural productivity. Specifically, these watershed programs reinstate deteriorated topographies through soil and water conservation activities that increase availability of water for crops, raise groundwater levels(Singh et al.), improve land use and cropping intensity and arrest soil erosion and strengthen community institutions (National Institute of Rural Development (NIRD) 2010).

Over the years, the nature and magnitude of watershed programs have seen a paradigm shift. In its nascent stages, watershed development mainly involved soil and water conservation in the form of bunding, farm ponds, *in-situ* moisture conservation practices amongst many others. Watershed approach has evolved to be a more holistic and participatory approach recently, shifting the focus to involvement of beneficiaries in all the stages of the program starting from planning, implementing, monitoring and sharing benefits and costs (Joshi et al., 2005). The factors that contribute to the success of watershed management are multidimensional, including biophysical, socioeconomic with support from institutions and stakeholders. Resource utilization is complementary to realization of watershed. It involves optimum use of area's rainfall along with soil, water and crop management. People's participation is a notable factor contributing to the success of a watershed program. IWMP interventions strengthen and build capacity of the agricultural system to cope with changes in climate, for example, terminal heat and inherent dry spells and eventually, diminishing adverse impacts on crop yields and subsequently livelihoods of people.

Owing to efficient agricultural practices and community building capacity, various economic benefits are recorded in terms of increased yield and income. Gebregziabher et al., (2016) on Ethiopian watershed suggests that watershed management is responsible for improvement in farm income and food security by an average of 50% and 56%, respectively. Also, the risk of crop failure due to moisture stress and climate shocks also reduced by up to 30%. Evidence from studies on India on efficiency, measured by benefit-cost ratio, of watershed program associated with people's participation suggest a ratio of 1.97 to 2.4 across different income groups (German et al., 2007; Joshi et al., 2005; Sahu, 2008). Contemporary studies of watershed programs in India show that watershed programs help to increase availability of water for crops, raise groundwater levels(Kerr, Pangare, & Pangare, 2002; P Singh, Behera, & Singh, 2010), improve land use and cropping intensity, arrest soil erosion and strengthen community institutions (NIRD, 2010) as a strategy to adapt to climate change. In-situ conservation at Adarsha watershed of Kothapally, Andhra Pradesh recorded increased water availability by 10-30% due to improved infiltration and water holding capacity of the soil (Garg, Karlberg, Barron, Wani, & Rockstrom, 2012) and groundwater level by 4.2 m in open wells near check dams compared to wells far off from check dams (Pathak, Wani, Singh, Sudi, & Rao, 2002). There is enough evidence shows how access to affordable irrigation increase in productivity and make agriculture more resilient (Birthal, et. al, 2015, Kishore et.al 2017).Similar benefits of groundwater level increase are accrued by Lalotara and Ringnodia watershed at Madhya Pradesh (Pathak et al., 2002).

Up until recently, issues faced by farmers were related ecology and socio-economics but lately climate change is further adding to the problem of water scarcity and low productivity many fold. In the wake of climate change, the definition of watershed management has expanded and is now inclusive of ecosystem based management frameworks addressing environmental concerns.Variability in the climatic system can alter natural processes of a watershed ecosystem and have long- term economic consequences and ecological imbalances. Thus, watershed development has gained tremendous importance in present scenario. Evaluation of climate change on watershed system is important in order to develop alternative strategies and policies that adapt to and mitigate the adverse impacts of change in temperature and rainfall.While watershed approach arguably helps farmers adapt better to climatic variability and become more drought-proof and resilient to climate change, however, only a few studies on watershed programs capture the essence of watershed programs as truly climate smart.

With our analysis of impact of watershed management on farmers' livelihood through increased productivity and decrease in fallow land during *kharif* and *rabi* reason, we aim to add to the existing pool of policy on watershed programs by studying projects of the Integrated Watershed Management Program (IWMP).More precisely, the objective of this paper is to evaluate the factors affecting yield of cotton and soya with emphasis on impact of IWMP interventions. Secondly, to understand and measure the contribution of IWMP interventions to drought-proofing of agriculture in the long run using 30 year (1985-2015) rainfall data.

Rest of the paper is set as follows: Section 2 gives description of IWMP and its interventions. Section 3 is background information of study area. Section 4 describes empirical approach including data, descriptive analysis and econometric model used. Section 5 presents results of the model described in section 4. Section 6 concludes the paper.

2. Integrated Watershed Management Programme

IWMP is a flagship programme of Ministry of Rural Development (MoRD) of Government of India with an outlay of Rs. 29,000 crores ($ 4.6 billion) in the 12th five-year plan. Since the inception of the program, GoI has released Rs. 12,285 crores ($ 1.98 billion) to implement 4620 IWMP projects across 520 districts covering total area of 23.3 million hectares[1]. Still 121.64 million hectares of treatable area is to be covered by the IWMP. The focus of IWMP is large project area (more 500 hectares) with higher budget allocation, flexibility and delegation of authority and emphasizes on institutions, capacity building, monitoring & evaluation and convergence of projects.

In our study, selection of watershed districts involved collaboration between local government officials and Vasundhara State Level Nodal Agency (VSLNA) for Watershed Development. This agency is responsible for implementation and monitoring Integrated Watershed Management Programme (IWMP), a centrally sponsored programme in Maharashtra. The criteria for selection of watershed included vulnerability of these districts to water scarcity. According to a report by Central Research Institute for Dryland Agriculture (CRIDA), Advanced Very High Resolution Radiometer (AVHRR) NDVI dataset Amravati is identified as moderately vulnerable to climate change and length of crop growing period derived from AVHRR NDVI dataset indicate a reduction in its duration for major crops grown in Maharashtra (Kaushalya et al., 2015). Among all regions in Maharashtra, Marathwada and Vidarbha experienced agricultural distress continuously and are severely damaged by droughts repeatedly in the last few years. Owing to the stress caused by drought, suicide mortality rate (SMR, suicide death for 100,000 persons) in Maharashtra for male farmers has increased from 15 in 1995 to 57 in 2004 especially in certain districts of Vidarbha (Mishra, 2006) and drought-prone areas of Marathwada (Kulkarni et al., 2016). Thus, Yavatmal and Amravati from

1. http://www.dolr.nic.in/iwmp_main.htm

Vidarbha and Osmanabad and Beed from Marathwada were singled out for the study. Marathwada and Vidarbha regions have 10.22 percent of the total area identified as treatable areas under IWMP, but only one-in-four of all IWMP projects have been implemented there.

IWMP interventions include check dams and gully plugs, farm bunding, percolation pits, broad bed furrow, farm ponds, tank rehabilitation work, on farm earthen water shortage and afforestation. Table 1 summarizes activities implemented across 4 districts of Maharashtra. Out of 8 IWMP interventions, only 5 are popular amongst farmers. IWMP activities are field-based and community-based soil and water conservation practices with specific and overlapping roles, involving farmers at village level. They essentially aim at reducing soil erosion and water run-off while at the same time conserving in-situ moisture. For example, farm bunding helps to accumulate surface runoff upto 43 percent and reduces soil erosion upto 0.329 t ha-1 in farm bunded land (Traore et al., 2017). While check dams and gully plugs are less individualistic and more community based services, they help reduce peak discharge, entrap sediments and increase groundwater recharge(Xiang-zhou, Hong-wu, & Ouyang, 2004).

A study from Bharuch district, Gujarat reports a shift in crop cultivation from jowar to cotton due to availability of water. This was made possible due to application of contour bunding, gully plugging, check dams, percolation tanks amongst others (Khanna, 1997). The effects of farm bunding technology for soil and water retention has led to 24 percent increase in cotton yield and 49 percent millet yield in Mali (Traore et al., 2017).Similarly, a study from Bhalki Watershed of Bardhaman District of West Bengal estimates homogeneous and non-homogeneous effects of watershed development. Results shows that the net returns have improved; however cropping intensity and diversity remains almost unchanged. Another example from Tad Fa watershed in Thailand witnessed reduction in water run-off and soil loss with establishment of contour cultivation and vegetative bunds (Pathak et al., 2002). The uptake of these practices is surprisingly low, however, farm bunding is the mostpopular and widely used in Maharashtra.

Table 1: Frequency of IWMP activities

IWMP activity	Frequency (N=417)	Percentage
Check dams and gully plugs	8	1.91
Farm bunding	390	93.52
Percolation pits	4	0.95
Board bed	2	0.47
Farm ponds	7	1.6

Source: Authors

3. Description of study Area

Due to the large land size of Maharashtra, the state falls under different agro-climatic zones such as Amravati is part of Central Maharashtra Plateau Zone (MH-7), Beed and Osmanabad falls under Western Maharashtra Scarcity Zone (MH-6) and MH-7 and Yavatmal belongs to Central Vidarbha Zone (MH-8). Ecologically, Amravati, Beed, Osmanabad and Yavatmal belong to hot moist semi-arid to hot semi-arid region. With less than 19% of net irrigated area to cultivated area(Indiastat, 2017), agriculture in Maharashtra is rain-fed. Table 2 summarizes various characteristics of the study sites.Annual average rainfall is 740-15050 mm, most of which is received during June-September. Although cotton is grown widely across the country, but Maharashtra alone is responsible for 55 percent of cotton output (Lalitha et al., 2009). Out of many IWMP projected started in 2009-10 that continued for the following 5 years 25 village clusters are selected. From these village clusters, 2 villages from each IWMP projects are picked randomly assigning 50 villages in total for the survey. Most of the farm households are small and marginal with an average land holding of 4.5 to 5.1 acres (Table 3). Based on our study, amongst many other crops, we found that cotton and soya are grown primarily in this region.

Table 2: Characteristics of study area

Characteristics	Amravati	Beed	Osmanabad	Yavatmal
Coordinates	20°55´53·82" N 77°45´32·57" E	18°23´50·51" N 74°54´76·60" E	18°10´12·0" N 76°3´00·0" E	20°23´50·51" N 78°07´42·42" E
Annual rainfall (mm)[1]	942.6	743.4	807.4	1051.4
Ecological sub-region	Hot moist semi-arid	Hot semi-arid	Hot semi-arid	Hot moist semi-arid
Agro-climatic zone	Central Maharashtra Plateau (MH-7)	Western Maharashtra Scarcity (MH-6) Central Maharashtra Plateau (MH-7)	Western Maharashtra Scarcity (MH-6) Central Maharashtra Plateau (MH-	Central Vidarbha (MH-8)
Geographical Area ('000 ha)[2]	1304	1068.6	748.5	1352

Source. (Maharain, 2016)

4. Empirical Approach

To evaluate the impact of IWMP interventions on yield of cotton and soya, we use an empirical model to examine several determinants affecting productivity of these crops in *kharif* and *rabi* season. The remainder of this section is divided into two parts. First, we present that data collection and used along with a short descriptive analysis in Data section. Second, we describe the econometric approach used.

4.1. Data

To calculate minimum sample size to achieve a detectable effect we use the software Optimal Design (OD) to conduct power calculations. Next, we consider the necessary sample size for a clustered RCT with household level outcomes. Cluster randomization is much more common than person randomization, especially in agricultural economics, where interventions are often at the village level to help avoid spillover effects with everyone in the village assigned to the same group. Figure1 shows the optimal design results for sample size calculation and its statistical power. It confirms that, near around 8 sample size per cluster can achieve the statistical power (>=80%).To calculate minimum sample size to achieve a detectable effect we use the software Optimal Design (OD) to conduct power calculations. Next, we consider the necessary sample size for a clustered RCT with household level outcomes. Cluster randomization is much more common than person randomization, especially in agricultural economics, where interventions are often at the village level to help avoid spillover effects with everyone in the village assigned to the same group. Figure1 and table 7 shows the optimal design results for sample size calculation and its statistical power. It confirms that, near around 8 sample size per cluster can achieve the statistical power (>=80%).

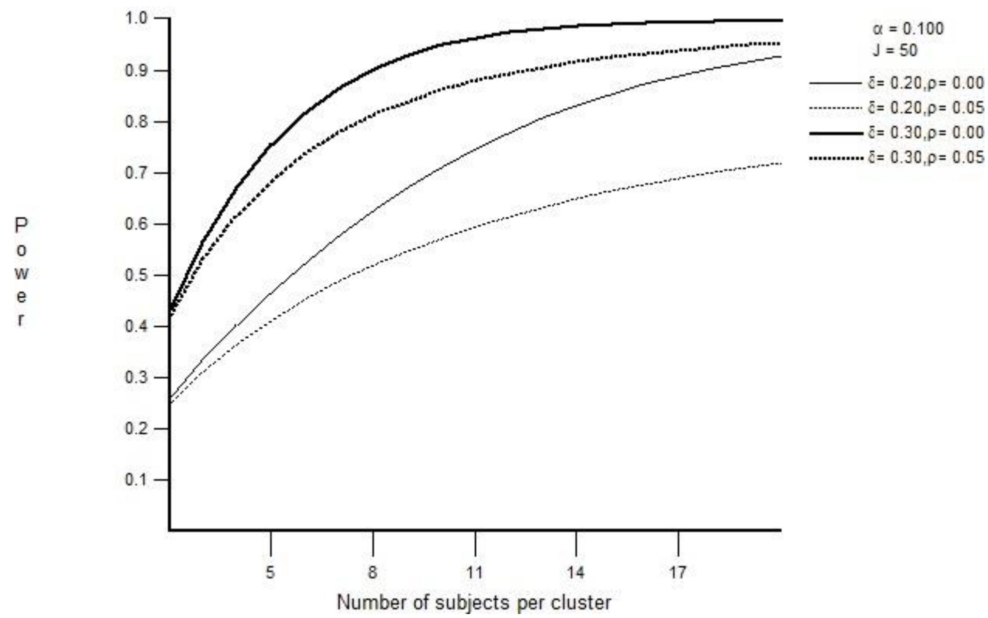

Fig. 1. Power Calculation

The primary survey data used in this paper came from detailed household survey of 800 farm households from 4 districts of Maharashtra. We have surveyed 50 villages and within each selected village, we surveyed 8 each beneficiary and non-beneficiary farm households randomly. The data used to study the impact of IWMP interventions activities on productivity of crops is collected through a household survey carried out in Maharashtra during January to March 2017. Along with primary data, secondary data is collected to understand the impact and the functioning of IWMP projects on farmers' livelihood. A total of 783 final households across 4 districts – Amravati, Beed, Osmanabad and Yavatmal were used for the analysis, as 17 farm household data were missing and not used in the analysis. Among 783 farm households, 417 households are beneficiaries with treatment plots, 366 are non-beneficiaries/control plots.

Table 3: Sample surveyed

Districts	No. of Projects	No. Of Blocks	No. of Villages	Sample size in each village	Total households
Amravati	6	6	12	8 each from treatment and control group each	800 (400 each from treatment and control)
Beed	12	5	24		
Osmanabad	4	3	8		
Yavatmal	3	2	6		
Total	25	16	50	16	800

The questionnaire included qualitative and quantitative questions pertaining to various aspects of farming and farmers' characteristics (household and social characteristics, crop economics, and irrigation). Information on policy and institutional dimensions of farming, such as awareness of Minimum Support Price (MSP), access to institutions services and extensions, crop insurance and adaptation strategies to climate change is also garnered. Moreover, recall data on crop yield, area cropped and area left is also collected for the period 2013-2015 from same households to measure drought resilience of IWMP beneficiary farmers vis-à-vis non-beneficiary farmers.

For this study, we employ purposive stratified sampling instead of random sampling. Purpose to the sampling was given by VSLNA considering the situation of agriculture and farmers in Maharashtra. The sample that is allotted was further divided into strata of different clusters. These clusters are based on inception of project. In our scenario, projects that started in 2009 and 2010 were selected are the basis of the cluster. Villages where IWMP work is implemented, has one watershed committee for managing and execution of the IWMP work. The committee comprises of members from all the social and marginalized groups including females. The committee decides the selection of beneficiary households by villagers in a Panchayat meeting. Hence, we can assume the selection of beneficiary to be unbiased in nature in second stage of sampling.

4.2. Descriptive Analysis

Table 4 provides an overview of the sample distributed across districts. Maximum number of households were interviewed in Beed and minimum were in Yavatmal. Average land size follows the same trend. Average land size ranges from 4.51 acres in Yavatmal to 5.33 acres in Beed.

Table 4: Distribution of sample by district

Districts	No of households	Average Land size (acres)	Total Area (acres)
Amravati	193	5.09	983
Beed	378	5.33	2014.75
Osmanabad	254	5.08	646
Yavatmal	160	4.51	361.5

Source: Authors

Table 5 presents the descriptive analysis from the variables described above. In order to test balance of covariates, we perform t-test for difference in means on a set of farmers' characteristics and economic variable. Socio-economic covariates including age, education, years of farming and money borrowed are balanced between beneficiary and non-beneficiaries as the ttest/chi2 test is insignificant. However, land associated characteristics – total area, irrigated area and no. of parcels are statistically significant in favor of beneficiaries. Households with treatment plots report an average land size of 5.50 acres or 17 percent greater land size than control plots. One of the key variables i.e. yield of cotton and soya is significantly higher for beneficiaries than non-beneficiaries. However, the difference between yields of crops of beneficiary vs non-beneficiary recall data is not significant. We also observe that 54% of beneficiary farmers borrow money for agricultural purposes. Crop insurance is also more popular among beneficiary farmers.

Table 5: Descriptive Analysis of household characteristics

Variable	Beneficiary	Non-beneficiary	T-test/chi2
Age of the household head (in years)	49.39	49.74	0.37
Education(in years)	4.61	4.53	-0.41
Years of farming (in years)	23.99	24.93	1.05
Working in farm (yes=1, else=0)	53.14	46.86	0.04
Total area (in acres)	5.50	4.75	-2.29**
Total irrigated plot (in acres)	4.69	3.94	-2.45**
No of parcels (in numbers)	1.82	1.64	-2.41**
Crop insured (yes=1, else=0)	57.10	42.90	4.31**
Borrow money(yes=1, else=0)	54.10	45.90	0.21
Cotton yield in 2016 (quintals/acre)	5.76	4.30	-6.69***
Soya yield in 2016 (quintals/acre)	5.04	4.38	-3.26**
Cotton yield in 2015(quintals/acre)	2.66	2.71	0.33
Soya yield in 2015(quintals/acre)	2.94	2.2	-1.72*
Cotton yield in 2014(quintals/acre)	3.81	3.81	-0.03
Soya yield in 2014(quintals/acre)	3.32	3.32	-0.01
Cotton yield in 2013(quintals/acre)	3.98	3.98	-0.15
Soya yield in 2013(quintals/acre)	3.77	3.32	-2.29**

Source: Authors

5. Econometric Model

We use simple OLS regression model, with yield of crops (cotton and soya) as dependent variables. The model assumes, that is, probability density function of $X\beta$ follows a normal distribution. Hence, the model estimates…Using this model we are able to examine factors affecting yield of cotton and soya, controlling for other variables. The functional estimate takes the form:

$$Yield_i = \beta_0 + \beta_1 beneficiary + \beta_2 borrow\ money + \beta_3 crop\ diversification + \beta_4 weather\ advisory + \beta_5 irrigated\ area + u$$

Where, $i$is cotton and soya, $\beta_0$is the constant term and $\beta_n$are cofficients of explanatory variables included in the model.We have used tehsil fixed effect that absorbs all the unobserved tehsil-specific factors, for example, drainage and soil type which affects crop yields or selling price received for crops, reducing bias arising due to omitted variables.

To estimate drought resilience, an empirical relationship between cotton yield and weather variables using pooled OLS. This model is typically for cotton as there is a significant difference between beneficiary and non-beneficiary cotton yield (Table 6). This is adopted from Deschênes & Greenstone (2007) to measure the impact of climate change by estimating the effect of year-to-year variations in precipitation on agricultural profits. Some of the factors are time-invariant such as age, gender, years of farming, training received by farmers and credit or loans. Summarizing the model mathematically,

$$Yield = \beta_0 + \beta_1 beneficiary + \beta_2 drought + \beta_3 beneficiary * drought + u$$

The effect of change in rainfall is captured by the variable drought. Section 4.3.1 describes how this variable is calculated.

5.1. Drought Index

Long-term (30 years) rainfall data for tehsils is extracted from 0.25*0.25degree high resolution daily gridded data obtained from the India Meteorological Department (IMD), Government of India. The nearest grid to our study sites are chosen. Further, this dataset is aggregated to calculate monthly normal rainfall. Following meteorological definition of drought given by IMD, rainfall in 2014 and 2015 are moderate drought years while 2013 and 2016 are normal years with excess and normal rain (DACFW, 2015)(Maharain, 2016). Using long term and per year rainfall data, we calculated our key variable – drought. It is expressed as:

$$Drought = \frac{(A_i - \mathbb{N})}{\mathbb{N}}$$

$$\mathbb{N} = \frac{\sum Normal\ rain\ for\ 30\ years}{30}$$

A_i = Actual rainfall for year i. $i = 2013 - 2016$
$\mathbb{N}$ = Average rainfall for 30 years.

Positive values for drought variable indicate greater than median precipitation, while negative values indicate less than median precipitation. For our analysis, we converted this index as a binary variable. Rainfall less than 80 percent of change in rainfall from current year to average of normal year is marked as drought (Yes=1) and 0 if no drought. Tehsil level rainfall data is more robust than district level, firstly, it is a high-resolution data and secondly, it allows for more variation than in the dataset.

6. Model Results

6.1. Impact of IWMP activities on crop yield

Table 6 report results of ordinary least squares (OLS) to evaluate the impact of IWMP activities on productivity of Cotton and soya in a cross-section sample. Our dependent variable is yield of cotton and soya. We have presented two models for each of the crop using OLS regression. Column 1 and 2 show the estimation results of yield of soya, without controls (restricted model) and with controls (full model), respectively. Column 3 and 4 report the results of corresponding model for cotton yield. Tehsil dummy is controlled in model 2 and 4 but not shown here in regression model to avoid cluttering. One of the key variable is beneficiary – the variable assumes 1 if the household has used even one IWMP practice on his plot and 0 where none is used. Actual rain is the rainfall received at tehsil level in 2016.The data for this variable is collected from state government portal (Maharain, 2016). Irrigated area, borrow money, and weather advisory are some of the adaptation strategies that farmers are encouraged to take to respond to adverse effects of climate change.

The impact of difference between yield of IWMP activities (treatment) vis-à-vis no IWMP activities (control) is captured by variable – beneficiary. Crop yield of beneficiaries is significantly positive in all 4 models however, magnitude differs. Soya yield of beneficiaries is 12-25% more than that of non-beneficiaries. Cotton yield difference between beneficiaries and non-beneficiaries ranges from 11-32%. Nonetheless, Maharashtra received an average rainfall of 1181.6 mm in 2016 (Maharain, 2016), the effect of actual rain on cotton yield is negative and not significant.This negative association could be ascribed to runoff to rainfall ratio in cotton cultivation. In Maharashtra, runoff to rainfall in cotton ranges from 18 to 39 percent for 1000 mm annual rainfall, contingent upon management of the watershed(Groundwater Surveys & Development Agency, n.d.; Vittal et al., 2004). A clear substitution effect is observed in soya yield in model 1 i.e. increase in yield of soya is attributed partly to IWMP interventions and partly to rainfall during 2016. The reason why we have not included rainfall in model 2 and 4, we added tehsil dummy which contains effect of all unobserved factors – rainfall being one of them.

Adaptation practices is observed to have significant but negative impact on crop yields. In this region, farmers opt to cultivate tur after soya to diversify their crop base. Another important adaptation strategy to reduce climate risks is weather advisory services. A priori, it is expected that weather advisory services would a significant effect on crop yield. Results from our model are coherent with expectations and weather advisory seems to have a positive effect on crop yield.

Credit or money borrowed for agricultural activities has significantly positive impact on yield. Cotton and soybean being one of the high value crops attract more loan amount than postrainy season crops such as sorghum, chickpea (More et al. , 2013). (Das et al. , 2009 through their empirical analysis of direct and indirect agriculture credit suggests that direct agriculture credit to farmers has a positive immediate impact on agricultural output. Cotton growers following weather based-forecast from Agrometeorological Advisory Service (AAS) of India in Coimbatore and Hyderabad benefitted 10-15% more yield than counterparts (non-AAS farmers) (Maini & Rathore, 2011). In the models with controls (column 2 and 4), area under irrigation for respective crops have a positive and significant impact on yield.

Table 6:Impact of IWMP interventions and determinants affecting yield

Variable	Soya (quintal/acre)	Soya (quintal/acre)	Cotton (quintal/acre)	Cotton (quintal/acre)
Beneficiary	0.68***	0.57***	1.46***	0.84***
	(0.20)	(0.19)	(0.21)	(0.22)
Actual Rain	0.0020**		-0.00	
	(0.0009)		(0.00)	
Borrow money		0.55***		0.42**
		(0.18)		(0.19)
Weather advisory		0.71**		0.59**
		(0.32)		(0.27)
Irrigated area		0.19***		0.25***
		(0.03)		(0.04)
Constant	2.67***	4.62***	4.5497***	7.09***
	(0.80)	(0.51)	(0.57)	(1.25)
No. of observation	322	319	318	315
Log lik.	-642.74	-590.21	-638.60	-593.09
Adj-R2	0.04	0.24	0.11	0.28

Note: Standard errors are in parenthesis and ***, ** and * denotes significance at 1, 5 and 10 percent level.

6.2. Impact on watershed to drought resilience

Our study area comprised of four of the worst drought-affected districts in Maharashtra, and a study found that a single year of crop loss or failure can push the rural population below the poverty line (Kishore et al., 2015). In our study area where a large majority of farmers are small and marginal and severely resource constrained, droughts affects the livelihood. Table 7 reports results of pooled OLS of cotton and soya yield for a pooled panel data. Based on the farmers recall data on crop yield, the coefficients of drought indicate that yield of cotton is 1.5 quintal/acre lower during drought period compared to no drought period. Similar, results are found for soya yield i.e. 1.16 quintal/acre lower. On average cotton and yield of beneficiaries is 0.65 quintal/acre and 0.51 quintal/acre more than non-beneficiaries, respectively. Results of cotton are interesting for non-beneficiaries during drought. In case of a drought, non-beneficiaries' yield is 13 percent higher than beneficiaries. In case of soybean also, during IWMP beneficiaries suffer lower yield losses in drought years, but the coefficient for soybean is only marginally significant.

Table 7: Resilience of IWMP beneficiaries against drought

Variable	Cotton	Soya
Drought	-1.545***	-1.167***
	(-12.75)	(-6.81)
Beneficiary	0.655***	0.514***
	(5.65)	(2.93)
Beneficiary*drought (0,1)	0.56**	0.12*
	(0.18)	(.25)
Constant	4.052***	3.819***
	(45.92)	(29.27)
No. of observation	1434	1342
Log likelihood	-2773.7	-3035.5
Adj-R2	0.144	0.0602

Note: Standard errors are in parenthesis and ***, ** and * denotes significance at 1, 5 and 10 percent level.

7. Conclusion

Watershed programmes remains a popular programmatic approach for rural development in India and many other developing countries.This paper tries to assess the impactof IWMP, India's largest watershed program, in four of the most drought affected districts in predominantly rainfed areas of Maharashtra. Since watershed programs tend to have greater impact in years of deficit rainfall than in the normal rainfall years, we collected recall data on crop area and yield for 4 years, and not just the current year, to assess the effect of IWMP in reducing yield loss in a drought year.We find that farmers in Maharashtra who received watershed treatment under IWMP harvested higher yields of cotton and soybean in years of normal rainfall and suffered lower crop loss in a drought year. Thus, IWMP increased both crop productivity and resilience to droughts.

Our research shows that collecting only one year cross-section data on crop area and yields underestimates the contribution of watershed programs to improve farmers' welfare and reduce their vulnerability to weather shocks like droughts. Since reducing year to year fluctuations in crop area and yields in rainfed agriculture is a major goal of watershed development, we need panel data on crop area, yields and farm incomes to for assessing the impact of programs like IWMP.

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