Impact assessment of the Doha Model as a water harvesting structure

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Abstract

In recent decades, use of groundwater for irrigation in India has increased manifolds, contributing for 63% of the net area under irrigation in 2011-12. Groundwater is also the primary source of domestic water supply, contributing 85% in rural water supply. However, groundwater development is facing stress in a few states and a growing population is destined to put more stress on the available groundwater resource. This makes rainwater harvesting a crucial measure in arid and semi-arid regions particularly. This study, in water scarce Marathwada region of Maharashtra, conducts a social and economic cost-benefit analysis of the Doha Model water harvesting structures. Study collects quantitative and qualitative data from 68 households in Jalna district of Marathwada. It finds out that the Doha Model has resulted in positive impact on agriculture – increase in water availability for irrigation, cropping intensity, crop yield. Few farmers have adopted capital-intensive commercial seed crop cultivation with assured irrigation. Study also finds out an increase in the water level of wells and a reduction in drudgery related to fetching water for domestic use. Livestock ownership and availability of fodder has also increased. Income from agriculture and livestock shows an increment as reflected in a positive IRR obtained through cost-benefit analysis. Study also finds out few challenges and limitations to this water harvesting structure. It finds out that the scope of benefits from Doha Model is limited to few households in the vicinity of the stream. It infers that a low community participation has led to a negligence of the maintenance of Doha Models. Another critical area of concern coming out from the study is the geohydrology of the site of intervention.

CONTEXT OF THE STUDY

Agriculture is the primary livelihood source for a significant Indian population as 54% of India's total workforce was engaged in agriculture in 2011 (Directorate of Economics and Statistics, 2016). However, agricultural sector growth shows a high volatility due to its dependence on precarious monsoon rain (Directorate of economics and statistics, 2016). Use of tanks and other traditional irrigation structures by farmers to overcome these uncertainties is widely available in the literature (Shah, 2009).

In recent decades, use of groundwater for irrigation has gained coin among the Indian farmers. Small and marginal farmers dominate the Indian agricultural landscape, owning close to 85% of the total agricultural landholdings, as per agricultural census 2011. Moreover, with farmers' growing dependence on groundwater for irrigation, a significant fraction of small and marginal farmers means a large number of individually owned groundwater sources (Shah, 2009). It is putting stress on the available groundwater resource as is evident from the groundwater development data across India. Few of the Indian states are already facing the development of groundwater beyond its annual replenishable capacity (Central Ground Water Board, 2017). In 2011-12, groundwater was irrigating 63% of the net area under irrigation in India (Directorate of Economics and Statistics, 2016).

Groundwater is the primary source of domestic water supply in rural India, contributing 85% in the rural water supply (Central Ground Water Board, 2017). Declining groundwater table poses threat to safe drinking water availability as well. UN estimates Indian population to grow from 1.3 billion in 2017 to 1.66 billion in 2050 (United Nations, 2017); increasing population will mean increased pressure on groundwater sources.

In face of these challenges, rainwater harvesting is a crucial measure. Water harvesting helps in groundwater recharge and in providing supplementary irrigation – in arid and semi-arid regions particularly. This study is an attempt to study the impacts of water harvesting in Marathwada sub-division of Maharashtra.

Maharashtra has close to 20% area under arid and semi-arid zones (Krishnan, 1980). Marathwada sub-division in Maharashtra receives the lowest annual rainfall among the four meteorological sub-divisions in the state – average annual rainfall of 735 mm from 2013 to 2017. Few districts in Marathwada sub-division have faced severe water crisis over the last decade to the extent that they had to ensure the drinking water supply through water tankers and trains during peak summer.

An NGO, Dilasa Santha, has designed and implemented a water harvesting structure namely Doha Model in the region. It is a watershed drainage area measure, implemented across the lower order streams.

Objective

The primary objective of the study is to perform a socio-economic impact assessment of the Doha Model as a water harvesting structure.

Preliminary understanding about the Doha Model is that it helps the stream in retaining water for long. Because it prolongs the stream water retention, it induces recharge of wells in the vicinity. Potential indirect benefits owing to the well recharge range from enhanced irrigation support to redressal of water shortage for domestic use. This study aims to assess these impacts of the Doha Model intervention in agriculture, availability of water for domestic use and support for livestock along with any other benefit as recorded during the study.

Brief of study area

Study area includes four villages in the Jalna district of Marathwada sub-division. Jalna district in Marathwada region of Maharashtra falls in a rain shadow region, prone to frequent droughts. Rainfall in the district over last five years averages to 682 mm annually, excluding the last severe drought of 2012

Villages under study are Akola Deo, Papal, Shirala and Rohanwadi. Rohanwadi falls in the Jalna block while other three villages are part of the Jafrabad block in Jalna district. As per census 2011, except Akola Deo which has a population of close to 3700, rest of the villages under study have a population of less than 2000. In all the villages, percentage of scheduled caste and scheduled tribe is less than 30%. Maratha is the dominant community in the region which forms nearly 80% of the sample population. Agriculture is the primary livelihood in all four villages.

Intervention

The year of intervention is 2013 in Akola Deo and 2014 in rest of the villages. The intervention varies across the villages, regarding the number of streams and their length under the intervention – 3.5 km, on two streams in Akola Deo, 6 km on five streams in Rohanwadi, 1.5 km on three streams in Papal and 0.5 km along the length of a single stream in Shirala.

Dimensions of each Doha Model dug can be averaged out throughout the study area for the study. In general, depth of the Doha Models is up to 3 meters from the ground level. Average width of a Doha Model is 10 meters. Length of each Doha Model is 150 to 200 meters.

METHODOLOGY

Sampling

Village selection for the study follows purposive sampling methodology. Selection of villages considers two criteria – sufficient number of years have passed since the intervention took place and villages have relatively larger section of stream under the intervention – to facilitate accurate study findings.

Study involves selection of 68 farmer households from these four villages, divided into the treatment and the control groups. Treatment group consists of 38 households having their agricultural field near stream; and control group consists of the remaining 30 households having their agricultural field away from the stream.

Data collection

Questionnaire and focus group discussion are the data collection instruments for this study. It uses a semi-structured questionnaire to collect data from the treatment and control group households. Questionnaire collects data for both the pre-intervention and the post-intervention phases. Data collection is recall based, relying on the memory of the respondents, for both pre-intervention and the post-intervention phase – due to absence of any written records.

Focus group discussion (FGD) with men and women in the study area identifies other social and ecological impacts as perceived by the village inhabitants. FGDs have tried to consider the various points of views. Total six FGDs took place as part of the study – four with men and two with women. One FGD with men had majority of participants from the control group with minimum representation from the treatment group. In another FGD with men, all the participants were from the treatment group population. Rest of the FGDs witnessed mixed participation from the treatment and the control group.

Analysis

Analysis includes comparison of incremental changes across the treatment and the control group samples. This method of analysis, known as difference-in-differences (DID) method, helps in controlling the impact of changes that might happen in the absence of any intervention.

The aspects analysed include changes in agriculture, livestock and domestic water requirements. Additionally, analysis of the qualitative data collected through focus group discussions and field observations yields information on the impacts related to other social and ecological impacts of the Doha Models. Analysis also involves a cost-benefit analysis comparing incremental benefits of the intervention with its costs.

Assumptions for the study

For analysis, specifically the cost-benefit analysis of the Doha Model, the study makes certain assumptions. These assumptions are as follows.

Threshold distance from the stream

As the Doha Model intervention is along the stream length, its benefits are available to all the agricultural fields in the vicinity of the stream. Also, the agricultural fields are in a continuous spread starting from the stream banks. However, water table recharge benefits from the deepened streams, through induced filtration from the streams confines to a limited distance from the stream banks and there are no cases of direct water pumping from the stream. Therefore, it is necessary to take a threshold distance from the stream banks separating the treatment group from the control group, for analysis. This threshold estimation requires a geohydrological analysis of the study area. In the absence of this analysis, this study assumes a threshold distance based on the response from the field – 200 meters from the streams banks, on either side.

Distribution of land among the treatment group farmers

15 out of 38 respondents in the treatment group have their agricultural land in two different patches – one near the stream and another far from the stream; even if the entire land is in a single patch it is stretching beyond 200 meters from the stream bank. None of the respondents have a separate record of the income and expenditures on their agricultural land up to 200 meters from that beyond this threshold. Therefore, an assumption to calculate the costs and benefits from agriculture, based on the discussion with the respondents, is that respondents from the treatment group use their dug-wells near the stream to irrigate their entire agricultural land and the intervention benefits their entire agricultural land. It is a conservative assumption because the cost of irrigation increases as the agricultural land stretches further from the dug-wells.

Inflation rate

Income and expenditure in agriculture is dependent on the prices of agricultural inputs, tools, irrigation equipment, and demand of an agricultural product in the market among other aspects. This study assumes the consumer price index (CPI) inflation rate to represent the inflation of all these aspects. An average of last ten years of average CPI inflation is used to take care of the year on year variations in the inflation rate, which comes to 8%.

FINDINGS

This section discusses changes in the cropping intensity, crop yield, crop diversity and about the newly growing trend of commercial seed production among respondents. It identifies changes in the livestock ownership, and in feed and water availability for the livestock as indicators of the impact of intervention on livestock. For impacts related to the domestic water supply, it discusses the changes in the water level of the wells, drinking water sources and any changes in the physical drudgery related to fetching water – quantifying the benefits by calculating the opportunity cost of the alternatives. For assessing the benefits of the Doha Model intervention, this section calculates a cost-benefit analysis of the intervention. Other aspects discussed in brief include the scope of benefits, ownership of intervention by the community and the related hydrogeological aspects.

Agriculture

General agriculture practice in the study area is cultivating two crops in a year, kharif and rabi crops (locally known as *bagayati* agriculture). For supplementary irrigation during kharif as well as rabi, farmers are majorly dependent on the groundwater. It is evident from our study sample – 97% of the surveyed respondents have private access to groundwater through dug-well or borewell. In one village, surface water irrigation is also available through a government canal project. Electric and diesel pumps are in use for extracting water for irrigation with all respondents. 97% of the respondents have an electric pump. During the last few years, a significant proportion of farmers have adopted micro-irrigation methods mostly drip irrigation and sporadically sprinklers.

The general impression about the impact of this intervention on agriculture is that the proportion of farmers who can overcome vagaries of weather has increased. During the discussions, participants reported increase in the number of farmer households able to provide supplementary irrigation to kharif crops and those irrigating rabi crops till February or March. Respondents attributed this to the increased water availability in their wells.

Cropping intensity

Post-intervention cropping intensity has increased for the treatment group respondents, whereas it has reduced for the respondents of the control group (Figure 1). A t-test comparing cropping intensities from the pre and post-intervention phases in the treatment group (p-value = 0.337552) and across the treatment and the control groups (p-value = 0.151271) reveal that the change in the cropping intensity is not significant (at 5% significance level) in either case. It reflects upon the commonly practised two season cropping pattern, kharif and rabi, among the respondents, both pre and post-intervention.

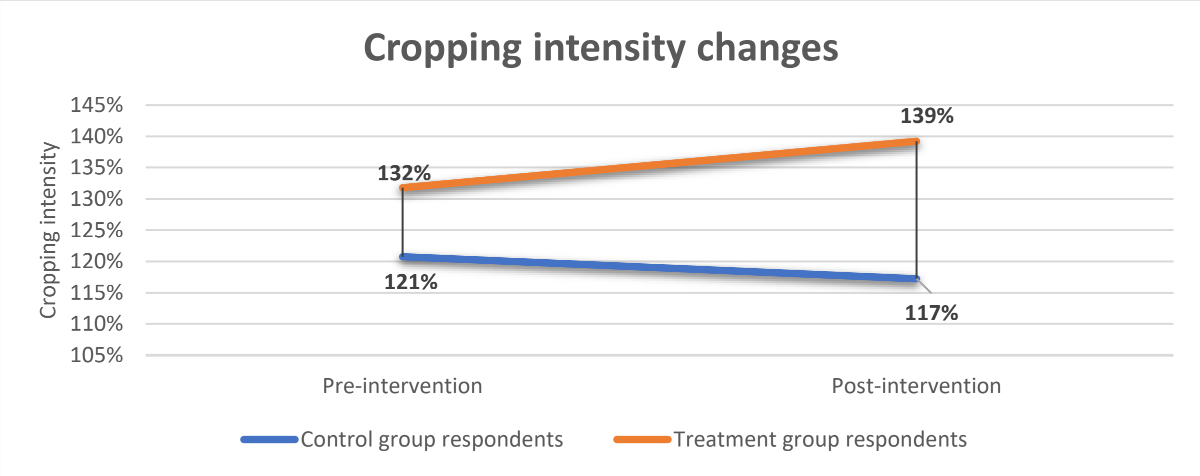

Figure 1: Comparison of cropping intensity changes across treatment and control groups

A detailed analysis of the cropping intensity changes shows that small and marginal farmers among the respondents have not gained from the intervention – although reduction in cropping intensity for small farmers is less in the treatment group as compared to the control group (Table 1). More than 50% of respondents fall in the category of semi-medium landholders. Results indicate that this population has gained from the intervention – cropping intensity increased for the treatment group farmers while it reduced for the control group farmers.

Table 1 Cropping intensity changes for different operational holder post-intervention across treatment and control groups

Respondent operational holding	Control group respondents			Treatment group respondents		
	Respondents	Pre	Post	Respondents	Pre	Post

Marginal	3	137%	137%	1	100%	100%
Small	2	160%	149%	7	127%	124%
Semi-medium	17	131%	121%	21	126%	133%
Medium	8	108%	109%	5	129%	130%
Large	0	-	-	4	139%	151%
Cropping	30	121%	117%	38	132%	139%

Crop yield

Study analyses crop yields for ten commonly cultivated crops across the treatment and the control group respondents, both before and after the intervention (Table 2). Among kharif crops, crop yield has increased for cotton, maize and pigeon pea for the treatment group respondents. Among rabi crops, sorghum, wheat, chickpea, green gram and black gram show an increment in the crop yield for the treatment group farmers. Study conducts t-tests – comparing crop yields pre and post-intervention among the treatment group respondents – for few of these crops occupying at least 10 acres of the cropped land, to validate the yield changes (Table 3). It indicates that the difference in yields is significant for three crops – cotton, in kharif, and wheat and sorghum in rabi – at 5% level of significance.

Table 2 Changes in crop yield post-intervention for treatment and control groups

Kharif crops				
Crop	**Control group pre-intervention**	**Control group post-intervention**	**Treatment group pre-intervention**	**Treatment group post-intervention**
Cotton	7.90	8.11	7.16	9.02
Green Gram	1.07	1.97	1.73	1.69
Maize	10.47	12.94	9.11	10.84
Pearl Millet	8.33	2.55	5.00	0.36
Pigeon Pea	3.35	5.11	3.94	5.10
Soyabean	4.16	4.58	5.31	4.51
Black Gram	1.13	1.13	2.36	0.18
Sorghum	-	-	-	8.00
Rabi crops				
Sorghum	3.76	2.76	2.77	4.07

Wheat	6.16	5.69	7.40	8.45
Chick Pea	1.50	1.50	3.02	4.58
Green Gram	-	-	2.00	2.92
Maize	-	-	27.50	26.18
Pearl Millet	-	-	5.33	1.33
Black Gram	-	-	1.00	14.00

Table 3 p-values from t-tests comparing crop yield pre and post-intervention for treatment group farmers

Crop	p-value
Cotton	**0.001269888**
Soyabean	0.467394438
Wheat	**0.018989721**
Sorghum (rabi)	**0.029298452**
Pigeon Pea	0.275182747
Maize (kharif)	0.12170639
Green Gram (kharif)	0.660758187
Chick Pea	0.094866693

Figure 2 and figure 3 depict percentage change in the crop yields post-intervention – both kharif and rabi crops – across the treatment and the control group respondents. This comparison confirms to the results of the t-test; among kharif crops for the treatment group respondents, only cotton has a higher yield increment as compared to the corresponding change for the control group respondents. For rabi, crop yield is comparatively higher for all the crops for the treatment group respondents.

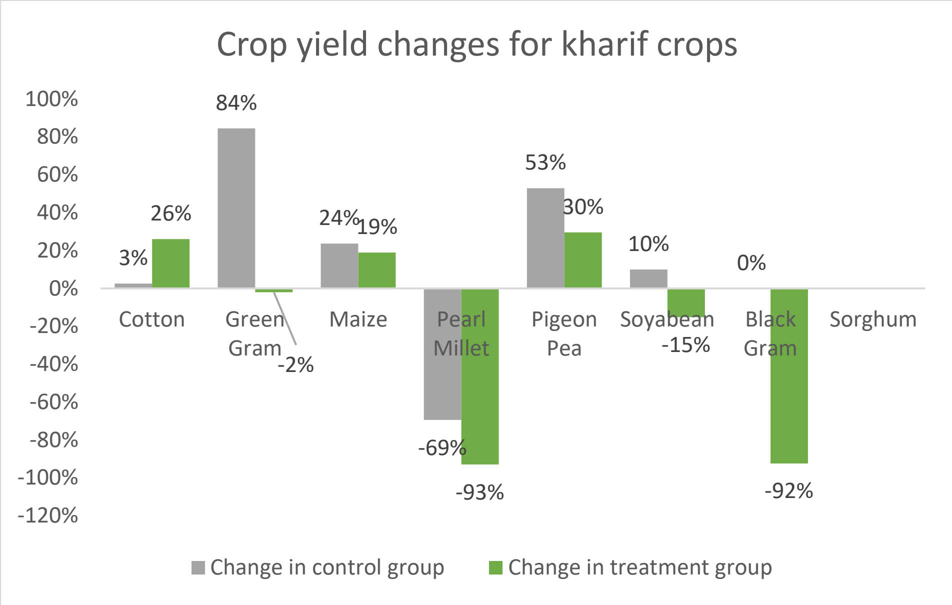

Figure 2 Comparison of percentage changes in kharif crop yields post-intervention across for treatment and control groups

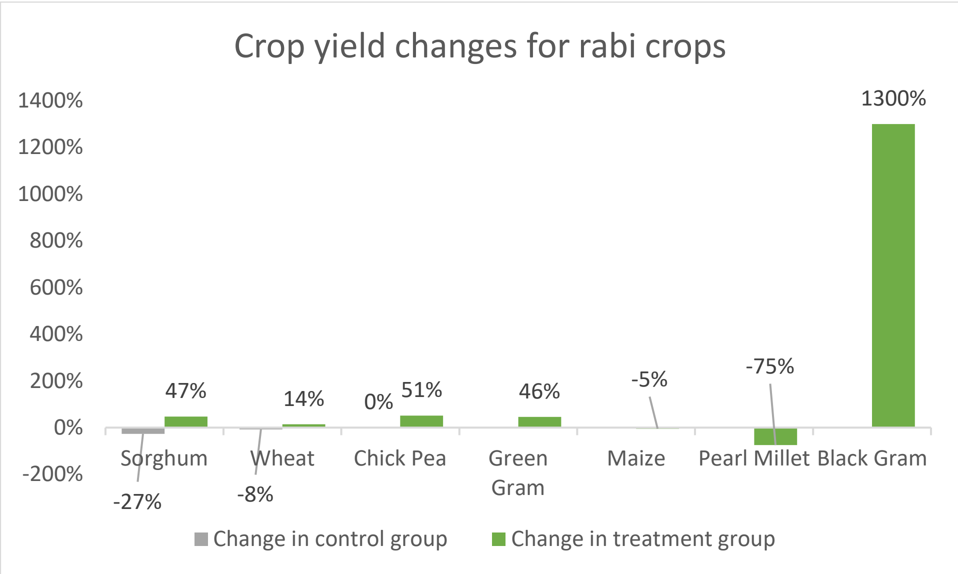

Figure 3 Comparison of percentage changes in rabi crop yields post-intervention across for treatment and control groups

An analysis of crop yields for the treatment group respondents, distributed across different landholding categories is in table 4. It shows that among all the landholding categories, large operational holders have witnessed the loss of yield across the greatest number of crops post-intervention, semi-medium operational holders have witnessed an increase in crop yield for all the crops. Marginal landholder category has just one respondent, insufficient to make an inference.

Table 4 Crop yield changes for different operational holdings from the treatment group population post-intervention

Respondent operational holding	Cotton		Soyabean		Wheat		Sorghum		Pigeon Pea		Maize		Green Gram		Chick Pea	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Marginal	8.0	8.0	-	-	-	-	13.3	-	2.0	4.0	-	-	-	-	-	-
Small	5.3	5.0	3.3	3.7	6.2	7.3	3.9	5.4	3.3	4.7	13.8	11.6	2.3	3.0	-	-
Semi-medium	6.5	10.1	4.8	5.9	6.7	10.3	4.2	6.4	3.2	4.3	21.0	22.7	2.2	2.5	4.2	5.7
Medium	7.2	8.2	3.2	2.6	8.3	11.8	6.0	6.9	4.6	5.2	2.5	2.5	2.0	2.0	7.0	4.9
Large	9.3	9.1	7.1	4.7	7.6	7.0	1.8	2.7	4.5	5.7	4.2	8.3	1.4	1.3	0.5	3.7
All respondents	7.2	9.0	5.3	4.5	7.4	8.5	2.8	4.1	3.9	5.1	9.1	10.8	1.7	1.7	3.0	4.6

Crop diversity

Herfindahl index of crop diversity shows a marginal change in the crop diversities for both the treatment and the control groups, post-intervention. It shows that cropping diversity has reduced in case of the treatment group respondents and increased for the control group respondents – a lower value of Harfindalh index indicates a higher crop diversification.

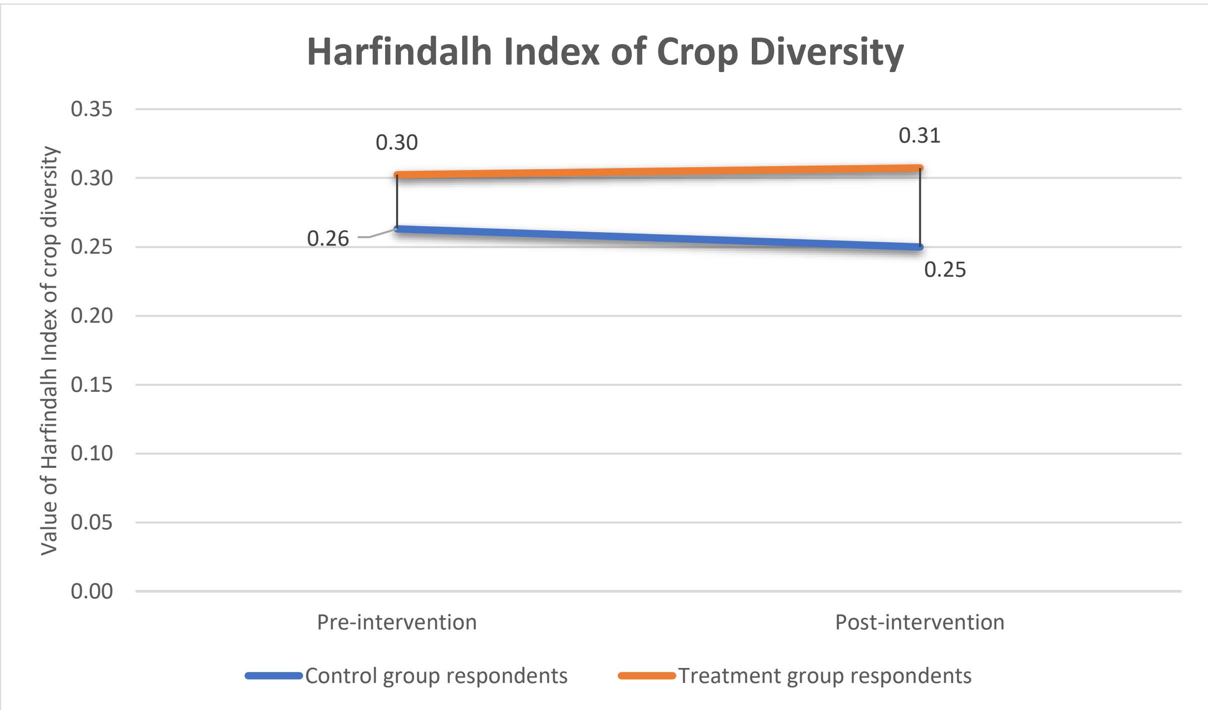

Figure 4 Comparison of crop diversity changes across treatment and control groups

Commercial seed crop cultivation

Jalna hosts a few seed production companies, as observed during the field visit. One specific trend which came out from discussions and is also evident from analysis is the growing land under commercial seed crop cultivation. This trend is visible among both the treatment and the control group respondents. Respondent data and interactions in field indicate that cultivation of the commercial seed crop is capital intensive and also requires assured irrigation. Assuming that an increased adoption rate of commercial seed crop can indicate the impact of the intervention, study tries to analyse the seed crop cultivation details. As a comparison of the seed crop yields is not feasible, given a variety of crops, therefore this study compares increase in the land under commercial seed production and increase in the number of farmers cultivating seed crop across the treatment and the control group respondents.

Figure 5 shows the details across two groups of respondents. It finds out the increase in the cropping area as a percentage of the total cropping area and increase in the number of farmers as a percentage of the total number of respondents in both the respondent categories. Both the parameters have a higher value for the treatment group respondents as compared to the control group.

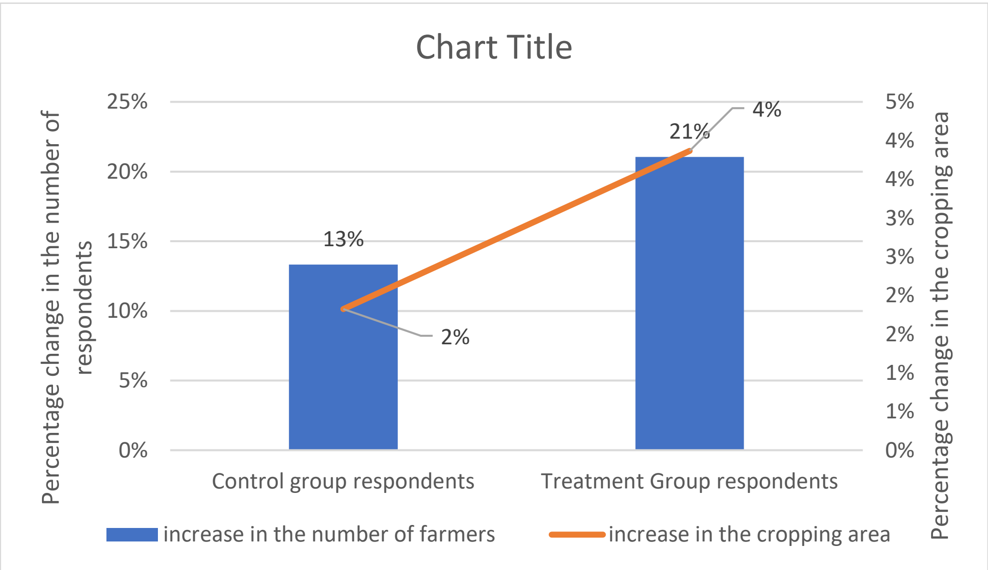

Figure 5 Comparison of changes related to commercial seed crop production across treatment and control groups

Water availability for domestic requirements

Out of the total 68 respondent households, except two – one household from the treatment group and one household from the control group – all have private access to the groundwater.

Of the 66 households having groundwater access, 86% households have only dug-wells in their fields, 2% households have only bore wells and 12% households have both dug-wells as wells as bore well in their agricultural fields. Among the households owning at least one bore well, two-thirds are from the control group and one-third are from the treatment group. Again, of the 66 households, all but one has at least one of their groundwater wells – dug-well or bore-well from pre-intervention phase. These 65 households – 36 households of treatment group and 29 households of control group – are part of the analysis below.

Water level changes in the dug wells

In the treatment group, 35 of 36 households have reported either a change in the water level or an increased retention of water in their dug-wells; borewell owners have reported an increase in the number of pumping hours for their bore well, post-intervention. In the control group as well, 31% of 29 respondents have reported a similar increase.

One respondent from the control group perceives the water level increase in his well due to the de-silting of a nearby dam. Rest all the respondents from both the treatment and the control groups perceive Doha Model intervention as the reason for an increase in the water level of their dug-wells.

Water level changes in the drinking water sources

In Akola Deo, FGD participants unanimously agreed upon the positive impact of the Doha Model intervention on village's domestic water supply problem. Motor pumping hours have increased significantly in the water supply well, from one hour to eight hours in May.

In Rohanwadi, both men and women do not perceive the Doha Model intervention of any benefit to the general water scarcity scenario. Women from the village quoted that this intervention has been beneficial only for agriculture.

In other two villages, Papal and Shirala, respondents do not have access to the supply water; they reported using private wells in their agriculture fields as domestic water source. In Shirala, participants reported no change in the domestic water supply situation, adding that they have never faced a domestic water supply shortage.

In Papal discussions revealed a positive impact on the water availability for domestic use. All but one respondent in the village reported drying-off month for their wells as November or

December, pre-intervention; discussion revealed drinking water availability for three more months, up to March. Post-intervention, treatment group respondents reported round the year availability of water for domestic use. Participants reported the cost of one water tanker of 5000 litres capacity at Rs 2000. They also reported that one tanker would last for 10 to 15 days for a household. This study calculates the saved opportunity cost of these water tankers post-intervention (Table 5). It takes a conservative assumption – one water tanker required for one month's domestic water requirement for a household. Therefore, with an additional water availability for domestic use for two-month – March end to May end – the opportunity cost saved comes to Rs 100000 (for the 25 HHs from the hamlet reaping domestic water benefit).

Table 5 Opportunity cost of water tankers in Papal

Village	No of households	Opportunity cost per household (per/year)	Total Opportunity cost (per/year)
Papal	25	4000	100000

Reduced physical drudgery

In Akola Deo and Papal, FGD participants perceive that the Doha Model intervention has led to reduction in their physical drudgery in fetching water for the domestic use. One participant, Laxman Sawade, illustrated the pre-intervention drought year scenario saying, *"to keep the pump running in the well, we had to pour dirty water from the stream into the well. Post supply exhaustion, people would use dug-wells in agricultural fields at least 1 to 1.5 km from the village."* The situation has improved with round the year supply water availability in the village.

In Papal FGD participants shared arranging water through private water tankers in the pre-intervention phase. Post-intervention, with the assured water availability through wells, several households have installed a dedicated pipeline to supply water directly to their homes after this intervention.

Livestock

This study establishes the impact of the Doha Model intervention on livestock by identifying changes in three parameters namely the number of respondents rearing livestock, income from livestock rearing and availability of feed and water for the livestock.

Livestock ownership and income

Table 6 shows the details of livestock farmer households pre and post the intervention. Post-intervention number of livestock farming households has increased significantly.

Table 6 Livestock ownership details of the treatment group respondents

Number of treatment group respondents owning different cattle		
	Pre-intervention	**Post-intervention**
Cow	3	11
Buffalo	2	5
Goat	0	3
Cumulative	**5**	**12**

Respondents practice dairy farming also; doing door-to-door milk delivery and selling milk to shops at the nearest markets at prices ranging from Rs 25 to 35 per litre. Average amount of milk sold daily by a farmer owning one dairy animal is 6 litres, while the average daily expenditure is Rs 100 as reported by respondents. In two villages, respondents shared selling milk only during the summer season while in other two villages dairy is a year around livelihood. An analysis of the incremental income from livestock to the treatment group respondents shows that it has increased by Rs 3,46,000 annually (Table 7). Respondents rearing goats sell those for meat earning additional income.

Table 7 Income earned by treatment group respondents from dairy post-intervention

Gross income from a cattle/day	**Net income from a cattle/day**	**Annual incremental income (for 12 respondents)**
150	50	₹ 3,46,000

Feed and water availability

FGDs with men revealed that, a significant fraction of farmers in the study area cultivate sorghum primarily as a livestock feed and the crop produce would be a secondary product; post-intervention, it has received a push with assured irrigation. Crop yield analysis of respondents' data supports this claim for the treatment group farmers – crop yield for sorghum in rabi has significantly increased post-intervention.

In all four villages under study, stream is a drinking water source for livestock population, and therefore a longer water retention in the streams directly benefits the livestock population (Figure 6). Also, discussions revealed that the domestic water which is available throughout the year has helped in setting aside water for livestock.

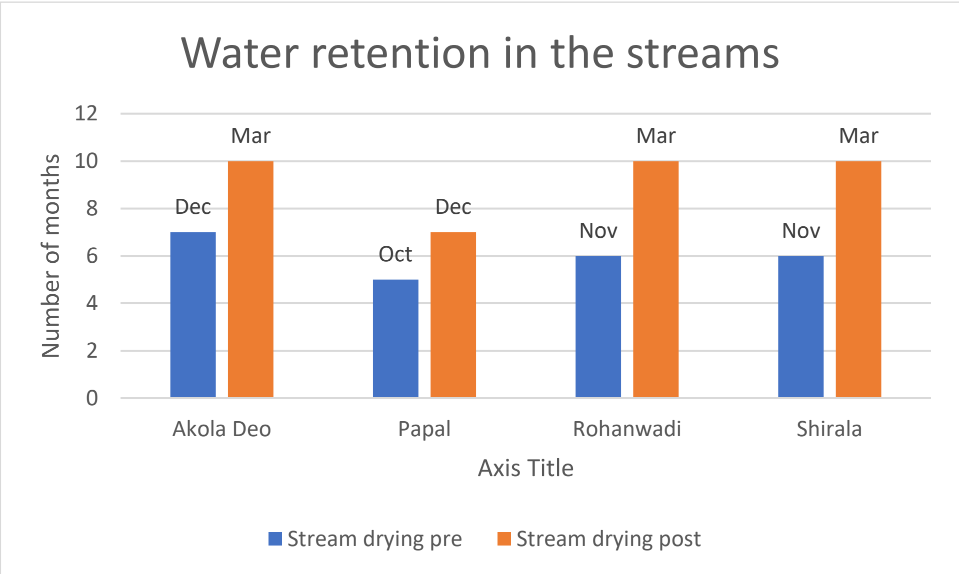

Figure 6 Change in the water retention in streams in the study area post-intervention

Cost-benefit analysis

Cost-benefit analysis uses data of 28 respondents out of a total 38 respondents from the treatment group, for which there is sufficient data to carry out the analysis. These 28 respondents are from Papal, Shirala and Akola Deo villages. Cost benefit analysis does not consider responses from Rohanwadi because of the difficulty in projecting the impact based on a small sample size. It leaves Doha Models on one stream from Akola Deo also, due to its large aberration from the standard dimensions of a Doha Model. Analysis considers agricultural benefits, sericulture benefits, benefits from dairy farming and benefits related to water availability. The cost-benefit analysis yields an internal rate of return of 40% (Table 8).

Cost-benefit analysis considers the life of the intervention as five years. As the years of intervention are 2013 and 2014, and the year of study is 2018, analysis calculates both costs and benefits at 2013 prices, using annual inflation rate of 8%. Incremental capital costs related to agriculture include costs of installing micro-irrigation systems – drip, sprinkler, pipelines – and in installing net shed for commercial seed production; capital costs related to dairy animals include cost of procuring cows and buffalos.

Table 8 Cost-benefit analysis of the Doha Model intervention

Costs			Benefits			IRR
Doha intervention	**Incremental capital costs - agriculture**	**Incremental capital cost - dairy animals**	**Net incremental benefits - agriculture**	**Opportunity cost of water saved**	**Incremental income - dairy**	**IRR**
₹ 4351851.85	₹ 99,25,518.52	₹ 18,14,814.81	₹ 3,74,39,594.22	₹ 4,31,212.68	₹ 14,91,995.89	40 %

Scope of impact

Agricultural fields near the stream

Responses confirm to the assumption that water level in wells close to the stream – limited to 150 to 200 meters from the stream. In some instances, it has reached up to 500 meters or a km where there is a downward slope from the stream.

During the discussions also, participants not receiving any benefits seemed averse to the discussion. In Akola Deo, there was an agitated debate among the beneficiaries and non-beneficiaries about the relevance of this intervention.

Lowland farmers

In all the four villages, Doha Model work has been taken up downstream leaving a portion upstream to its earlier state. There is, therefore, no mechanism to slow down the water or help its percolation upstream and also no apparent benefits accruing to the farmers upstream.

Wells that are upstream have primarily stayed unaffected from the intervention. It is usually the downstream wells – with Doha Model work across the stream – which retain water for an extended period post monsoon.

Increased disparity

Doha Model intervention, by design is more beneficial for farmers who already have an edge over the non-beneficiaries of the intervention – water recharge is better for wells in the lowland agricultural fields in the stream vicinity as compared to those upland and far from the stream – even without the intervention. Thus, this intervention is though beneficial, is not breaking the existing disparity in benefits.

Community participation

Field observation and discussions indicated that there is no particular mechanism for maintenance of the Doha Model work. At the time of the visit, researchers could find broken mud bunds and silt settled in the streams. Participants shared that structure had started deteriorating since next year after the intervention. There is no participatory mechanism to ensure community's participation in maintaining these structures in their original state.

Hydrogeological aspect

One of the streams in the study area, was significantly more in-depth than the 3 meters average depth set for the Doha Model intervention. Discussions revealed that it was a part of the intervention and post-intervention its depth was 6 meters from the ground. A report by the Central Ground Water Board, recording depths of water below ground in Maharashtra, shows the groundwater availability between 5 mbgl (meters below ground level) to 10 mbgl, throughout the year, in Jalna (Central Ground Water Board, Central Region, Nagpur, 2016). The same report shows groundwater availability at depths less than 5 meters from the ground level also, in few districts of Maharashtra. Therefore, an ensuing apprehension in digging streams below 3 meters is of interrupting the shallow groundwater aquifers; it may result in opening up of a giant groundwater well rather than harvesting the rainwater.

CONCLUSION

Study results indicate a positive impact on agriculture post-intervention. Study shows an increase in the overall cropping intensity and a significant increase in the crop yields for cotton, wheat and sorghum. While cotton has a longer crop cycle extending beyond monsoon, wheat and sorghum crops showing increased yield are rabi crops in the intervention area. Therefore, an increased yield for these three crops means an increased water availability for irrigation, which reflects in the increased water level in wells. An increase in the number of farmers and the area under the cost-intensive commercial seed crop cultivation also reflects an increased irrigation support post-intervention. 90% of the treatment group population reported an increase in their wells' water level, and respondents in two villages perceive a reduction in the physical drudgery related to fetching water for domestic use – benefits reflected in the opportunity cost saved. Livestock rearing has also received a push post-intervention, both in numbers and through water and feed availability for livestock. Increased water retention in streams – primary water source for livestock – and an increased yield of sorghum – popular livestock feed in the study area – are potential reasons for increase in dairy animals. A cost-benefit analysis comparing costs of the intervention with the agricultural benefit from the Doha Model intervention also yields an IRR of 40%. These results speak in favour of the Doha Model intervention.

However, the study also shows specific challenges and limitations to this intervention. One significant challenge is the equity in distribution of the benefits. Impacts of the Doha Model intervention are limited to the land area in the vicinity of the stream and lowland primarily. Thus, a significant proportion of the households are out of the purview of this intervention. Further, analysis of cropping intensity and crop yield for different landholding categories shows that semi-medium and medium landholders receive the most significant share of agricultural benefits post-intervention and small and marginal landholders are not the primary focus of the intervention. Limited community participation in the process of implementation and maintenance of the intervention is yet another challenge along with the hydrogeological concern.

Participation of farmer households in the process of design and implementation of the Doha Model intervention has a potential of overcoming these challenges by taking care of the interests of all categories of farmers. Hydrogeological concerns related to this intervention require further investigation; an aquifer mapping, during the design phase, at the site of intervention will be helpful in determining the maximum permissible depth of the intervention.

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