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Impact of Irrigation Water Scarcity on Rural Household Food Security, Income and Poverty Levels in Pakistan

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Pakistan is currently facing severe shortage of irrigation water. Current study is based on comprehensive cross sectional data set collected from 950 farmers from all the four major provinces of Pakistan. The paper analyzes the determinants of water scarcity and its impact on cereal crops yield (wheat, maize and rice), household income, food security and poverty levels by employing the propensity score matching approach. The empirical analysis indicated that farmers with water scarcity problem have lower yield (wheat, maize and rice) and household income and are food insecure. Poverty levels were higher in the range of 7-12% for the household facing water scarcity problem. Policy implications of the study is that public and private sector in Pakistan needs to invest in irrigation water management to maintain the productivity of cereal crops which is important for household food security and poverty reduction.

Keywords: Irrigation Water, Cereal Crops, Food Security, Poverty, Household Income, Propensity Score Matching, Pakistan

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1. Introduction

With increasing climate variability and rapid melting of glaciers, water resource scarcity is becoming a major constraint to agricultural production in South Asia (Cruz et al., 2007). Given that the water is the critical inputs for agriculture, climate variability and glacial retreat might threaten the food security of the region. Increasing temperature will also accentuate the demand for irrigation water in future. Recent studies predict that there will be at least a 10% increase in irrigation water demand with 1˚C rise in temperature in arid and semi-arid regions of Asia (Sivakumar & Stefanski, 2011). Furthermore, water availability is expected to decline, whereas global agricultural water demand is estimated to increase by approximately 19% by 2050. In Pakistan, for example, almost 90% of the total fresh water withdrawal is used for agricultural production (World Bank, 2013), resulting in depletion of aquifers in the country's main food producing states. With the increase in the global temperature and the melting of the Himalayan glacial, the severity of the water shortage in South Asia is likely to increase exponentially. Water scarcity combined with the rising demand for food due to population growth will create increasing pressure to produce more with less irrigation water (Qureshi et al., 2003).

Water scarcity is defined 'from the perspective of individual water users who lack secure access to safe and affordable water to consistently satisfy their need for food production, drinking, washing, or livelihoods. Water scarcity is first and foremost a poverty issue. About 1.2 billion people live in areas of physical water scarcity and up to one in three people in the world face water shortages (Molden *et al.* 2007).

Irrigation consumes about 70 percent of the world available water. There is urgent need for the new strategies to improve the productivity of water in both irrigated and rain-fed agriculture and ensure access to water and technologies by the poor (Baker and Koppen, 1999). In Pakistan about 80 percent of the area is irrigated through canal irrigation system but water scarcity is emerging challenge in Pakistan (Government of Pakistan, 2013). In the past the main source of the agricultural growth was the public sector funded canal irrigation and the private sector funded tube well irrigation (Shah, 1993).

In Pakistan water storage capacity stands at merely 30 days as opposed to the minimum requirement of 120 days. In Pakistan per capita water availability at the time of independence was 5,600 cubic meters against the current measure of 1,000 cubic meters and the water shortage is expected to rise to 31% of people's needs by 2025.

Pakistan loses 13 million cusecs of water every year into the sea while seawater encroachment damages land up to 100 kilometers of cultivable land during periods of reduced river flow which is a dangerous trend for a country that uses nearly 90% of its water resources for agriculture and depends on agriculture sector to remain buoyant (Ashraf, 2013). Severity of the water crisis cannot be ignored while pursuing economic development as it serves as the backbone of the economy. The water scarcity is spiraling up due to increasing population coupled with global warming and climate change thereby inviting the serious intervention from the policy makers.

The current energy crisis especially the severe load shedding in rural areas has broadened the irrigation water scarcity issues. Due to climate changes the canal water is decreasing continuously and due to load shedding problem the farmers cannot run the tube wells. In addition the diesel tube wells are not afforded by the small land holders (>80%) in Pakistan. Due to changing climatic conditions the issue of water scarcity is becoming serious and in the past not much studies have focused on the impact of water scarcity on cereal crops productivity, household income and poverty levels in Pakistan. To fill the gap in the existing literature in the current paper the impact of the water scarcity is estimated on the cereal crops productivity, household income and poverty levels in Pakistan. For that the rest of the paper is organized as follows; In section 2 conceptual framework is presented in section 3 data and description of variables is presented in section 4 empirical results are presented and paper finally concludes with some policy implications.

2. Conceptual Framework

This is assumed that rural household's utility from the availability of water $U(W_A)$ is higher as compared to non-availability of water or when there is water scarcity $U(W_{NA})$

$$U(W_A) > U(W_{NA}) \quad (1)$$

Availability of water leads to higher crops yield (C_i), household income (I_i), food security (F_i) and less poverty levels (P_i)

$$UW_A (C_i, I_i, F_i P_i) > UW_{NA} (C_i, I_i, F_i P_i) \quad (2)$$

In equation (2) this is assumed that household utility levels are higher from the water availability as compared to non-availability of water. The impact of water availability is estimated by employing the propensity score matching approach

The method of matching has achieved popularity more recently as a tool of evaluation. It assumes that selection can be explained purely in terms of observables characteristics. Propensity score matching can be implemented with both cross-sectional and longitudinal dataset. Matching deals with the selection process by constructing a comparison group of individuals with observable characteristics similar to those of treated. Applying the method is, in principle, simple. For every individual in the treatment group a matching individual is found from among the non-treatment group. The choice of match is dictated by observable characteristics. What is required is to match each treatment group individual with individual sharing similar characteristics. The mean effect of treatment can then be calculated as the average difference in outcomes between the treated and non-treated.

The matching method is a non-parametric approach and is more general in the sense that no particular specification has to be assumed. The main purpose of the matching is to re-establish the conditions of an experiment when no such data are available.

It follows that the expected treatment effect for the treated population is of primary significance. This effect may be given as

$$\tau|_{I=1} = E(\tau \mid I=1) = E(R_1 \mid I=1) - E(R_0 \mid I=1) \quad (3)$$

where τ is the average treatment effect for the treated (ATT), R_1 denotes the value of the outcome for farmers without water scarcity and R_0 is the value of the same variable for farmers facing water scarcity. As noted above, a major problem is that we do not observe $E(R_0 \mid I=1)$. Although the difference $[\tau^e = E(R_1 \mid I=1) - E(R_0 \mid I=0)]$ can be estimated, it is a potentially biased estimator.

In the absence of experimental data, the propensity score-matching model (PSM) can be employed to account for this sample selection bias (Dehejia and Wahba, 2002). The PSM is defined as the conditional probability that a farmer adopts the new technology, given pre-adoption characteristics (Rosenbaum and Rubin, 1983). To create the condition of a randomized experiment, the PSM employs the unconfoundedness assumption also known as conditional independence assumption (CIA), which implies that once Z is controlled for, technology adoption is random and uncorrelated with the outcome variables.[i] The PSM can be expressed as,

$$p(Z) = \Pr\{I=1 \mid Z\} = E\{I \mid Z\} \quad (4)$$

where $I=\{0,1\}$ is the indicator for farmers without water scarcity and Z is the vector of pre-non-scarcity characteristics. The conditional distribution of Z, given $p(Z)$ is similar in both groups of non-water scarce household and water scarce households.

Unlike the parametric methods, propensity score matching requires no assumption about the functional form in specifying the relationship between outcome and predictors of outcome. The drawback of the approach is the strong assumption of unconfoundedness. As argued by Smith and Todd (2005), there may be systematic differences between adopters and non-adopters outcomes even after conditioning because selection is based on unmeasured characteristics. However, Jalan and Ravallion (2003) point out that the assumption is no more restrictive than those of IV approach employed in cross-sectional data analysis. In a study by Michalopoulos et al. (2004) to assess which non-experimental method provides the most accurate estimates in the absence of random assignment, they conclude that propensity score methods provided a specification check that tended to eliminate biases that were larger than average. On the other hand, fixed effects model did not consistently improve the results.

In practice, the choice of matching method often appears to make little difference (Smith and Todd, 2000). In small samples the choice of matching approach can be important (Heckman et al. 1997). However, there appears to be little formal guidance in the choice of optimal method. The choice should be guided in part by what the distribution of scores in the comparison and treatment samples looks like. For example, if some treated persons have lots of close neighbours and others only have one, one would favour kernel matching or caliper matching over multiple nearest neighbour matching because either latter would result in many poor matches. Taking another example, if the comparison and treatment samples are of roughly equal size, then single nearest neighbour matching makes more sense than it does when the comparison sample is much larger than the treatment sample because in the latter case single nearest neighbour matching would result in throwing out lots of useful information. Pragmatically, it seems sensible to try a number of approaches because, as noted earlier, the performance of different matching estimators varies case-by-case and depends largely on the data structure at hand (Zhao, 2000). Should they give similar results, the choice may be unimportant. Should the results differ, further investigation may be needed in order to reveal more about the source of the disparity. This serves to reinforce the belief that matching should be implemented in a thoughtful way and not treated as black box. More, specifically, judgement and consideration is required at each stage of the process.

The four commonly used matching algorithms are nearest neighbour matching, caliper and radius matching, kernel and local linear matching and stratification matching. In the current paper nearest neighbour matching and kernel based matching methods are employed. If there are unobservable variables which affect assignment into treatment and the outcome variables simultaneously than the problem of hidden bias might arise for that the sensitivity analysis has been carried out.

3. Data and Description of Variables

Using structured questionnaire, data was collected through field survey from 950 farmers in Pakistan. In the first stage all the four provinces of Pakistan were selected and in the second staged about 350 farmers from Punjab province, 250 from the KPK and Sindh provinces and 100 farmers from the Baluchistan province were randomly selected. Socioeconomic, farm and household information were collected. A large number of questions were also included regarding the water availability and shortage of water.

The description of variables in presented in table 1. The mean age of the farmers was 43 years and mean education level was about 9 years of schooling indicating that farmers in the study area are quite educated. The experience of the farming community was about 14 years. About 92 percent were local and rest 8 percent were migrant. About 74 percent were owner of the land and rest were tenant of the land. About 89 percent of the respondents were head of the households and the rest were relative to head. Approximately 65 percent of the farmers have good quality soil and rest have poor quality soil. About two third of the farmers (67 percent) have fragmented land and vice versa. An over whelming majority 85 percent of the farmers have same slope land and the rest have steep slope. About 23 percent of the farmers have practiced land leveling and vice versa. Only 8 percent of the farmers have cultivated legumes for increasing the soil fertility and vice versa. The mean land holding of the farmers was about 2.65 hectares. In majority of the cases 96 percent of the farmers are males as head of the household and rest 4 percent are the tenants. The average family size was about 10 family members per household. Majority of the rural households (68 percent) are living in the joint family system. About 48 percent of the rural households have access to metal road and vice versa. Few households have tractor and tube well ownership and car. The average livestock ownership are about 7 per household. About two third of the farmers use home seed and the rest use the seed from other sources mostly fellow farmers and dealers etc. Only 6 percent of the farmers have access to credit facility and vice versa. About 26 percent of the farmers have access to extension services and vice versa. The mean income of the household is 42,165 rupees and household expenditure of the household is about 36905. The climate changes have significant impact on the crops yield (Ashfaq *et al.,* 2011)). Massive number (94%) of the sample respondents observed the change in climatic conditions over time while only 6% viewed that they couldn't observe change in the climatic conditions over time. Similarly a massive figure (more than 90%) of sample respondents professed the change in rainfall, temperature, rainfall timing and monsoon overtime (10 years) while a less than 10 percent stated that had not observed any change in rainfall, temperature, rainfall timing and monsoon in last 10 years. The data in table revealed that more than half (57%) of the sample farmers had adjusted the sowing time of wheat according to the climatic conditions while the rest

43% of the sample respondents had not adjusted the wheat sowing time according to the change in the climatic conditions.

Regarding the adoption of heat/stress tolerant varieties, a massive figure (91%) of the sample respondents stated that they had not adopted the heat/stress tolerant varieties while remaining 9% of the sample respondents stated that they had adopted the heat/stress tolerant varieties. Relatedly a massive figure (93%) of the sample respondents indicated that they had not adopted new crops/left out some crops due to climatic conditions while remaining 7% of the sample respondents specified that they had adopted new crops/left out some crops due to climatic conditions.

4. Irrigation Sources Used by the Farmers

The common irrigation sources used by the farmers are presented in table 2. In the study area the most popular source of irrigation are the canals (72%) followed by tube wells (24%) and wells (3%) respectively as presented in table 2.

In the study area the canal water is not sufficient to meet the irrigation water requirements as 64 percent of the farmers face water scarcity problem during the season (Table 3). The farmers turn to alternate source of irrigation water i.e. tube well and due to load shedding problem 74 percent of the farmers are not able to get benefit from the tube wells. About 18 percent of the farmers use diesel tube well for the irrigation purposes and this is really costly and the majorities of the farmer are small holder farmers in Pakistan and is not able to afford the costly irrigation water.

5. Empirical Results

5.1 Determinants of Water Scarcity

The matching process is preceded by specification of the propensity scores for the treatment variable. A logit model was employed to predict the probability of irrigation water scarcity among the farming community in Pakistan. The dependent variable is dummy i.e. 1 if the farmer faces water scarcity and 0 otherwise. A set of independent variables were also included in the model. The age coefficient is positive and significant at 1 percent level of significance indicating that mostly the aged farmers face the water scarcity problem and vice versa. The education is negative and significant at 5 percent level of significance indicating that less educated farmers are more facing the water scarcity problem and vice versa. Similarly the head coefficient is negative and significant at 10 percent level of significance indicating that if the farmer himself is head of the household than he faces less water scarcity problem and vice versa.

The land fragmentation was also included as dummy variable and the coefficient is positive and significant indicating that farmers with the fragmented land holding normally face more water scarcity issue and vice versa. The slope was also included as dummy variable and the coefficient is positive although non-significant. The land leveling and the land holding size coefficient are negative and significant indicating that farmers who have leveled the land and have higher land holdings normally face less water scarcity problem and vice versa.

The family size coefficient is positive and highly significant at 1 percent level of significance indicating that farmers with higher family size normally face more water scarcity problem and vice versa. The joint family was included as dummy variable and the coefficient is negative and significant indicating that farmers living in the joint family normally face less water scarcity problem and vice versa.

The metal road and tractor ownership coefficient are positive and non-significant. The most importantly tube well ownership is negative and highly significant at 1 percent level of significance indicating that farmers having tube well ownership normally face less water scarcity problem and vice versa. The car ownership is negative and significant while the number of livestock owned is positive and significant indicating that households having higher number of livestock normally face the water scarcity problem and vice versa. The access to credit facility, extension services and organization membership are all negative and significant indicating that farmers having this support are normally facing less water scarcity problem. The provincial dummies were also included in the model.

The value of R-square is 21 percent and LR-chi Square is highly significant at 1 percent level of significance indicating the robustness of the variables included in the model.

5.2 Impact of Water Scarcity Cereal Crops Yield and Household Income and Poverty Levels

The impact of water scarcity on cereals crops yield, household income and poverty levels is estimated by employing the propensity score matching approach. In the current analysis two different matching algorithms i.e. nearest neighbor matching (NNM) and kernel based matching (KBM) are employed. In case of propensity score matching the most important parameter of interest is the Average Treatment Affect for the Treated (ATT) i.e. difference in the outcome of the farmers facing irrigation water scarcity and those farmers not facing the irrigation water scarcity of the similar propensity score. For NNM the caliper and for KBM the bandwidth is reported in Table 5. The ATT for wheat yield is negative and is in the range of 20-29 kgs indicating that farmers facing water scarcity have less wheat yield in the range of 20-29 kgs both in NNM and KBM respectively. Similarly the rice yield are less in the range of 38-43 kgs both in NNM and KBM respectively. The maize yields are less in the range of 15-17 kgs both in NNM and KBM. These results has important policy implications that due to water scarcity the yields of the cereal crops is significantly less as compared to similar farmers facing no water scarcity problem.

Due to water scarcity the household income is less in the range of rupees 8032-10741 Pakistani rupees both in NNM and KBM respectively indicating that households are earning less as compared to similar households having no water scarcity issue. Due to water scarcity the household food security levels are badly affected and the households have less food security in the range of 7-12 percent as compared to household having no water scarcity problem. The results are in line with the previous studies like Hussain and Hanjra (2004).

Most important finding of the current study is the impact on the poverty levels. For that the head count index of poverty was estimated and included as outcome variable in PSM estimated. The ATT results indicate that due to water scarcity the poverty levels are higher in the range of 5-7 percent. The results are in line with the previous studies like Ali and Abdulai (2010).

From the empirical findings this can be concluded that access to irrigation water is affecting cereals crops yield, household food security, income and poverty levels. Huge investment is needed from both public and private sector so that farming community have access to irrigation water for sustaining crops yield, household income and food security levels. Otherwise the efforts of reducing poverty will be severely affected as the results in current analysis indicates. The critical level of hidden bias is also included and the critical level of hidden bias indicates the level up to which the farmers facing water scarcity and farmers not facing water scarcity differs in their odds of having access to irrigation water. The number of treated and number of control are also reported in table 5.

The main purpose of the propensity score matching is to balance the covariates before and after matching, for that a number of balancing tests are employed like median absolute bias before and after matching. The value of R-square before and after matching. The p-value of joint significance of covariates before and after matching. The results of the matching quality are presented in table 6. The median absolute bias before matching is quite high and is in the range of 18-23 both in NNM and KBM. After matching considerable amount of bias has been reduced and the bias is in the range of 3-7. The percentage bias reduction is in the range of 64-81 percent.

The value of R-square is quite high before matching and is quite low after matching indicating that after matching the covariates has been balanced and there are no systematic differences between the farmers facing irrigation water scarcity and not facing irrigation water scarcity. Similarly the p-value of the joint significance of covariates is also presented in table 6. The p-value is significant before matching indicating that before matching both the groups are quite different from each other, while the p-value is non-significant after matching indicating that after matching both are quite similar to each other. The results are in line with the previous studies like Ali and Abdulai (2010).The Figure 1 also indicates the imposition of the common support condition and the balancing of the covariates.

6. Conclusions

The irrigation water scarcity is becoming serious issue in Pakistan and many farmers are facing the water scarcity problem. As the empirical results indicated that due to water scarcity the yield of the cereal crops is considerably decreased. The decrease in cereal crops yield has decreased the food security levels in the range of 7-12 percent. Subsequently the household income levels are less in the range of 8000-1000 Pakistani rupees. Due to water scarcity the poverty levels are high in the range of 4-5 percent. In the rural irrigation sector investment is needed from the public and private sector so that the water losses can be decreased and the farmers have access to irrigation water at the time of need which will help to sustain the crops yields beside ensuring food security levels and poverty reduction in the rural areas of Pakistan.

Table 1: Data and Description of Variables

Variable	Description	Mean	Std Dev.
Age of household head	Age of the farmer in number of years	43	11.6
Years of Schooling of head	Education of the farmer in number of years	8.71	5.42
Farming Experience	Farming Experience in number of years	14.44	7.83
Local resident	1 if the farmer is local, 0 migrant	0.92	0.41
Land ownership	1 if the farmer is owner of land, 0 otherwise	0.74	0.55
Male headed	1 if the farmer is head, 0 otherwise	0.89	0.39
Good soil quality	1 if the soil is of good quality, 0 otherwise	0.65	0.48
Fragmented land	1 if the land is fragmented, 0 otherwise	0.67	0.35
Slope: Plain land	1 if the slope is same, 0 otherwise	0.85	0.51
Land Leveling	1 if the farmer have practiced land leveling, 0 otherwise	0.23	0.43
Legumes crop rotation	1 if the farmer have included legumes in crop rotation and 0 otherwise	0.08	0.15
Land Size (Hectare)	Land owned by the farmer in number of hectares	2.65	1.42
Male head	1 if the head is male and 0 otherwise	0.96	0.75
Household size	Number of family members in the household	10.13	5.12
Joint Family	1 if living in joint family, 0 otherwise	0.68	0.34
Access to metal road	1 if the household have access to metal road, 0 otherwise	0.48	0.57
Owned tractor	1 if the farmer own a tractor, 0 otherwise	0.09	0.13
Owned tubewell	1 if the farmer own a tube well, 0 otherwise	0.07	0.27
Owned car	1 if the farmer owns a car, 0 otherwise	0.19	0.24
Livestock assets	Number of livestock owned by the farmer	7.35	5.03
Seed Source	1 if home seed is used, 0 otherwise	0.66	0.32
Access to credit	1 if the household have access to credit facility and 0 otherwise	0.06	0.28

Access to extension	1 if the farmer have contact with extension services, 0 otherwise	0.26	0.15
Income (Pak Rupee)	Per month household income from all the sources	42165	12560
Expenditure (Pak Rupee)	Per month household expenditure in rupees	36906	25783
Membership to organization	1 if farmer is member of any organization, 0 otherwise	0.16	0.12
Punjab Province	1 if the farmer is from Punjab, 0 otherwise	0.35	0.20
Sindh Province	1 if the farmer is from Sindh, 0 otherwise	0.25	0.18
KPK Province	1 if the farmer is from KPK, 0 otherwise	0.25	0.18
Baluchistan Province	1 if the farmer is from Baluchistan, 0 otherwise	0.10	0.06

Table 2: Irrigation Source

Source	Percentage
Canal	72
Tubewell	24
Wells	3
Other	1

Table 3: Water Scarcity, Load shedding and Source of Power for Tube wells

Variable	**Percentage**
Irrigation water scarcity	64
Load shedding	74
Tube well (Diesel)	18
Tube well (Electric)	87

Table 4: Determinants of the Water Scarcity (Logit estimates)

Variable	Coefficient	t-value
Age	0.04***	2.81
Education	-0.01**	2.05
Owner	-0.02**	-1.98
Head	-0.01*	-1.67
Land Fragmentation	0.01**	2.19
Slope	0.01	1.45
Land Leveling	-0.01**	2.10
Land Holding	-0.02**	-2.30
Family size	0.03***	2.76
Joint Family	-0.01**	-2.54
Metal Road	0.01	1.33
Tractor	0.01	1.41
Tube well	-0.01***	2.75
Car	-0.01**	2.37
Livestock	0.02***	2.58
Credit	-0.01**	-2.06
Extension	-0.03**	-2.15
Membership	-0.01***	-2.27
Punjab	-0.02**	-2.10
Sindh	-0.05*	1.83
KPK	0.01	1.12
Value of R-square	0.21	
LR-Chi Square	198.34	
Prob>Chi Square	0.000	
Number of Observations	950	

*Note: The results are significant at ***,**,* 1,5 and 10 percent levels respectively.*

Table 5: Impact of Water Scarcity on Cereal Crops Yield and Household Income and Poverty Levels

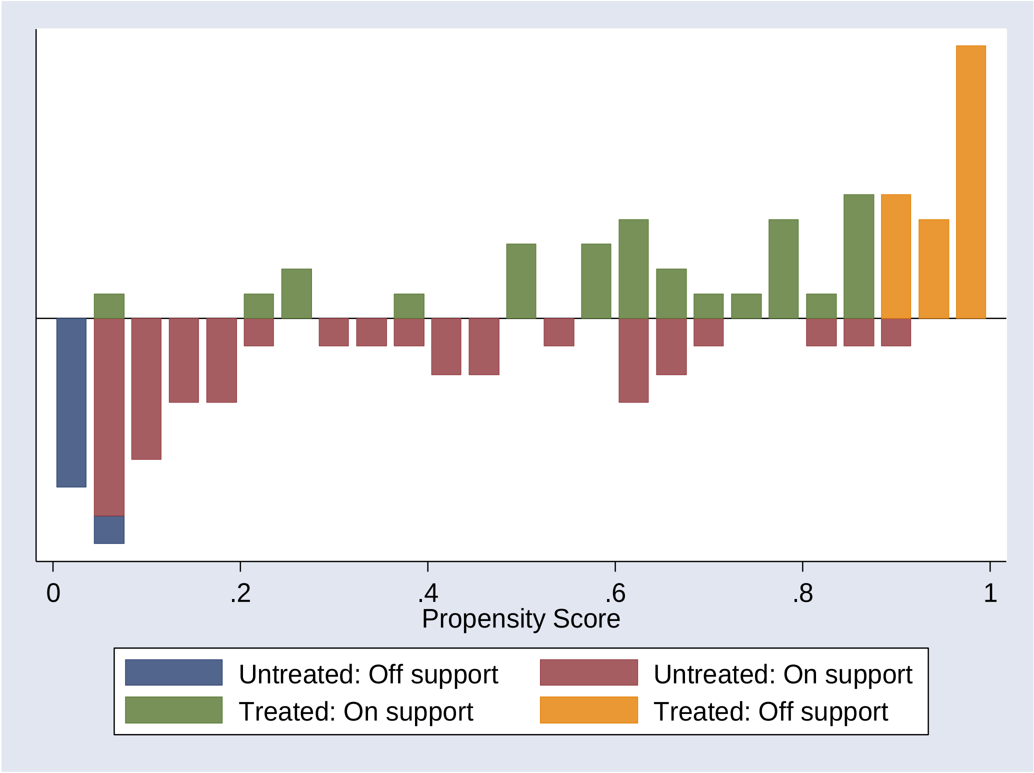
Matching Algorithm	Outcome	Caliper/ Bandwidth	ATT	t-values	Critical Level of Hidden Bais	Number of treated	Number of Control
NNM	Wheat Yield	0.001	-20.31***	-3.17	1.20-1.25	356	451
	Rice Yield	0.05	-38.57**	-2.04	1.45-1.50	399	473
	Maize Yield	0.01	-15.25**	-1.98	1.15-1.20	362	485
	Income	0.003	-8032*	-1.75	1.80-1.85	378	494
	Food Security	0.005	-0.07*	-1.67	1.30-1.35	316	426
	Poverty	0.06	0.05*	1.73	1.25-1.30	322	491
KBM	Wheat Yield	0.1	-29.60***	-2.63	1.35-1.40	379	478
	Rice Yield	0.04	-43.18***	-2.58	1.15-1.20	352	444
	Maize Yield	0.05	-17.24***	-3.04	1.50-1.55	385	460
	Income	0.001	-10741***	-3.41	1.25-1.30	401	452
	Food Security	0.002	-0.12**	-2.15	1.40-1.45	383	471
	Poverty	0.003	0.07**	2.32	1.35-1.40	370	453

*Note: NNM stands for the nearest neighbor matching, KBM stands for the kernel based matching. ATT stands for the Average treatment affect for the treated. The results are significant at ***,**,* 1, 5 and 10 percent levels respectively.*

Table 6: Indicators of Covariates Balancing Before and After Matching

Matching Algorithm	Outcome	Median absolute bias before matching	Median absolute bias after matching	Percentage bias reduction	Value of R-square before matching	Value of R-square after matching	P-vale of LR-Chi square before matching	P-value of LR-chi square after matching
NNM	Wheat Yield	18.24	4.23	76.8	0.264	0.002	0.003	0.278
	Rice Yield	19.27	5.07	73.6	0.257	0.003	0.002	0.351
	Maize Yield	20.18	3.87	80.8	0.234	0.004	0.001	0.443
	Income	20.15	4.71	76.6	0.231	0.003	0.002	0.517
	Food Security	21.42	3.98	81.4	0.280	0.002	0.003	0.239
	Poverty	22.54	5.73	74.5	0.432	0.003	0.002	0.361
KBM	Wheat Yield	20.36	7.20	64.6	0.591	0.001	0.001	0.453
	Rice Yield	21.73	6.54	69.9	0.783	0.004	0.003	0.481
	Maize Yield	20.75	4.51	78.2	0.591	0.005	0.002	0.493
	Income	21.67	4.39	79.7	0.842	0.002	0.001	0.260
	Food Security	20.43	5.38	73.6	0.649	0.003	0.002	0.482
	Poverty	23.51	6.04	74.3	0.233	0.001	0.003	0.431

Figure1: PSM (Imposition of the common support condition)



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Notes

[i] As pointed out by Imbens and Wooldridge (2009), unconfoundedness implies that we have a sufficiently rich set of predictors for the adoption indicator, contained in the vector of covariates, such that adjusting for differences in these covariates leads to valid estimates of causal effects.