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Climate Change Adaptation in the Indus Ecoregion:

A Micro-Econometric Study of the Determinants, Impact and Cost Effectiveness of Adaptation Strategies

LUMS

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IDRC CRDI

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List of Acronyms

ATE	Average Treatment Effect
ATT	Average Treatment on the Treated
ATU	Average Treatment Untreated
CGIAR	Consortium of International Agricultural Research Centers
DRR	Disaster Risk Reduction
GIS	Geographic Information System
IFPRI	International Food Policy and Research Institute
IDRC	International Development Research Centre
LEAD	Leadership for Environment and Development
LSE	London School of Economics and Political Science
LUMS	Lahore University of Management Science
N or (n)	Sample size
NGOs	Non-govermental Organizations
NN	Nearest Neighbour
OLS	Ordinary Least Squares
PDR	Pakistan Development Review
PIDE	Pakistan Institute of Development Economics
PKR	Pakistan Rupee
PMD	Pakistan Meteorological Department
PSDP	Public Sector Development Plan
PSM	Propensity Score Matching
SPDC	Social Policy and Development Centre
WWF-Pakistan	World Wide Fund for Nature-Pakistan

Acknowledgements

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rate policy briefs and policy events.

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Foreword

The World Wide Fund for Nature-Pakistan (WWF-Pakistan) has since nearly a decade worked on multiple climate change adaptation programmes. These range from priority themes for Pakistan's northern areas (e.g., schemes to incentivize prevention of climate-induced landslides, or, mitigation of glacial lake outburst floods) as well as its coastal areas (e.g., investment in mangrove plantations as a defense against sea-level rise, or, adaptation business models that use crab fattening pond proceeds to build elevated homes). Increasingly, adaptation projects taken on by WWF-Pakistan are now making use of our proven strengths in community, district, and provincial coordination that is ideal for bridging between disaster risk reduction investments, on the one hand, and climate change adaptation spending, on the other hand. Another important niche into which WWF-Pakistan has introduced climate change adaptation is our work on reducing water footprints and improving soil quality in partnership with farmers of Punjab, Sindh, and Balochistan.

I am pleased to have served as a Natural Resource Management Advisor for the present study which identifies for the agricultural sector of Pakistan the monetary cost of climate change and asks if adaptation can play a role in reducing that cost. The study has benefitted from the experience of one of WWF International's Board trustees, Dr. Adil Najam, Dean, Federick S. Pardee School of Global Studies, Boston University, who served as the study's Principal Investigator. Here, WWF-Pakistan is seen to once again establish among the highest standards of research scholarship. This crucially heightens the policy relevance and usability of the findings. It also increases the possibility of subsequent use by academics as well as climate change planners of this study's queryable database, something increasingly demanded by donors measuring investment impact. WWF-Pakistan's economists are fast earning a place in conservation in Pakistan through their appeal to monetary benefits to justify a heavy conservation expense or to justify allocations for one out of many competing land-uses. We are grateful to the Chief Meteorologist of Pakistan, Dr. Ghulam Rasul, for supplying 24 years of customized rainfall and temperature data, making this an unprecedented 40, 60 and 80 year Hedonic analysis of 4 of Pakistan's 9 agro-climatic zones which will interest the 15 research centres that are members of the CGIAR Consortium, no less.

WWF-Pakistan hopes to continue to train master trainers in its new breed of climate field schools made possible by this study. In particular, based on a manual utilizing this micro-econometric study's household level observations, WWF-Pakistan's Sustainable Agriculture Programme revised its existing sugarcane curriculum and trained 162 farmers from Jhang, Rahim Yar Khan, Bhawalpur, Sujawal, Thatta, Badin, Gwadar, and Lasbela districts. We also look forward to continuing our 3-4 year old climate change collaboration with the Lahore University of Management Sciences which has been made possible by the financial support of the International Development Research Centre.

Rab Nawaz
Director - Sindh
Team Leader - Indus for All Programme

Executive Summary

Pakistan is ranked among the top 10 countries that have over the past decade experienced devastating loss of life and property owing to events some link to climate change. In its 2015 Global Climate Risk Index, Germanwatch ranked Pakistan in 6th place for 2013, while the country was identified as the most affected by climate change globally in 2012. The response to this challenge has not only come from (inter)national aid and relief agencies, the Government of Pakistan provided new and more extensive mandates to its national and provincial disaster management authorities. It also re-oriented federal ministries, establishing a climate change ministry first in 2010 (with reinstatement in 2015). Aside from lives lost to climate related floods in 2010 (1,985 in 2010 alone) a damage estimate by the World Bank and the Asian Development Bank placed the cost of floods that year at USD 9.7 bn. At the time, as many as 11,000 villages, 1.74 m homes, and 18 m affectees required urgent relief and also medium to long term assistance.

In the agricultural sector, the floods acted as a setback to Pakistan's food security objectives, besides frustrating economic growth. The objective of food security was hindered because of reduced productivity and cropping intensity for most crops. However, it was also hindered because of impacts that climate change hazards tend to have on agricultural households' ability to access and afford food by depleting their assets and savings. Note, Public Sector Development Plan (PSDP) allocations directed towards natural hazards cannot alone result in building the agriculture sector's resilience to climate change. Subtler changes relating to day time/night time temperatures and onset/duration/intensity of rainfall or its absence will, at once, affect crop yields, farm incomes, overall food supply, and food import expenses.

The present study's relevance to planners is precisely for the latter concern. It supplies much that will assist them. First, it provides a PKR cost estimate of losses -- in terms of agricultural productivity and land values -- due to temperature (+0.5-2°C) changes over the coming 25 to 65 years. The loss estimate is essential to any planning exercise listing actions needed to restore agricultural productivity as well as their costs. Affording the actions would require curbing national consumption, increasing savings, or, reducing spending in other sectors so as to increase the allocation share of the agricultural sector. A traditional response to increasing agricultural productivity in Pakistan is increasing irrigation water, the cost of which is measured in the building of new storage reservoirs, or, the lining of canals to reduce existing water losses. A Pakistan Development Review (PDR) article suggests that for every 1% increase to Pakistan's overall agricultural production, an additional 0.47 bn m^3 of water is required (PDR, 2007). Some would argue that additional water would need to be made available even if the government invested in measures to equip farmers to reduce crop losses at their end by altering inputs and land preparation. The present study's Hedonic analysis finds that in 25 years' time, productivity of land will reduce by 8-10% or up to PKR 30,000 per acre in Punjab and Sindh owing to climate change. Were the government to meet this shortfall by determining it necessary to increase productivity by 10%, then going by the PDR's estimate it would need to spend on efficiency and storage measures capable of supplying 4.7 bn m^3 of water from 2015 onwards.

Beyond its loss estimate for 25-65 years, the present study provides planners another readily usable piece of information: the Kg productivity gains -- or returns on investment -- associated with farmers belonging to "adapter" and "non-adapter" classes. Those in the latter class are "non-adapters" in that they stand to gain Kg yield advantage from applying the following 5 on-farm “adaptation measures” already in use by some farmers (adapters) in Sindh and Punjab: (1) altered sowing/harvesting dates, (2) shifted cropping patterns, (3) changed levels and composition of inputs, (4) increased soil conservation investment, and, (5) increased water conservation. The study’s result, namely that non-adapters stand to gain in terms of yield (maunds/acre) by 52% for cotton, 49% for wheat, and negligibly for rice, is actionable for planners minding the sector’s climate change resilience but in a specific sense. That is, the payoff from investment in Agricultural Extension Department trainings on the above 5 measures can be high. The payoff is high relative to the low cost of holding of farmer field schools, broadcasting of radio messages, curriculum printing, flyers and meetings. However, the payoff is also high compared to what it would be for the considerably high DRR expenses or the expense associated with increased irrigation flows or increased efficiency of existing irrigation systems. The lining of canals or building of reservoirs is highly cost intensive. It is also, in many ways, the kind of expenditure that one comes around to only after exhausting low-cost and high-gain interventions such as holding farmer trainings. Moreover, the crop-specific information and the sampling of 4 of Pakistan’s 9 agro-climatic zones enables the adapter and non-adapter yield findings to be prioritized (e.g., rice is not a priority) and contextualized for “Barani Punjab”, “Cotton/Wheat Punjab”, “Cotton/Wheat Sindh” and “Rice/Other Sindh” zones.

Finally, having examined the role of adaptation in attenuating the cost of climate change, the study provides planners a menu of “leverage points” that may be said to encourage adoption of any single one of the 5 on-farm adaptation measures or a combination of them. The study’s examination of the determinants of adaptation behaviour also helps prioritize farm types from among all farms for any given crop. The study finds, for instance, we need not prioritize wealthy farmers (as measured by total land holdings) who according to the survey data tend to already be advanced in their use of adaptation measures for all crops. Even if large farms are targeted for adaptation measures, the study helps us to understand that we need not prioritize the following adaptation measures: shifted cropping patterns; and, changed levels and composition of inputs (both of which are correlated with large land holding). In terms of leverage points, were planners to seek beneficiaries for investments to encourage cropping pattern shifts and increased soil conservation investment, they would do well to delve deeper into the institutional context of adaptation decisions. The study finds that there are strong correlations between share cropping arrangements, ownership of land and the role of middlemen in certain adaptation decisions such as crop choice. Also, the study defines educated and older/experienced farmers as beneficiaries that will likely respond well to information or training on soil conservation and water conservation. One potentially useful correlation finding emerging from the study is that between adaptation measure use and membership of farmers associations. Even as sceptical economists who may point out that adapters are likely to self-select into farmers’ associations (and therefore that doling out of memberships alone is unlikely to precipitate adaptation behaviour), the study’s finding of a correlation between adaptation and farm association membership can have value. In particular, planners can bear in mind that the range of experiences and services offered by membership can encourage adaptation among farmers abruptly exposed to information.

The methodological rigour of the present study is an endorsement for its immediate use by planners. It is the first application in Pakistan of a Hedonic function to estimate the climatic determinants of agriculture land values and productivity. It is also the first model of its kind to use primary survey-based household data in 4 of Pakistan's 9 agro-climatic zones, while incorporating a 1990-2014 time-series data set processed by the Pakistan Meteorological Department (PMD) at a 25km grid resolution and rendered in monthly averages. Moreover, while incorporating the meteorological data it was downscaled from a 25 km grid to precise sampled village coordinates through an application of the Kriging technique. Production functions have been applied in the past for the different purpose of estimating crop specific supply shortfalls. Sometimes these have not gone so far as to estimate climate change impacts. Even if they have, the Ricardian approach in the present study admits a wider range of production technologies, i.e., agricultural activities such as livestock and crop production. Production function models unlike the Hedonic analysis in the present study tend to assume a fixed technology such as mono-cropping of wheat. One benefit of our Ricardian approach is no such assumption is made. The International Food Policy Research Institute (IFPRI) estimates wheat and rice supply for 2030 without use of climatic data (Nazli, Haider, & Tariq, October 2012). The Department of Environmental and Resource Economics, University of Agriculture Faisalabad, in conjunction with the Department of Economics and Agricultural Economics, PMAS-Arid Agricultural University, Rawalpindi, estimated a Cobb-Douglas production function to estimate rice yields (Mahmood et al., 2012). The Pakistan Institute for Development Economics (PIDE), for its part, estimated a Cobb-Douglas production function using time series meteorological data from 1979-2004 for a 2006 supply forecast for wheat (Sher and Ahmad, 2008).

Over the 2000-2012 period, an unbroken trend in Pakistan's rising average temperature has been recorded, with a national area weighted mean temperature moving from 22°C to well over 22.5°C (Rasul, 2012). The frequency of monsoons doubled in India over the last 50 years (Goswami et al., 2006; Pal and Al Tabbaa, 2010). Also, Arabian Sea data from 1880 to date reveals a threefold increase in severe cyclonic events over the past few decades (Singh, 2010). In the last 15 years alone, considerable low pressure cyclonic events have struck Pakistan. They have been of similar orders of magnitude to those of 2010 (cyclone Phet) and the ones which occurred in 1993, 1999, 2004, and 2007 (cyclone Yemyin). All these trends, beginning with temperature, but also the monsoon rain and cyclones, suggest considerable and growing pressure on Pakistan's agricultural sector. Annual trends of course do not explain what will happen to Pakistan's different crops; rather, predicting how rainfall and temperature will be distributed across Kharif and Rabi seasons is important. Accordingly studies such as the present one which focusses on seasons should continue in this vein.

When all is said and done, i.e., once farmers have introduced certain varieties of resistant seed as well as managed their land better (covering a range of measures from tillage, crop husbandry, irrigation, to agrochemical input use and control of pests), it is understood that yield is certainly not as dependent on seed varieties as it is on land management. Moreover, a growing number of studies indicate that irrigation holds an overriding and important role within land management aiming to adjust inputs to get the most from cultivable land. This is perhaps most important for the "Barani Punjab" agro-climatic zone. A large fraction of Pakistan's agriculture is irrigated (particularly "Mixed Punjab", "Cotton/Wheat Punjab", and "Low Intensity Punjab" agro-climatic zones), making it generally speaking more resilient to climate change than countries in the world that aren't endowed with such vast irrigation systems. A closer look reveals that of the 6 m hectares of Pakistan's government canals, 60%

are in Punjab and only 30% are in Sindh. Also, of the total of 3.4 m hectares under tube well use – tube wells ownership crossed the 1m mark in 2013 – as much as 80% lies in Punjab. Ostensibly, this would mean that Sindh is more vulnerable to climatic shocks, be they gradual temperature and rainfall changes or abrupt and extreme weather. The picture this paints is clear. Climatic influence over Pakistan's food security is likely to remain. This heightens the need for a category of studies such as the present one. One key message from the present study is that climate change is likely to have a large impact on agricultural productivity. It also shows that adaptation can attenuate this impact by improving food security. Importantly, the study shows that the biggest benefits to adaptation are likely to occur for those who have not yet adapted. Finally, it provides a detailed analysis of the determinants of adaptation. This can guide policy makers in facilitating adaptation in the agricultural sector

Introduction

The objective of this study is to understand the impact of climate change on food security in Pakistan, and the role of adaptation in determining this effect and possibly attenuating the costs of climate change. As is typical in the agricultural adaptation literature, our interest is in autonomous and reactive adaptation strategies at the level of the farm or household producer consumer, rather than exogenous (e.g. government policy) and anticipatory (Smith 1997, Mendelsohn 2010). There are 4 broad research questions that we planned to address:

1) What is the likely cost of climate change to agricultural households in rural Pakistan?;
2) To what extent does adaptation to climate change ameliorate these costs?;
3) What are the key determinants of adaptation to climate change; and,
4) What policy recommendations can we draw from the answers to the above?

These broad research questions are underpinned by a number of more detailed hypotheses concerning the institutional and other micro determinants of adaptation. In order to address them we undertook an in-depth household survey of almost 1,500 households in Punjab and Sindh provinces from 20 April 2013 to 29 June 2013, preceded by a reconnaissance survey in December 2012. Our April-June 2013 survey instrument elicited detailed information on all aspects of rural agrarian life in Pakistan. Appendix 7 shows the questionnaire that we designed specifically for this purpose. The data from the survey was combined with spatial climatological data obtained from the Pakistan Meteorological Department (PMD), namely 24 years of average monthly rainfall and temperature data at a 25 km grid resolution spanning 1990 to 2014. Beyond the 25 km grid, Kriging was used to link temperature and rainfall observations to each of the villages in the 7 districts from which households were sampled. The completed survey dataset (for which the PMD time-series data was matched) contains over 5,000 variables for each of the 1,500 households.

The detailed survey allows the most detailed analyses of climate change adaptation in rural Pakistan to date. In this report we document the key findings of our analysis. These can be briefly summarised as follows:

1) The cost of climate change: Climate change will reduce agricultural productivity by around 8-10% by 2040 as measured by land values. This assumes temperature (+0.5-2°C) changes over the coming 25 to 65 years that were forecasted by the Pakistan Meteorological Department. The monetary cost associated with the 8-10% loss figure for 2040 is approximately PKR 30,000 per acre. Table 1.1 below provides per cent changes and PKR costs per acre for other years besides, namely 2012, 2060 and 2080.

2) The benefit of adaptation: Farmers who adapt to climate change through on-farm methods: crop timing; changing inputs; crop choice; have higher yields for wheat and rice and are more food secure than non-adapters. The benefits of adapting for the rice crop are less clear. Importantly, it appears that non-adaptors would benefit to a significant degree from adaptation strategies had they undertaken these. The final results are that non-adapters stand to gain in terms of yield (maunds/acre) by 52% for cotton, 49% for wheat, and negligibly for rice. This is an interesting finding and suggests adapters and non-adapters differ significantly in their characteristics. Why farmers are unable to realise potential gains from adaptation are of key future interest.

3) Determinants of adaptation: Households with a higher proportion of females are strongly associated with an increased likelihood of adaptation. Experience of drought significantly increases the probability of adaptation, suggesting that the effects of droughts may be

persistent and change the way farmers can and do behave. In contrast, previous experience of flooding reduces the probability of adaptation. Access to off-farm work correlates negatively with adaptation suggesting, perhaps, substitution between on-farm and off-farm adaptations. Access to formal information services appear to appear to strongly affect adaptation, although information gathered through peer groups seems to be important as well.

The influence of informal institutions such as middlemen appears to be complex, necessitating further study of the role these agents play across different crops and geographical locations (Quartey et al. (2012); Lohano et al. (1998). Land tenure also appears to be important. Households are more likely to undertake costly adaptation strategies on owned land, a finding echoed by other studies of technology adoption and land tenure in Pakistan (Ali et al., 2014; Jacoby and Mansuri, 2008).

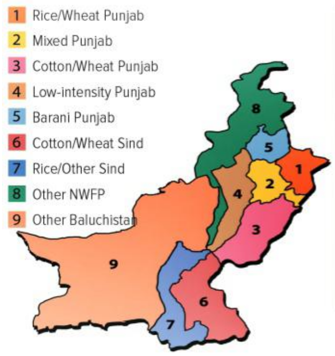
4) Adaptation is influenced by seasonal climatic trends, with certain adaptation strategies preferred over others. Higher Rabi temperatures raise the probability of water and soil conservation strategies, while temperature does the opposite. Some adaptation strategies, such as crop and input choice are only effective within narrow ranges of temperature, particularly at the higher Kharif temperatures.

5) Policy recommendations: Assisting adaptation is likely to have welfare benefits via productivity enhancement and food security. Targeting policies to encourage adaption is of key importance, however. Whether farmers adapt is determined by their access to current and reliable information concerning farming innovations and a changing climate. This work shows that formal extension services have some effect at providing key information on climate adaptation. More resources could be put into providing effective advice to help farmers who have not adapted realise potential benefits to adaptation. Institutional features of the Pakistani rural economy, namely the existence and role of middlemen and tenure seem to impact on how productive and willing farmers are to use adaptation. Future work on how institutional features, such as middlemen and land tenure, affect farmers' lives is of high importance. Similarly, the role of credit seems to have implications for adaptation and productivity. Ensuring the adequate supply of credit is of importance to the ability of farmers to make future decisions. Such institutions have differential effects on adaptation strategy choice and productivity, so the costs and benefits of these choices needs to be investigated before strong policy recommendations can be made.

Sampling Strategy:

Due to the need for spatial variation in the climate data the survey sites were selected to ensure this variability. The Pakistan Meteorological Department's (PMD) data was a crucial input into this process. One downside is that survey sites are more widely dispersed and each necessarily has smaller sample sizes. This is typically the case in micro-economic analysis of climate adaptation (see Di Falco et al., 2010). Figure 1a shows 4 agro-climatic zones of Pakistan's total of 9 were sampled.

Figure 1a : Number of households sampled at survey sites



Agroclimatic Zones				
Map reference no (see left panel)	Name of zone	Sites Sampled	Numbers of household sampled	2014 District population
5	Barani Punjab	Chakwal	219	1,951,728
		Rawalpindi	209	6,058,214
3	Cotton/wheat Punjab	Rahim Yar Khan	194	5,656,859
6	Cotton/wheat Sindh	Sanghar	181	2,616,821
		Sukkur	219	1,635,928
7	Rice/other Sindh	Larkana	200	3,470,537

Map source: adapted from International Food Policy Research Institute's Research Report No. 77 (IFPRI, 1989) based on an agro-climatic zone division proposed originally in Pakistan Agricultural Research Council's Collaborative Project Paper 86/7 (PARC/CIMMYT, 1986).

Site selection shows variation in another important way since some areas are predominantly rain fed (zone 5 in Figure 1a above) while others are predominantly irrigated, either through surface or groundwater. This spatial coverage allowed us to evaluate the impact of climate change and adaptation on different agricultural technologies. A total of nearly 1,500 households were sampled.

A 2-stage stratified cluster sampling strategy was applied at all 7 sites. This was geared to produce a representative sample of our sites in order that consistent estimates of population means and totals can be calculated. This approach allowed us to offset the prohibitive financial, time, and informational constraints required to elicit a simple random sample. For each research site, we determined the appropriate sample size approximately by selecting a 95% confidence interval and an error of 5%. Recall, owing to our sampling, study findings cover all farmers of Sindh and Punjab.

Table 1 shows temperature variation between and within survey sites. Sufficient variation, tested against other studies, enabled modelling of the relationship between the agricultural choices and weather data. The Kriging technique was used to downscale meteorological data to the village scale.

Table 1. Variation in temperature in December within and between the sites from 1990-2010

	Standard Deviations						Average (C)
	1990	1995	2000	2005	2010	1990-2010	1990-2010
Chakwal	1.02	0.78	0.87	0.69	0.57	0.74	10.24
Jhang	0.37	0.28	0.59	0.30	0.22	0.33	11.42
Larkana	1.32	1.14	1.52	1.12	0.93	1.11	15.84
Rahim Yar Khan	0.59	0.43	0.43	0.46	0.62	0.47	14.99
Rawalpindi	1.85	1.65	1.68	1.36	1.49	1.54	9.72
Sanghar	0.36	0.23	0.17	0.80	0.27	0.35	17.72
Sukker	0.32	0.19	0.25	0.40	0.22	0.25	16.59
TOTAL*	3.19	2.47	3.21	2.35	2.94	2.71	13.87

Source: PMD data. * Totals include Shaheed Benazirabad, Jhelum, Faisalabad, and Bhawalpur (not shown in table)

1. What is the likely cost of climate change to agricultural households in rural Pakistan?

Method

We exploit the spatial nature of our survey and climate data to undertake a Ricardian Hedonic analysis of agricultural land values. The analysis is highly influenced by the academic literature emanating from the seminal work by Mendelsohn et al. (1994). Figures 1.1 and 1.2 show the spatial variation of the temperature and precipitation data for Sindh and Punjab provinces for the 5-year period 2008-2012 inclusive. We also exploit monthly data from the period 1990-2012 for the Hedonic analysis.

Hedonic analysis captures the relationship between environmental factors such as climate, and the value of land. Spatial variation in the climate is a good predictor of land values, even when controlling for other important factors, such as soil quality, farm size, water supply and proximity to markets. Land values (the market price of land) reflect its long-run productive potential. Therefore, the estimated relationship can be used to evaluate the costs and benefits of climate change by undertaking predictions of land values based on predictions of future climate variables such as rainfall and temperature.

The survey collected data on land values. Figures 1.1 and 1.2 show the variation in climate data. Appendix 1 shows the results of 2 regressions of climate data on land values. One exploits monthly data and analyses the role of seasonal variation on land values (Table A1.1). The second regression uses long-term average precipitation and temperature data to establish the relationship used for establishing the cost of climate change. We control for spatial fixed effects and land holding and are interested in the per acre land values.

Results

In the Appendix, the Hedonic regressions show that climate is a significant determinant of land values. Table A1.1. shows the results of a regression of climate variables (5 year precipitation and temperature averages) on the logarithm of land value per acre. Separate analysis shows that the seasonal variation is important, coinciding with important periods of planting and harvesting for different crops. Establishing the impact of seasonal changes on land values is an area for future research. Here, we just report annual averages as the main climate determinants of the hedonic equation. Of course other aspects of land will determine its value also. We also included variables such as access to water, access to tubewells, ownership variables, and disaster variables: drought and flood experience in the past 15 years. Regional fixed effects are also included to account for local unobservables.

Looking firstly at the determinants of land values we find that land values are significantly higher in Punjab, and also if land has access to canal water. Experience of drought in the past 15 years, which we take to mean drought prone land, reduces the value of land by almost 30%. Ownership and property rights are also important. Sharecropped land is valued 20% lower than non-sharecropped land, or owned land. These are all intuitive and sensible results which tend to support the robustness of the hedonic analysis.

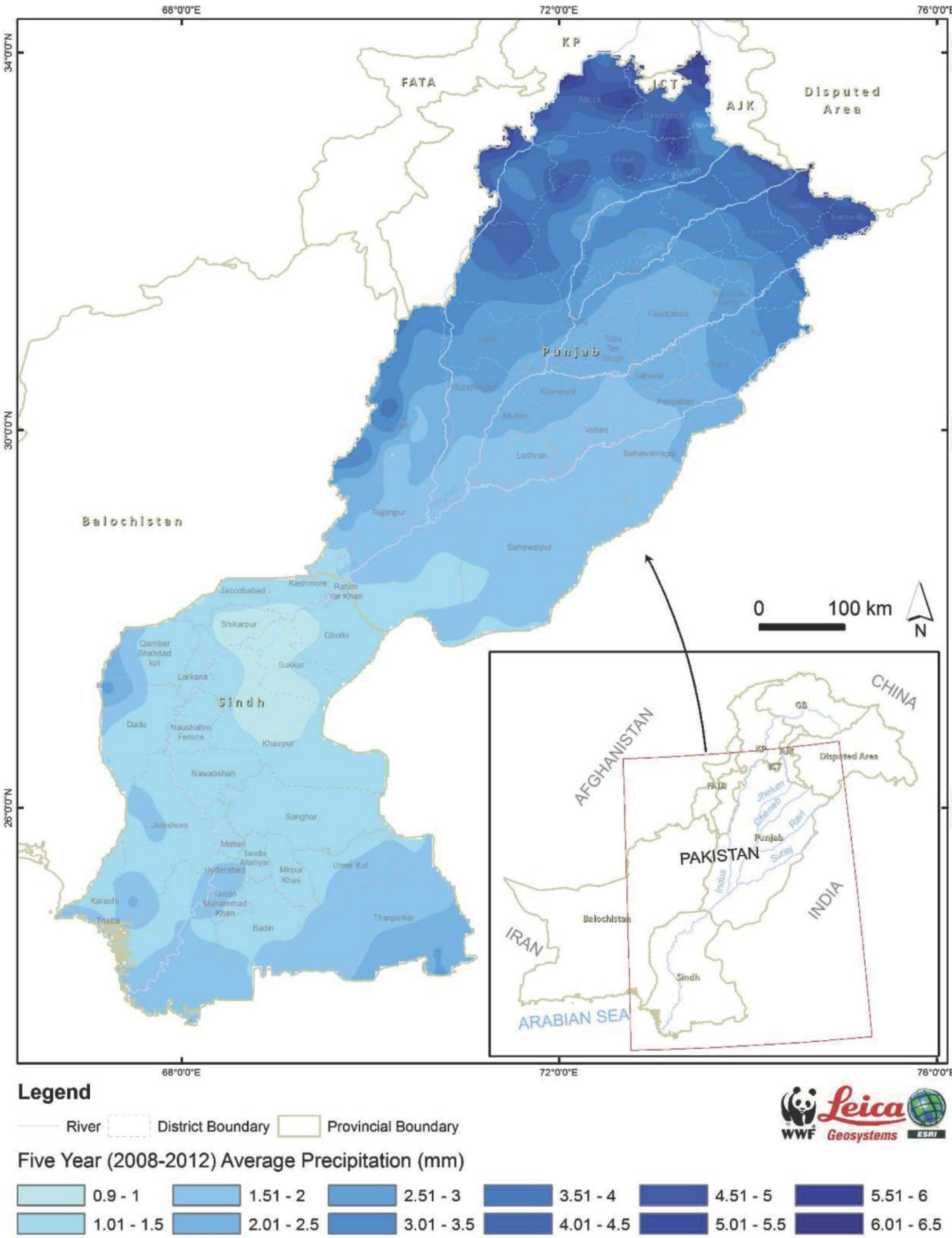
The model allows us to run a simulation of the possible change in land values as a consequence of predicted climate change. Table A1.1 shows that holding all else constant, increasing temperatures reduce land values. Precipitation has a non-linear effect but is predominantly negative once one has controlled for location, access to water and climatic shocks. Table 1.1 shows the results of impact of climate change for different anticipated temperature changes: 0.5 – 2C. This range of changes includes the range predicted by the Pakistan Meteorological Department, which actually predicts a 4°C rise by 2080. Regional climate modelling exercises are more conservative about the rate of change of temperature over time.

Here we take an ad hoc approach to the simulation which reflects a number of frailties associated with this kind of forecasting exercise. These frailties include i) uncertainty about the future temperatures; ii) greater uncertainty still about the future precipitation effects of climate change; and, iii) uncertainty about the hedonic model itself. We have concerns in relation to each of these dimensions and so the following simulation should be seen as indicative rather than highly accurate.

With that said, the hedonic analysis shown in Table A1.1shows that, holding spatial fixed effects (local characteristics associated with land values), landholdings and all other institutional and climate aspects constant, rainfall and temperature decrease the value of agricultural land. Our simulation results are shown in Table 1.1. The analysis is based on the following assumptions: i) our reading of the climate change models for Pakistan, and the Meteorological Departments prediction of temperature is a tentative 2 degrees by 2080; ii) our reading of the predicted changes in precipitation are that rainfall will also increase, but the uncertainty around these predictions is prohibitive; iii) in the absence of a decent measures of uncertainty (variance and standard deviation) of future rainfall and temperature we first drop precipitation from the analysis, and then assume a band of 2C (plus and minus 1C) around the predictions (see "upper" and "lower" in Table 1.1). This rather ad hoc assumption really is based upon standard deviations of future prediction by the PMD and does not reflect uncertainty in the predictive model of temperature or the Hedonic equation itself; iv) we assume a rough time horizon for these temperature changes based on forecasts by the Pakistan Meteorological Department. The results should be seen as indicative only due to the uncertainties involved in making forecasts of this nature. The confidence bounds are already wide. Yet the central values suggest a sizable impact of climate change on land values of around 8% in the near term of 2020, increases to 32% in the future, 60+ years hence.

1. What is the likely cost of climate change to agricultural households in rural Pakistan?

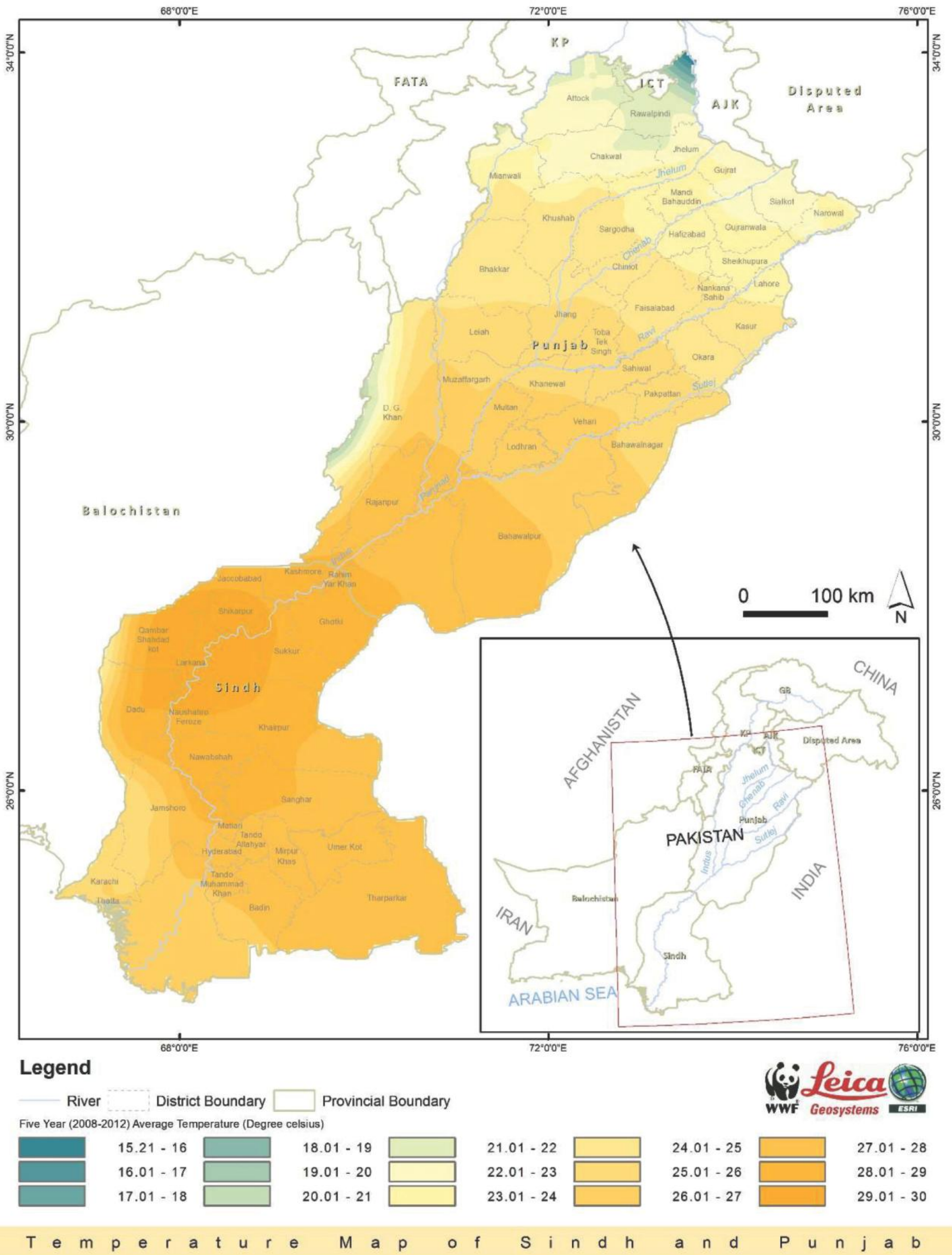
Figure 1.1 Annual Average Precipitation for Sindh and Punjab Province (mm, 2008-2012)



Precepitation Map of Sindh and Punjab

1. What is the likely cost of climate change to agricultural households in rural Pakistan?

Figure 1.2. Annual Average Temperature for Sindh and Punjab Province (Celsius, 2008-2012)



Concluding Remarks on the Hedonic Analysis

The cautious message we take from Table 1.1 is that there are potentially considerable costs associated with climate change if the predictions turn out to be correct. The costs to agriculture could be in the order of a 10% loss of agricultural productivity on average by 2040, reflected in a 10% loss in land values on average across Punjab and Sindh. In monetary terms this is a loss of around PKR 30,000 per acre.

There are some caveats that need to be discussed however. Firstly, the data on weather and climate that we have is not as high quality as it might be. One issue is that of variation of climate data within the sample, and whether it is sufficient for our purposes. Much of the variation in weather and climate data disappears when district fixed effects are introduced, for instance. Nevertheless, the relationship between climate and land values is statistically significant and relatively robust in this analysis which suggests that at least the medium term predictions are somewhat reliable.

Table 1.1 The average land value in 2040, 2060, 2080 given predictions of climate change (PKR/acre)

Temperature Change (C)	Year	Land Value (PKR/acre)	Percentage Change	Lower (-2 s.d.)	Upper (-2 s.d.)
0	2015	344,000	-	-	-
0.5	2040	315,000	8%	0%	25%
1	2060	259,000	25%	4%	32%
2	2080	233,000	32%	10%	50%

2. To what extent does adaptation to climate change ameliorate these costs?

Method

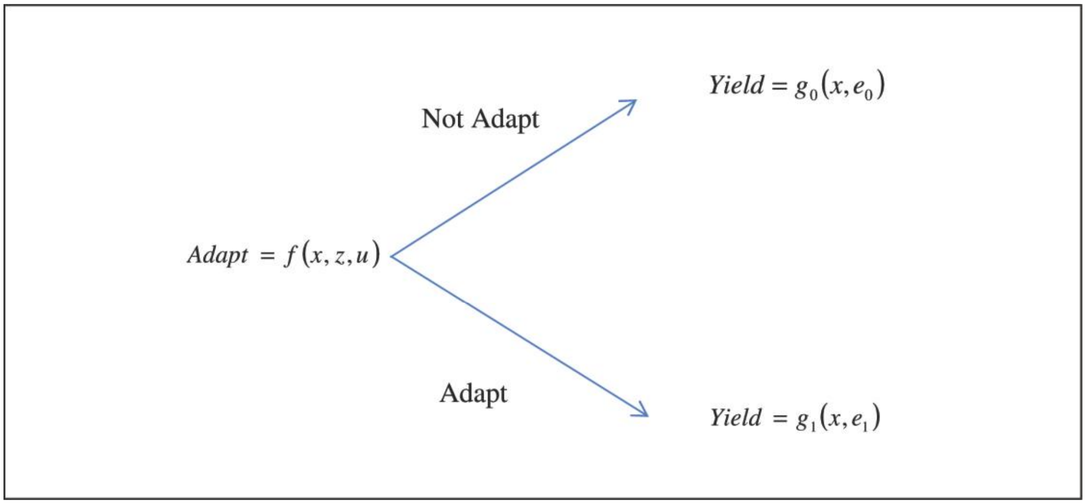
In order to address this question we focus on the impact of adaptation to climate change on food security. We look at three crops: wheat, rice and cotton. Our objective is to compare the yields and production of those that have adapted to climate change to those who have not.

We follow the counterfactual approach associated with programme evaluation techniques, and in particular the methods used by Di Falco et al. (2010, 2012). This allows us to compare the outcomes for those that adapt to climate change with the counterfactual scenario in which they had not adapted. Similarly, the outcomes for those that did not adapt can be compared to the counter factual scenario in which they had adapted. These comparisons allow a rigorous estimation of the impact of adaptation. With this analysis in mind, the survey contained a detailed module on climate change adaptation and perceptions of climate change (Section A and E, see Appendix 7).

The numbers are rounded to the nearest PKR 1,000.

2. To what extent does adaptation to climate change ameliorate these costs?

Figure 2.1. Adaptation and Yield: The Concept behind the Switching Regression model



The decision-making model can be thought of as in Figure 2.1, where yield is the outcome variable. It is possible to estimate each of these functions simultaneously: i) the determinants of adaptation; ii) the determinants of yield for adapters; and, iii) the determinants of yield for the non-adapters, using an "endogenous switching regression" model. This also controls for the fact that the yields and productivity in general are affected by unobservable (to the analyst) factors and hence subject to selection bias: the fact that those who adapt are likely to be very different in unobservable ways from those who don't adapt. This is problematic because it could be that the more talented and productive farmers are also more likely to adapt, so simply comparing adapters and non-adapters would capture these unobservable differences as well and potentially overestimate the impact of adaptation in the population. Modelling the decision to adapt simultaneously with the yield/production functions provides a means of removing selection bias of this kind. In order to verify the robustness of results, we compare the impact results to those obtained through the use of an ordinary least squares (OLS) regression of productivity and adaptation. If selection bias is present, the results obtained through OLS will biased by these unobservable effects.

For comparative purposes, we also used a propensity score matching (PSM) estimator. This method differs from the endogenous switching regression approach in that the adaptation decision is assumed to be determined only by the observable characteristics of farmers. The results for two propensity score matching estimators (Nearest Neighbour and Kernel) are presented in Appendix 4. These provide a useful baseline for comparison based on an estimator which is simpler than the switching regression, although reliant on the restrictive assumption of selection on observables.

Measures of Impact

Both the switching regression and the PSM estimator provide estimates of three distinct impact measures: the Average Treatment on the Treated (ATT), Average Treatment on the Untreated (ATU) and the Average Treatment Effect (ATE). The ATT is the estimated impact of adaptation for the group that undertake adaptation. This is obviously a useful measure which compares the observed outcome under adaptation with a constructed counterfactual outcome reflecting what 'would have happened' to the adapting household hadthey not adapted. The ATU is the analogous impact measure for the non-adapting sub-population. It shows the difference between their observed outcome (yield in this case) and the outcome that they would have enjoyed in the even that they had adapted. The ATE reflects is the average impact in the population as a whole and is the average of ATT and ATU. PSM and the switching regression essentially use different methods to build the counterfactuals in each case.

2. To what extent does adaptation to climate change ameliorate these costs?

The analysis takes place at the plot level. For both approaches four outcome variables are analysed for impact: i) the pooled yield (across seasons and crops); ii) Wheat yields; iii) Rice yields; iv) Cotton yields. Pooling the crops into an aggregate measure of yield has been used in similar analyses in the past (e.g. Di Falco and Veronesi 2012). Although it might appear odd to do such a thing, one of the chief advantages is that this measure captures adaptations that rely on adjustments between seasons and between crops, e.g. changing crop or input choices, or crop timing, which are some of the more important adaptations that we identify in our sample (see Table 2.1). Nevertheless, we then disaggregate the outcome measures to evaluate the impact of adaptation by crop. This reveals the production practices that benefit most from adaptation, and indeed, those that benefit least.

In the results section below we present some brief descriptive statistics of the types of adaptation strategies favoured by the sample. We then present the results of the switching regression model. As discussed in Appendix 4, while the propensity score matching (PSM) provides a useful starting point for the analysis, the method does not pass the appropriate tests to suggest that the identification assumptions (selection on observables) are true (see the balancing test and bias estimate in Appendix 5). So, while the PSM estimators suggest that the ATT (ATU) of adaptation on those that adapted (did not adapt) is positive for the pooled and individual crop analysis and between 10% and 20% (0-20%), it is highly likely that selection into adaptation is based on unobservable characteristics, so these impacts measure differences in unobservables as well as the impact of adaptation itself. For this reason, we focus on the switching regression approach which explicitly accounts for this approach.

The survey data on adaptation, production and detailed household characteristics allows us to estimate these decision models and calculate the impact of adaptation for adapters and non-adapters. For the productivity estimates, we use data collected at the farmer plot level to get detailed output on yields for individual crops. See Appendix 7 for more detail.

Results

Adaptation Methods

Farmers undertook a number of agronomic strategies to deal with climatic change. Table 2.1 shows the different strategies employed. Water conservation, income diversification (mainly off-farm labour), and reliance on public infrastructure are the chief adaptation strategies. Crop timing (planting, harvesting) and altering agricultural inputs are the next most popular adaptation strategies. Least popular is changing the cropping pattern (crop choice). This pattern is largely similar across provinces. The main provincial difference is in the lower reliance on public infrastructure in Sindh province, and the larger reliance on diversification in Sindh. Around half the population do not adapt at all.

In the following analysis we focus on the following 5 on-farm adaptation strategies:

- Crop timing
- Cropping patterns/crop choice
- Input choice
- Soil conservation
- Water conservation

We leave the discussion of off-farm labor and diversification outside of agriculture for future work.

[2] For what it is worth, see Table A5.1 in Appendix 5 where test for bias reduction arising from PSM. Bias reduction was most successful for the crop with the largest number of observations, wheat. The bias reduction results also show that the kernel method of matching was better at achieving this reduction compared with nearest neighbour matching.

2. To what extent does adaptation to climate change ameliorate these costs?

Table 2.1 Climate Adaptation Strategies in Sindh and Punjab Provinces (n = 1422)

Adaptation Strategy	Whole Sample Frequency	Percentage	Punjab Frequency	Percentage	Sindh Frequency	Percentage
Crop Timing	52	3.7	26	3.2	26	4.3
Cropping Pattern	28	2.0	6	0.7	22	3.7
Altering Agricultural Inputs	75	5.3	45	5.5	30	5.0
Soil Conservation	44	3.1	14	1.7	30	5.0
Water Conservation	172	12.2	87	10.7	85	14.2
Diversification	175	12.4	78	9.6	97	16.2
Public Infra-structure	141	10.0	123	15.1	18	3.0
Total Adapters	**695**	**48.6**	**387**	**47.6**	**308**	**51.3**
No Adaptation	**727**	**51.4**	**435**	**52.4**	**292**	**48.7**
Total	**1422**	100.0	**822**	100.0	**600**	100.0

The impact of adaptation on food security

Introduction

In this section we present an analysis which updates the original work presented on 26 April 2014 at the Lahore University of Management Sciences campus to a wide audience of academics and policy makers (Dehlavi et al., 2014). A number of differences exist between the two analyses.

First, the present analysis focuses on the three main crops grown in the sample. In addition to an aggregate production measures (the pooled analysis), we estimate separate regressions for wheat, rice and cotton to study the impact adaptation has on different crops. Given that impacts of climate change on agriculture is likely to have heterogeneous impacts on different crops (Siddiqui et al., 2014; Sultana et al., 2009), it is important to study the opportunities for adaptation across crops and seasons. Wheat is the most widely grown crop during the Rabi (winter) season. During the Kharif (summer) season we study rice and cotton, which are the most widely sown in this season. It is important to examine each of these crops separately for a number of reasons. Agronomic needs of each crop are likely to be different. The receptiveness of crop yields to various farm inputs will vary across crops. In addition, the seasonal nature of production means it is essential to consider factors that may affect crops differentially across seasons. For instance, lower temperatures and precipitation during the Rabi clearly alter the suitability of growing different crop types. Similarly, the range of adaptation strategies available in each season is likely to be dependent on different factors: e.g. institutions, information, availability of credit etc. Finally, it is important to consider the reasons for planting each crop. Wheat and rice may be consumed by the household as a food crop or could be sold as a cash crop. Cotton, on the other hand, is usually grown solely as a cash crop.

Second, this updated work also includes a much richer set of variables. Inclusion of more variables enables us to build up a more detailed picture of how and why adaptation may be influencing farm productivity. In the next section we describe this improved set of variables.

Summary statistics and variable description

Summary statistics for each of the variables included in the regression are displayed. These variables are grouped into the categories farm inputs, household characteristics and climatic variables.

The first entry in the Table 2.2 summarises our measure of yield. In Appendix 2 we plot the distribution of yields to get a sense of how yields differ across adapters and non-adapters. We clearly see that for rice and wheat, yields seem to be generally higher for adapters. For cotton, we observe that yields for adapters and non-adapters appear very similar.

Farm inputs included in the model measure the impact that factors of production have on overall productivity. Land, labour, capital and other variable factors such as the amount of fertiliser and water are included.

The characteristics of each farm household are also controlled for in the model. Factors such as education, household size and number of females may be important both in determining whether households adapt and how much they produce. Similarly, measures of how well households are able to access credit and off-farm employment may be important in determining how successful adaptation is. Credit and off-farm work can act as income smoothing mechanisms that may affect the way in which households manage production on-farm. We also include variables that indicate whether a household has previously experienced flood or drought. Experience of such extreme events could conceivably alter both the willingness and ability to adapt to climate change.

Weather and climate variables are clearly of importance to any study of the impact of climate adaptation. The model contains seasonal temperature and precipitation data both for the agricultural year of the survey and also historical climate data covering the previous 23 years.

Also included are variables pertaining to where farmers obtain information about farming practices. We include five variables to model these networks. These take the value of one if the farmer obtains information from that particular source and zero otherwise. The possible sources of information include formal extension services such as programmes run through the government or NGOs (Hussain et al. (1994). Information gathered from media services such as television or radio is also included. Given Pakistan's rich network of informal institutions, we also include separate variables if advice comes from a farmer's landlord or middleman. This may capture one of the channels that these informal institutions impact upon the uptake of new technology and the overall productivity of farmers (Haq et al. 2013; Ali et al. 2012). Finally, we include peer advice to capture the impact that advice from other farmers may have on the adaption decision.

The inclusion of these information variables is of particular importance to the endogenous switching regression model. We are interested in the impact of adaptation on productivity. The adaptation decision by farmers, however, may be driven by unobservable factors that also determine how productive farmers are. Since we are not able to control for unobservable factors in the regression model, we need to credibly ensure that bias due to hidden factors is dealt with. To deal with the issue of selection on observables, we include a set of variables relating to farmer perceptions of long-term climate change as instruments that select farmers into adaptation. These include evaluations on the long-term change in temperature and precipitation and also changes in the timing of seasonal weather events such as the monsoon. The justification of these instruments rests on the assumption that farmer perceptions of climate change are 1) a good predictor of the adaptation decision 2) not correlated with unobserved differences in productivity.

2. To what extent does adaptation to climate change ameliorate these costs?

Table 2.2. Summary Statistics: Non-Adapters vs. Adapters: Wheat, Rice and Cotton Producers

	Non-Adapters	Adapters
Yield(ln)	17.42	19.91
Inputs		
Area(acres)	4.12	4.54
Pesticides(litres)	4.51	6.72
Urea(bags)	6.68	8.96
DAP/SOP(bags)	2.61	3.27
Manure(trolleys)	1.10	1.04
Seed(kg)	129.15	152.44
Soil Qual.(1=Good, 0=Poor)	2.12	2.15
Household Labour(hrs/day)	9.51	10.93
Hired Labour(hrs/days)	6.61	6.81
Water Apps.	6.34	7.09
Canal (1/0)	0.34	0.39
Tubewell(1/0)	0.31	0.45
Tractor(1/0)	0.30	0.31
Household Characteristics		
Household Size(persons)	7.63	8.21
Literate(1/0)	0.29	0.14
Average Years in Educ.	4.53	4.98
% Females	0.44	0.47
Credit(1/0)	0.34	0.38
Off-farm Work(1/0)	1.26	1.07
Flood(1/0)	0.56	0.64
Drought(1/0)	0.16	0.09
Owns Land(1/0)	0.79	0.69
Livestock(number of animals)	3.21	4.15
Weather		
Kharif Rain(cm)	5.82	3.60
Kharif Temp. (ºC)	33.57	34.36
Rabi Rain(cm)	0.25	0.15
Rabi Temp. (ºC)	21.90	23.28
Climate		
Ave. Kharif Rain(cm)	2.94	2.25
Ave. Kharif Temp. (ºC)	33.49	34.62
Ave. Rabi Rain(cm)	0.28	0.16
Ave. Rabi Temp. (ºC)	16.16	17.52
Information		
Extension Services(0/1)	0.23	0.23
Media(0/1)	0.15	0.14
Middleman(0/1)	0.07	0.02
Peer(0/1)	0.63	0.69
Landlord(0/1)	0.07	0.08
Observations	1181	822

Estimation of impacts assuming selection on unobservables: The switching regression model

In Appendix 3 we show the results of the OLS and endogenous switching regression for the pooled, wheat, rice and cotton that estimates the model described in Figure 1 (See Tables A3 – A3.4). For the OLS regression, the impact of adaptation is estimated by the inclusion of a variable that indicates whether a household has adapted or not. Size impact of adaptation on crop yield is interpreted by the size and significance of the coefficient on the adaptation variable.

For the endogenous switching model, the first two columns in the table show parameter estimates of the determinants of yield for farmers that adapted and those that did not. The third column presents estimates of the determinants of the decision to adapt. The dependent variable in the productivity equations, Yield, represents plot-level crop yield measured in maunds per acre.

Ordinary Least Squares (OLS)

The results in Table A3 show the estimated impact of adaptation from the OLS regression and the associated determinants of productivity for the pooled, wheat, rice and cotton samples. The signs and significance of the coefficients establish the regularity of the productivity equations, showing expected positive coefficients for many of the plot-level productive inputs such as fertiliser, labour and water. The parameter of interest in these regressions is labelled Adapt. We notice that in three of these regression equations, the sign of the adaptation variable is positive and significantly different from zero. This indicates that adaptation is associated with higher yields for the pooled, wheat and cotton sample. Interestingly, the impact of adaptation on rice yield is not significantly different from zero, providing preliminary evidence that adaptation is not associated with higher productivity for rice. The interpretation of these coefficients, however, should be treated with caution given the previous discussion of possible selection bias in the decision to adapt.

Pooled

Table A3.1 shows the regression results for the pooled sample of wheat, rice and cotton crops. For non-adapters, the production inputs are generally statistically significant. Interestingly, irrigation variables are very important determinants of productivity for non-adapters in the sample, whereas irrigation is not shown to be significant for adapters. This is probably indicative of differences in farm-types, in that farms that do not select into adaptation have better access to irrigation. In terms of household characteristics, we notice that an increased percentage of females in a household is not associated with higher productivity for the adapters. This could be explained by the differences in gender roles in farm household production. This result accords with other studies that find female farm labour to have lower productivity than male labour. For adapters, it seems that the experience of recent drought has a negative relationship with productivity, which is suggestive of long-run effects of low water availability on farm production. The credit dummy variable is negative for non-adapters suggesting that low productivity farmers are more reliant on credit. For non-adapters experience of drought and floods has productive implications, with households having experienced flooding being more productive and those having experienced drought less so. Land tenure is also important, since for non-adapters owned plots are more productive on average.

2. To what extent does adaptation to climate change ameliorate these costs?

The last column in Table A3.1 displays the estimates of the decision to undertake adaptation for the pooled sample. The dependent variable Adapt takes the value of 1 if farmers have adapted and 0 if not. We see that soil quality is positively related to adaptation. Larger households are also more likely to adapt. Interestingly, households with a higher proportion of females are positively associated with adaptation, suggesting that household composition may affect the decision to adapt. Experience of extreme weather events, in this case drought, is positively associated with adaptation suggesting previous experience of such an event may induce households into adapting. Although temperatures in the Kharif appear to be significant, we note that the weather and climate variables appear to cancel each other out in terms of magnitude, indicating a neutral effect of climate effects on adaptation for the pooled sample. None of the informational variables appear to be significant in the pooled sample, but as we will see, this arises because information has different effects on different crops, and so in aggregate these factors cancel. Finally, climate perception variables are important for the decision to adapt. Changing precipitation and less cold spells patterns suggest greater propensity to adapt. In contrast, farmers who thought that temperatures had decreased were less likely to adapt. Those who perceived the onset of the hot season to have changed were less likely to adapt. Overall, these perception results suggest that climate and climate perception have a complex relationship with agricultural activities in Pakistan.

The column labelled Rho is included in the regression output to test the assumption of unobservables affecting productivity and the decision to adapt. For the adapters, the coefficient is negative and significant which indicates positive selection bias, suggesting that those with higher unobserved productivity were more likely to adapt. The significance of this term supports our choice of method that accounts for unobservable factors.

Wheat

For the wheat crop, it is shown that yields are significantly affected by a number of agronomic and socioeconomic factors. Pesticides and water is shown to have positive effects on yield for adapters and non-adapters respectively. Household supply of labour is also important for productivity for both groups. Household characteristics may also affect how productive farmers are. For the adapters, it seems that previous household experience of extreme natural events, such as flood, are negatively associated with yield. More females in the household also reduces productivity for the adapters. Seasonal weather variables are shown to have strong impacts on yields. It is shown that high Kharif (summer) rainfall is of particular importance to the Rabi (winter) crop. We note here that the use of climatic data is not without its issues. Estimated coefficients can sometimes be very large. This seems to reflect difficulty in observing enough variation within study areas. As a test of robustness we omit all weather and climate variables to test for confounding effects on other variables. The coefficients change very little both in terms of magnitude and significance if these variables are excluded. Under the heading Information are included variables related to how farmers get information on farming practices. These variables are shown to be significantly associated with productivity of farmers. Those that rely solely on media for their information seem to be less productive, suggestive of lack of access to good information significantly reducing productivity for adapters and non-adapters. Interestingly, we notice that in the adapter's column, middlemen are associated with higher productivity outcomes. Although exactly how middlemen affect productivity cannot be ascertained from this model, this result suggests that there seems to be some matching between high productivity farmers and middlemen. This may be in accordance with the finding by Haq et al. (2013) that middlemen are not as prevalent in wheat production due to low margins and may choose to deal with farmers who are more productive.

The last column in Table A3.2 models the determinants of the adaption decision. A number of factors seem to be related to the adaptation decision. The use of more inputs seems to correlate with adaptation. For the household variables, a higher percentage of females in the household increase the likelihood of adapting. As was seen in the pooled regression, experience of drought seems to strongly increase the impetus to adapt. There is also some evidence to suggest that rainfall in the Kharif affects adaptation but the overall impact of rainfall is not clear owing to weather and climate variables going in opposite directions. The perception variables are not particularly strong predictors of adaptation in the wheat sample. Only farmers that perceive temperature to have decreased are evidenced as having a lower propensity to adapt. In accordance with the result from the pooled sample, the negative and significant Rho is indicative of positive selection bias into adaptation in the wheat sample: higher productivity wheat producers are more likely to adapt.

Rice

Yields for rice plots show a number of patterns that affect productivity in Table A3.3. There is evidence that fertiliser (Urea) is important for non-adapters as is the application of manure. Access to both household and hired labour is shown to be highly important for both adapters and non-adapters, suggesting that labour intensity is an important determinant of rice yields. Water-use also seems to be important, although the use of tubewell technology does not seem to be associated with increasing yield. The use of modern farm technology, such as tractors, is shown to be beneficial to rice production productivity for non-adapters. Both the variables household size and the proportion of females are correlated with lower yields. For adapters, we see that access to credit is significantly associated with higher productivity, speaking to credit's role in farmers being able to buy high quality and invest in farm improvement. An important result is that the ownership of land is associated with higher yields for both samples, indicating that rented or sharecropped farms are less productive than farms owned by the household. This accords with the finding by Ali et al. (2013) and Jacoby and Mansuri (2008) who find that rented land is farmed less productively. Disentangling the influence of climate on rice yields is difficult in this regression owing to the counteracting tendency of weather and climate variables. It does, however, seem that higher Rabi seems to have important positive effects on production, as would be expected for rice growing. For the information variables, there seems to be a complex relationship. Peer information seems to be good for productivity, while media and landlord information suggest lower productivity. The negative relationship between landlord information and productivity lends further support to the importance of tenancy as a negative factor to productivity. Interestingly, we also notice that the influence of middlemen seems to vary between adapters and non-adapters.

Turning to the determinants of adaptation for rice farmers, we see that households with more land are more likely to adapt. Crucially, it appears that credit constrained households are less likely to adapt. Since that adaptation may require costly up-front investment, credit may be very important in enabling farmers to have the resources to adapt. The impact of land ownership on adaptation is negative in the selection equation, suggesting that land owners are less likely to adapt for rice. For the weather and climate variables, it seems that high Rabi rainfall is associated with a higher probability of adapting. It also seems that information services for farmers may not be that effective at bringing about adaptation. The negative sign on the Extension Services variable suggests that this source of information is not effective at bringing about on-farm adaptation. Finally, we note the significance of Rho which suggests that, as with the wheat sample, farmers with higher unobserved productivity are more likely to adapt.

2. To what extent does adaptation to climate change ameliorate these costs?

Cotton

The increased use of nitrogen fertiliser, urea, is suggestive of higher yields for both adapters and non-adapters. Inputs such as manure, labour and water are also shown to be important for productivity, as is access to a tractor. For characteristics of the household, it is notable that the use of credit services is shown to be related to lower overall yields. Whilst credit is an important way for farmers to obtain inputs over the agricultural season, this result suggests that use of credit is primarily used by farmers with lower productivities. This contrasts with the results for rice which suggests credit is beneficial for yields. More work needs to be done to ascertain how credit is used differently across cotton and rice farmers. Work by Aleem (1990) highlights how complex credit markets are in Pakistan's rural economy. Other household factors such as flood, drought and off-farm work also appear to affect yields in different ways. Interestingly, the impact of land ownership seems on productivity seems to vary across adapters and non-adapters.

For the determinants of adaptation in the final column of Table A3.4, we see that larger households are more likely to adapt. Interestingly, we note that literacy does not seem to imply more adaptation; rather literate farmers are less likely to adapt. We continue to see the result that more females in the household are conducive to adaptation. Past extreme weather events also seem to matter, with flood experience positively related.

Are there gains from adaptation?

Tables 2.3 to 2.6 show the impact of adaptation in terms of yield. Using the endogenous switching framework, counterfactual results are estimated to predict the impact of adaptation. For farmers that adapted, a counterfactual is constructed to model yields had these farmers not adapted. Conversely, for those farmers who did not adapt, predicted yields are estimated had they decided to adapt.

Table 2.3 shows these scenarios for the pooled sample. For adapters, it is predicted that adaptation is associated with increased yield – a comparison of the observed adapting yield with the counterfactual on-adapting yield suggests an increase of 7%. This result compares in magnitude with the estimate from the OLS regression. As discussed earlier, the estimate from the switching regression is likely to be more robust given that there my be heterogeneity between adapters and non-adapters and selection bias. For non-adapting farmers the yield without adaptation is much higher than the predicted yield with adaptation suggesting large gains for non-adapters if they adapted.

2. To what extent does adaptation to climate change ameliorate these costs?

Table 2.3. The impact of adaptation on pooled yield

Households	OLS	Yield with Adaptation (maunds/acre)	Yield without Adaptation (maunds/acre)	Impact of Adaptation (Difference)
Adapters (n=757)	2.16*** (0.57)	19.71 (0.25)	18.47 (0.26)	1.24*** (7%) (0.16)
Non-adapters (n = 780)		27.69 (0.30)	17.02 (0.24)	10.67*** (63%) (0.02)

Table 2.4. The impact of adaptation on wheat

Households	OLS	Yield with Adaptation (maunds/acre)	Yield without Adaptation (maunds/acre)	Impact of Adaptation (Difference)
Adapters (n=408)	1.565** (0.625)	19.55 (0.30)	17.38 (0.31)	2.17*** (12%) (0.20)
Non-adapters (n = 499)		25.39 (0.33)	17.01 (0.25)	8.38*** (49%) (0.23)

Table 2.5. The impact of adaptation on rice

Households		Yield with Adaptation (maunds/acre)	Yield without Adaptation (maunds/acre)	Impact of Adaptation (Difference)
Adapters (n=175)	2.674 (1.65)	24.56 (0.93)	29.30 (1.44)	0.69 (3%) (0.79)
Non-adapters (n = 162)		33.37 (1.25)	19.92 (0.98)	13.45*** (67%) (0.96)

Table 2.6. The impact of adaptation on cotton

Households	OLS	Yield with Adaptation (maunds/acre)	Yield without Adaptation (maunds/acre)	Impact of Adaptation (Difference)
Adapters (n=174)	2.134* (1.09)	15.21 (0.58)	16.79 (1.00)	1.58** (9%) (0.79)
Non-adapters (n = 119)		19.92 (0.77)	13.09 (0.65)	6.83*** (52%) (0.71)

*** = significant at the 1% level. Standard Errors in parenthesis.

Since the impact of adaptation may differ across crop types, we now split the sample by crop and examine the impact of adaptation for wheat, rice and cotton separately.

For wheat growers in Table 2.4, we see a similar pattern to the pooled sample. Adapters are predicted to have gained by around 12% from adapting, whereas non-adapters are predicted to gain in terms of yield by close to 50%. The impact estimate for adapters is also of comparable size to the estimate from the OLS regression.

For farmers growing rice in Table 4, the impact for gain from adapting for adapters is 3%. However, this result is statistically insignificant suggesting that adaptation practices for rice growers have had negligible effect on productivity. This is echoed by the OLS prediction that shows up as insignificant. Non-adapters are predicted to have a lot to gain from undertaking adaptive measures, increasing their yields by as much as two-thirds current yield.

Estimated yields for cotton farmers show that adapters do not gain by about 9% by using adaptation practices. However, as with the estimated impacts on non-adapters for the other crops, non-adapters seem to have high gains in productivity from adapting, with around a 50% yield gain to be realised if they adapt.

The predicted gains from adaptation for adapters are, thus, not uniform across crops. There appear to have been significant productive gains for wheat and cotton. In contrast, for rice adaptation does not appear to have been significant at increasing productivity. The predicted gains, however, for the non-adapters are positive and potentially large for all crops. Why these farmers who are predicted to gain significantly from the undertaking of adaptation practices do not undertake adaptation seems to indicate the presence of constraints that are stopping these farmers realising gains. Similarly, given that crops differ substantially in terms growing conditions, these results may reflect different opportunities for harnessing the benefits of adaptation. Wheat, which is an important winter crop, seems to be amenable to adaptation. Similarly, cotton grown in the summer also shows evidence that adaptation has been a successful strategy. The other summer crop, rice, does not seem to be so easily adapted to changing conditions, perhaps suggesting important constraints to increased rice production given climatic constraints. Work by Siddiqui et al. (2014) has shown that the effects of climate change on summer crops such as rice and cotton are likely to be negative, with impacts on wheat non-negative with moderate temperature increases. Such a finding seems to back up our results, suggesting that current adaptations might not be adequate to deal with future warming, especially for already climatically-stressed crops like rice.

Discussion of Results

The main results from the regressions analysis can be summarised as follows. According to the counterfactual approach employed here, the success of adaptation strategies is heterogeneous across farmers. For wheat and cotton farmers, the counterfactual analysis predicts that farmers who adapted are better off as a result of their adaptive responses. However, for rice farmers who adapted, the model predicts that these farmers would not on average benefit from on-farm adaptation. These results compare well in magnitude with the OLS estimates in Table 3. However, the results from the endogenous switching regression suggest that the types of farmers who adapt have differential characteristics from those that don’t adapt and that unobserved selection plays a part in which farmers adapt.

The impact of adaptation on productivity for rice is more puzzling. Why adaption strategies have not been so successful for rice is an important issue. Further investigation is required to establish why it is that non-adapters cannot benefit from adaptive behaviour for rice.

For the wheat crop, we can also compare these results to an earlier analysis conducted in Dehlavi et al. (2014), where it was found that adaptation had a favourable impact on yields for both those who adapted and those who did not. The most recent analysis in the present paper adds significantly more detail in terms of farm-level and regional variables. The inclusion of detailed plot-level inputs, more household variables and climate data means that the latest results supersede the findings of the first report. Similarly, the institutional aspects of Punjab and Sindh are accounted for in this most recent study.

3. What are the key determinants of adaptation to climate change?

In this section we undertake 3 related analysis. First we look at the determinants of adaptation, that is, undertaking any one of 5 specified adaptation strategies. We then look at the determinants of each strategy in turn. Finally, we display the relationship between climate (25-year average temperature or precipitation) and the probability of undertaking one of 5 on-farm adaptation strategies. From this we can infer the nature of adaptation based on anticipated changes in climate associated with the regional impact of global climate change.

To adapt or not adapt?

In this section we discuss the results of our analysis of the determinants of adaptation strategy are evaluated. Table 3.1 shows the results of a simple probit analysis of the decision to undertake any one of 5 on-farm adaptation strategies: i) crop timing; ii) crop choice; iii) input changes; iv) soil conservation; and, v) water conservation. Adaptation is defined as undertaking at least one of these strategies. The signs of the coefficients indicate whether an explanatory variable increases or decreases the likelihood of adaptation. The analysis includes numerous socio-economics explanatory variables, as well as climatic and weather variables.

Taking adaptation as the aggregated measure indicating implementation of any of the on-farm strategies, the results are not particularly strong. The household characteristics that are the strongest determinants of adaptation are "Total Land", "% Females" and "Off-farm Labour". Of course, this analysis does not claim to measure causal relationships among these highly endogenous explanatory variables, but the correlations can be understood in the following way. Total land increases the likelihood of adaptation. To the extent that land holdings are a measure of wealth this could be interpreted as adaptation being more likely among the wealthy. The variables "% Females" and "Off-Farm Labour" have opposite effects on adaptation, the former being positive and the latter being negative. The negative effect of off-farm labour suggests that moving labour off farm is likely to be a substitute adaptation strategy to on-farm adaptation. The gender variable is very difficult to interpret.

Of the weather and climate variables, experience of drought increases the likelihood of adaptation, whereas the experience of flood does the opposite. Many adaptation strategies require an investment in land (e.g. water and soil conservation) which may be lost in the event of flooding. This could make reinvestment less likely in the future. Drought, however, does not necessarily introduce this issue. As for the climate variables (25-year averages), it is Rabi temperature that is the main trend that is associated with adaptation. The higher the Rabi temperature, the less likely it is that adaptation will occur in the sample. As we will see below, this result is reversed in the disaggregated analysis of adaptation.

Among the institutional and information variables, it is "peer information" that is the most significant determinant of adaptation. There is a positive correlation between those who rely on peer-group networks and undertaking one or other adaptation strategy. Other sources of information, including government extension are not so important with regard to adaptation, it seems. Finally, one further institutional factor is land tenure: secure land tenure is positively correlated with adaptation. This fits with the discussion above concerning the need for sinking investment into adaptation (Jacoby and Mansuri, 2008). If tenure is insecure, or land is rented, the incentives to invest are diluted.

3. What are the key determinants of adaptation to climate change?

Table 3.1. The Household Level Determinants of Adaptation

Determinants of Adaptation	
Household	
Canal	-0.059
	(0.141)
Tubewell	0.078
	(0.132)
Total Land	0.009***
	(0.003)
Literacy	0.117
	(0.090)
% Females	0.627***
	(0.233)
Credit	-0.109
	(0.082)
Off-farm Labour	-0.066**
	(0.029)
Flood	-0.213**
	(0.096)
Drought	0.263**
	(0.110)
Livestock	-0.009
	(0.009)
Owns Land	0.167*
	(0.100)
Climate	
Ave. Kharif Rain	-0.092
	(0.119)
Ave. Kharif Temp	-0.006
	(0.039)
Ave. Rabi Rain	0.066
	(0.049)
Ave. Rabi Temp	-0.843**
	(0.343)
Information/Institutional	
Extension Information	0.041
	(0.092)
Peer Information	0.181**
	(0.083)
Media Information	0.025
	(0.109)
Middleman Information	-0.067
	(0.173)
Landlord Information	0.213
	(0.146)
Constant	-0.870
	(1.985)
N	1423

*** = significant at 1% level, ** = significant at 5% level, *=significant at 10% level

3. What are the key determinants of adaptation to climate change?

How to adapt? The determinants of adaptation strategies

In this section we disaggregate the adaptation measures into 5 on-farm measures of adaptation:

- Crop timing
- Crop choice
- Changing inputs
- Soil conservation
- Water conservation

A multinomial logistic regression is undertaken which establishes the relationship between the household, weather, climate and institutional variables on the decision to undertake each of the 5 adaptation measures. Table 3.2 shows the results of this analysis in detail.

Table 3.2 shows that the determinants of adaptation are different for each adaptation strategy. This explains why the previous model in which the aggregated adaptation measure was explained provided relatively few insights: many factors were cancelling each other out since they sometimes positively affect one adaptation strategy while negatively affecting others. The more nuance story is as follows.

Holding all else constant, among the household characteristics education (measured as literacy) is positively related to soil conservation and negatively related to input choice relative to the baseline group (non-adapters). These correlations are statistically significant at the 1% level. Age, which can be thought of as a measure of experience, is positively related to soil and water conservation, and negatively related to crop choice as an adaptation strategy. The latter relationship is only significant at the 10% level however. These relationships speak to the ability of the farmer and the choices that an able famer makes. Another strong positive relationship is between land and crop and input choice as adaptation strategies. That is, large farms tend to use crop and input choice as adaptation measures more than small farms.

With regard to the institutional variables, again the picture is varied, with institutions affecting the choice of adaptation strategies in different ways. For instance, sharecroppers are more likely to use crop choice and soil conservation, and less likely to use crop timing as an adaptation strategy. These correlations are all significant at the 5% level (5% s.l.). Land ownership increases the likelihood of undertaking a soil conservation investment and in using crop choice as an adaptation strategy, but reduces the likelihood of crop-timing being deployed. Where statistically significant correlations exist they are negative for both credit and off-farm labour. It is interesting that credit plays not role in increasing the likelihood of any on-farm adaptation strategy. As discussed before, off-farm labour could be negatively correlated with water conservation and input choice since it is a substitute for these potentially labour intensive strategies.

With regard to information, membership of a farmer's association is a uniformly positive and highly significant influence on adaptation strategies. Other sources of information, such as peer information are positively related to some adaptation strategies (water conservation, 5% s.l.) and negatively related to others (crop timing and crop switching, 5% s.l). The way that this can be understood is that those who obtain information from their peers are typically less likely to use crop timing and crop choice as an adaptation, and more likely to use soil conservation compared to those who do not adapt (the baseline group). Other interesting relations concern the role of middlemen in adaptation. There is a strong positive correlation between those whose main source of information is middlemen and the likelihood of changing crops as an adaptation strategy, while the reverse is the case for water conservation strategies being undertaken.

Last, the weather and climate variables also affect the choice of adaptation strategy. Experience of floods in the past 15 years ("Flood (15yrs)") is positively correlated with crop timing, crop choice and soil conservation as adaptation strategies, while it is negatively correlated with water conservation, holding all the other variables constant. This is an intuitive finding. Experience of drought increases the likelihood of using soil conservation.

Concluding remarks on the determinants of adaptation

Taken together, these relationships describe a complex picture of the decision-making process for adaptation in rural Pakistan. We summarise the implications for policy in the concluding section of the report, however it is already easy to see that there will be no general statements about how to induce adaptation in Pakistan. Calls for more information and greater education need to be nuanced to take account of the type of adaptation strategy that is seen as desirable from the perspective of producing improvements in well-being. Beyond the finding from the previous section, that adaptation appears to improve yields for the adapters and would improve yields for the non-adapters, the analysis so far does not provide a clear answer to what the appropriate policy ought to be for adapters and non-adapters.

Perhaps the closest that we can come to identifying a universally promising means of promoting adaptation is to focus on improving extension to farmers through farmer's associations, which is positively correlated with all adaptation strategies. Beyond this, further investigation is required to understand the complex decision making process underpinning observed adaptation behaviour.

Adaptation and climate

In this section we elaborate on the relationship between climate variables, by which we mean measures of long-term weather trends rather than instantaneous measures of weather, and adaptation strategies. There are relationships between seasonal average temperature and precipitation that were illustrated in Table 3.2 above but not discussed. Here we graph these relationships by season for temperature and precipitation and show how these climatic changes affect the likelihood of undertaking each of the 5 adaptation strategies discussed above. In order to undertake this analysis we estimate a multinomial logistic model using a quadratic function form for the climate variables. We then perform predictive simulations within sample. The results are contained in Figures 3.1 – 3.9 which can be summarised as follows.

Rabi Season: Temperature response

Figure 3.1. shows how the likelihood of choosing the adaptation strategies changes with the Rabi (winter) season temperature. Broadly speaking, as the temperature rises, the likelihood of adapting increases. This is shown more clearly in Figure 3.2. which shows the likelihood of "not adapting" which falls as the temperature rises. Crop timing, soil conservation and crop choice all increase monotonically with temperature, particularly at the warmer end of the scale. Water conservation and input choice are popular choices which also increase with temperature up to a point, the likelihood declines at high temperature. These results use the spatial variation in long term climate that we have in our dataset to say something about the likelihood of different adaptation strategies at different temperatures. It is typical to use such spatial variation to make an inter-temporal prediction of how farming may adapt as a whole as temperatures change over time (e.g. Mendelsohn and Nordhaus 1994, Dinar et al., 2012). We do not do that here, apart from stating that temperatures are expected to rise as a consequence of climate change in Pakistan.

Table 3.2. Multinomial Regression on Choice of Adaptation Strategy

Explanatory Variables	Crop Timing	Crop Choice	Input Choice	Soil Conservation	Water Conservation
	Coeff/(se)	Coeff/(se)	Coeff/(se)	Coeff/(se)	Coeff/(se)
Household Variables					
Age	0.01	-0.03*	0.00	0.02**	0.02***
	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)
Literate	-0.54	0.00	-0.60***	0.05	0.35***
	(0.43)	(0.39)	(0.21)	(0.23)	(0.12)
% Female	-0.03	0.30***	0.04	-0.12**	0.09***
	(0.08)	(0.07)	(0.04)	(0.05)	(0.03)
Canal	0.19	0.21	0.03	-0.56*	0.20
	(0.60)	(0.43)	(0.24)	(0.29)	(0.18)
Tubewell	1.41**	0.35	0.06	-0.21	0.04
	(0.63)	(0.41)	(0.22)	(0.26)	(0.16)
Total Land	0.01	0.04***	0.03***	0.01	-0.01*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)
Institutional Variables					
Credit	-0.44	-0.69**	0.03	-0.48**	-0.04
	(0.28)	(0.28)	(0.16)	(0.20)	(0.11)
Off-farm labour	0.01	-0.03	-0.10**	-0.01	-0.30***
	(0.09)	(0.08)	(0.05)	(0.06)	(0.04)
Owns Land	-1.06***	1.16**	0.25	0.79*	-0.05
	(0.34)	(0.49)	(0.26)	(0.41)	(0.19)
Sharecrop	-1.27***	1.27**	-0.12	1.44***	0.10
	(0.40)	(0.52)	(0.32)	(0.42)	(0.22)
Information Variables					
Gov. Extension	-1.60***	-0.05	-1.01***	-0.50*	0.18
	(0.51)	(0.49)	(0.22)	(0.29)	(0.13)
Farmer Assoc.	2.35***	1.87**	2.05***	1.69**	2.17***
	(0.58)	(0.87)	(0.56)	(0.74)	(0.44)
NGO Extension	0.62	-19.01	-2.88***	-17.86	0.81***
	(0.48)	(42.19)	(0.71)	(32.07)	(0.26)
Research Extension	0.29	-1.32	0.06	-0.54	0.16
	(0.58)	(1.04)	(0.31)	(0.50)	(0.24)
Peer Information	-0.94***	-0.57**	-0.22	0.10	0.86***
	(0.29)	(0.27)	(0.17)	(0.21)	(0.12)
Print Media	-15.52	-18.57	0.50	-0.46	0.09
	(34.60)	(10.56)	(0.41)	(0.62)	(0.23)
TV	-0.28	0.12	-0.56**	0.08	0.26*
	(0.45)	(0.38)	(0.26)	(0.28)	(0.14)
Landlord Inf.	-0.97*	-0.36	-0.48	-1.17**	1.08***
	(0.52)	(0.49)	(0.39)	(0.54)	(0.18)
Middlemen Inf.	-17.92	1.47***	0.34	-0.49	-1.21***
	(45.07)	(0.40)	(0.26)	(0.44)	(0.31)

*** = significant at 1% level, ** = significant at 5% level, *=significant at 10% level

Table 3.2. (cont'd) Multinomial Regression on Choice of Adaptation Strategy

Table Cont'd	Crop Timing	Crop Choice	Input Choice	Soil Conservation	Water Conservation
	Coeff/(se)	Coeff/(se)	Coeff/(se)	Coeff/(se)	Coeff/(se)
Climate Variables					
Flood (15yrs)	0.98**	0.97*	-0.03	0.89**	-0.32**
	(0.49)	(0.51)	(0.24)	(0.35)	(0.15)
Drought (15yrs)	0.44	0.55	-0.20	1.11***	0.12
	(0.32)	(0.36)	(0.27)	(0.23)	(0.15)
Rabi Temp (ave C)	5.42***	-6.39***	-0.47	-0.93	0.73***
	(1.89)	(1.64)	(0.67)	(0.70)	(0.22)
Rabi Rain (ave cm)	46.92***	-25.53**	-2.65	5.22	1.39
	(14.03)	(12.91)	(2.76)	(3.92)	(1.18)
Kharif Temp (ave C)	-2.18*	4.90***	0.63	1.23*	0.29
	(1.16)	(1.22)	(0.50)	(0.65)	(0.29)
Kharif Prec (ave cm)	0.97***	-1.29**	0.69***	0.17	0.18**
	(0.37)	(0.58)	(0.27)	(0.34)	(0.08)
Constant	-62.55**	-19.97	-13.89	-25.54	-29.75***
	(26.17)	(22.38)	(19.51)	(21.43)	(9.56)
District F.E.	Yes	Yes	Yes	Yes	Yes
N	3425				
chi2	1776.48***				
bic	7792.95				

*** = significant at 1% level, ** = significant at 5% level, *=significant at 10% level

Kharif Season: Temperature response

A similar pattern can be seen in the Kharif season. The likelihood of water and soil conservation strategies being implemented increases monotonically with Kharif temperatures. This suggests that these strategies remain effective even at the extreme temperatures. However, with this interpretation in mind, the effectiveness of the other strategies is limited to a certain range of temperatures. The unimodal nature of the likelihood of crop timing, crop choice and input choice, which peak at around 32-35 degrees respectively, indicates that these strategies become less likely in areas with higher mean Kharif temperatures. Figure 3.3 shows, however, that the likelihood of not-adapting (adapting) falls (rises) with Kharif temperatures, with the adoption of some or other adaptation strategy becoming more likely.

Rabi Precipitation

The relationship between Rabi precipitation and adaptation is more straightforward. In the winter season all of the on-farm adaptation strategies that we focus on here decline with the long term average precipitation (measured as the average precipitation over the past 25 years). Water conservation is the most likely strategy followed by input choice. Simply put, declining precipitation in the winter season increases the likelihood of each adaptation strategy being deployed, and decreases the likelihood of not adapting.

Kharif Precipitation

The relationships between precipitation and adaptation are more complex in the Kharif season. Here we see non-monotonic relationships, with crop timing increasing in likelihood for those areas with between 2 and 3 cm of rain, and yet decline in likelihood at higher levels of precipitation. Input choice has a similar albeit less pronounced patter. Once again it is water conservation that is the most popular strategy, with the likelihood increasing somewhat in those areas with less precipitation.

Figure 3.1. Rabi Temperature and the Probability of Adopting Different Adaptation Strategies

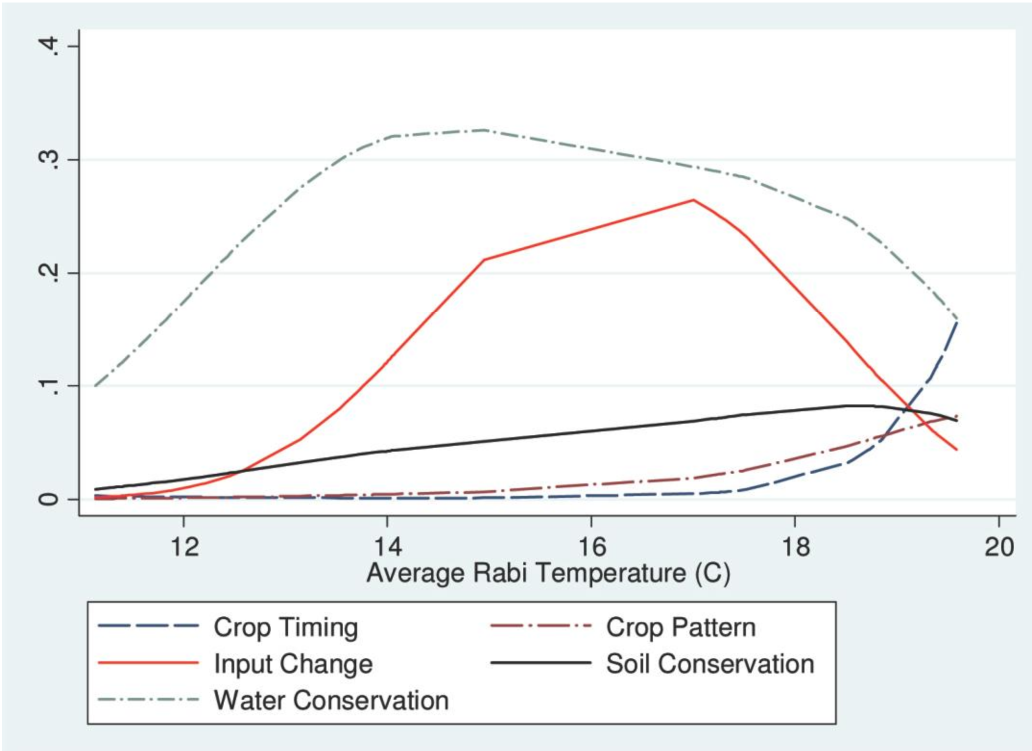


Figure 3.2. Rabi Temperature and the Probability of Not Adapting

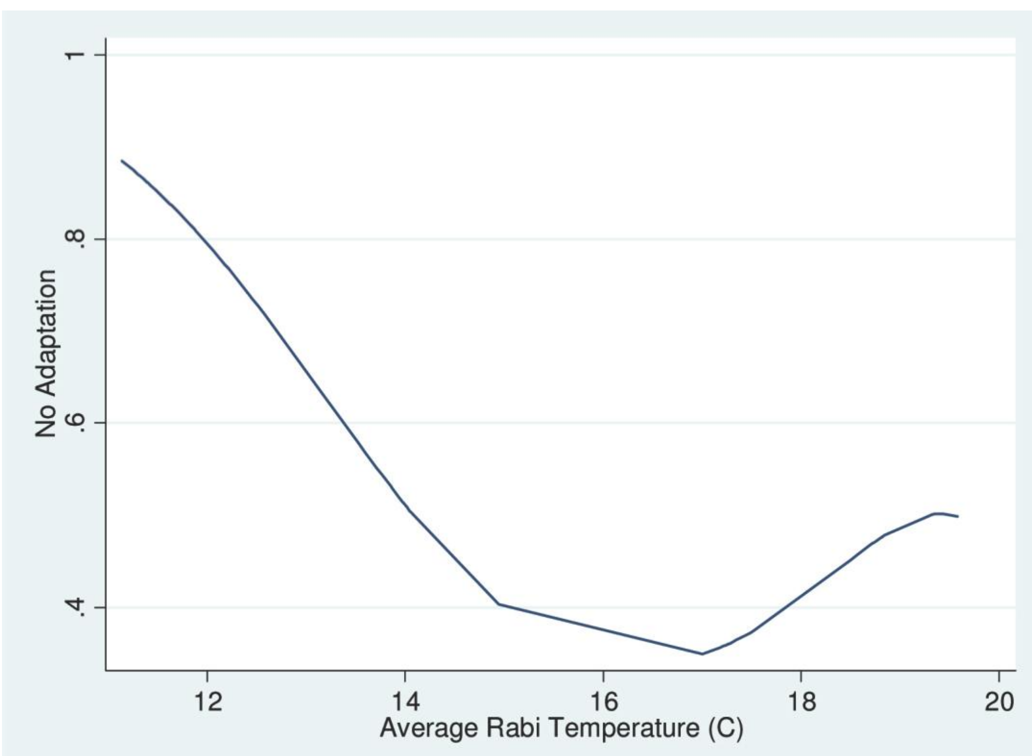


Figure 3.3. Kharif Temperature and the Probability of Adopting Different Adaptation Strategies

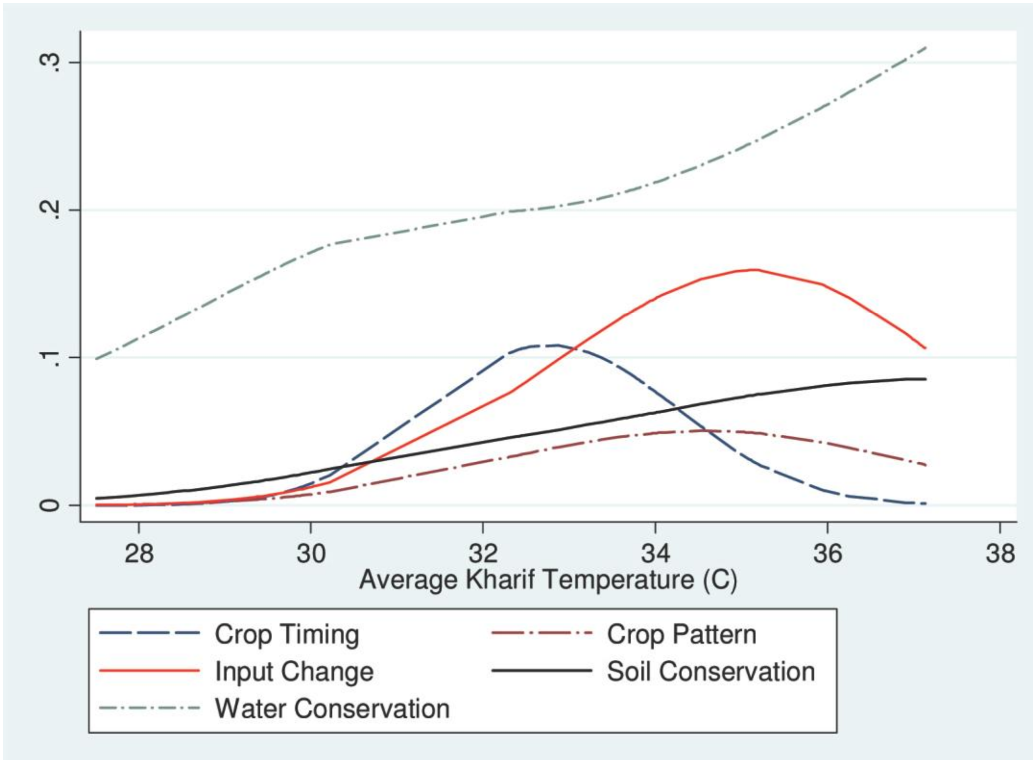


Figure 3.4. Kharif Temperature and the Probability of Not Adapting

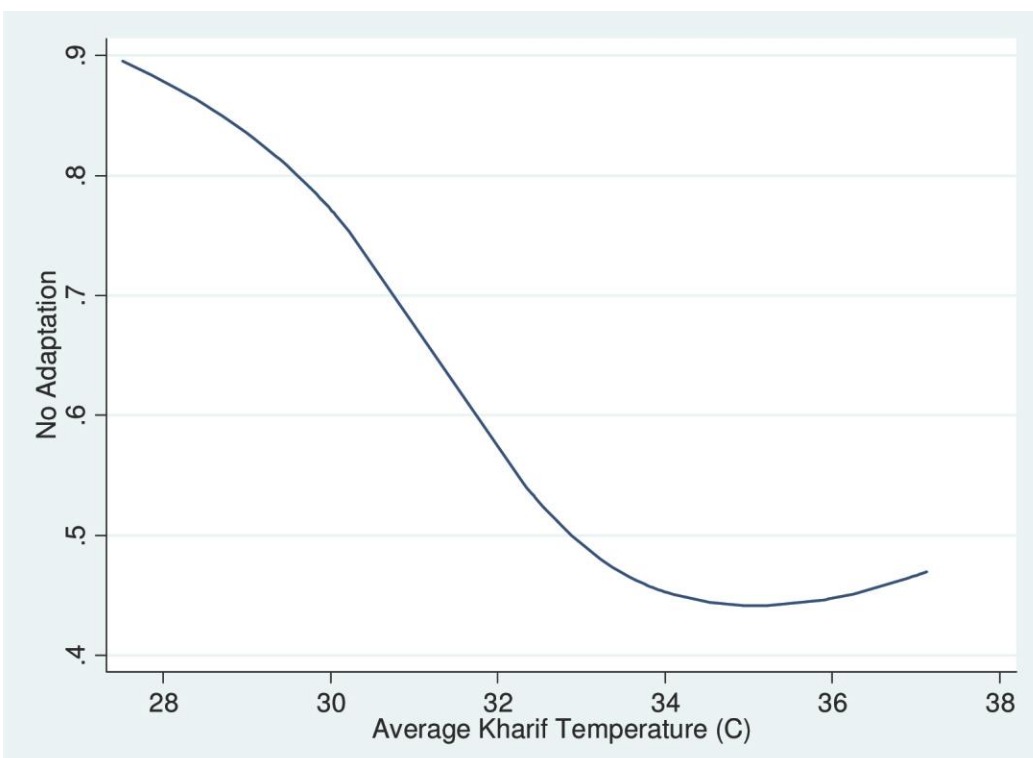


Figure 3.5. Rabi Precipitation and the likelihood of adopting different adaptation strategies

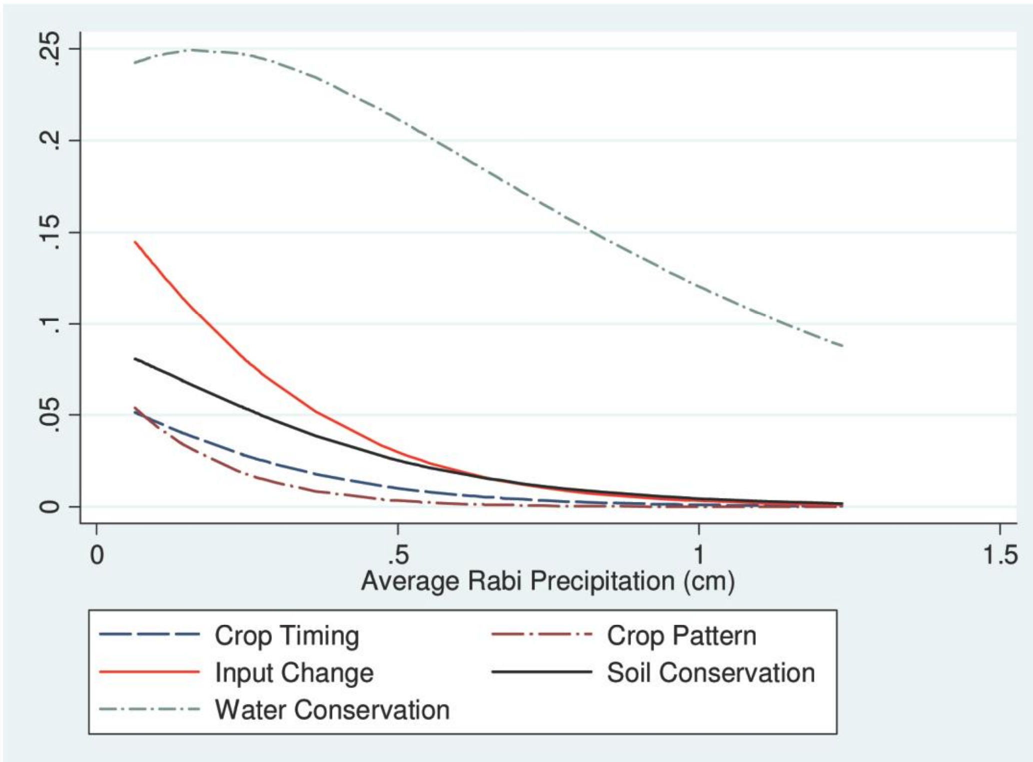


Figure 3.6. Rabi Precipitation and the Probability of Not Adapting

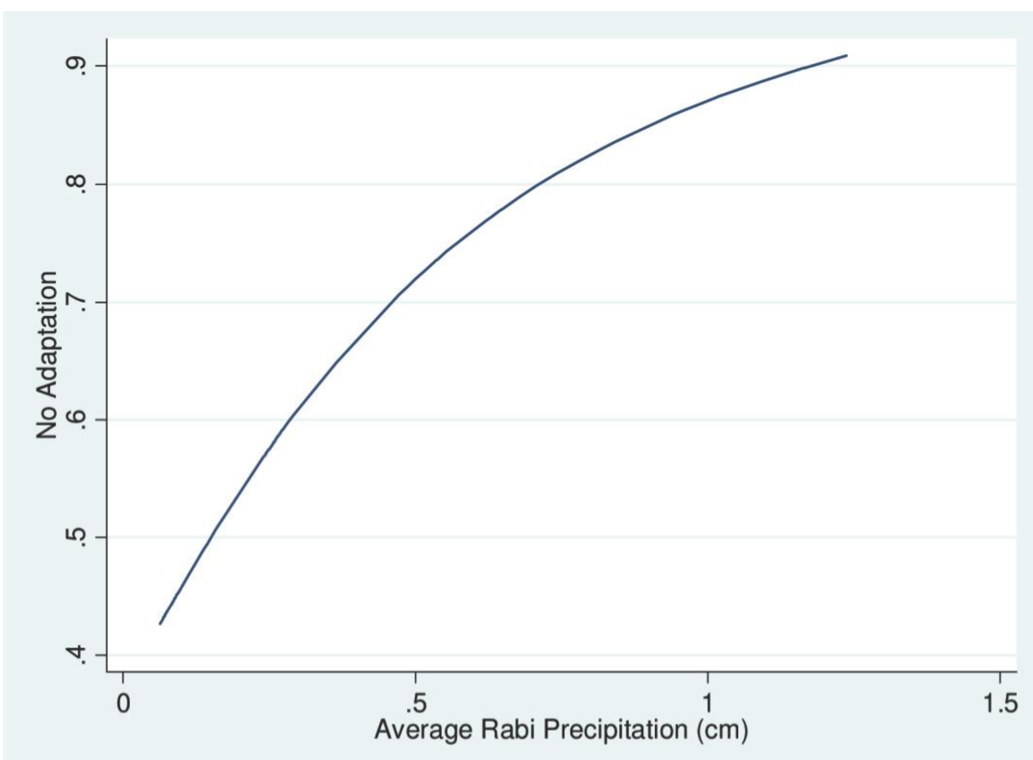


Figure 3.7. Kharif Precipitation and the likelihood of adopting different adaptation strategies

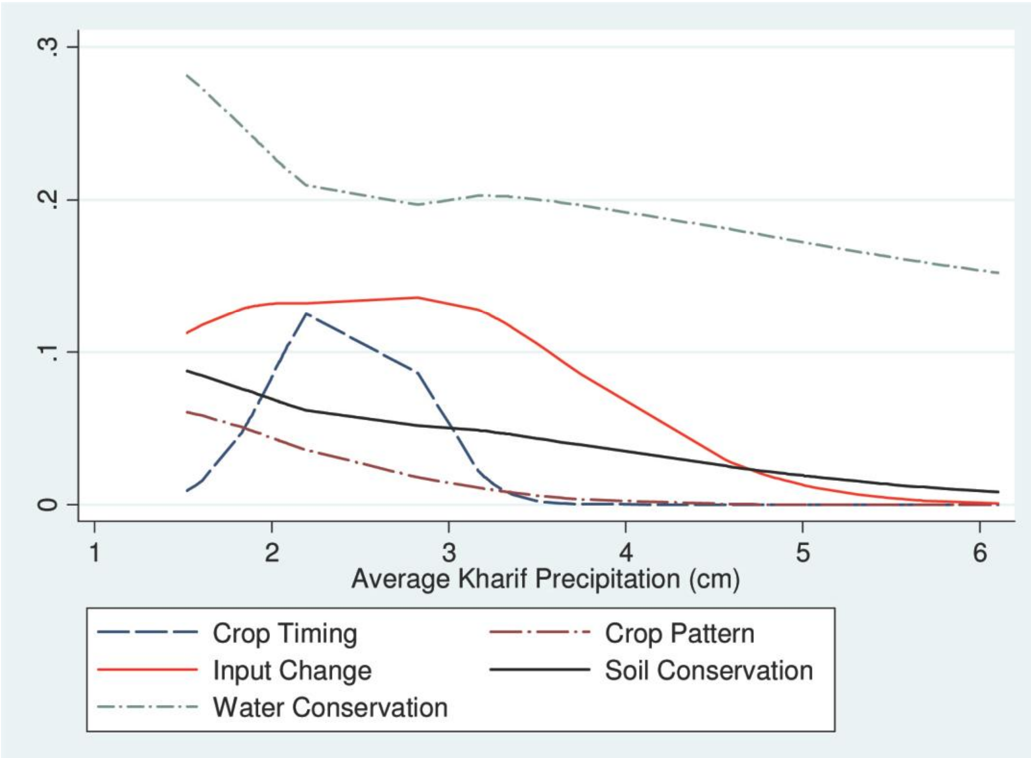
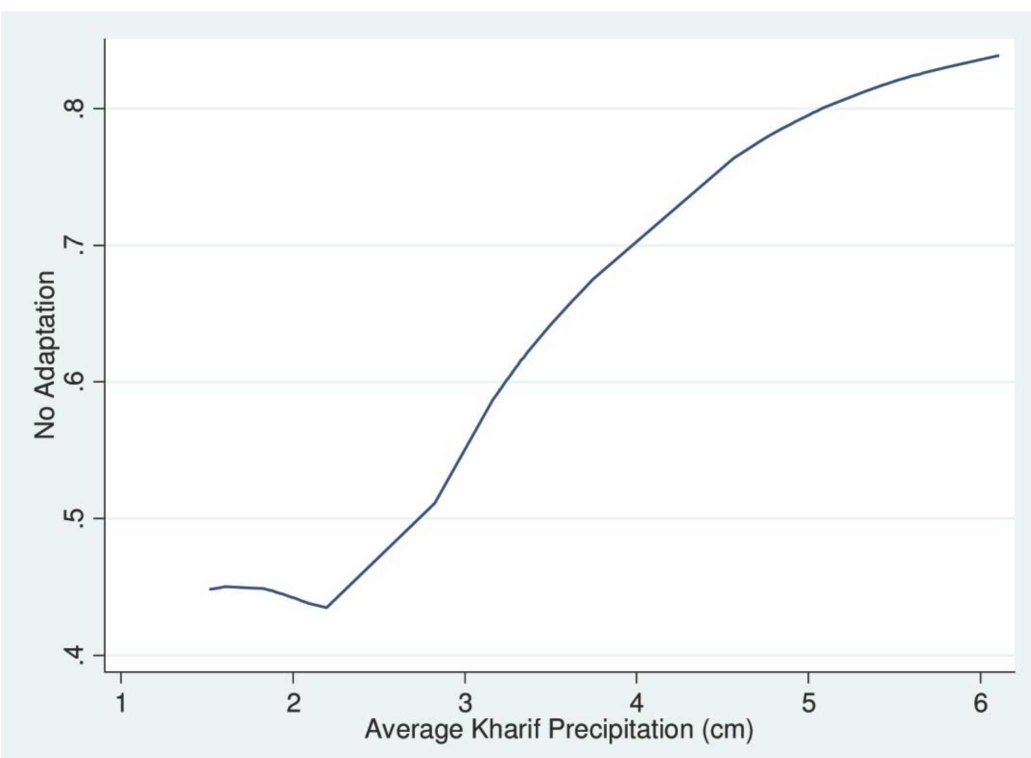


Figure 3.8. Kharif Precipitation and the Probability of Not Adapting



3. What are the key determinants of adaptation to climate change?

Concluding remarks on Adaptation and Climate

While these relationships are based on spatial variation, they provide a useful basis for the climate change thought experiment. Climate change is likely to involve higher temperatures, and so on this basis the analysis here shows that water conservation and input choices (such as more labour and fertilizer) will be a likely response in both the Rabi and Kharif seasons. The predictions for precipitation are less clear, but most adaptation strategies will increase in likelihood as precipitation decreases, regardless of the season in which this occurs.

4. Summary and Policy recommendations

We have found that climate change is likely to be costly to agriculture in Pakistan. We have found that adaptation can ameliorate the impact of climate change and help achieve food security and higher productivity in some circumstances. There are significant differences in the success of adaption across different crops. Thus, taking into account where adaptation is likely to be most effective is of importance to policy.

We have also found that a rich set of factors determine the likelihood of adaptation. Gender and access to quality farming inputs are particularly strong predictors of adaption. Conversely, experience of drought is a positive predictor of adaptation suggesting that the long-run effects of extreme weather may impact farmers in the long-term.

A key finding of this study is that information sources are of crucial importance to farmers' perceptions and actions to avert the impacts of climate change. It appears that formal extension services are a particularly important way of spreading adaptation knowledge. Similarly, it seems that farmers share information between each other suggesting that access to peer networks is of high importance to reacting to a changing climate. Farmer Associations appear to provide a positive impetus to all adaptation strategies. The role of other institutions and information sources varies from one crop to another. Middle men, for instance, are positively correlated with adaptation involving crop choice, but negatively so in relation to water conservation. This differential effect is an important finding given the prevalence of middlemen in Pakistan's rural economy, and worthy of further investigation to establish causality. Similarly, this also sets the study apart from others on determinants of climate adaptation that are often conducted in regions that do not have such informal and well-developed networks. The finding that middlemen have varying effects on adaptation, while other networks have uniformly positive effects is both a unique and important finding from this study.

The policy recommendations that flow from this are as follows:

1) With the costs to agriculture estimated at 8-10% of land values, efforts need to go into finding ways to ameliorate these adverse impacts;

2) Adaptation has been shown to have benefits for those who have adapted in terms of yields for most crops. This enhances productivity and food security. Targeting policies to encourage adaptation is of key importance.

3)It is an important finding of this survey that access to informational services such as farming and specific climate change advice is crucial. Institutional features of the Pakistani rural economy, namely the existence and role of middlemen in the agricultural production chain may distort the flow of information that farmers receive. Similarly, land tenure arrangements may also affect the incentive to adapt. Whether farmers adapt is determined by their access to current and reliable information concerning farming innovations and a changing climate. Policies to improve the institutional environment within which adaptation takes place are to be recommended to both improve productivity and encourage adaptation. This includes access to information as well as improved land-tenure and good access to quality inputs and credit markets.

Future work on how institutional features, such as middlemen, affect farmers' lives is of high importance and is answerable given the level of detail contained in the data from the survey. It is important to recognise that addressing these issues is likely to have an important and immediate developmental effect for poor farmers. Managing risk in general is an important development issue as well as pertaining to long-run issues such as climate change.

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Hedonic Analysis

Table A1.1. Hedonic analysis of land values (log(PKR/acre)) and Seasonal average climate variables (1990-2012)

Dependent Variable: Log(land value PKRs)	Hedonic Model
	Coefficient/(s.e.)
Average Annual Temperature	-0.08*
	(0.05)
Average Annual Temperature Squared	-0.01**
	(0.00)
Average Annual Precipitation	-0.60***
	(0.17)
Average Annual Precipitation Squared	0.05
	(0.05)
Land Area	-0.06***
	(0.00)
Access to canal water (0/1)	0.23*
	(0.13)
Access to tubewell (0/1)	-0.14
	(0.10)
Owns land (0/1)	-0.01
	(0.09)
Land is sharecropped	-0.21*
	(0.12)
Drought (past 15 years)	-0.27***
	(0.10)
Flood (past 15 years)	0.02
	(0.05)
Punjab (0/1)	0.73***
	(0.12)
Constant	12.70***
	(0.27)
N	2953
chi2	991.45***
Bic	9716.53
R-sq	0.26

*** = significant at 1% level, ** = significant at 5% level, *=significant at 10% level

Appendix 2.

Kernel Density Estimation of unconditional yields: wheat, rice and cotton

Figure A2.1 Density of wheat yields for adapters and non-adapters (maunds/hectare)

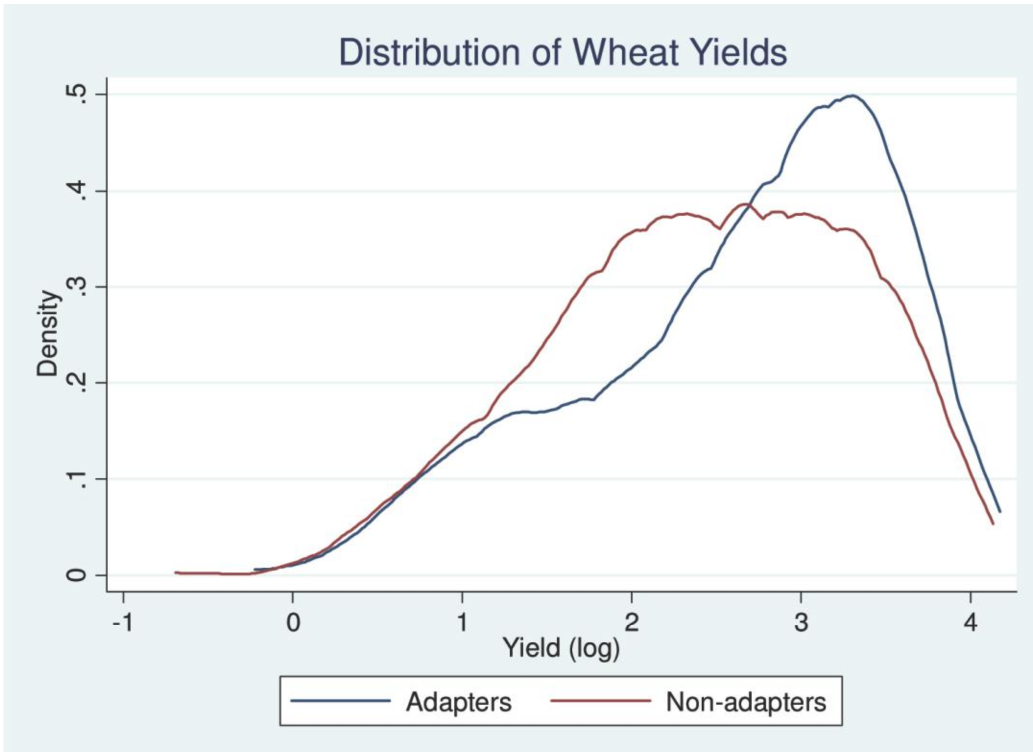


Figure A2.2. Density of rice yields for adapters and non-adapters (maunds/hectare)

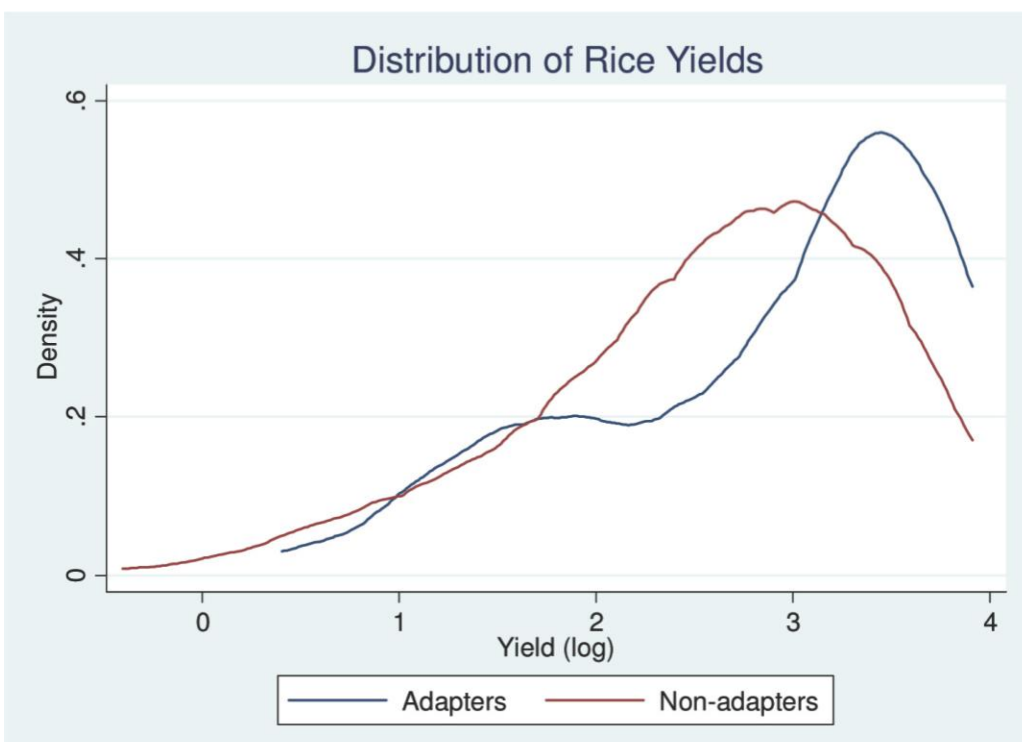
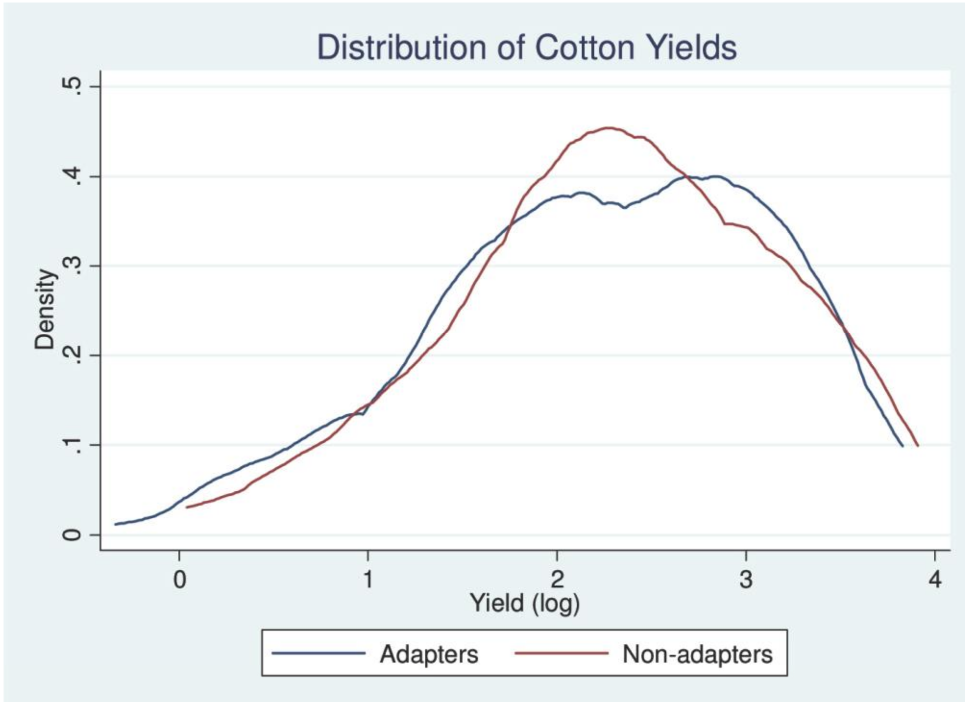


Figure A2.3. Density of rice yields for adapters and non-adapters (maunds/hectare)



Appendix 3.

Impact Analysis: Selection on unobservables

Table A3 Ordinary Least Squares Regression				
	Pooled (1)	Wheat (2)	Rice (3)	Cotton (4)
	Yield (maunds/acre)	Yield (maunds/acre)	Yield (maunds/acre)	Yield (maunds/acre)
	Coef./se	Coef./se	Coef./se	Coef./se
Adapt	2.163***	1.565**	2.674	2.134*
	(0.568)	(0.625)	(1.647)	(1.088)
Inputs Pesticides/acre	0.164	1.033***	0.824*	-0.214
	(0.131)	(0.283)	(0.457)	(0.165)
Urea/acre	0.344**	-0.028	2.362***	1.202***
	(0.138)	(0.131)	(0.782)	(0.344)
DAPSOP/acre	0.044	0.027	1.613	1.357
	(0.080)	(0.068)	(1.161)	(0.860)
Manure/acre	0.661*	0.862**	1.849	-0.443
	(0.365)	(0.410)	(1.712)	(0.630)
Seed/acre	0.018*	0.006	-0.002	0.027
	(0.010)	(0.012)	(0.053)	(0.041)
Soil Qual.	0.260	-0.103	0.808	0.440
	(0.386)	(0.414)	(1.102)	(0.788)
Household Labour/acre	0.671***	0.659***	0.708***	0.555***
	(0.072)	(0.082)	(0.188)	(0.169)
Hired Labour/acre	0.206***	0.124	0.440**	-0.045
	(0.067)	(0.138)	(0.178)	(0.077)
Water Apps./acre	0.067***	0.379***	0.011	0.401***
	(0.023)	(0.134)	(0.038)	(0.147)
Canal	3.647***	0.519	6.945***	0.178
	(1.017)	(1.268)	(2.454)	(1.901)
Tubewell	1.449	1.164	1.571	-1.366
	(0.938)	(1.144)	(2.557)	(1.654)
Tractor	2.166***	1.151	5.141**	0.865
	(0.669)	(0.730)	(2.097)	(1.215)
Household Total Land (acres)	-0.060**	0.016	-0.097	-0.123**
	(0.030)	(0.037)	(0.075)	(0.060)
Household Size	-0.265***	-0.120	-0.439*	-0.086
	(0.096)	(0.105)	(0.254)	(0.234)
Literate	0.504	0.599	0.375	0.479
	(0.758)	(0.815)	(2.343)	(1.551)
% Females	-2.309	-0.174	-10.445*	-2.570
	(1.833)	(1.968)	(5.643)	(3.533)
Credit	-1.118*	-1.035	1.57	-3.860***
	(0.617)	(0.683)	(1.755)	(1.158)

Appendix 3.

Off-farm Work	-0.203	-0.232	-0.604	-0.237
	(0.206)	(0.223)	(0.663)	(0.376)
Flood	0.861	1.059	0.89	-2.314
	(0.879)	(0.937)	(2.914)	(1.618)
Drought	-1.412*	-2.313***	-3.771	2.102
	(0.842)	(0.886)	(2.916)	(1.709)
Livestock	-0.033	-0.022	0.044	-0.169
	(0.068)	(0.076)	(0.202)	(0.119)
Owns Land	1.586**	0.939	2.653	0.398
	(0.700)	(0.776)	(2.028)	(1.358)
Weather **Kharif Rain**	0.714	1.483	8.118	6.775
	(2.143)	(2.200)	(13.827)	(6.085)
Kharif Temp.	0.091	2.150	0.368	6.194
	(6.878)	(6.884)	(37.890)	(24.877)
Rabi Rain	4.745	21.527	-100.55	-110.513
	(35.770)	(35.129)	(194.138)	(155.148)
Rabi Temp.	-7.528	-5.003	-60.88	-47.889
	(12.217)	(11.675)	(72.235)	(58.594)
Climate **Ave. Kharif Rain**	-3.288	-4.944	-20.283	7.010
	(8.034)	(8.065)	(58.761)	(37.891)
Ave. Kharif Temp.	-6.149	-4.818	-6.275	6.412
	(7.772)	(7.917)	(39.558)	(27.000)
Ave. Rabi Rain	-34.414	-32.408	39.380	62.283
	(29.403)	(30.458)	(182.037)	(113.361)
Ave. Rabi Temp.	11.113	7.658	75.827	34.682
	(11.853)	(11.162)	(75.028)	(52.568)
Information **Peer**	-0.850	-1.194*	0.181	-2.183*
	(0.626)	(0.684)	(1.853)	(1.236)
Media	-3.633***	-3.876***	-3.478	-1.014
	(0.804)	(0.880)	(2.189)	(1.796)
Middleman	-0.167	2.629*	-6.391*	0.001
	(1.276)	(1.462)	(3.790)	(2.286)
Landlord	-0.554	0.779	-5.213	-0.171
	(1.051)	(1.161)	(3.243)	(1.918)
Constant	230.429**	84.878	434.568	91.547
	(94.167)	(91.971)	(403.997)	(285.773)
Region Dummies	Yes	Yes	Yes	Yes
N	1539	907	337	293
R-squared	0.267	0.273	0.403	0.455

Appendix 3.

Table A3.1 Endogenous Switching Regression: Pooled Crops			
	Yield Non-Adapters	Yield Adapters	Adapt(0/1)
	Coef./se	Coef./se	Coef./se
Inputs			
Pesticides/acre	0.263**	-0.02	0.077**
	(0.115)	(0.273)	(0.036)
Urea/acre	0.205	0.283	0.001
	(0.308)	(0.248)	(0.023)
DAPSOP/acre	0.090*	0.121	-0.001
	(0.051)	(0.095)	(0.012)
Manure/acre	0.973	0.369	0.077
	(0.761)	(0.905)	(0.064)
Seed/acre	0.015	0.009	0.004***
	(0.036)	(0.01)	(0.001)
Soil Qual.	0.127	-0.099	0.125*
	(0.844)	(0.602)	(0.065)
Household Labour/acre	0.826***	0.649*	-0.011
	(0.225)	(0.374)	(0.013)
Hired Labour/acre	0.460***	0.138	0.031
	(0.107)	(0.115)	(0.027)
Water Apps./acre	0.032	0.058	-0.001
	(0.027)	(0.046)	(0.004)
Canal	3.759***	3.207	0.002
	(1.308)	(2.141)	(0.301)
Tubewell	2.165*	0.624	-0.084
	(1.128)	(1.621)	(0.231)
Tractor	1.614	2.601	-0.025
	(1.309)	(2.31)	(0.236)
Household Total Land (acres)	-0.026	-0.090**	0.014*
	(0.097)	(0.041)	(0.008)
Household Size	-0.354***	-0.05	-0.01
	(0.124)	(0.122)	(0.011)
Literate	-0.227	1.121	-0.138
	(0.856)	(1.473)	(0.176)
% Females	3.14	-8.770*	0.675***
	(1.913)	(4.961)	0.24
Credit	-1.858**	-0.36	-0.083
	(0.874)	(0.501)	(0.127)
Off-farm Work	0.336	-0.659*	-0.053
	(0.358)	(0.394)	(0.047)
Flood	2.079*	0.902	-0.061
	(1.124)	(1.243)	(0.118)

Appendix 3.

Drought	-1.287	-3.513***	0.379**
	(1.121)	(1.045)	(0.158)
Livestock	-0.042	-0.096	0.000
	(0.078)	(0.062)	(0.016)
Owns Land	2.374*	-0.092	-0.066
	(1.368)	(1.813)	(0.209)
Weather Kharif Rain	0.218	5.04	0.288
	(1.874)	(3.981)	(0.213)
Kharif Temp.	1.021	-0.355	-3.089***
	(6.923)	(18.438)	(0.753)
Rabi Rain	16.389	-24.395	7.401
	(29.346)	(49.587)	(5.993)
Rabi Temp.	-4.88	-27.065*	2.211
	(11.759)	(16.296)	(2.396)
Climate Ave. Kharif Rain	-1.545	-17.185	-1.179
	(6.82)	(12.209)	(1.011)
Ave. Kharif Temp.	-11.685*	2.411	3.498***
	(6.786)	(18.329)	(0.417)
Ave. Rabi Temp.	8.976	31.590**	-2.683
	(11.857)	(15.726)	(2.406)
Ave. Rabi Rain	-65.858***	55.78	-0.868
Information	(19.697)	(72.294)	(4.332)
Extension Services	0.012	-0.111	-0.018
	(0.876)	(0.868)	(0.127)
Peer	-1.135	-0.157	0.191
	(1.233)	(1.263)	(0.203)
Media	-4.829***	-2.321***	0.246
	(1.645)	(0.853)	(0.275)
Middleman	2.333	-3.445	-0.075
	(1.625)	(3.674)	(0.332)
Landlord	-1.409	0.34	-0.008
	(2.598)	(4.211)	(0.525)
Climate Change Perceptions Prec. Decrease			-0.147
			(0.141)
Prec. Increase			0.028
			(0.155)
Prec. Onset			0.420***
			(0.132)
Temp. Decrease			-0.339*
			(0.175)
Temp. Cold Spell			0.812*
			(0.458)

Appendix 3.

Temp. Onset Hot			-0.773***
			(0.179)
Constant	344.350***	26.56	-20.388
	(132.419)	(272.476)	(18.839)
Sigma	2.257***	2.474***	
	(0.097)	(0.128)	
Rho	0.066	-0.462***	
	(0.209)	(0.16)	
Region dummies	Yes	Yes	Yes
N			1539
Standard errors are robust and clustered by region			
*** p<0.10 ** p<0.05 *** p<0.01**			

Appendix 3.

Table 3.2. Endogenous Switching Regression: Wheat			
	Yield Non-Adapters	Yield Adapters	Adapt(0/1)
	Coef./se	Coef./se	Coef./se
Inputs Pesticides/acre	0.853	0.839***	0.103*
	(0.692)	(0.210)	(0.059)
Urea/acre	-0.097	-0.054	-0.015
	(0.174)	(0.209)	(0.015)
DAPSOP/acre	0.094	0.029	-0.005
	(0.074)	(0.054)	(0.013)
Manure/acre	1.352	0.597	0.118*
	(0.972)	(0.826)	(0.067)
Seed/acre	0.017	-0.032	0.009***
	(0.061)	(0.026)	(0.002)
Soil Qual.	-0.414	-0.302	0.074
	(0.673)	(0.820)	(0.085)
Household Labour/acre	0.708***	0.737*	-0.027***
	(0.212)	(0.399)	(0.005)
Hired Labour/acre	0.193	0.059	0.032*
	(0.126)	(0.127)	(0.018)
Water Apps./acre	0.653	0.265	-0.003
	(0.445)	(0.453)	(0.035)
Canal	0.829	-0.835	-0.08
	(1.352)	(1.046)	(0.357)
Tubewell	2.946***	-0.238	-0.126
	(0.967)	(1.156)	(0.278)
Tractor	1.177	1.79	-0.123
	(1.411)	(2.056)	(0.248)
Household Total Land (acres)	0.059	-0.023	0.012
	(0.137)	(0.038)	(0.011)
Household Size	-0.175	0.085	-0.004
	(0.167)	(0.171)	(0.011)
Literate	0.137	0.976	-0.106
	(1.442)	(1.435)	(0.168)
% Females	3.529	-6.910*	0.562*
	(3.849)	(3.671)	(0.313)
Credit	-1.28	0.491	-0.177
	(1.151)	(0.959)	(0.150)
Off-farm Work	0.144	-0.568	-0.062
	(0.564)	(0.405)	(0.042)
Flood	1.787	0.018	-0.086

	(1.478)	(1.587)	(0.187)
Drought	-3.295	-5.026***	0.494***
	(2.604)	(1.057)	(0.137)
Livestock	-0.081	-0.071	-0.007
	(0.123)	(0.109)	(0.016)
Owns Land	2.082	-0.517	-0.098
	(1.338)	(1.519)	(0.139)
Weather Kharif Rain	-3.113	13.043***	0.141
	(3.317)	(3.957)	(0.354)
Kharif Temp.	1.87	-4.549	-2.474***
	(16.4)	(20.06)	(0.681)
Rabi Rain	-15.628	159.412***	2.937
	(27)	(55.293)	(7.38)
Rabi Temp.	-15.608	24.467	0.809
	(11.903)	(19.458)	(2.559)
Climate Ave. Kharif Rain	9.894	-47.812***	-0.524
	(10.493)	(12.832)	(1.492)
Ave. Kharif Temp.	-7.27	-0.207	3.351***
	(19.272)	(20.477)	(0.474)
Ave. Rabi Temp.	17.051	-17.621	-1.385
	(11.448)	(18.723)	(2.507)
Ave. Rabi Rain	-33.5	-85.812	3.336
	(30.411)	(72.133)	(6.376)
Information Extension Services	0.38	-2.180**	0.072
	(1.153)	(0.928)	(0.146)
Peer	-1.824	-0.196	0.246
	(2.285)	(1.069)	(0.264)
Media	-3.472***	-5.176***	0.267
	(1.146)	(1.023)	(0.232)
Middleman	2.667	3.274*	-0.23
	(3.152)	(1.713)	(0.291)
Landlord	0.604	0.628	0.022
	(3.74)	(2.965)	(0.522)
Climate Change Perceptions Prec. Decrease			-0.062
			(0.22)
Prec. Increase			0.059
			(0.297)
Prec. Onset			0.358
			(0.337)
Temp. Decrease			-0.377*
			(0.195)
Temp. Cold Spell			0.905

			(0.658)
Temp. Onset Hot			-0.39
			(0.395)
Constant	264.431	14.502	-27.594
	(178.512)	(310.946)	(20.51)
Sigma	2.111***	2.222***	
	(0.058)	(0.056)	
Rho	-0.013	-0.496**	
	(1.197)	(0.229)	
Region dummies	Yes	Yes	Yes
N			907
Standard errors are robust and clustered by region			
*** p<0.10 ** p<0.05 *** p<0.01**			

Table 3.3. Endogenous Switching Regression: Rice			
	Yield Non-Adapters	Yield Adapters	Adapt(0/1)
	Coef./se	Coef./se	Coef./se
Inputs Pesticides/acre	-1.283***	1.051	0.036
	(0.168)	(1.119)	(0.054)
Urea/acre	5.891***	0.437	0.005
	(1.746)	(1.758)	(0.147)
DAPSOP/acre	0.053	3.857	0.117
	(0.947)	(2.389)	(0.123)
Manure/acre	2.910***	1.575	0.121
	(1.013)	(1.368)	(0.133)
Seed/acre	-0.027	-0.001	0.012***
	(0.05)	(0.062)	(0.005)
Soil Qual.	0.728	1.143	0.157***
	(0.702)	(1.668)	(0.055)
Household Labour/acre	0.595*	1.191***	-0.005
	(0.357)	(0.300)	(0.013)
Hired Labour/acre	1.771***	0.351***	0.060*
	(0.274)	(0.027)	(0.033)
Water Apps./acre	-0.02	-0.097*	-0.004
	(0.033)	(0.057)	(0.002)
Canal	6.045	8.787**	0.288
	(4.189)	(3.803)	(0.383)
Tubewell	-2.252	3.443	0.094
	(2.014)	(3.995)	(0.269)
Tractor	2.104*	3.988	0.371
	(1.141)	(5.046)	(0.328)
Household Total Land (acres)	0.017	-0.109***	0.016***
	(0.027)	(0.041)	(0.004)
Household Size	-0.601***	-0.112	-0.014
	(0.185)	(0.497)	(0.021)
Literate	-0.591	2.834	-0.205
	(3.550)	(5.198)	(0.216)
% Females	-2.474	-15.420***	0.518
	(7.159)	(5.293)	(0.344)
Credit	-2.513	5.243**	-0.233*
	(2.347)	(2.044)	(0.122)
Off-farm Work	0.930**	-1.326	-0.074
	(0.413)	(1.386)	(0.089)

Flood	4.360*	2.998	-0.096
	(2.451)	(4.534)	(0.207)
Drought	2.907	-3.865	0.276
	(3.621)	(2.462)	(0.301)
Livestock	0.039	0.029	0.045***
	(0.081)	(0.209)	(0.009)
Owns Land	3.061***	4.830*	-0.448**
	(0.956)	(2.549)	(0.212)
Weather **Kharif Rain**	26.753***	0.94	1.309
	(10.101)	(13.972)	(1.665)
Kharif Temp.	22.102	54.928*	-5.285
	(33.302)	(29.523)	(3.872)
Rabi Rain	528.507*	-277.506**	77.619***
	(303.243)	(132.085)	(21.507)
Rabi Temp.	104.761	-162.980***	30.721***
	(96.481)	(32.012)	(5.493)
Climate **Ave. Kharif Rain**	-161.715**	-57.361	-9.105
	(65.806)	(47.586)	(7.838)
Ave. Kharif Temp.	-42.821	-43.617	3.412
	(37.208)	(26.944)	(4.177)
Ave. Rabi Temp.	-68.054	198.660***	-30.341***
	(85.22)	(31.034)	(4.620)
Ave. Rabi Rain	-100.436	681.843***	-18.713
	(101.549)	(134.349)	(23.082)
Information **Extension Services**	-1.570	5.276*	-0.485*
	(2.053)	(2.776)	(0.287)
Peer	2.179**	0.638	0.08
	(1.015)	(3.971)	(0.328)
Media	-6.777***	2.652	-0.062
	(2.544)	(3.805)	(0.407)
Middleman	3.688*	-17.780*	0.033
	(2.151)	(9.086)	(0.339)
Landlord	-10.230**	1.829	-0.385
	(4.157)	(8.858)	(0.528)
Climate Change Perceptions **Prec. Decrease**			-0.38
			(0.247)
Prec. Increase			-0.155
			(0.103)
Prec. Onset			-0.062
			(0.189)
Temp. Increase			0.472
			(0.295)

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Temp. Night			-1.017
			(0.744)
Temp. Cold Spell			-3.048**
			(1.275)
Temp. Onset Hot			-1.872***
			(0.363)
Constant	-402.839	-93.308	-107.474*
	(432.437)	(405.493)	(57.940)
Sigma	2.349***	2.662***	
	(0.220)	(0.097)	
Rho	0.395	-0.546***	
	(0.379)	(0.203)	
Region dummies	Yes	Yes	Yes
N			337
Standard errors are robust and clustered by region			
*** p<0.10 ** p<0.05 *** p<0.01**			

Table 3.4. Endogenous Switching Regression: Cotton			
	Yield Non-Adapters	Yield Adapters	Adapt(0/1)
	Coef./se	Coef./se	Coef./se
Inputs Pesticides/acre	-0.473	-0.165	0.017
	(0.355)	(0.157)	(0.036)
Urea/acre	1.082***	0.929***	0.114***
	(0.261)	(0.331)	(0.026)
DAPSOP/acre	0.693**	2.166	0.200
	(0.299)	(1.627)	(0.129)
Manure/acre	3.496*	-0.688	0.036
	(1.008)	(0.510)	(0.236)
Seed/acre	-0.004	0.093	0.004
	(0.029)	(0.123)	(0.006)
Soil Qual.	1.686	-0.401	0.327**
	(1.187)	(0.585)	(0.145)
Household Labour/acre	1.242**	0.341**	0.028
	(0.503)	(0.160)	(0.035)
Hired Labour/acre	0.319***	-0.010	0.019**
	(0.061)	(0.041)	(0.009)
Water Apps./acre	0.668***	0.178	0.037
	(0.201)	(0.250)	(0.029)
Canal	-0.322	-1.820	0.000
	(2.024)	(1.943)	(0.355)
Tubewell	-1.435	-1.639	0.113
	(1.328)	(2.403)	(0.291)
Tractor	2.458***	-0.703	-0.111
	(0.656)	(1.851)	(0.352)
Household Total Land (acres)	-0.010	-0.095***	0.024*
	(0.148)	(0.029)	(0.014)
Household Size	-0.198	0.003	-0.014
	(0.234)	(0.448)	(0.070)
Literate	-0.624	1.217	-0.366***
	(2.231)	(1.791)	(0.122)
% Females	1.465	-9.032	1.011*
	(4.038)	(5.753)	(0.534)
Credit	-4.584***	-4.241***	0.202
	(0.738)	(1.579)	(0.154)
Off-farm Work	0.226	-0.422**	0.01
	(0.712)	(0.182)	(0.057)
Flood	-1.402*	-1.213	0.393***
	(0.845)	(1.299)	(0.096)

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Drought	4.343**	3.165	0.348
	(1.896)	(3.051)	(0.236)
Livestock	-0.02	-0.322***	-0.014
	(0.059)	(0.068)	(0.024)
Owns Land	1.824***	-1.581***	0.217
	(0.683)	(0.551)	(0.145)
Weather **Kharif Rain**	1.639	6.017	0.404
	(3.117)	(5.572)	(0.930)
Kharif Temp.	1.99	59.307	-7.295***
	(17.772)	(53.135)	(1.494)
Rabi Rain	-321.895***	-71.409	52.392***
	(105.001)	(128.459)	(14.725)
Rabi Temp.	-104.306***	-16.523	15.977***
	(38.295)	(41.495)	(5.331)
Climate **Ave. Kharif Rain**	43.151***	-20.406	-6.491
	(11.509)	(38.090)	(5.435)
Ave. Kharif Temp.	-1.842	-47.489	4.824**
	(20.093)	(45.824)	(2.096)
Ave. Rabi Temp.	88.586**	7.162	-12.774**
	(34.981)	(35.933)	(5.225)
Ave. Rabi Rain	-143.38	-139.821***	-11.93
	(140.284)	(37.169)	(28.910)
Information **Extension Services**	-0.732	0.016	0.337
	(1.122)	(2.051)	(0.213)
Peer	-4.333***	-2.208	0.323
	(0.869)	(1.789)	(0.198)
Media	-0.518	-0.695	0.388
	(2.033)	(1.951)	(0.308)
Middleman	0.031	-3.975	0.38
	(1.994)	(3.232)	(0.642)
Landlord	-2.833**	0.962	-0.294
	(1.215)	(2.315)	(0.807)
Climate Change Perceptions **Prec. Decrease**			0.022
			(0.397)
Prec. Increase			0.358
			(0.515)
Prec. Onset			0.679
			(0.422)
Temp. Decrease			-0.142
			(0.262)
Temp. Cold Spell			6.647***
			(1.190)

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Temp. Onset Hot			0.239
			(0.601)
Constant	833.833***	-21.047	-66.285
	(311.746)	(215.415)	(55.659)
Sigma	1.785***	2.048***	
	(0.181)	(0.140)	
Rho	0.367	-0.332	
	(0.372)	(0.285)	
Region dummies	Yes	Yes	Yes
N			293
Standard errors are robust and clustered by region			
*** p<0.10 ** p<0.05 *** p<0.01**			

Appendix 4.

Impact of Adaptation: Propensity Score Matching Results

As discussed, in order to provide a baseline for the results presented in the text which assumed that selection bias was driven by selection on unobservables, the results in this section arise from the practically simpler and yet much more restrictive assumption that we can control for selection bias using observable characteristics. The assumption of selection on unobservables motivated the use of the endogenous switching model. Where selection on observables is the appropriate assumption Propensity Score Matching (PSM) is a typical procedure to account for selection bias between treated and untreated groups. We have already presented one estimator that makes the assumption of selection on observables: the OLS regressions, however, PSM makes different parametric assumptions, and fewer in the outcome equation, and is often regarded to reduce bias compared to OLS for this reason. This method is based on the idea that to construct a valid analysis of the effects of a given program, we need to compare groups who did and didn't undertake the program who have similar characteristics. This is done by calculating a score based on how likely a person was to undertake adaptation given their observable characteristics. Households with similar propensity scores from both adapting and non-adapting groups are then compared to estimate the impact of adaptation on yields.

This method of selection based on observable characteristics has some important benefits in comparison with the endogenous switching selection on unobservables. Firstly, we do not rely on the validity of selection instruments to predict the role of adaptation on yields. Secondly, we don't have to rely on the potentially restrictive distributional assumption of joint normality of the errors in both production functions and adaptation equations.

Matching on propensity scores does, however, make a number of key assumptions about the nature of our modelling. Firstly, we must assume that once we have controlled for a set of observable household variables, then assignment of the adaptation treatment variable is as good as random. This allows us to estimate unbiased results of the treatment effect since we have assumed that selection biases are controlled for by our set of control variables. Secondly, we must assume that there exists overlap between the characteristics of the two treatment groups. That is, for each observable control there is a positive probability of adapting. If this assumption is not fulfilled for some agents, we would be unable to find suitable matches in which to compare propensity scores. Thirdly, the type of variables included is also crucial to the estimation of treatment effects based on PSM. Variables must be strictly predetermined in that they cannot be affected by the treatment. This excludes a number of important variables associated with the agricultural production process. Farm inputs such as fertiliser may be significantly affected by whether farmers choose to adapt or not. Thus, our selection model includes only a parsimonious set of predetermined control variables.

Results

We start by running a probit regression for wheat, rice and cotton with adaptation as the binary dependent variable on our predetermined set explanatory variables. We report the estimates of this regression in Appendix 7. After this first stage, we calculate propensity scores for adaptation based on the observed covariates. For illustrative purposes, we also include plots showing the distribution of propensity scores for adapters (treated) and non-adapters (untreated) for each crop in the Appendix 7. We observe for each of the crops that higher estimated propensity scores are associated with the group that adapt. This pattern supports the working hypothesis that there exist significant differences between adapters and non-adapters in the sample. It must be noted that there is significant overlap in the propensity scores.

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In the next step, we use the estimated propensity scores to match similar adapting and non-adapting farmers. We make a number of modelling decisions to improve the quality of the estimates of the effect of adaption on yields. Firstly, we drop any observations that lack common support from the sample. Secondly, we try two different matching algorithms: nearest neighbour matching and kernel weighted matching. These matching methods differ in that nearest neighbour matching compares an individual in the treated group with the individual in the treated group who is matched most closely by propensity score. In contrast, kernel weighting selects a group of individuals from the untreated group to match with an individual from the treated group and then assigns weights to the untreated observations based on the closeness of the match.

Estimates of the impact of adaptation on crop yields from the PSM exercise are shown below. We report three estimates: the Average Treatment Effect on Treated (ATT), Average Treatment Effect on Untreated (ATU), and Average Treatment Effect (ATE). In order to obtain consistent estimates for the standard errors of the treatment estimates, we bootstrap the errors. We use two matching estimators: the Nearest Neighbour estimator (NN) and the kernel estimator (Kernel) which differ only in the method of matching counterfactual observations.

Table A5.1 shows the estimates for the impact of adaptation on the three main crops in a pooled analysis. This shows a positive ATE of just over 2 maunds per hectare which is significant at the 1% levels. This constitutes a 10% rise in on average across each of the crops. This is comprised of a 1.5 maund per hectare (7%) increase for the treated group and a potential 2.6 maund per hectare (15%) increase for the untreated group. We then disaggregate by crop. Tables A5.2-4 show the results for wheat, rice and cotton respectively. A similar pattern emerges in each case. By and large the impact of adaptation is positive for all crops, and for both the treated and untreated groups when significance is measured at the 10% level. However, at the 5% significance level only the ATT and the ATE are consistently significant. For wheat the ATT is around 2.2 maunds per hectare (approx.. 15%). For cotton the impact is between 2 and 3 maunds per hectare (approx.. 20%). For Rice, the ATT and ATE are around 20%. For Cotton the estimate of ATT is not robust to the estimator used, varying between a 13% and a 30% impact. These are economically significant increases in yields as a consequence of adaptation.

Tables A5.5 and A5.6 disaggregate the data by region. The results quite clearly show that the impacts that were estimated in the previous tables were being driven by the positive and significant impact of the adaptation measures on production in Sindh province. The impact for the pooled crops is minimal in Punjab, and unreported analysis also shows that this is a general feature across these three main crops. Unfortunately, these results cannot be taken as being causal. As the following section shows, the matching procedure fails to balance the covariates and remove all bias. This is an a priori indication that there are unobservable characteristics determining the outcomes of such technology adoption decisions.

Appendix 4.

Table A4.1 Average Treatment on the Treated and Untreated: Pooled

Pooled		Adaptation State: Adapter	Adaptation State: Non-Adapter	Difference	Percentage Change
ATT	NN	18.12	16.64	1.49* (0.86)	9.0%
	Kernel	18.08	16.01	2.07*** (0.56)	12.9%
ATU	NN	18.01	15.38	2.63*** (0.89)	17.1%
	Kernel	17.12	15.38	1.74*** (0.66)	11.3%
ATE	NN	18.06	15.98	2.09*** (0.75)	13.1%
	Kernel	17.59	15.69	1.90*** (0.66)	12.1%
Obs.		940	1082		

*** = significant at 1% level, ** = significant at 5% level, *=significant at 10% level

Table A4.2 Average Treatment on the Treated and Untreated: Wheat

Wheat		Adaptation State: Adapter	Adaptation State: Non-Adapter	Difference	Percentage Change
ATT	NN	18.72	15.72	2.20* (1.22)	16.7%
	Kernel	18.72	16.57	2.14*** (0.74)	13.4%
ATU	NN	17.00	15.65	1.35* (0.96)	4.4%
	Kernel	16.77	15.63	1.15 (0.79)	6.9%
ATE	NN	17.77	16.04	1.73* (0.93)	9.8%
	Kernel	17.65	16.04	1.58** (0.71)	9.7%
Obs.		560	755		

*** = significant at 1% level, ** = significant at 5% level, *=significant at 10% level

Table A4.3. Average Treatment on the Treated and Untreated: Rice

Rice		Adaptation State: Adapter	Non-Adapter	Difference	Percentage Change
ATT	NN	20.73	16.77	**3.96**** **(1.84)**	**23.6%**
	Kernel	20.80	17.74	**3.06*** **(1.58)**	**17.2%**
ATU	NN	20.99	18.31	2.69 (2.57)	12.8%
	Kernel	20.95	18.35	2.60 (1.70)	12.4%
ATE	NN	20.50	17.16	**3.34*** **(1.92)**	**19.5%**
	Kernel	20.70	17.86	**2.84**** **(1.31)**	**15.9%**
Obs.		173	167		

Table A4.4. Average Treatment on the Treated and Untreated: Cotton

Cotton		Adaptation State: Adapter	Non-Adapter	Difference	Percentage Change
ATT	NN	14.04	10.87	**3.17**** **(1.39)**	**29.2%**
	Kernel	14.02	12.36	**1.66*** **(0.96)**	**13.4%**
ATU	NN	12.77	11.86	0.92 (1.74)	7.0%
	Kernel	14.64	11.79	**2.85**** **(1.27)**	**19.5%**
ATE	NN	13.50	11.30	**2.20**** **(1.05)**	**19.4%**
	Kernel	14.28	12.12	**2.17*** **(1.32)**	**17.8%**
Obs.		207	160		

Table A4.5 Average Treatment on the Treated and Untreated: Pooled Crops, Punjab

Pooled		Adaptation State: Adapter	Adaptation State: Non-Adapter	Difference	Percentage Change
ATT	NN	15.82	15.07	0.74 (0.98)	4.9%
ATU	NN	15.39	13.94	1.45 (1.06)	10.4%
ATE	NN	15.59	14.47	1.12 (0.91)	7.7%
Obs.		604	733		

Table A4.6 Average Treatment on the Treated and Untreated: Pooled Crops, Sindh

Pooled		Adaptation State: Adapter	Adaptation State: Non-Adapter	Difference	Percentage Change
ATT	NN	19.66	15.67	**3.98***** **(1.08)**	**25.4%**
ATU	NN	20.81	16.70	**4.12***** **(1.19)**	**24.7%**
ATE	NN	20.24	16.19	**4.05***** **(0.95)**	**25.0%**
Obs.		702	676		

Propensity Score Matching Diagnostic Tests

Figure A5.1. Propensity score plot for analysis of wheat production

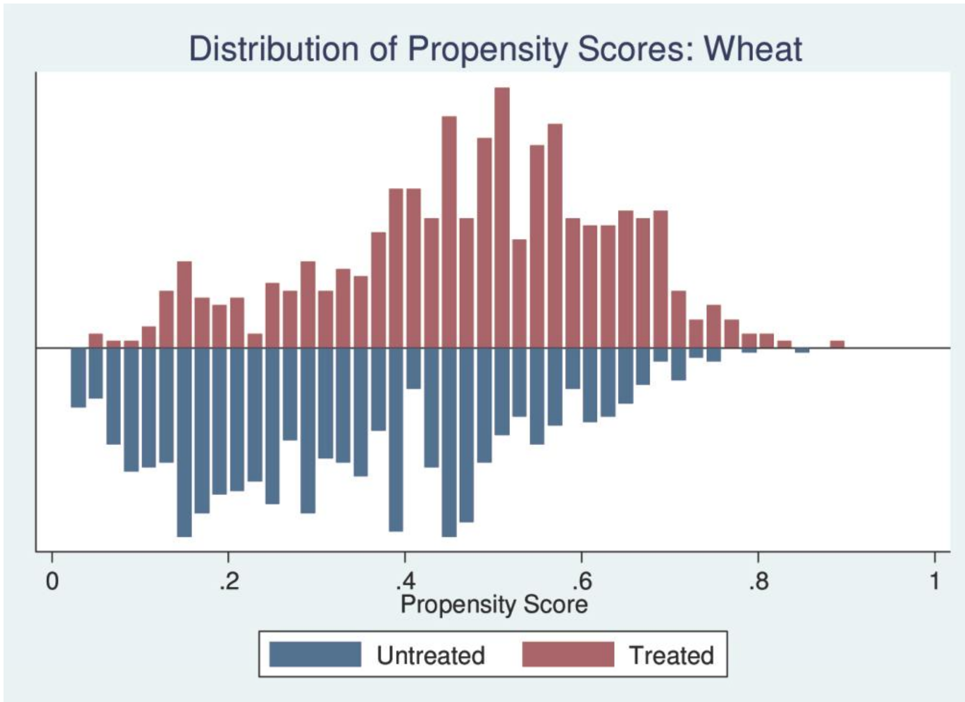

Figure A5.2. Propensity score plot for analysis of rice production

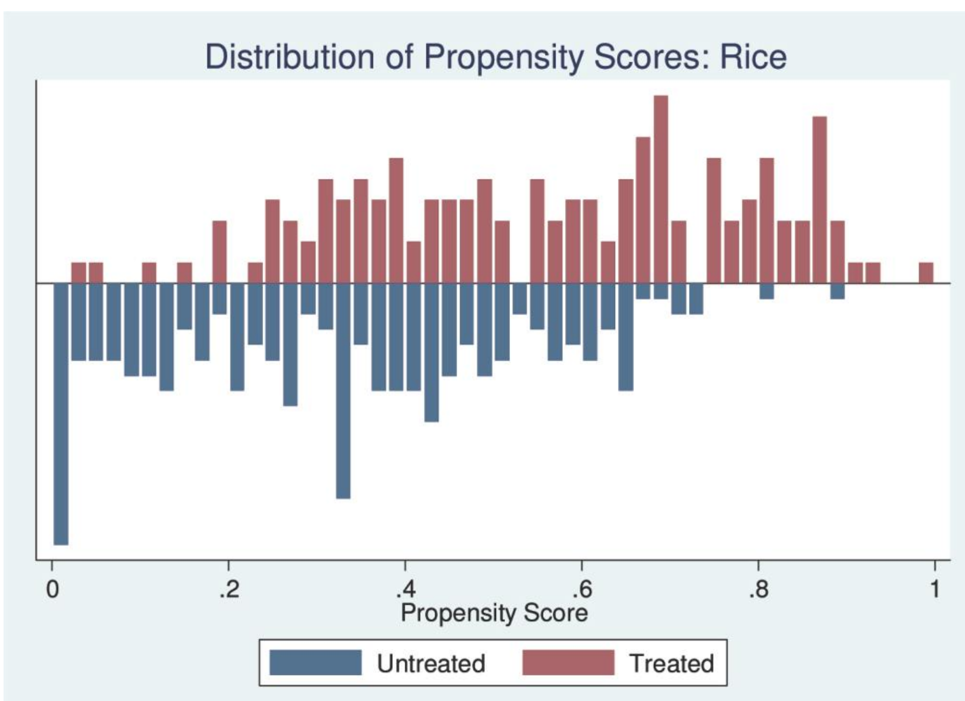

Figure A5.3. Propensity score plot for analysis of cotton production

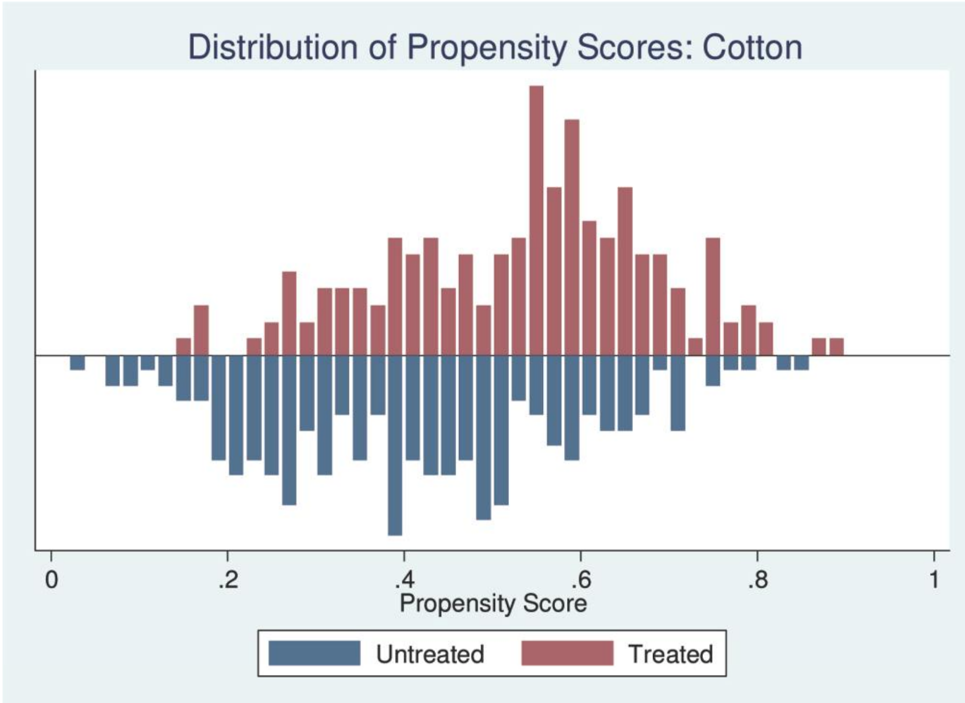

Table A5.1. Balance test for PS matching			
Cotton		**% Bias**	
		Pre-matching	**Post-matching**
Wheat	**NN**	23.71%	4.07%
	Kernel	23.71%	2.37%
Rice	**NN**	21.37%	10.96%
	Kernel	21.37%	5.99%
Cotton	**NN**	19.34%	6.87%
	Kernel	19.34%	5.96%

Appendix 6.

Table A6.1 Determinants of Adaptation by Crop: Probit Regression for Propensity Score Matching			
	Wheat	**Rice**	**Cotton**
Land	-0.000	-0.22**	0.001
Household Size	0.020	-0.004	0.015
Literate	-0.272**	-0.514**	-0.275
% Females	0.384	0.231	0.987**
Credit	0.022	0.541***	-0.085
Off-farm Work	-0.059**	0.006	-0.073
Flood	-0.324***	-0.213	0.009
Drought	-0.186	0.017	-0.120
Livestock	0.011	0.075***	0.031**
Owns Land	-0.220**	-0.192	-0.288
Ave. Kharif Rain	-0.096	-2.548**	-1.785**
Ave. Rabi Temp.	0.051	-0.053	0.541**
Ave. Kharif Temp.	-0.008	0.068	0.252
Ave. Rabi Rain	0.020	13.792	19.548**
Soil Qual.	0.239***	0.108	0.062
Canal	0.229	0.615**	-0.055
Tubewell	0.352**	0.545**	0.384
Extension Services	0.328***	0.104	0.020
Peer	0.377***	0.797***	0.380**
Media	0.107	-0.170	0.175
Middleman	-0.623***	-1.547***	-0.725**
Landlord	0.211	0.126	0.489*
Constant	-1.235***	-1.566**	-0.525
Region dummy	Yes	Yes	Yes
N	1315	340	367

*** = significant at 1% level, ** = significant at 5% level, *=significant at 10% level

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Table A6.2. Household Determinants of Adaptation		
	Probit	Marginal Effect at Mean
Household		
Land Holdings	0.000	0.000
Household Size	0.005	0.001
Average Education	0.033	0.011
Literate ¥	-0.145	-0.050
% Females	0.471**	0.162**
Credit ¥	0.049	0.017
Off-farm Work ¥	-0.034	-0.012
Flood ¥	-0.163	-0.056
Drought ¥	0.366***	-0.126***
Livestock	0.008	0.003
Owns Land ¥	-0.110	-0.038
Climate		
Ave. Kharif Rain	-0.106	-0.037
Ave. Rabi Temp.	0.097	0.033
Ave. Kharif Temp.	-0.016	-0.005
Ave. Rabi Rain	0.425	0.146
Region		
Punjab ¥	-0.019	-0.006
Inputs Available		
Soil Qual. ¥	0.213***	0.073***
Canal ¥	0.178	0.061
Tubewell ¥	0.344**	0.118**
Information		
Extension Services ¥	0.168*	0.058*
Peer ¥	0.293***	0.101***
Media ¥	0.106	0.036
Middleman ¥	-0.607***	-0.209***
Landlord ¥	0.146	0.050
N	1423	1423

*** = significant at 1% level, ** = significant at 5% level, *=significant at 10% level
¥ denotes that variable is binary

Appendix 7: Questionnaire

Questionnaire No. |__|__|__|

"The Determinants, Impact and Cost Effectiveness of Climate Change Adaptation in the Indus Ecoregion"
Micro Econometric Study

HOUSEHOLD SURVEY (1,600 households)
(Household is defined as group of people living under the same roof and sharing a budget for food)

IDRC CRDI

International Development Research Centre

Centre de recherches pour le développement international

Complete address:______________ village name: ______________Union Council: ___________

Village GPS Code:_______ HH GPS code_________

Name of Respondent with Father's/Husband's Name:_________________________________

Age of the respondent:

National Identification Number (NIC) of the respondent ________________________________

Cell Number of the respondent (optional) ____

Relationship of the Respondent with the Head of Household:

Relation with head of the household:

1. Self;
2. Wife/husband;
3. Son/daughter;
4. Son-in-law/daughter-in-law;
5. Grand son/grand daughter;
6. Mother/Father;
7. Brother/sister;
8. Other relatives;
9. Other non-relatives

Date of interview:

1st visit __/__/__

Interviewer's name : ____

Supervisor's name : ____

Checked by (Checker's Name & Signature) : ____.____

Edited by (Editor's Name & Signature) : ___________________________________.__________

Relevant Codes:

NA: Not Applicable
DK: Don't Know
Zero: O
P: Protest

SECTION A: HOUSEHOLD CHARACTERISTICS

A1. Basic structure and livelihood source

A11. How many persons usually live in this household? (Exclude guests and those currently residing elsewhere even for 2-3 months of the year) [ ][ ]

Table A12: Family structure, and livelihood source

Person Code		Relation with head of family *1		Gender 1.Male 2.Female		Age (years)		Education status *2		Principal Means of livelihood *3		Secondary means of livelihood*3		State if primary occupation is: 1.Outside village 2. In urban area		Marital Status*4	
A121		A121a		A121b		A121c		A121d		A121e		A121f		A121g		A121h	
A122		A122a		A122b		A122c		A122d		A122e		A122f		A122g		A122h	
A123		A123a		A123b		A123c		A123d		A123e		A123f		A123g		A123h	
A124		A124a		A124b		A124c		A124d		A124e		A124f		A124g		A124h	
A125		A125a		A125b		A125c		A125d		A125e		A125f		A125g		A125h	
A126		A126a		A126b		A126c		A126d		A126e		A126f		A126g		A126h	
A127		A127a		A127b		A127c		A127d		A127e		A127f		A127g		A127h	
A128		A128a		A128b		A128c		A128d		A128e		A128f		A128g		A128h	
A129		A129a		A129b		A129c		A129d		A129e		A129f		A129g		A129h	
A1210		A1210a		A1210b		A1210c		A1210d		A1210e		A1210f		A1210g		A1210h	
A1211		A1211a		A1211b		A1211c		A1211d		A1211e		A1211f		A1211g		A1211h	
A1212		A1212a		A1212b		A1212c		A1212d		A1212e		A1212f		A1212g		A1212h	
A1213		A1213a		A1213b		A1213c		A1213d		A1213e		A1213f		A1213g		A1213h	
A1214		A1214a		A1214b		A1214c		A1214d		A1214e		A1214f		A1214g		A1214h	
A1215		A1215a		A1215b		A1215c		A1215d		A1215e		A1215f		A1215g		A1215h	

*1 Self [1]; Wife/husband [2]; son/daughter [3]; son/daughter in law [4]; Grandson/daughter [5]; Mother/father [6]; Brother/sister [7]; other relatives [8]; other non-relatives [9]
*2Read & write [1]; primary [2]; middle [3]; Matriculation [4]; intermediate [5]; graduate [6]; masters [7]; illiterate [8]
*3Farming [1]; private employee (e.g. small business/ shop) [2]; Government employee (e.g. teacher, peon)[3]; (daily) wage earner [4]; Fishing [5]; Other __________[6]
*4Married [1]; Single [2]; Divorced [3]; Widow/er [4]

Table A13: Tenure Arrangements: [seasons: Kharif (May - September); Rabi (Oct - April)]

Separate land areas used as farm land	Size of the total parcel (acres)	Distance from field to home (1-way distance in km)	What is the soil type of this parcel?	Season	Cultivated crop (incl. fallow land) in 2012? *1	Total areas under cultivation? (acres)	Tenure Arrangement *2	How many years have you continuously used this plot?	Shared cropping: What is the sharing arrangement? (In %)	Shared cropping: Any other payment e.g. inputs? (PKR/ year)	Annual Rent paid/ received if plot is leased? (PKR)	What is the length of the tenancy contract (years)?	Has the tenancy changed for this land in the last 5 years? *3	How far is it from the landlord? (filled in by tenants) (Km)	How often does landlord visit rented plots? (filled in by tenant or landlord who rents out land)
Parcel 1	A131	A131a		Rabi	A1311b	A1311d	A1311f	A1311h	A1311j	A1311l	A1311n	A1311p	A1311r	A1311t	A1311v
					A1312b	A1312d	A1312f	A1312h	A1312j	A1312l	A1312n	A1312p	A1312r	A1312t	A1312v
					A1313b	A1313d	A1313f	A1313h	A1313j	A1313l	A1313n	A1313p	A1313r	A1313t	A1313v
					A1314b	A1314d	A1314f	A1314h	A1314j	A1314l	A1314n	A1314p	A1314r	A1314t	A1314v
				Karif	A1311c	A1311e	A1311g	A1311i	A1311k	A1311m	A1311o	A1311q	A1311s	A1311u	A1311w
					A1312c	A1312e	A1312g	A1312i	A1312k	A1312m	A1312o	A1312q	A1312s	A1312u	A1312w
					A1313c	A1313e	A1313g	A1313i	A1313k	A1313m	A1313o	A1313q	A1313s	A1313u	A1313w
					A1314c	A1314e	A1314g	A1314i	A1314k	A1314m	A1314o	A1314q	A1314s	A1314u	A1314w
Parcel 2	A132	A132a		Rabi	A1321b	A1321d	A1321f	A1321h	A1321j	A1321l	A1321n	A1321p	A1321r	A1321t	A1321v
					A1322b	A1322d	A1322f	A1322h	A1322j	A1322l	A1322n	A1322p	A1322r	A1322t	A1322v
					A1323b	A1323d	A1323f	A1323h	A1323j	A1323l	A1323n	A1323p	A1323r	A1323t	A1323v
					A1324b	A1324d	A1324f	A1324h	A1324j	A1324l	A1324n	A1324p	A1324r	A1324t	A1324v
				Karif	A1321c	A1321e	A1321g	A1321i	A1321k	A1321m	A1321o	A1321q	A1321s	A1321u	A1321w
					A1322c	A1322e	A1322g	A1322i	A1322k	A1322m	A1322o	A1322q	A1322s	A1322u	A1322w
					A1323c	A1323e	A1323g	A1323i	A1323k	A1323m	A1323o	A1323q	A1323s	A1323u	A1323w

								A1324c		A1324e		A1324g		A1324i		A1324k		A1324m		A1324o		A1324q		A1323s		A1324u		A1324w	
Parcel 3	A313		A133a				Rabi	A1331b		A1331d		A1331f		A1331h		A1331j		A1331l		A1331n		A1331p		A1331r		A1331t		A1331v	
								A1332b		A1332d		A1332f		A1332h		A1332j		A1332l		A1332n		A1332p		A1332r		A1332t		A1332v	
								A1333b		A1333d		A1333f		A1333h		A1333j		A1333l		A1333n		A1333p		A1333r		A1333t		A1333v	
								A1334b		A1334d		A1334f		A1334h		A1334j		A1334l		A1334n		A1334p		A1334r		A1334t		A1334v	
							Karif	A1331c		A1331e		A1331g		A1331i		A1331k		A1331m		A1331o		A1331q		A1331s		A1331u		A1331w	
								A1332c		A1332e		A1332g		A1332i		A1332k		A1332m		A1332o		A1332q		A1332s		A1332u		A1332w	
								A1333c		A1333e		A1333g		A1333i		A1333k		A1333m		A1333o		A1333q		A1333s		A1333u		A1333w	
								A1334c		A1334e		A1334g		A1334i		A1334k		A1334m		A1334o		A1334q		A1334s		A1334u		A1334w	

*1: Wheat - Sahar (1); wheat - Shafaq (2); wheat - Faisalabad 10 (3); wheat - Punjab 90 (4); wheat – Lasani (5); wheat – Bhakkar (6); Kapas(cotton) - Neelum 121 (7); Kapas(cotton) - Neelum 3700 (8); Kapas(cotton) - CIM-142 (9); Kapas(cotton) - CIM-886 (10); Kapas(cotton) - AA-703 (11); Kapas(cotton) - AA-802; Chawal (Paddy Rice)
(3)Kado Loki (Bottle Gourd);(4)Tuori (Ribbed Guord);(5)Bengan (Egg plant);(6)Bhendi (Lady Finger);(7) Hari Mirch (Green Chilies);(8)Tematar (Tomatoes);(9)Khira (Cucumber);(10)Kerela (Bitter Guord);(11)Gidra (Musk Melon);(12)Pan (Piper Bettle);(13)Kela (Pan);(14); Narial (Coconut);(15)Cheekoo (Mud Apple);(17)Ganna (Sugar Cane);(18)Kapas(cotton), specify variety _______________;(19)Aam(Mango);(20)Aloo (Potato);(21)Other (Specify here_______________)

*2:Own land and cultivated (1); own land and rent to others (2); share cropped land (3); Land rented in (pay fixed rate to landlord) (4); Use of fructuary right (5) Other (specify)______ (6)

*3:Rented extra land out (1); rented extra land in (2); Gone from sharecrop to fixed rent (3); Fixed rent to share crop (4)purchase land.

A14:If you were able to buy all of your owned land today, what is the maximum you would pay for it ?______________________(in PKR) and **A14 a:** ___________ (Total acres)

A15: How often are the term of tenancy reviewed? __________________________
Every year (1); every 2 years (2); every 4 years (3); At discretion of the landlord (4)

A16: Are rights to farm the land you're using? ___________________________________
Inherited (1); Purchased (2); Designated by national government; (3) Designated by local government (4)

A17: Since you have been a farmer, have you been evicted from any previous land? Yes/No
A18: Have you experienced other farmers in your village being evicted from their land? Often/Occasionally/Never

A19: Crop Choice

Who decides crop choice?		Circle as appropriate	If selected FARMER in the previous question, what are the primary reasons for the crop choices you make?		Rate 3 options		
A191	Farmer	1	Highest profit, high risk	1	1-Most Important	A191a	
A192	Landlord	2	Lower profit, lower risk	2	2-Most Important	A192a	
A193	Middleman	3	Past experience with these crops	3	3-Most Important	A193a	
A194	Credit supplier	4	Recommended by the landlord	4			
A195	Other (specify)	5	Recommended by the middleman	5			
			Preferred for home consumption	6			
			Low water use	7			
			Other (specify ___________________)	8			

Section B. Agricultural products: Inputs, outputs, and prices

B1. Agricultural products: outputs, and prices

Farm Land	Season	Crop code as above	Planting Date	Harvesting date	Production in 2012 (Maunds)	Average Production in 2011 (Maunds)	Home Consumption (Maund)	Quantity consumed by Livestock (Maund)	Quantity stored (Maund)	Harvest lost due to pest/ heat/ storm etc. (Maund)	Quantity Sold (Maund)	Farmer Price (PKR/ Maund)	Market Price (PKR/ Maund)	Govt. price (PKR/ Maund)
Parcel 1	Rabi	B111b	B111d	B111f	B111h	B111j	B111l	B111n	B111p	B111r	B111t	B111v	B111x	B111z
		B112b	B112d	B112f	B112h	B112j	B112l	B112n	B112p	B112r	B112t	B112v	B112x	B112z
		B113b	B113d	B113f	B113h	B113j	B113l	B113n	B113p	B113r	B113t	B113v	B113x	B113z
		B114b	B114d	B114f	B114h	B114j	B114l	B114n	B114p	B114r	B114t	B114v	B114x	B114z
	Karif	B111c	B111e	B111g	B111i	B111k	B111m	B111o	B111q	B111s	B111u	B111w	B111y	B111a
		B112c	B112e	B112g	B112i	B112k	B112m	B112o	B112q	B112s	B112u	B11w	B112y	B112a
		B113c	B113e	B113g	B113i	B113k	B113m	B113o	B113q	B113s	B113u	B113w	B113y	B113a
		B114c	B114e	B114g	B114i	B114k	B114m	B114o	B114q	B114s	B114u	B114w	B114y	B114a
Parcel 2	Rabi	B121b	B121d	B121f	B121h	B121j	B121l	B121n	B121p	B121r	B121t	B121v	B121x	B121z
		B122b	B122d	B122f	B122h	B122j	B122l	B122n	B122p	B122r	B122t	B122v	B122x	B122z
		B123b	B123d	B123f	B123h	B123j	B123l	B123n	B123p	B123r	B123t	B123v	B123x	B123z
		B124b	B124d	B124f	B124h	B124j	B124l	B124n	B124p	B124r	B123t	B124v	B124x	B124z
	Karif	B121c	B121e	B121g	B121i	B121k	B121m	B121o	B121q	B121s	B121u	B121w	B121y	B121a
		B122c	B122e	B122g	B122i	B122k	B122m	B122o	B122q	B122s	B122u	B122w	B122y	B122a
		B123c	B123e	B123g	B123i	B123k	B123m	B123o	B123q	B123s	B123u	B123w	B123y	B123a
		B124c	B124e	B124g	B124i	B124k	B124m	B124o	B124q	B124s	B124u	B124w	B124y	B124a
Parcel 3	Rabi	B131b	B131d	B131f	B131h	B131j	B131	B131n	B131p	B131r	B131t	B131v	B131x	B131z
		B132b	B132d	B132f	B132h	B132j	B132l	B132n	B132p	B132r	B132t	B132v	B132x	B132z
		B133b	B133d	B133f	B133h	B133j	B133l	B133n	B133p	B133r	B133t	B133v	B133x	B133z
		B134b	B134d	B134f	B134h	B134j	B134l	B134n	B134p	B134r	B134t	B134v	B134x	B134z
	Karif	B131c	B131e	B131g	B131i	B131k	B131m	B131o	B131q	B131s	B131u	B131w	B131y	B131a
		B132c	B132e	B132g	B132i	B132k	B132m	B132o	B132q	B132s	B132u	B132w	B132y	B132a
		B133c	B133e	B133g	B133i	B133k	B133m	B133o	B133q	B133s	B133u	B133w	B133y	B133a
		B134c	B134e	B134g	B134i	B134k	B134m	B134o	B134q	B134s	B134u	B134w	B134y	B134a

B12. For total production (column d), what is the % upward or downward revision? ____________ (%) (Consider average of past 5 years (2007-2011))

B13. For farmer price (column j), what is the % upward or downward revision? ______________ (%) (Consider average past 5 years (2007-2011))

B14. For market price (column k), what is the % upward or downward revision? ______________ (%) (Consider average past 5 years (2007-2011))

B2: Agricultural Inputs

B21. How far is it to the market where you purchase your inputs? One way distance ________ (km)

B22. What kind of transport do you mostly use to bring input from the market? ____ (walk, local bus, personal vehicle, rented vehicle, donkey/ camel cart);
B22a. One way cost for a visit ________(PKR) (Not to be filled if farmer receives delivery of inputs by a middleman etc. Only relevant if farmer actually goes to the market to pick up goods)

B23: Fertilizers and Weedicides/ Pesticides

Farm land	Season	Enter Plot code as above	Weedicides/ Pesticides				UREA				D.A.P/ S.O.P				Manure			
			Quantity (Kgs)	Total Cost (PKR)	Source*	Proportion paid by the farmer?	Quantity (Kgs)	Total Cost (PKR)	Source*	Proportion paid by the farmer?	Quantity (Kgs)	Total Cost (PKR)	Source*	Proportion paid by the farmer?	Quantity (Kgs)	Total Cost (PKR)	Source*	Proportion paid by the farmer?
Parcel 1	Rabi	B231 1b	B231 1d	B231 1f	B231 1h	B2311j	B2311 l	B231 1n	B231 1p	B2311 r	B231 1t	B2311 v	B231 1x	B2311 z	B2311 bb	B2311 dd	B2311 ff	B2311 hh
		B231 2b	B231 2d	B231 2f	B231 2h	B2312j	B2312 l	B231 2n	B231 2p	B2312 r	B231 2t	B2312 v	B231 2x	B2312 z	B2311 bb	B2312 dd	B2312 ff	B2312 hh
		B231 3b	B231 3d	B231 3f	B231 3h	B2313j	B2313 l	B231 3n	B231 3p	B2313 r	B231 3t	B2313 v	B231 3x	B2313 z	B2313 bb	B2313 dd	B2313 ff	B2313 hh
		B231 4b	B231 4d	B231 4f	B231 4h	B2314j	B2314 l	B231 4n	B231 4p	B2314 r	B231 4t	B2314 v	B231 4x	B2314 z	B2314 bb	B2314 dd	B2314 ff	B2314 hh
	Kharif	B231 1c	B231 1e	B231 1g	B231 1i	B231 1k	B231 1m	B231 1o	B231 1q	B231 1s	B231 1u	B231 1w	B231 1y	B231 1a	B2311 cc	B2311 ee	B231 1gg	B231 1ii
		B231 2c	B231 2e	B231 2g	B231 2i	B231 2k	B231 2m	B231 2o	B231 2q	B231 2s	B231 2u	B231 2w	B231 2y	B231 2a	B2312 cc	B2312 ee	B231 2gg	B231 2ii
		B231 3c	B231 3e	B231 3g	B231 3i	B231 3k	B231 3m	B231 3o	B231 3q	B231 3s	B231 3u	B231 3w	B231 3y	B231 3a	B2313 cc	B2313 ee	B231 3gg	B231 3ii
		B231 4c	B231 4e	B231 4g	B231 4i	B231 4k	B231 4m	B231 4o	B231 4q	B231 4s	B231 4u	B231 4w	B231 4y	B231 4a	B2314 cc	B2314 ee	B231 4gg	B231 4ii
Parcel 2	Rabi	B232 1b	B232 1d	B232 1f	B232 1h	B232 1j	B232 1l	B232 1n	B232 1p	B232 1r	B232 1t	B232 1v	B232 1x	B232 1z	B2321 bb	B2321 dd	B232 1ff	B232 1hh
		B232 2b	B232 2d	B232 2f	B232 2h	B232 2j	B232 2l	B232 2n	B232 2p	B232 2r	B232 2t	B232 2v	B232 2x	B232 2z	B2322 bb	B2322 dd	B232 2ff	B232 2hh
		B232 3b	B232 3d	B232 3f	B232 3h	B232 3j	B232 3l	B232 3n	B232 3p	B232 3r	B232 3t	B232 3v	B232 3x	B232 3z	B2323 bb	B2323 dd	B232 3ff	B232 3hh
		B232 4b	B232 4d	B232 4f	B232 4h	B232 4j	B232 4l	B232 4n	B232 4p	B232 4r	B232 4t	B232 4v	B232 4x	B232 4z	B2324 bb	B2324 dd	B232 4ff	B232 4hh
	Kharif	B232 1c	B232 1e	B232 1g	B232 1i	B232 1k	B232 1m	B232 1o	B232 1q	B232 1s	B232 1u	B232 1w	B232 1y	B232 1a	B2321 cc	B2321 ee	B232 1gg	B232 1ii
		B232 2c	B232 2e	B232 2g	B232 2i	B232 2k	B232 2m	B232 2o	B232 2q	B232 2s	B232 2u	B232 2w	B232 2y	B232 2a	B2322 cc	B2322 ee	B232 2gg	B232 2ii
		B232 3c	B232 3e	B232 3g	B232 3i	B232 3k	B232 3m	B232 3o	B232 3q	B232 3s	B232 3u	B232 3w	B232 3y	B232 3a	B2323 cc	B2323 ee	B232 3gg	B232 3ii
		B232 4c	B232 4e	B232 4g	B232 4i	B232 4k	B232 4m	B232 4o	B232 4q	B232 4s	B232 4u	B232 4w	B232 4y	B232 4a	B2324 cc	B2324 ee	B232 4gg	B232 4ii
Pa	Ra	B233 1b	B233 1d	B233 1f	B233 1h	B233 1j	B233 1l	B233 1n	B233 1p	B233 1r	B233 1t	B233 1v	B233 1x	B233 1z	B2331 bb	B2331 dd	B233 1ff	B233 1hh

		B233 2b		B233 2d		B233 2f		B233 2h		B233 2j		B233 2l		B233 2n		B233 2p		B233 2r		B233 2t		B233 2v		B233 2x		B233 2z		B2332 bb		B2332 dd		B233 2ff		B233 2hh	
		B233 3b		B233 3d		B233 3f		B233 3h		B233 3j		B233 3l		B233 3n		B233 3p		B233 3r		B233 3t		B233 3v		B233 3x		B233 3z		B2333 bb		B2333 dd		B233 3ff		B233 3hh	
		B233 4b		B233 4d		B233 4f		B233 4h		B233 4j		B233 4l		B233 4n		B233 4p		B233 4r		B233 4t		B233 4v		B233 4x		B233 4z		B2334 bb		B2334 dd		B233 4ff		B233 4hh	
	Kharif	B233 1c		B233 1e		B233 1g		B233 1i		B233 1k		B233 1m		B233 1o		B233 1q		B233 1s		B233 1u		B233 1w		B233 1y		B233 1a		B2331 cc		B2331 ee		B233 1gg		B233 1ii	
		B233 2c		B233 2e		B233 2g		B233 2i		B233 2k		B233 2m		B233 2o		B233 2q		B233 2s		B233 2u		B233 2w		B233 2y		B233 2a		B2332 cc		B2332 ee		B233 2gg		B233 2ii	
		B233 3c		B233 3e		B233 3g		B233 3i		B233 3k		B233 3m		B233 3o		B233 3q		B233 3s		B233 3u		B233 3w		B233 3y		B233 3a		B2333 cc		B2333 ee		B233 3gg		B233 3ii	
		B233 4c		B233 4e		B233 4g		B233 4i		B233 4k		B233 4m		B233 4o		B233 4q		B233 4s		B233 4u		B233 4w		B233 4y		B233 4a		B2334 cc		B2334 ee		B233 4gg		B233 4ii	

*1: On cash payment from market/ local dealer (1); on credit from market/ local dealer (2); on cash from Middleman (3); On credit from Middleman (4); free from middleman (5); free from Landlord (6); on credit from land owner (7); Government (8); NGO/agricultural extension (9); other, pls. specify _______ (10)

B24: Seed

Farm land	Season	Enter Plot code as above		Seed							
				Quantity(Kg)		Total Cost (PKR)		Source*		What proportion is shared by the farmer?	
Parcel 1	Rabi	B2411b		B2411b		B2411f		B2411h		B2411j	
		B2412b		B2412b		B2412f		B2412h		B2412j	
		B2413b		B2413b		B2413f		B2413h		B2413j	
		B2414b		B2414b		B2414f		B2414h		B2414j	
	Kharif	B2411c		B2411e		B2411g		B2411i		B2411k	
		B2412c		B2412e		B2412g		B2412i		B2412k	
		B2413c		B2413e		B2413g		B2413i		B2413k	
		B2414c		B2414e		B2414g		B2414i		B2414k	
Parcel 2	Rabi	B2421b		B2421b		B2421f		B2421h		B2421j	
		B2422b		B2422b		B2422f		B2422h		B2422j	
		B2423b		B2423b		B2423f		B2423h		B2423j	
		B2424b		B2424b		B2424f		B2424h		B2424j	
	Kharif	B2421c		B2421e		B2421g		B2421i		B2421k	
		B2422c		B2422e		B2422g		B2422i		B2422k	
		B2423c		B2423e		B2423g		B2423i		B2423k	
		B2424c		B2424e		B2424g		B2424i		B2424k	
Parcel 3	Rabi	B2431b		B2431b		B2431f		B2431h		B2431j	
		B2432b		B2432b		B2432f		B2432h		B2432j	
		B2433b		B2433b		B2433f		B2433h		B2433j	
		B2434b		B2434b		B2434f		B2434h		B2434j	
	Kharif	B2431c		B2431e		B2431g		B2431i		B2431k	
		B2432c		B2432e		B2432g		B2432i		B2432k	
		B2433c		B2433e		B2433g		B2433i		B2433k	
		B2434c		B2434e		B2434g		B2434i		B2434k	

*1: On cash payment from market/ local dealer (1); on credit from market/ local dealer (2); on cash from Middleman (3); On credit from Middleman (4); free from middleman (5); free from Landlord (6); on credit from land owner (7); Government (8); NGO/agricultural extension (9); other, pls. specify _______ (10)

B25: Usage of Water

Farmland	Season	Crop code as above	What is your source of water?*1	Total No of water application per cropping cycle?	How many canal water applications?		How many tubewell applications?		If you use tubewell, who owns it? *1	If selected 2, 3 or 4, what was the rent of the tubewell per application? (PKR)	What is fuel expense for the tubewell per application for this crop? (PKR)	Which method do you use to water your farm?
					No of applications	Hours per application	No of applications	Hours per application				
Parcel 1	Rabi	B2511b	B2511d	B2511f	B2511h	B2511j	B2511l	B2511n	B2511p	B2511r	B2511t	B2511v
		B2512b	B2512d	B2512f	B2512h	B2512j	B2512l	B2512n	B2512p	B2512r	B2512t	B2512v
		B2513b	B2513d	B2513f	B2513h	B2513j	B2513l	B2513n	B2513p	B2513r	B2513t	B2513v
		B2514b	B2514d	B2514f	B2514h	B2514j	B2514l	B2514n	B2514p	B2514r	B2514t	B2514v
	Kharif	B2511c	B2511e	B2511g	B2511i	B2511k	B2511m	B2511o	B2511q	B2511s	B2511u	B2511w
		B2512c	B2512e	B2512g	B2512i	B2512k	B2512m	B2512o	B2512q	B2512s	B2512u	B2512w
		B2513c	B2513e	B2513g	B2513i	B2513k	B2513m	B2513o	B2513q	B2513s	B2513u	B2513w
		B2514c	B2514e	B2514g	B2514i	B2514k	B2514m	B2514o	B2514q	B2514s	B2514u	B2514w
Parcel 2	Rabi	B2521b	B2521d	B2521f	B2521h	B2521j	B2521l	B2521n	B2521p	B2521r	B2521t	B2521v
		B2522b	B2522d	B2522f	B2522h	B2522j	B2522l	B2522n	B2522p	B2522r	B2522t	B2522v
		B2523b	B2523d	B2523f	B2523h	B2523j	B2523l	B2523n	B2523p	B2523r	B2523t	B2523v
		B2524b	B2524d	B2524f	B2524h	B2524j	B2524l	B2524n	B2524p	B2524r	B2524t	B2524v
	Kharif	B2521c	B2521e	B2521g	B2521i	B2521k	B2521m	B2521o	B2521q	B2521s	B2521u	B2521w
		B2522c	B2522e	B2522g	B2522i	B2522k	B2522m	B2522o	B2522q	B2522s	B2522u	B2522w
		B2523c	B2523e	B2523g	B2523i	B2523k	B2523m	B2523o	B2523q	B2523s	B2523u	B2523w
		B2524c	B2524e	B2524g	B2524i	B2524k	B2524m	B2524o	B2524q	B2524s	B2524u	B2524w
Parcel 3	Rabi	B2531b	B2531d	B2531f	B2531h	B2531j	B2531l	B2531n	B2531p	B2531r	B2531t	B2531v
		B2532b	B2532d	B2532f	B2532h	B2532j	B2532l	B2532n	B2532p	B2532r	B2532t	B2532v
		B2533b	B2533d	B2533f	B2533h	B2533j	B2533l	B2533n	B2533p	B2533r	B2533t	B2533v
		B2534b	B2534d	B2534f	B2534h	B2534j	B2534l	B2534n	B2534p	B2534r	B2534t	B2534v
	Kharif	B2531c	B2531e	B2531g	B2531i	B2531k	B2531m	B2531o	B2531q	B2531s	B2531u	B2531w
		B2532c	B2532e	B2532g	B2532i	B2532k	B2532m	B2532o	B2532q	B2532s	B2532u	B2532w
		B2533c	B2533e	B2533g	B2533i	B2533k	B2533m	B2533o	B2533q	B2533s	B2533u	B2533w
		B2534c	B2534e	B2534g	B2534i	B2534k	B2534m	B2534o	B2534q	B2534s	B2534u	B2534w

*1. Canal Irrigation (1); Rain fed (2); Tubewell (3); Canal and Tubewell(4); Rain and Tubewell (5); Other (specify_____________) (6)
*2.Personal (1); rented (2); borrowed (3); landlord (4)
*3. Drip Irrigation (1); Flood irrigation (2); Sprinkler irrigation (3); Furrow irrigation (4); other (specify _____________) (4)

B26: During which month(s) did you face water scarcity in the past 12 months? _______________

B71: Machinery Expense – Parcel 1

Light Equipment (Tick appropriate one)	Use of equipment/machinery (Enter crop code as above)								Who owns the equipment/ animal? *1(If selected 1, mention total quantity of each equipment)	If equipment is shared, what % of costs does farmer pay?	Who are these costs shared with*2?	Year of Purchase	Value at year of Purchase (PKR)
	Parcel 1												
	Rabi				Kharif								
	Crop 1	Crop 2	Crop 3	Crop 4	Crop 1	Crop 2	Crop 3	Crop 4					
Hand Hoe	B711a	B711b	B711c	B711d	B711e	B711f	B711g	B711h	B711i	B711j	B711k	B711l	B711m
Axe	B712a	B712b	B712c	B712d	B712e	B712f	B712g	B712h	B712i	B712j	B712k	B712l	B712m
Scythe (Drati)	B713a	B713b	B713c	B713d	B713e	B713f	B713g	B713h	B713i	B713j	B713k	B713l	B713m
Rake (kilna)	B714a	B714b	B714c	B714d	B714e	B714f	B714g	B714h	B714i	B714j	B714k	B714l	B714m
Other	B715a	B715b	B715c	B715d	B715e	B715f	B715g	B715h	B715i	B715j	B715k	B715l	B715m
Heavy Machinery (Enter rental cost in PKR)													
Draft animal power	B716a	B716b	B716c	B716d	B716e	B716f	B716g	B716h	B716i	B716j	B716k	B716l	B716m
Rotor weigh	B717a	B717b	B717c	B717d	B717e	B717f	B717g	B717h	B717i	B717j	B717k	B717l	B717m
Plough (Gobal)	B718a	B718b	B718c	B718d	B718e	B718f	B718g	B718h	B718i	B718j	B718k	B718l	B718m
Leveler (Dhallai)	B719a	B719b	B719c	B719d	B719e	B719f	B719g	B719h	B719i	B719j	B719k	B719l	B719m
Khiria	B7110a	B7110b	B7110c	B7110d	B7110e	B7110f	B7110g	B7110h	B7110i	B7110j	B7110k	B7110l	B7110m
Loader	B7111a	B7111b	B7111c	B7111d	B7111e	B7111f	B7111g	B7111h	B7111i	B7111j	B7111k	B7111l	B7111m
Cultivator	B7112a	B7112b	B7112c	B7112d	B7112e	B7112f	B7112g	B7112h	B7112i	B7112j	B7112k	B7112l	B7112m
Reaper	B7113a	B7113b	B7113c	B7113d	B7113e	B7113f	B7113g	B7113h	B7113i	B7113j	B7113k	B7113l	B7113m
Thresher	B7114a	B7114b	B7114c	B7114d	B7114e	B7114f	B7114g	B7114h	B7114i	B7114j	B7114k	B7114l	B7114m
Tractor	B7115a	B7115b	B7115c	B7115d	B7115e	B7115f	B7115g	B7115h	B7115i	B7115j	B7115k	B7115l	B7115m
Generator	B7116a	B7116b	B7116c	B7116d	B7116e	B7116f	B7116g	B7116h	B7116i	B7116j	B7116k	B7116l	B7116m
Tubewell	B7117a	B7117b	B7117c	B7117d	B7117e	B7117f	B7117g	B7117h	B7117i	B7117j	B7117k	B7117l	B7117m

*1 & 2: Personal (1); landlord (free) (2), land lord rented (3), middleman/trader free (4), middleman rented (5) Rented from market (6)

B72: Machinery Expense – Parcel 2

Light Equipment (Tick appropriate one)	Use of equipment/machinery (Enter crop code as above)								Who owns the equipment/ animal? *1	If equipment is shared, what % of costs does farmer pay?	Who are these costs shared with*2?	Year of Purchase	Value at year of Purchase (PKR)
	Parcel 2												
	Rabi				Kharif								
	Crop 1	Crop 2	Crop 3	Crop 4	Crop 1	Crop 2	Crop 3	Crop 4					
Hand Hoe	B721a	B721b	B721c	B721d	B721e	B721f	B721g	B721h	B721i	B721j	B721k	B721l	B721m
Axe	B722a	B722b	B722c	B722d	B722e	B722f	B722g	B722h	B722i	B722j	B722k	B722l	B722m
Scythe (Drati)	B723a	B723b	B723c	B723d	B723e	B723f	B723g	B723h	B723i	B723j	B723k	B723l	B723m
Rake (kilna)	B724a	B724b	B724c	B724d	B724e	B724f	B724g	B724h	B724i	B724j	B724k	B724l	B724m
Other	B725a	B725b	B725c	B725d	B725e	B725f	B725g	B725h	B725i	B725j	B725k	B725l	B725m
Heavy Machinery (Enter rental cost in PKR)													
Draft animal power	B726a	B726b	B726c	B726d	B726e	B726f	B726g	B726h	B726i	B726j	B726k	B726l	B726m
Rotor weigh	B727a	B727b	B727c	B727d	B727e	B727f	B727g	B727h	B727i	B727j	B727k	B727l	B727m
Plough (Gobal)	B728a	B728b	B728c	B728d	B728e	B728f	B728g	B728h	B728i	B728j	B728k	B728l	B728m
Leveler (Dhallai)	B729a	B729b	B729c	B729d	B729e	B729f	B729g	B729h	B729i	B729j	B729k	B729l	B729m
Khiria	B7210a	B7210b	B7210c	B7210d	B7210e	B7210f	B7210g	B7210h	B7210i	B7210j	B7210k	B7210l	B7210m
Loader	B7211a	B7211b	B7211c	B7211d	B7211e	B7211f	B7211g	B7211h	B7211i	B7211j	B7211k	B7211l	B7211m
Cultivator	B7212a	B7212b	B7212c	B7212d	B7212e	B7212f	B7212g	B7212h	B7212i	B7212j	B7212k	B7212l	B7212m
Reaper	B7213a	B7213b	B7213c	B7213d	B7213e	B7213f	B7213g	B7213h	B7213i	B7213j	B7213k	B7213l	B7213m
Thresher	B7214a	B7214b	B7214c	B7214d	B7214e	B7214f	B7214g	B7214h	B7214i	B7214j	B7214k	B7214l	B7214m
Tractor	B7215a	B7215b	B7215c	B7215d	B7215e	B7215f	B7215g	B7215h	B7215i	B7215j	B7215k	B7215l	B7215m
Generator	B7216a	B7216b	B7216c	B7216d	B7216e	B7216f	B7216g	B7216h	B7216i	B7216j	B7216k	B7216l	B7216m
Tubewell	B7217a	B7217b	B7217c	B7217d	B7217e	B7217f	B7217g	B7217h	B7217i	B7217j	B7217k	B7217l	B7217m

*1 & 2: Personal (1); landlord (free) (2), land lord rented (3), middleman/trader free (4), middleman rented (5) Rented from market (6

B73: Machinery Expense – Parcel 3

Light Equipment (Tick appropriate one)	Use of equipment/machinery (Enter crop code as above)								Who owns the equipment/ animal? *1	If equipment is shared, what % of costs does farmer pay?	Who are these costs shared with*2?	Year of Purchase	Value at year of Purchase (PKR)
	Parcel 3												
	Rabi				Kharif								
	Crop 1	Crop 2	Crop 3	Crop 4	Crop 1	Crop 2	Crop 3	Crop 4					
Hand Hoe	B731a	B731b	B731c	B731d	B731e	B731f	B731g	B731h	B731i	B731j	B731k	B731l	B731m
Axe	B732a	B732b	B732c	B732d	B732e	B732f	B732g	B732h	B731i	B732j	B732k	B732l	B732m
Scythe (Drati)	B733a	B733b	B733c	B733d	B733e	B733f	B733g	B733h	B733i	B733j	B733k	B733l	B733m
Rake (kilna)	B734a	B734b	B734c	B734d	B734e	B734f	B734g	B734h	B734i	B7334j	B734k	B734l	B734m
Other	B735a	B735b	B735c	B735d	B735e	B735f	B735g	B75h	B735i	B735j	B735k	B735l	B735m
Heavy Machinery (Enter rental cost in PKR)													
Draft animal power	B736a	B736b	B736c	B736d	B736e	B736f	B736g	B736h	B736i	B736j	B736k	B736l	B736m
Rotor weigh	B737a	B737b	B737c	B737d	B737e	B737f	B737g	B737h	B737i	B737j	B737k	B737l	B737m
Plough (Gobal)	B738a	B738b	B738c	B738d	B738e	B738f	B738g	B738h	B738i	B738j	B738k	B738l	B738m
Leveler (Dhallai)	B739a	B739b	B739c	B739d	B739e	B739f	B739g	B739h	B739i	B739j	B739k	B739l	B739m
Khiria	B7310a	B7310b	B7310c	B7310d	B7310e	B7310f	B7310g	B7310h	B7310i	B7310j	B7310k	B7310l	B7310m
Loader	B7311a	B7311b	B7311c	B7311d	B7311e	B7311f	B7311g	B7311h	B7311i	B7311j	B7311k	B7311l	B7311m
Cultivator	B7312a	B7312b	B7312c	B7312d	B7312e	B7312f	B7312g	B7312h	B7312i	B7312j	B7312k	B7312l	B7312m
Reaper	B7313a	B7313b	B7313c	B7313d	B7313e	B7313f	B7313g	B7313h	B7313i	B7313j	B7313k	B7313l	B7313m
Thresher	B7314a	B7314b	B7314c	B7314d	B7314e	B7314f	B7314g	B7314h	B7314i	B7314j	B7314k	B7314l	B7314m
Tractor	B7315a	B7315b	B7315c	B7315d	B7315e	B7315f	B7315g	B7315h	B7315i	B7315j	B7315k	B7315l	B7315m
Generator	B7316a	B7316b	B7316c	B7316d	B7316e	B7316f	B7316g	B7316h	B7316i	B7316j	B7316k	B7316l	B7316m
Tubewell	B7317a	B7317b	B7317c	B7317d	B7317e	B7317f	B7317g	B7317h	B7317i	B7317j	B7317k	B7317l	B7317m

*1 & 2: Personal (1); landlord (free) (2), land lord rented (3), middleman/trader free (4), middleman rented (5) Rented from market (6)

C1: Labor Composition– Parcel 1

Season	Enter Crop Code	Activities	Household labor (please enter person code in no column) 1 day= 6-8 hours of work completed by 1 individual						Hired Labor 1 day= 6-8 hours of work completed by 1 individual.							
			Male		Female		Child (<16)		Male			Female			Child (<16)	
			No	days	No	Days	No	Days	Days	Days	Daily wage rate	No	Days	Daily wage rate	No	Days
Rabi	Crop 1	Land Preparation	c11a	c11b	c11c	c11d	c11e	c11f	c11g	c11h	c11i	c11j	c11k	c11l	c11m	c11n
		Planting	c12a	c12b	c12c	c12d	c12e	c12f	c12g	c12h	c12i	c12j	c12k	c12l	c12m	c12n
		Watering	c13a	c13b	c13c	c13d	c13e	c13f	c13g	c13h	c13i	c13j	c13k	c13l	c13m	c13n
		Weeding/ pesticides	c14a	c14b	c14c	c14d	c14e	c14f	c14g	c14h	c14i	c14j	c14k	c14l	c14m	c14n
		Harvesting	c15a	c15b	c15c	c15d	c15e	c15f	c15g	c15h	c15i	c15j	c15k	c15l	c15m	c15n
		Post harvesting	c16a	c16b	c16c	c16d	c16e	c16f	c16g	c16h	c16i	c16j	c16k	c16l	c16m	c16n
	Crop 2	Land Preparation	c17a	c17b	c17c	c17d	c17e	c17f	c17g	c17h	c17i	c17j	c17k	c17l	c17m	c17n
		Planting	c18a	c18b	c18c	c18d	c18e	c18f	c18g	c18h	c18i	c18j	c18k	c18l	c18m	c18n
		Watering	c19a	c19b	c19c	c19d	c19e	c19f	c19g	c19h	c19i	c19j	c19k	c19l	c19m	c19n
		Weeding/ pesticides	c110a	c110b	c110c	c110d	c110e	c110f	c110g	c110h	c110i	c110j	c110k	c110l	c110m	c110n
		Harvesting	c111a	c111b	c111c	c111d	c111e	c111f	c111g	c111h	c111i	c111j	c111k	c111l	c111m	c111n
		Post harvesting	c112a	c112b	c112c	c112d	c112e	c112f	c112g	c112h	c112i	c112j	c112k	c112l	c112m	c112n
	Crop 3	Land Preparation	c113a	c113b	c113c	c113d	c113e	c113f	c113g	c113h	c113i	c113j	c113k	c113l	c113m	c113n
		Planting	c114a	c114b	c114c	c114d	c114e	c114f	c114g	c114h	c114i	c114j	c114k	c114l	c114m	c114n
		Watering	c115a	c115b	c115c	c115d	c115e	c115f	c115g	c115h	c115i	c115j	c115k	c115l	c115m	c115n
		Weeding/ pesticides	c116a	c116b	c116c	c116d	c116e	c116f	c116g	c116h	c116i	c116j	c116k	c116l	c116m	c116n
		Harvesting	c117a	c117b	c117c	c117d	c117e	c117f	c117g	c117h	c117i	c117j	c117k	c117l	c117m	c117n
		Post harvesting	c118a	c118b	c118c	c118d	c118e	c118f	c118g	c118h	c118i	c118j	c118k	c118l	c118m	c118n
	Crop 4	Land Preparation	c119a	c119b	c119c	c119d	c119e	c119f	c119g	c119h	c119i	c119j	c119k	c119l	c119m	c119n
		Planting	c120a	c120b	c120c	c120d	c120e	c120f	c120g	c120h	c120i	c120j	c120k	c120l	c120m	c120n
		watering	c121a	c121b	c121c	c121d	c121e	c121f	c121g	c121h	c121i	c121j	c121k	c121l	c121m	c121n
		Weeding/ pesticides	c122a	c122b	c122c	c122d	c122e	c122f	c122g	c122h	c122i	c122j	c122k	c122l	c122m	c122n
		Harvesting	c123a	c123b	c123c	c123d	c123e	c123f	c123g	c123h	c123i	c123j	c123k	c123l	c123m	c123n
		Post harvesting	c124a	c124b	c124c	c124d	c124e	c124f	c124g	c124h	c124i	c124j	c124k	c124l	c124m	c124n

Kharif	Crop 1	Land Preparation	c125a		c125b		c125c		c125d		c125e		c125f		c125g		c125h		c125i		c125j		c125k		c125l		c125m		c125n	
		Planting	c126a		c126b		c126c		c126d		c126e		c126f		c126g		c126h		c126i		c126j		c126k		c126l		c126m		c126n	
		Watering	c127a		C127b		c127c		c127d		c127e		c127f		c127g		c127h		c127i		c127j		c127k		c127l		c127m		c127n	
		Weeding/ pesticides	c128a		c128b		c128c		c128d		c128e		c128f		c128g		c128h		c128i		c128j		c128k		c128l		c128m		c128n	
		Harvesting	c129a		c129b		c129c		c129d		c129e		c129f		c129g		c129h		c129i		c129j		c129k		c129l		c129m		c129n	
		Post harvesting	c130a		c130b		c130c		c130d		c130e		c130f		c130g		c130h		c130i		c130j		c130k		c130l		c130m		c130n	
	Crop 2	Land Preparation	c131a		c131b		c131c		c131d		c131e		c131f		c131g		c131h		c131i		c131j		c131k		c131l		c131m		c131n	
		Planting	c132a		c132b		c132c		c132d		c132e		c132f		c132g		c132h		c132i		c132j		c132k		c132l		c132m		c132n	
		Watering	c133a		c133b		c133c		c133d		c133e		c133f		c133g		c133h		c133i		c133j		c133k		c133l		c133m		c133n	
		Weeding/ pesticides	c134a		C134b		c134c		c134d		c134e		c134f		c134g		c134h		c134i		c134j		c134k		c134l		c134m		c134n	
		Harvesting	c135a		c135b		c135c		c135d		c135e		c135f		c135g		c135h		c135i		c135j		c135k		c135l		c135m		c135n	
		Post harvesting	c136a		c136b		c136c		c136d		c136e		c136f		c136g		c136h		c136i		c136j		c136k		c136l		c136m		c136n	
	Crop 3	Land Preparation	c137a		c137b		c137c		c137d		c137e		c137f		c137g		c137h		c137i		c137j		c137k		c137l		c137m		c137n	
		Planting	c138a		c138b		c138c		c138d		c138e		c138f		c138g		c138h		c138i		c138j		c138k		c138l		c138m		c138n	
		Watering	c139a		c139b		c139c		c139d		c139e		c139f		c139g		c139h		c139i		c139j		c139k		c139l		c139m		c139n	
		Weeding/ pesticides	c140a		C140b		c140c		c140d		c140e		c140f		c140g		c140h		c140i		c140j		c140k		c140l		c140m		c140n	
		Harvesting	c141a		c141b		c141c		c141d		c141e		c141f		c141g		c141h		c141i		c141j		c141k		c141l		c141m		c141n	
		Post harvesting	c142a		c142b		c142c		c142d		c142e		c142f		c142g		c142h		c142i		c142j		c142k		c142l		c142m		c142n	
	Crop 4	Land Preparation	c143a		c143b		c143c		c143d		c143e		c143f		c143g		c143h		c143i		c143j		c143k		c143l		c143m		c143n	
		Planting	c144a		c144b		c144c		c144d		c144e		c144f		c144g		c144h		c144i		C44j		c144k		c144l		c144m		c144n	
		Watering	c145a		c145b		c145c		c145d		c145e		c145f		c145g		c145h		c145i		c145j		c145k		c145l		c145m		c145n	
		Weeding/ pesticides	c146a		C146b		c146c		c146d		c146e		c146f		c146g		c146h		c146i		c146j		c146k		c146l		c146m		c146n	
		Harvesting	c147a		c147b		c147c		c147d		c147e		c147f		c147g		c147h		c147i		c147j		c147k		c147l		c147m		c147n	
		Post harvesting	c148a		c148b		c148c		c148d		c148e		c148f		c148g		c148h		c148i		c148j		c148k		c148l		c148m		c148n	

C1: Labor Composition – Parcel 2

Season	Enter Crop Code	Activities	Household labor (please enter person code in no column) 1 day= 6-8 hours of work completed by 1 individual						Hired Labor 1 day= 6-8 hours of work completed by 1 individual.							
			Male		Female		Child (<16)		Male			Female			Child (<16)	
			No	days	No	Days	No	Days	Days	Days	Daily wage rate	No	Days	Daily wage rate	No	Days
Rabi	Crop 1	Land Preparation	C21a	C21b	C21c	C21d	C21e	C21f	C21g	C21h	C21i	C21j	C21k	C21l	C21m	C21n
		Planting	C22a	C22b	C22c	C22d	C22e	C22f	C22g	C22h	C22i	C22j	C22k	C22l	C22m	C22n
		Watering	C23a	C23b	C23c	C23d	C23e	C23f	C23g	C23h	C23i	C23j	C23k	C23l	C23m	C23n
		Weeding/ pesticides	C24a	C24b	C24c	C24d	C24e	C24f	C24g	C24h	C24i	C24j	C24k	C24l	C24m	C24n
		Harvesting	C25a	C25b	C25c	C25d	C25e	C25f	C25g	C25h	C25i	C25j	C25k	C25l	C25m	C25n
		Post harvesting	C26a	C26b	C26c	C26d	C26e	C26f	C26g	C26h	C26i	C26j	C26k	C26l	C26m	C26n
	Crop 2	Land Preparation	C27a	C27b	C27c	C27d	C27e	C27f	C27g	C27h	C27i	C27j	C27k	C27l	C27m	C27n
		Planting	C28a	C28b	C28c	C28d	C28e	C28f	C28g	C28h	C28i	C28j	C28k	C28l	C28m	C28n
		Watering	C29a	C29b	C29c	C29d	C29e	C29f	C29g	C29h	C29i	C29j	C29k	C29l	C29m	C29n
		Weeding/ pesticides	C10a	C10b	C10c	C10d	C10e	C10f	C10g	C10h	C10i	C210j	C10k	C10l	C10m	C10n
		Harvesting	C11a	C11b	C11c	C11d	C11e	C11f	C11g	C11h	C11i	C11j	C11k	C11l	C11m	C11n
		Post harvesting	C12a	C12b	C12c	C12d	C12e	C12f	C12g	C12h	C12i	C12j	C12k	C12l	C12m	C12n
	Crop 3	Land Preparation	C13a	C13b	C13c	C13d	C13e	C13f	C13g	C13h	C13i	C13j	C13k	C13l	C13m	C13n
		Planting	C14a	C14b	C14c	C14d	C14e	C14f	C14g	C14h	C14i	C14j	C14k	C14l	C14m	C14n
		Watering	C15a	C15b	C15c	C15d	C15e	C15f	C15g	C15h	C14i	C15j	C15k	C15l	C15m	C15n
		Weeding/ pesticides	C16a	C16b	C16c	C16d	C16e	C16f	C16g	C16h	C16i	C16j	C16k	C16l	C16m	C16n
		Harvesting	C17a	C17b	C17c	C17d	C17e	C17f	C127g	C17h	C17i	C17j	C17k	C17l	C17m	C17n
		Post harvesting	C18a	C18b	C18c	C18d	C18e	C18f	C18g	C18h	C18i	C18j	C18k	C18l	C18m	C18n
	Crop 4	Land Preparation	C19a	C19b	C19c	C19d	C19e	C19f	C19g	C19h	C19i	C19j	C19k	C19l	C19m	C19n
		Planting	C220a	C220b	C220c	C220d	C220e	C220f	C220g	C220h	C220i	C220j	C220k	C220l	C220m	C220n
		watering	C221a	C221b	C221c	C221d	C221e	C221f	C221g	C221h	C221i	C221j	C221k	C221l	C221m	C221n
		Weeding/ pesticides	C222a	C222b	C222c	C222d	C222e	C222f	C222g	C222h	C222i	C222j	C222k	C222l	C222m	C222n
		Harvesting	C223a	C223b	C223c	C223d	C223e	C223f	C223g	C223h	C223i	C223j	C223k	C223l	C223m	C223n
		Post harvesting	C224a	C224b	C224c	C224d	C224e	C224f	C224g	C224h	C224i	C224j	C224k	C224l	C224m	C224n

Kharif	Crop 1	Land Preparation	C225a		C225b		C225c		C225d		C225e		C225f		C225g		C225h		C225i		C225j		C225k		C225l		C225m		C225n	
		Planting	C226a		C226b		C226c		C226d		C226e		C226f		C226g		C226h		C226i		C226j		C226k		C226l		C226m		C226n	
		Watering	C227a		C227b		C227c		C227d		C227e		C227f		C227g		C227h		C227i		C227j		C227k		C227l		C227m		C227n	
		Weeding/ pesticides	C228a		C228b		C228c		C228d		C228e		C228f		C228g		C228h		C228i		C228j		C228k		C228l		C228m		C228n	
		Harvesting	C229a		C229b		C229c		C229d		C229e		C229f		C229g		C229h		C229i		C229j		C229k		C229l		C229m		C229n	
		Post harvesting	C230a		C230b		C230c		C230d		C230e		C230f		C230g		C230h		C230i		C230j		C230k		C230l		C230m		C230n	
	Crop 2	Land Preparation	C231a		C231b		C231c		C231d		C231e		C231f		C231g		C231h		C231i		C231j		C231k		C231l		C231m		C231n	
		Planting	C232a		C232b		C232c		C232d		C232e		C232f		C232g		C232h		C232i		C232j		C232k		C232l		C232m		C232n	
		Watering	C233a		C233b		C233c		C230d		C230e		C230f		C230g		C230h		C230i		C230j		C230k		C230l		C230m		C230n	
		Weeding/ pesticides	C234a		C234b		C234c		C234d		C234e		C234f		C234g		C234h		C234i		C234j		C234k		C234l		C234m		C234n	
		Harvesting	C235a		C235b		C235c		C235d		C235e		C235f		C235g		C235h		C235i		C235j		C235k		C235l		C235m		C235n	
		Post harvesting	C336a		C336a		C236c		C236d		C236e		C236f		C236g		C236h		C236i		C236j		C236k		C236l		C236m		C236n	
	Crop 3	Land Preparation	C237a		C237b		C237c		C237d		C237e		C237f		C237g		C237h		C237i		C237j		C237k		C237l		C237m		C237n	
		Planting	C238a		C238b		C238c		C238d		C238e		C238f		C238g		C238h		C238i		C238j		C238k		C238l		C238m		C238n	
		Watering	C239a		C239b		C239c		C239d		C239e		C239f		C239g		C239h		C239i		C239j		C239k		C239l		C239m		C239n	
		Weeding/ pesticides	C240a		C240b		C240c		C240d		C240e		C240f		C240g		C240h		C240i		C240j		C240k		C240l		C240m		C240n	
		Harvesting	C241a		C241b		C241c		C241d		C241e		C241f		C241g		C241h		C241i		C241j		C241k		C240l		C240m		C240n	
		Post harvesting	C242a		C242b		C242c		C242d		C242e		C242f		C242g		C242h		C242i		C242j		C242k		C242l		C242m		C242n	
	Crop 4	Land Preparation	C243a		C243b		C243c		C243d		C243e		C243f		C243g		C243h		C243i		C243j		C243k		C243l		C243m		C243n	
		Planting	C244a		C244b		C244c		C244d		C244e		C244f		C244g		C244h		C244i		C244j		C244k		C244l		C244m		C244n	
		Watering	C245a		C245b		C245c		C245d		C245e		C245f		C245g		C245h		C245i		C245j		C245k		C245l		C245m		C245n	
		Weeding/ pesticides	C246a		C246b		C246c		C246d		C246e		C246f		C246g		C246h		C246i		C246j		C246k		C246l		C246m		C246n	
		Harvesting	C247a		C247a		C247c		C247d		C247e		C247f		C247g		C247h		C247i		C247j		C247k		C247l		C247m		C247n	
		Post harvesting	C248a		C248a		C248c		C248d		C248e		C248f		C248g		C248h		C248i		C248j		C248k		C248l		C248m		C248n	

C1: Labor Composition – Parcel 3

Season	Enter Crop Code	Activities	Household labor (please enter person code in no column) 1 day= 6-8 hours of work completed by 1 individual						Hired Labor 1 day= 6-8 hours of work completed by 1 individual.							
			Male		Female		Child (<16)		Male			Female			Child (<16)	
			No	days	No	Days	No	Days	Days	Days	Daily wage rate	No	Days	Daily wage rate	No	Days
Rabi	Crop 1	Land Preparation	C31a	C31b	C31c	C31d	C31e	C31f	C31g	C31h	C31i	C31j	C31k	C31l	C31m	C31n
		Planting	C32a	C32b	C32c	C32d	C32e	C32f	C32g	C32h	C32i	C32j	C32k	C32l	C32m	C32n
		Watering	C33a	C33b	C33c	C33d	C33e	C33f	C33g	C33h	C33i	C33j	C33k	C33l	C33m	C33n
		Weeding/ pesticides	C34a	C34b	C34c	C34d	C34e	C34f	C34g	C34h	C34i	C34j	C34k	C34l	C34m	C34n
		Harvesting	C35a	C35b	C35c	C35d	C35e	C35f	C35g	C35h	C35i	C35j	C35k	C35l	C35m	C35n
		Post harvesting	C36a	C36b	C36c	C36d	C36e	C36f	C36g	C36h	C36i	C36j	C36k	C36l	C36m	C36n
	Crop 2	Land Preparation	C37a	C37b	C37c	C37d	C37e	C37f	C37g	C37h	C37i	C37j	C37k	C37l	C37m	C37n
		Planting	C38a	C38b	C38c	C38d	C38e	C38f	C38g	C38h	C38i	C38j	C38k	C38l	C38m	C38n
		Watering	C39a	C39b	C39c	C39d	C39e	C39f	C39g	C39h	C39i	C39j	C39k	C39l	C39m	C39n
		Weeding/ pesticides	C310a	C310b	C310c	C310d	C310e	C310f	C310g	C310h	C310i	C310j	C310k	C310l	C310m	C310n
		Harvesting	C311a	C311b	C311c	C311d	C311e	C311f	C311g	C311h	C311i	C311j	C311k	C311l	C311m	C311n
		Post harvesting	C312a	C312b	C312c	C312d	C312e	C312f	C312g	C312h	C312i	C312j	C312k	C312l	C312m	C312n
	Crop 3	Land Preparation	C313a	C313b	C313c	C313d	C313e	C313f	C313g	C313h	C313i	C313j	C313k	C313l	C313m	C313n
		Planting	C314a	C314b	C314c	C314d	C314e	C314f	C314g	C314h	C314i	C314j	C314k	C314l	C314m	C314n
		Watering	C315a	C315b	C315c	C315d	C315e	C315f	C315g	C315h	C314i	C315j	C315k	C315l	C315m	C315n
		Weeding/ pesticides	C316a	C316b	C316c	C316d	C316e	C316f	C316g	C316h	C316i	C316j	C316k	C316l	C316m	C316n
		Harvesting	C317a	C317b	C317c	C317d	C317e	C317f	C317g	C317h	C317i	C317j	C317k	C317l	C317m	C317n
		Post harvesting	C318a	C318b	C318c	C318d	C318e	C318f	C318g	C318h	C318i	C318j	C318k	C318l	C318m	C318n
	Crop 4	Land Preparation	C319a	C319b	C319c	C319d	C319e	C319f	C319g	C319h	C319i	C319j	C319k	C319l	C319m	C319n
		Planting	C320a	C320b	C320c	C320d	C320e	C320f	C320g	C320h	C320i	C320j	C320k	C320l	C320m	C320n
		watering	C321a	C321b	C321c	C321d	C321e	C321f	C321g	C321h	C321i	C321j	C321k	C321l	C321m	C321n
		Weeding/ pesticides	C322a	C322b	C322c	C322d	C322e	C322f	C322g	C322h	C322i	C322j	C322k	C322l	C322m	C322n
		Harvesting	C323a	C323b	C323c	C323d	C323e	C323f	C323g	C323h	C323i	C323j	C323k	C323l	C323m	C323n
		Post harvesting	C324a	C324b	C324c	C324d	C324e	C324f	C324g	C324h	C324i	C324j	C324k	C324l	C324m	C324n

Kharif	Crop 1	Land Preparation	C325a		C325b		C325c		C325d		C325e		C325f		C325g		C325h		C325i		C325j		C325k		C325l		C325m		C325n	
		Planting	C326a		C326b		C326c		C326d		C326e		C326f		C326g		C326h		C326i		C326j		C326k		C326l		C326m		C326n	
		Watering	C327a		C327b		C327c		C327d		C327e		C327f		C327g		C327h		C327i		C327j		C327k		C327l		C327m		C327n	
		Weeding/ pesticides	C328a		C328b		C328c		C328d		C328e		C328f		C328g		C328h		C328i		C328j		C328k		C328l		C328m		C328n	
		Harvesting	C329a		C329b		C329c		C329d		C329e		C329f		C329g		C329h		C329i		C329j		C329k		C329l		C329m		C329n	
		Post harvesting	C330a		C330b		C330c		C330d		C330e		C330f		C330g		C330h		C330i		C330j		C330k		C330l		C330m		C330n	
	Crop 2	Land Preparation	C331a		C331b		C331c		C331d		C331e		C331f		C331g		C331h		C331i		C331j		C331k		C331l		C331m		C331n	
		Planting	C332a		C332b		C332c		C332d		C332e		C332f		C332g		C332h		C332i		C332j		C332k		C332l		C332m		C332n	
		Watering	C333a		C333b		C333c		C330d		C330e		C330f		C330g		C330h		C330i		C330j		C330k		C330l		C330m		C330n	
		Weeding/ pesticides	C334a		C334b		C334c		C334d		C334e		C334f		C334g		C334h		C334i		C334j		C334k		C334l		C334m		C334n	
		Harvesting	C335a		C335b		C335c		C335d		C335e		C335f		C335g		C335h		C335i		C335j		C335k		C335l		C335m		C335n	
		Post harvesting	C336a		C336a		C336c		C336d		C336e		C336f		C336g		C336h		C336i		C336j		C336k		C336l		C336m		C336n	
	Crop 3	Land Preparation	C337a		C337b		C337c		C337d		C337e		C337f		C337g		C337h		C337i		C337j		C337k		C337l		C337m		C337n	
		Planting	C338a		C338b		C338c		C338d		C338e		C338f		C338g		C338h		C338i		C338j		C338k		C338l		C338m		C338n	
		Watering	C339a		C339b		C339c		C339d		C339e		C339f		C339g		C339h		C339i		C339j		C339k		C339l		C339m		C339n	
		Weeding/ pesticides	C340a		C340b		C340c		C340d		C340e		C340f		C340g		C340h		C340i		C340j		C340k		C340l		C340m		C340n	
		Harvesting	C341a		C341b		C341c		C341d		C341e		C341f		C341g		C341h		C341i		C341j		C341k		C340l		C340m		C340n	
		Post harvesting	C342a		C342b		C342c		C342d		C342e		C342f		C342g		C342h		C342i		C342j		C342k		C342l		C342m		C342n	
	Crop 4	Land Preparation	C343a		C343b		C343c		C343d		C343e		C343f		C343g		C343h		C343i		C343j		C343k		C343l		C343m		C343n	
		Planting	C344a		C344b		C344c		C344d		C344e		C344f		C344g		C344h		C344i		C344j		C344k		C344l		C344m		C344n	
		Watering	C345a		C345b		C345c		C345d		C345e		C345f		C345g		C345h		C345i		C345j		C345k		C345l		C345m		C345n	
		Weeding/ pesticides	C346a		C346b		C346c		C346d		C346e		C346f		C346g		C346h		C346i		C346j		C346k		C346l		C346m		C346n	
		Harvesting	C347a		C347a		C347c		C347d		C347e		C347f		C347g		C347h		C347i		C347j		C347k		C347l		C347m		C347n	
		Post harvesting	C348a		C348a		C348c		C348d		C348e		C348f		C348g		C348h		C348i		C348j		C348k		C348l		C348m		C348n	

C4: Off-farm employment for members of household

Person Code		No. of days (6-8 hours) worked off-farm		Daily wage paid (in PKR)	
C41a		C41b		C41c	
C42a		C42b		C42c	
C43a		C43b		C43c	
C44a		C44b		C44c	
C45a		C45b		C45c	
C46a		C46b		C46c	
C47a		C47b		C47c	
C48a		C48b		C48c	

C5: Marketing and Transport Channel:

Where do you sell your produce *		What is middleman's commission? In %		Is there a metaled road to the market (Yes/No)		Cost for transport (In PKR) (Rent + fuel) (Conditional on farmer marketing own produce)		Cost of packaging (PKR) (Conditional on farmer marketing own produce)		How long have you sold produce through this marketing channel (years)?		How far is it to the market where you sell your harvest? (km)	
C51a		C51b		C51c		C51d		C51e		C51f		C51g	

*Local Market (1); Urban Market (2); Middle man (3); Govt. Agents (4); Landlord (5)

Table C6. Livestock production, consumption, prices etc. (2012)

Type of Animal *1	No. of Animals	No of animals born or bought in 2012	Ownership		Home consumption [Nos./Yr] *2	No. of animal sold [2012]			Who did you sell it to? *3	Monthly earning from animal produce (PKR) *4	Total feeding and veterinary cost (PKR/ yr)	Grazing cost (PKR/ yr)	Own Labour (Hours/ yr)	Hired Labour (PKR/ yr)	No of cultivable land from parcels that is instead used as enclosure for animals
			Own	Shared		Nos. Sold	Farmer's Price (PKR)	Market Price (PKR)							
B61	B61a	B61b	B61c	B61d	B61e	B61f	B61g	B61h	B61i	B61j	B61k	B61l	B61m	B61n	B61o
B62	B62a	B62b	B62c	B62d	B62e	B62f	B62g	B62h	B62i	B62j	B62k	B62l	B62m	B62n	B62o
B63	B63a	B63b	B63c	B63d	B63e	B63f	B63g	B63h	B63i	B63j	B63k	B63l	B63m	B63n	B63o
B64	B64a	B64b	B64c	B64d	B64e	B64f	B64g	B64h	B64i	B64j	B64k	B64l	B64m	B64n	B64o
B65	B65a	B65b	B65c	B65d	B65e	B65f	B65g	B65h	B65i	B65j	B65k	B65l	B65m	B65n	B65o
B66	B66a	B66b	B66c	B66d	B66e	B66f	B66g	B66h	B66i	B66j	B66k	B66l	B66m	B66n	B66o
B67	B67a	B67b	B67c	B67d	B67e	B67f	B67g	B67h	B67i	B67j	B67k	B67l	B67m	B67n	B67o

*1 (1) Cows (2) Buffalo (3) Goats (4) Sheep (5) Camels (6) Horses (7) Asses (8) Mules (9) Others
*2 including for sacrifice, gifting, marriages, religious and other festivals
*3 neighbor, local market, urban market, middleman, other ______
*4 Includes milk, butter, and leftovers sold for preparation

Section D: Institutional Arrangements

D1: Type and source of household credit

Credit Source		Loan in past year (In PKR)		Interest rate/ year		What is the repayment time? (In months)		Any collateral for the loan? *1		Where did you primarily spend this loan?*2		How long have you dealt with this loan provider (in years)		If applied but not received the loan, what are the reasons for your ineligibility? *3	
D11	Bank	D11a		D11b		D11c		D11d		D11e		D11f		D11g	
D12	Micro finance institutes	D12a		D12b		D12c		D12d		D12e		D12f		D12g	
D13	Farmer associations	D13a		D13b		D13c		D13d		D13e		D13f		D13g	
D14	Land lord	D14a		D14b		D14c		D14d		D14e		D14f		D14g	
D15	Relative or Friend	D15a		D15b		D15c		D15d		D15e		D15f		D15g	
D16	Local Lender	D16a		D16b		D16c		D16d		D16e		D16f		D16g	
D17	Middleman	D17a		D17b		D17c		D17d		D17e		D17f		D17g	

*1 Land (1); share of output (2); use of farmers labour (3); other (specify) (4)
*2Buy inputs (seeds, fertilizer, machinery) (1); invest in irrigation (2); buy food/clothing/medical care (3); education/training (4)
*3incomplete identification documents (1), lack of collateral (2), insufficient income/ employment for repayment (3), default on previous loans (4).

D2: Have you received any other loans in the past 5 years? ________________________ in PKR

D3: Village characteristics

How any people live in your village?		How far are you from the centre of the village?		No. of relatives in village	
D3a		D3b		D3c	

D4: Village Profile

Facilities		Tick as appropriate
D41	School	
D42	Dispensary/ hospital	
D43	Shop/market	
D44	Public Transport	
D45	Telephone network	
D46	Internet access	
D47	Electricity supply	
D49	Farmer association	
D410	Agricultural extension office	
D411	Agricultural NGO/ CBO	

Next 3 questions only to be answered by those farmers who trade through a middleman

D5: When did you agree to trade through a middleman?		Tick as appropriate	: Would it be a problem for you to switch to a different middleman if you felt the terms of your contract were not satisfactory? (Yes/No)		Have you switched middleman before? (Yes/no)	
D51	Just before harvest		D6		D7	
D52	Just after harvest					
D53	During crop preparation					

D8: Have you received any of the following types of subsidies during last 12 months (give amount (PKR) per year)

Source		Seed Subsidy		Fertilizer Subsidy		Other	
D81	Government	D81a		D81b		D81c	
D82	NGO	D82a		D82b		D82c	
D83	Private sector sources	D83a		D83b		D83c	
D84	Other (Pls. specify)	D84a		D84b		D84c	

D9: Do you get information or advice from agricultural extension workers or other sources on crop production technology?

Source		How many visit each season	How much do you pay annually for this service?			Did you implement any of the advice received on production techniques/ equipment? (Yes/ No)		If yes, was it useful? (Yes/ No)	If not, what was the reason for not implementing their advice*	
D91	Govt. agricultural extension services	D91a		D91b		D91c		D91d		D91e
D92	Local farmer associations	D92a		D92b		D92c		D92d		D92e
D93	NGOs/ CBOs	D93a		D93b		D93c		D93d		D93e
D94	Research institute	D94a		D94b		D94c		D94d		D94e
D95	Neighbor or Relative	D95a		D95b		D95c		D95d		D95e
D96	print Media	D96a		D96b		D96c		D96d		D96e
D97	Radio/ TV	D97a		D97b		D97c		D97d		D97e
D98	Landlord	D98a		D98b		D98c		D98d		D98e
D99	Middleman	D99a		D99b		D99c		D99d		D99e

*Too expensive (1); want to stick with known methods (2); unsure about how to use new technologies (3); Unable to use new technologies without landlords permission (4); lack of infrastructure to support new technologies (e.g. inadequate irrigation) (5); Other (6)

Section E: ADAPTATION

E1: How long have you been a farmer? _______ (in number of years)

E2: Changes in Rainfall and Temperature:

Change in Rainfall		Have you noticed any change over the last 15 years? Tick as appropriate		Change in Temperature		Have you noticed any change over the last 15 years? Tick as appropriate	
E21	No change in the rain	E21a		E21b	No change in temperature	E21c	
E22	Less rain	E22a		E22b	More Hot days	E22c	
E23	More rain	E23a		E23b	less Hot days	E23c	
E24	Change in the onset rainy seasons	E24a		E24b	Change in night time temperature	E24c	
				E25b	Increase in cold spells	E25c	
				E26b	Change in onset of hot season	E26c	

E4 Extreme Events

Events		Have you experienced any of the following events in the past 15 years? Yes/ No		How would you rate the frequency of this event over the last 15 years?*1		How would you rate the severity of the of this event over the past 20 years?*1		Loss of asset, property, income, food shortage, decline in consumption? (Y/N)	
E41	Floods/ flash floods	E41a		E41b		E41c		E41d	
E42	Wind/ Dust storm	E42a		E42b		E42c		E42d	
E43	Drought	E43a		E43b		E43c		E43d	
E44	Hail storm	E44a		E44b		E44c		E44d	

* 1: Increasing (1); Same (2); Decreasing (3)

E3: Rainfall

Which month did the rainy season begin in the past 15 years?		In which month did the rainy season begin this year?		How would you characterize the amount of rain relative to past 15 years? *1		In which month in this year's rainy season did you get the most rain?	
E31		E31a		E31b		E31c	

*1 more (1); same (2); less(3)

E5: Past Flood Experience

Were you affected by flooding in any of the following years? Yes=1, No=2			Did this affect your harvest? Yes=1, No=2		What % of harvest across all crops was lost?		Any other loss? *1		How did you cope with losses?*2	
E51	2012		E51a		E51b		E51c		E51d	
E52	2011		E52a		E52b		E52c		E52d	
E53	2010		E53a		E53b		E53c		E53d	

*1 Loss of livestock (1), loss of housing/ storage/ animal shed (2), loss of family member (3), loss of any other asset (machinery, vehicle, etc) (4)
*2 Took out a loan to cover expenses (1); Sold off farm assets (machinery, livestock) (2); Relied on savings (3); Worked as a labourer/other work away own farm (4); Financial support from relatives/local villagers (5); Government/NGO assistance (6); Other (specify) (7)

E6: Adaptation actually undertaken

Adaptation Measures		How has your household adapted to cope with climatic changes?		Go to Question:
E61	Altering the timing of "cropping activity" (e.g. harvest date)	E61a		E7
E62	Shift in cropping pattern (e.g. crop portfolio)	E62a		E8
E63	Altering agricultural input	E63a		E9
E64	Investment in soil conservation	E64a		E10
E65	Investment in water conservation	E65a		E11
E66	Diversification of Income	E66a		E12
E67	Public/ Household infrastructure incl. water defenses	E67a		E13
E68	No Adaptation	E68a		-
E69	Other, specify________________________	E69a		-

E7: Altering the timing of cropping activity:

Which activities have you shifted		Which plot/crop?		Previous time of the activity (month)		Current time of the activity (Month)		If you do not plan to continues this? Please explain your reason for discontinuation? *1	
E71	Delayed Sowing	E71a		E71b		E71c		E71d	
E72	Early Harvesting	E72a		E72b		E72c		E72d	
E73	Late Harvesting	E73a		E73b		E73c		E73d	

* 1 lack of money (1), lack of information (2); shortage of labor (3); Has little/no effect on crop outputs (4) Lower returns(5) Other (specify) (6) …

E8: Shift in cropping patterns

What crop did you swap?				When did you start to change (Year)		What is the change in the income?		Did you incur any additional cost of change? In PKR		If you do not plan to continues this? Please explain your reason for discontinuation *1	
Previous		New									
E81		E81a		E81b		E81c		E81d		E81e	

* 1 lack of money (1), lack of information (2); shortage of labor (3); Has little/no effect on crop outputs (4) Lower returns (5) Other (specify) (6) …

E9: Change in Agricultural Input due to climate change:

Which agricultural input did you change?		When did you start to change (Year)?		How did you change?*1		Did you incur cost of change? (In Rs.)		If you do not plan to continues this? Please explain your reason for discontinuation *1	
E91	Fertilizers	E91a		E91b		E91c		E91d	
E92	Seed	E92a		E92b		E92c		E92d	
E93	Pesticides	E93a		E93b		E93c		E93d	
E94	Labor	E94a		E94b		E94c		E94d	
E95	Water	E95a		E95b		E95c		E95d	

*1. Increase (1); Reduce (3); Different variety of input (seed, fertilizer etc.)
2. lack of money (1), lack of information (2); shortage of labor (3); Has little/no effect on crop outputs (4) Lower returns (5) Other (specify) (6)

E10 Soil Conservation Management

Have you used crop residue (Mulching), green manure, or cover crop before this season to provide organic matter to the soil? Y/ N		Did you use zero tillage, and direct sowing for soil preparation? Y/ N		Have you implemented contour planting to reduce soil erosion? Y/ N		Have you used shelter beltsfor improved soil–water retention and to reduce erosion? Y/ N	
E101		E101a		E101b		E101c	

E11: Water Management/ conservation:

Alteration of irrigation use, including amount, timing to conserve water ?Y/ N		Adoption of supplementary water sources such as rainwater harvesting? Y/ N		Construction of flood defense infrastructure? Y/ N		Construction of bunds around fields, or land leveling to preserve water and maximize water uptake of the crops? Y/ N		Adoption of water-efficient methods to conserve soil moisture (e.g. Furrow irrigation)? Y/ N	
E111		E111a		E111b		E111c		E111d	

E12: Diversification of Income of household members:

Shift source of Income		Change in Income		How many household members shifted to this livelihood	
E121	Livestock, fishing, etc	E121a		E121b	
E122	Off farm job	E122a		E122b	
E123	Private business (store)	E123a		E123b	
E124	Share Crop/ Lease your land	E124a		E124b	
E125	Move to urban area	E125a		E125b	
E126	Other (specify)	E126a		E126b	

E30: Recent infrastructure developments in past 15 years

Has your village witnessed public infrastructure construction with bearing to agriculture? (Y/N)		What infrastructure was built? *1	
E127		E127a	

*1: Dam/ Canal (1); Electricity lines (3); Roads (4); Tube well (5); Rain water harvest tanks/ ponds (6); Flood defense infrastructure (7); other, specify____________________

E13: Adaptation actually undertaken

Adaptation Measures		Kindly list 3 most important reasons other than climate change for applying these measures	
E131	Altering the timing of "cropping activity" (e.g. harvest date)	E131a	
E132	Shift in cropping pattern (e.g. crop portfolio)	E132a	
E133	Altering agricultural input	E133a	
E134	Investment in soil conservation	E134a	
E135	Investment in water conservation	E135a	
E136	Diversification of Income	E136a	
E137	Public/ Household infrastructure incl. water defenses	E137a	
E138	No Adaptation	E138a	
E139	Other, specify________________________	E139a	

*1. Change in price or availability of input such as seed, fertilizer, water (1); Household factors: food and fodder self-sufficiency (2); Market Price of output/ higher expected return (3); Change in agricultural contract/ terms (4); Other________ (5)

F3: Household assets owned: quantity and value (2012)

Type of assets		Quantity		Approx. Value (Rs.)	
Electronic Appliance	TV	E141a		E141b	
	Radio	E142a		E142b	
	Other: ______	E143a		E143b	
Communication	Telephone	E144a		E144b	
	Internet	E145a		E145b	
	Mobile Phone	E146a		E146b	
Motorized Transportation: (Truck, car, etc.)		E147a		E147b	
Generator		E148a		E148b	

Section F. **HOUSEHOLD INCOME:**

F1 Kindly provide information on all kinds of income to this households during the last one year (in Rs.)

		Annual Income
F1a.	Wages (kind, yearly) approximate value in Rs.	[ ][ ][ ][ ][ ][ ][ ]
F1b.	Farm income	[ ][ ][ ][ ][ ][ ][ ]
F1c.	From business (shops, factory etc.)	[ ][ ][ ][ ][ ][ ][ ]
F1d.	From handicrafts	[ ][ ][ ][ ][ ][ ][ ]
F1e.	Remittances from other household members & relatives	[ ][ ][ ][ ][ ][ ][ ]
F1f.	Sale of property/ other asset	[ ][ ][ ][ ][ ][ ][ ]
F1g.	Land rental	[ ][ ][ ][ ][ ][ ][ ]
F1h.	Livestock	[ ][ ][ ][ ][ ][ ][ ]
F1i.	Other sources (gift, zakat, charity etc.)	[ ][ ][ ][ ][ ][ ][ ]
F1j	TOTAL YEARLY INCOME: (in Rs.)	[ ][ ][ ][ ][ ][ ][ ][ ][ ][ ]

F2. Kindly provide information on monthly expenditure (in Rs.) of this household

F2a.	On food items bought / consumed	[ ][ ][ ][ ][ ][ ]
	F2a1 Wheat	[ ][ ][ ][ ][ ][ ]
	F2a2 Fodder	[ ][ ][ ][ ][ ][ ]
	F2a3 Vegetable	[ ][ ][ ][ ][ ][ ]
	F2a4 Rice	[ ][ ][ ][ ][ ][ ]
	F2a5 Pulses	[ ][ ][ ][ ][ ][ ]
	F2a6 Meat	[ ][ ][ ][ ][ ][ ]
	F2a7 Other nutritional items _______	[ ][ ][ ][ ][ ][ ]
F2b.	on purchase of clothing and other items	[ ][ ][ ][ ][ ][ ]
F2c.	on health care (doctors/provider's fees and purchase of medicines)	[ ][ ][ ][ ][ ][ ]
F2d.	Miscellaneous	[ ][ ][ ][ ][ ][ ]
	F2d1. Housing	[ ][ ][ ][ ][ ][ ]
	F2d2. Educated related expenses (e.g. school/ college fees etc)	[ ][ ][ ][ ][ ][ ]
	F2d3. Transport (e.g. fuel expense if car is owned, public transport etc)	[ ][ ][ ][ ][ ][ ]
F2e	TOTAL MONTHLY EXPENDITURE: (in Rs.)	[ ][ ][ ][ ][ ][ ][ ]

F3.Total Income (row F1j), what is the % upward or downward revision? _____________ (%) (Consider average of past 5 years (2007-2011))

F4.Total Expense (row F2e), what is the % upward or downward revision? _____________ (%) (Consider average of past 5 years (2007-2011))

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