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2 Executive Summary

The overall aim of this project was to identify constraints that impede smallholders' capacity to adopt innovative farming practices and better marketing strategies to improve farm-level productivity and profitability.

The key objectives of this SRA were:

- To understand the technological, institutional and capacity constraints that cause a wide range of differences in productivity outcomes for smallholders.
- To identify the main factors influencing productivity improvement for farmers and the kind of policy measures can be adopted to improve these criteria.
- To review the marketing strategies adopted by smallholders to maximize their returns and, thus, identify policy options to accelerate market reform.
- To evaluate: (a) the agricultural support strategies implemented by the government and donors to increase farm productivity, and (b) the capacity of these strategies to support productivity development.

This research that addressed these objectives involved several stages, including: (a) reviewing the literature and analysing the existing policies to promote pro-poor agricultural growth; (b) developing survey tools and econometric methods to measure the main sources of horticultural sector performance and various constraints that are hindering smallholders' productivity and profitability; (c) policy workshop(s) and consultation with stakeholders including academics, government officials, international donors and industry representatives; (d) focus-group interviews with smallholders to identify priority area for reform; and (e) dissemination of research findings through conference participation and policy briefs.

This SRA generated farm-level survey data to support estimations of comprehensive measures of productivity by breaking down the sources of productivity growth into those that affect resource allocation and profit margins. To achieve this goal, four districts were selected with varying horticultural practices in different agro-climatic zones in Punjab, Pakistan. A comprehensive survey of 850 smallholders who were engaged in the cultivation of vegetables, fruits and cereals in the districts of Kasur, Lahore, Muzaffargarh and Sargodha was conducted.

Our econometric analysis aimed to identify the main drivers of farm productivity and profitability. Firstly, we decomposed farm-level productivity into its various sources such as technical, scale and mix efficiency.[1] Secondly, we modelled the relationship between different farming practices and productivity to show how adoption of innovative practices, access to credit, provision of extension services and marketing strategies can improve the

[1] *Technical efficiency refers to best management practices and defined as the ability of a firm to either minimize its input use to produce a given level of output (i.e., input-oriented technical efficiency) or maximize output with a given level of inputs (i.e., output-oriented technical efficiency) by moving closer to the production frontier. In other words, technical efficiency is a measure of increase in productivity (reduction in cost or increase in revenue). Scale and mix efficiency refer to increase in productivity due to scale and/or scope economies. This can be achieved by moving around the production frontier, which occurs due to change in input and output prices*

productivity and profitability of smallholders. Lastly, we used logistic regression models to predict smallholder participation in extension services and innovation. The logistic regression analysis enables us to determine various factors (such as education) that motivate smallholders to participate in extension services and adopt innovations. The main advantage of logistic modelling is that we can include categorical variables (e.g., value 1 for adopting and 0 for not adopting innovation) as an outcome variable to analyse the impact of several factors on the farmer's decision to adopt innovations such as grading. We provide a summary of significant findings and key insights below.

2.1 Main Research Findings

Our descriptive analysis highlighted the following main features of the survey data:

- About a quarter of the farmers were illiterate and only a small proportion of them had completed intermediate (Year 12) or higher level education.
- The average landholding was about seven acres with little variation across districts.
- The average farming experience for the entire sample was 21 years, which varied across the districts as well.
- Female participation levels as secondary decision makers remained very low (i.e. 6% on average).
- Women were mostly involved in labour activities on farms. The ratio of females to males in family labour was found to be 1:9, whereas this ratio was 1:5 in the case of hired labour. Most involvement by women was confined to sowing, hoeing and harvesting activities.
- Only a quarter of farmers within these districts owned a tractor and/or other machinery (although the percentage was higher in District Kasur).
- The average non-farm income was about PKR 15000 per month.
- Only one-fifth of sampled farmers sought credit or financial assistance and the majority of these farmers were vegetables growers.
- The three main obstacles to obtaining credit were high interest rates, the fact that interest-based lending is perceived as being un-Islamic, and complicated loan processes. All of these factors could be targets for financial service innovation for an unmet market.
- The majority of these farmers purchased inputs from local markets at higher prices, yet they were not satisfied with the quality of these products (such as pesticides).
- Smallholders faced marketing and sales issues, delayed payments and post-harvest losses.

2.1.1 Major Sources of Farm-Level Productivity

Farm level productivity can be improved in several ways, such as improving technical efficiency (i.e., by increasing the level of outputs with the same inputs) or through technological change (i.e., shift in the production frontier through innovation) or scale and/mix efficiency (i.e., due to changes in relative input and output prices)[2] The reason for

[2] The concept of scale efficiency refers to achieving optimal scale of production (i.e., the most productive scale size) to achieve the maximum productivity. On the other hand, the concept of mix efficiency refers to increase

decomposing farm productivity into various components was to determine whether policy makers should focus on education and training programs, or input and output pricing policies, or a combination of both to achieve farm-level productivity improvements. We decomposed farm-level productivity into its various measures using data envelopment analysis (DEA) and econometric analysis (i.e. stochastic frontier analysis).[3] One of the advantages of DEA is that it does not require simplistic assumptions about market behaviour (e.g., a perfectly competitive market). Further, to draw statistical inferences on farm level productivity differentials, we used econometric estimation (i.e., stochastic frontier analysis) of various components of productivity. We noted several sources of farm-level productivity and profitability, which are summarised below:

- Technical, scale and mix efficiency were the main drivers of farm-level productivity. While technical efficiency informs us how far the farmers were from the best practices frontier, scale and mix efficiency tells us to what extent smallholders are able to improve farm level productivity by using appropriate input and output mixes in response to changes in input and/or output prices.[4] We found significant differences in best farm management practices (i.e. technical efficiency) as well as in scale and scope economies (i.e. scale and mix efficiency) among smallholder farmers.
- The wide variation in farm management practices (i.e., technical inefficiency) was the largest source of low productivity. The bottom 10% of farmers needed to improve their technical efficiency by about 35% in order to catch up with top 10% performing farmers.
- These findings indicate that farmers could improve their farm productivity through better utilization of input resources if there are better education and training programs.
- The results of scope economies (i.e. mix efficiency) suggested that the use of appropriate input mixes could result in about a 30% increase in farm productivity. However, farmers were not always able to respond to changing input prices to optimize input combinations.
- The mix efficiency gap between the bottom and top 10% was much larger than the technical efficiency factor, which may be due to lack of access to input resources or higher prices within the local market. These differentials were also significant across the districts.
- In addition, crop diversification (through changes in output mixes) appeared to improve farm productivity. This result was also significant across the sample.
- Scale economies (i.e. scale efficiency) had a positive influence on productivity. It increased when the farm size increased.
- Scale economies contributed about a quarter of farm productivity levels, but the differences in scale economies were large when we compare the bottom and top

in productivity through changes in input and output mixes (see, O'Donnell, 2012). These input and output mixes can be altered by targeting relative input and output prices through changes in taxes and subsidies.

[3] DEA is a non-parametric method, which is based on linear programming and constructs a surface to envelop the data points as compactly as possible without violating properties of production technology (such as convexity). All the data points lying on the surface represent that farms are fully technically efficient (i.e., best practices).

[4] Scale and mix efficiency refer to increase in productivity that can be achieved by capturing scale and scope economies.

10% of farmers. This finding implies that appropriate scale is important to maximize productivity levels from the available inputs. Agricultural policy initiatives, which equip smallholders with greater knowledge of appropriate input usage and crop diversification can result in productivity and profitability improvement.

2.1.2 External Factors Influencing Farm Productivity and Profitability

There are several external factors that affect the farm level productivity and profitability of smallholders. These factors include farm and farmer characteristics (e.g., crop types, education and experience), accessibility to credit and extension services, implementation of innovative methods of cultivation, and marketing strategies. In this section, we aim to analyse the impact of these various exogenous factors on farm productivity and profitability.

A summary of the findings from our study is provided below:

- Vegetables and fruits were more productive compared to cereals and other crops.
- Farmers connected with other farmers or those who had some association practicing new methods of cultivation (such as tunnel farming) improved productivity.
- Access to extension services and credit facilities improved farm-level profitability.
- Farmers who were linked more closely with supply chain actors were more profitable.
- Adoption of market-orientated practices (such as grading) increased profit margins.
- Increased costs of inputs (including fertilisers and energy) had a negative impact on profitability levels of farmers.
- Profit margins varied significantly across all districts, as well as across the crop types. For instance, chilli growers achieved the highest gross margin followed by mango and citrus growers. Cereal crops were comparatively less profitable.

The adoption of innovative practices and participation in extension services (through training and demonstration) are considered important factors in determining farm-level productivity. There are several reasons why farmers implement those practices, which we analysed using logistic regression estimation.

A brief summary of these findings is presented below:

- Education and experience appeared to be the key motivating factors for farmers who adopted innovative practices, such as tunnel farming, grading, the use of improved seed variety and postharvest value adding and marketing.
- Similarly, farmers who had closer contact with input dealers were more likely to be involved in such practices.
- Farmers in vegetable growing districts were more likely to adopt innovation compared to fruits and other crops, thus achieving higher productivity and profitability.
- Access to media and technology such as TV/radio and mobile phone also had a positive impact on the uptake of innovation practices, which resulted in higher productivity and profitability.

2.2 Recommendations

Our evidence shows that the most effective policy levers for improving farm productivity and profitability are as follows.

- Improved farming practices create significant gains in productivity, which should be facilitated by training and education programs.
- Value adding practices such as grading and marketing can be encouraged and enabled through the formation of farmer's cooperatives.
- Credit schemes need to be designed to be appropriate for the needs of farmers. The credit application system should be easy to understand and the cost of credit not too high.
- Public-private partnerships can be used to provide this type of finance to smallholders.
- Traditional extension services are not effective and many farmers are now using electronic media and contact with successful farmers to improve their knowledge base. It is recommended that a pilot project using SMS, TV and radio be initiated to provide farming information and direct farmers to demonstration sites or 'lead adopter' farmers.
- Policy initiatives and cost controls are needed to reduce input costs in rural areas, which may also help to improve the input supply chains and thus increase farmers' profitability.

2.3 Going Forward

Policy interventions could have a significant impact on productivity improvement, which underscores the importance of training programs in various activities. For instance, one of the quickest ways of disseminating information could be via mobile phone SMSs. We envisage a larger study to assess how education and training can help to improve smallholders' productivity and profitability. This investigation would use controlled trials and experimental research design to:

- Establish well-developed input- and output-supply chains to achieve improved farm-level profitability.
- Leverage the superior productivity of women through gender-specific policies (for instance, training women on value addition activities such as grading and processing) and the minimisation of post-harvest losses by processing fruits and vegetables to empower women in farming communities through increased farm incomes.
- Provide extension services and access to other innovation practices e.g. seed varieties, cropping and processing) that could help small farmers to enhance farm productivity.
- The findings from our current study suggested that policy interventions on credit availability, extension services, marketing, and value addition strategies are important to improve farm level performance. Further analysis is needed to investigate the impact of intervention strategies such as provision of extension services, credit facilities and collaborative marketing through controlled trials. Similarly comprehensive analysis of the potential of women entrepreneurs who are given training on value adding activities such as food processing and marketing (or trading) of farm produce is required.

3 Introduction and Background

The agricultural sector significantly contributes to Pakistan's economy – accounting for more than 20% of GDP and employing about 43% of the rural labour force.[5] Increased agricultural productivity is crucial not only to ensure food security and income generation, but also to release productive inputs for use in other sectors of the economy (Shultz, 1953).

To address this opportunity, agriculture has become a core agenda item in the Pakistan Vision 2025[6] in which the government aims to improve agricultural productivity through diversification of the agricultural sector. The Government of Pakistan has realised that high-value agricultural products derived from the horticultural, livestock, dairy and fisheries sectors need productivity enhancements to increase the incomes of rural households.[7] As a result, both federal and provincial governments are keen to enhance production of high-value crops and livestock.[8] For example, the Government of the Punjab emphasised improvement in agricultural productivity through supply-chain development as a means of addressing food security and poverty issues (Government of Punjab, 2015).

In terms of background context, Pakistan's agro-climatic environment is appropriate for the production of various horticultural crops, with fruit and vegetable production levels growing within the country. Pakistan's horticultural sector has tremendous scope to contribute to its economy through exports of fruits and vegetables which can help to bring cash into farming communities and overcome rural poverty. Yet, problems of poor yield and substandard quality commonly plague the horticultural sector and effective policy interventions are lacking.[9]

It is therefore important from a policy point of view for decision-makers to understand the nature and degree of the factors impeding agricultural productivity. This evidence should lead to better policy design and more effective interventions to lift agricultural productivity levels within Pakistan.

This evidence base is important because the majority of Pakistani farmers are smallholders who face a host of complex issues, including increasing costs of production, limited availability of credit and extension services, imperfect markets and volatile prices (Akhtar et al., 2013). Since the majority of farmers are smallholders, they often do not have the capacity to deal with these challenges, which results in low productivity and reduced incomes for them and their families.

Policy initiatives that target small farming practices that are well below productivity benchmarks due to multiple constraints have the capacity to boost social and economic

[5] http://budget.par.com.pk/economic-survey/

[6] http://www.pc.gov.pk/?p=2461

[7] http://www.agripunjab.gov.pk/strategy

[8] http://www.pc.gov.pk/wp-content/uploads/2015/06/Ch20-Food-security-agricultural-development.pdf

[9] http://www.fao.org/docrep/018/i3107e/i3107e03.pdf

wellbeing. Identification of various drivers of productivity such as management practices and innovation (i.e. technical efficiency); scale and scope economies (scale-mix efficiency); and education and training (labour efficiency) can help policy makers to introduce pro-horticultural sector agricultural policies that can enhance smallholders' productivity and profitability.

To this end, it is important to investigate the reasons for the wide disparity in farm productivity so interventions can be matched to problems. For instance, if one area of smallholder farms is technically inefficient, then training programs and technological support (e.g. extension services) may be effective. Utilising state-of-the-art methods in place for productivity analysis and data collection will provide a stronger evidence base for effective targeting of government initiatives to improve agriculture.

4 Objectives

The overall aim of this project was to identify constraints that impede smallholders' capacity to adopt innovative farming practices and better marketing strategies to improve farm-level productivity and profitability.

Understanding how various technological and institutional constraints as well as business practices of farmers impede farm level productivity is a pre-requisite to formulate effective agricultural policies to overcome these barriers. To build the evidence base for intervention strategies that could support smallholders the following objectives were established in this study:

- To understand the technological, institutional and capacity constraints that cause a wide range of differences in productivity outcomes for smallholders.
- To identify the main factors influencing productivity improvement for farmers and the kind of policy measures can be adopted to improve these criteria.
- To review the marketing strategies adopted by smallholders to maximise their returns and, thus, identify policy options to accelerate market reform.
- To evaluate: (a) the agricultural support strategies implemented by the government and donors to increase farm productivity, and (b) the capacity of these strategies to support productivity development.

To achieve the objectives mentioned above, this study raised the following questions:

1. What are main drivers of smallholders' productivity and the differences in productivity outcomes?
2. Which growers (e.g. vegetables, fruit) are using inputs more efficiently?
3. How does credit affect farm profitability and productivity?
4. What proportion of smallholder farmers are able to access credit?
5. What are the obstacles for smallholders to apply for credit?
6. What practices are associated with higher farm profitability?
7. How can farmers find out about better farming practices?
8. Are extension services effective in improving productivity?

5 Methodology

To identify and analyse various constraints that impede smallholders' productivity and profitability, we adopted the following approach:

- A wide-ranging literature survey was conducted to identify the constraints and opportunities faced by smallholders (particularly in the horticultural sector of Pakistan).
- An inception meeting with stakeholders to finalise the study areas and sectors was held in Islamabad on July 9, 2015. The inception meeting took place with officials from Ministry of Food Security, academics, researchers from NARC and a group of farmers engaged in horticultural practices in District Kasur.
- A two-day intensive survey training program was organised for capacity building of academics and students from five local universities. This training was followed by a survey pre-test in the field which helped to further refine the questionnaire for final data collection.
- A comprehensive survey instrument was developed based on the University of Cambridge's survey on small business growth. This instrument was developed by the Cambridge University Centre for Business Research and is widely regarded as a benchmark survey for gathering information on small businesses. It is readily adaptable to different circumstances, including small horticultural businesses. A brief discussion on the survey, sampling design, estimation strategy and focus group discussions is provided below.[10]
- A mixed-method strategy was employed by focusing both on qualitative and quantitative analysis of the smallholders' capabilities, productivity and profitability issues. While a qualitative analysis (through focused group interviews) helped us to identify the major issues (constraints) of smallholders, the quantitative analysis enabled to measure the main sources of productivity shortfall in the horticultural sector. The interface of qualitative and quantitative methods was helpful to rectify our empirical findings through detailed discussion with stakeholders to suggest evidence-based agricultural policy options.

5.1 Sample Description

We conducted a farm level survey to collect a detailed information on farm and famers' characteristics, crop level information on inputs and outputs, value chain issues and factors impeding adoption of innovation practices by the smallholders. We generated a sample of 850 households to gather data of these aspects. We adopted a multi-stage sampling to finalise the survey sample in different districts of Punjab. During the first stage (within our scoping study), we identified various clusters of vegetable and fruit farming and focused on four districts, namely Kasur, Lahore, Muzaffargarh, and Sargodha. These four districts are located in different agro-climatic zones and focus on varying farming practices. For instance, growers in District Kasur cultivate vegetables such as cauliflower, eggplant (brinjal), arvi, potato, tomato, okra, and turmeric (spice) while in District Lahore growers cultivate cucumber, cauliflower, tomato and okra. Fruit growers are in District Muzaffargarh which produce mangoes and citrus growers in District Sargodha. During the second stage,

[10] Details on sample design, implementation strategy and estimation techniques are provided in Appendix 11.1.

we selected the union councils/villages (based on the official list of mouzas obtained from the Punjab Government Department of Agriculture)[11] and focused on particular crops (e.g. potato, cauliflower) to generate the representative sample for the economic analysis. Lastly, from the selected mouzas, we randomly selected farms to collect the desired information. To collect a representative sample from all four areas, we conducted a farm-level survey of 850 farmers from the four districts. The number of farmers within the four districts were: Kasur (250), Lahore (100), Muzaffargarh (250) and Sargodha (250).[12] More detail on research methodology and sample selection is provided in Section 11.1 in the appendix.

5.2 Economic Analysis

We conducted the economic analysis at three different levels. Firstly, we created descriptive statistics of farmers' characteristics, crop-level costs of production, profit margins and household characteristics (such as age, experience, and education). Furthermore, to measure farm-level productivity, we used both linear programming and econometric methods and decomposed total factor productivity into its various components and investigated potential areas of productivity improvement.[13] We then used Bayesian estimation methods to estimate stochastic frontier production functions.[14] One of the advantages of this approach is that we were able to impose regularity conditions (i.e. monotonicity) to obtain plausible productivity estimates. For a meaningful productivity analysis, we require all input shares to be positive, which was violated in some of our survey data. Another advantage of Bayesian estimation is that it provides precise inferences about the parameters which are important for policy purposes. We estimated farm productivity measures at both crop and district levels.

In our second-stage analysis, we tested various hypotheses by estimating the relationship of different external factors with farm-level productivity and profitability. We estimated various regression models to link innovative practices and extension services with farm-level productivity and profitability. We employed the generalised method of moments to control the endogeneity issues in the econometric analysis. To study the likelihood of smallholders adopting innovative farming, we employed logistic regression models using our survey data. Lastly, we conducted focused interviews with stakeholders, including farmers, officials of the Department of Agriculture, academia and policymakers to further clarify the findings of the economic analysis.

[11] Mouza demarcates the land ownership of farmers (inhabitants) and is used for Agricultural Census. Further details are available on: http://www.pbs.gov.pk/content/pakistan-mouza-census-2008.

[12] In some areas, the sample was overdrawn, which is always better in terms of statistical power.

[13] We used DPIN3.0 software to compute TFP efficiency components in a non-parametric setting. This software is freely available from Centre for Efficiency and Productivity Analysis (CEPA), University of Queensland website: http://www.uq.edu.au/economics/cepa/software.php.

[14] We used MATLAB to estimate a Bayesian stochastic frontier.

6 Achievements Against Activities and Outputs/Milestones

Objective 1: To understand the technological, institutional and capacity constraints that cause a wide range of differences in productivity outcomes for smallholders.

Our first task in this SRA was to identify various constraints that were impeding smallholders' productivity and profitability. These issues were identified by reviewing the extensive literature on developing economies and Pakistan, as well as consulting various stakeholders. We found that farmers were faced with technological (e.g., adoption of innovation), institutional (e.g., access to credit and extension services) and capacity (e.g., limited education and training) barriers, which hampered their productivity significantly. We particularly focused on existing agricultural policies, including their implementation strategies to enhance farmers' productivity and income. Lack of technology and agricultural extension systems were frequently identified as contributing to the smallholders' farms inefficiencies (Ali and Flinn, 1989; Battese, Malik and Broca, 1993; Battese, Nazli and Smale, 2015). In the past, the focus of the majority of agricultural policies in Pakistan has been limited to major crops (e.g. wheat, rice, cotton and sugarcane) and government interventions have been confined to domestic wheat procurement and support pricing (e.g. subsidies), resulting in huge inefficiencies in the agriculture sector (World Bank, 2008). Although Pakistan is currently transforming its agriculture to high value-added commodities (e.g. horticulture), the literature on the role of smallholders in the horticultural sector is almost non-existent (Gulati et al., 2006).

An inception meeting was held and a scoping visit to small farms with focus group interviews was conducted to identify productivity and value chain issues faced by smallholders, particularly within the horticultural sector. Several technological, institutional and capacity constraints were identified, including inefficient input and output supply chains, increased input costs, delayed output payments, lack of interaction with the Extension Services department and absence of credit facilities. Discussions with researchers from academia and different research organisations helped to identify various gaps in smallholders' agricultural research and narrow down any farm-related research questions prior to the survey. The identification of these main issues (including input costs, access to innovation and extension services, credit facilities, post-harvest crop management practices, value-chain issues) assisted with the survey design.

Objective 2: To identify the main factors influencing productivity improvement for farmers and the kind of policy measures can be adopted to improve these criteria.

For effective policy measures to enhance horticultural sector productivity, it is imperative to identify and analyse the main factors that affect the smallholder's productivity. To this end, we measured and decomposed farm-level productivity into its various components, including technical efficiency (management practices), scale and mix effects (scale and scope economies that occur because of changes in input and output mixes as a result of input and output prices) help to identify the areas of improvement (such as education and training programs) for increased farm level productivity and profitability. The empirical analysis showed that majority of smallholders remained well-below the best practices due technical inefficiency). It implied that more attention should be given to education and

training programs to improve smallholders' best practices. In addition, higher farm productivity could be achieved through pricing policies.[15] Further analysis of various factors indicated that access to credit and extension services had a significant positive impact on farm level productivity. This helps us to priortise the most promising areas for public policy interventions.

Objective 3: To review the marketing strategies adopted by smallholders to maximise their returns and, thus, identify policy options to accelerate market reform.

We reviewed the strategies adopted by smallholders to maximize their returns in the horticultural sector. The analysis showed that farmers who adopted innovative marketing strategies had higher financial returns. While the majority of smallholders practice traditional cultivation methods and sell their produce to the local commission agents without any grading those who opted for innovative cultivation methods (such as tunnel farming) and grading of fruit and vegetables, achieved higher profit margins. Further econometric analysis of factors affecting productivity and profitability of smallholders revealed that those farmers with credit access earned higher profits per acre than those who did not receive credit. Smallholders' adoption of technology and innovative practices, such as better seed quality and grading of fruit and vegetables, are associated with improved farm productivity and profitability

Objective 4: To evaluate: (a) the agricultural support strategies implemented by the government and donors to increase farm productivity, and (b) the capacity of these strategies to support productivity development.

We evaluated various agricultural support strategies of the government of Pakistan and international organisations (e.g., ACIAR, IFPRI). We found that past government agricultural support, such as subsidies, had focused on traditional agricultural activities (e.g., grains) while the high value-added agricultural sector (e.g., vegetables and fruits) had not received much attention. The review of horticultural sector support strategies from international organizations (e.g., ACIAR) provided us with an opportunity to develop linkages between our project and other initiatives to identify ways to better implement agricultural support programs.

We also presented the findings of our survey study to various stakeholders in a one-day workshop organised by NARC on 8 April 2015 in Islamabad. The workshop was attended by representatives from several organisations, including the Pakistan Agricultural Research Council, Ministry of Food Security, Pakistan Institute of Development Economics, Food and Agriculture Organization, International Food Policy Research Institute, Asian Development Bank, Punjab Agriculture Department, policymakers, plus various academics from different universities in Pakistan and Australia. This provided an opportunity to review the empirical findings in light of current strategies to support smallholders within the horticultural sector. During the workshop, the study's findings were shared with international donors and one-to-one meetings with program managers also acknowledged the synergies of current agricultural support strategies by these donors and identified future areas for capability

[15] Subsidies and support prices are the main motives of changing input and output combinations, which result in varying productivity levels.

development and collaboration. These findings were also shared with policymakers in the Punjab agriculture department in Lahore and discussions were held with the aim of revising and modifying the analysis to inform better government policy.

7 Key Results and Discussion

In this section, we present the main findings of the study based on our descriptive (as well as econometric) analysis.

7.1 Descriptive Analysis of Farmer Characteristics and Farm Practices

Some basic characteristics of smallholders included in the survey are provided below. Table 7.1 provides a snapshot of different farm and farmers' characteristics.[16] The average landholding across all districts was seven acres, with little variation among the four districts (i.e. six acres in Lahore and Sargodha, seven acres in Muzaffargarh and eight acres in Kasur). Quantile statistics revealed that the lowest 25% of smallholders owned four acres of land, the top 25% had 10 acres of land, whereas the top 10% of farmers possessed 12 acres or above (See Table 11.2 in the Appendix).[17] On average, farmers had about 21 years of farming experience for the entire sample. About 24% of the farmers were illiterate, whereas 19% had completed intermediate or degree level education (see Figure 11.2). Average family size was found to be eight persons and 75% had fewer than 10 members in their households. Survey data show that about 25% of farmers owned tractors and other machinery (e.g. thresher). About 78% of farmers also had TV/radio and mobile phones. In addition to farm income, only 15% of surveyed farmers have other non-farm income sources (such as employment – government or private sector) to supplement their household livelihood.

Table 7.1: Farm and Farmers' Characteristics

Variable	Kasur	Lahore	Muzaffargarh	Sargodha	Full Sample
Primary Decision Maker*					
Age (years)	41	43	43	43	43
Farming Experience (years)	21	24	19	22	21
Household Size (number)	9	10	9	7	9
Farm Area (acres)	8	6	7	6	7
TV/Mobile ownership (%)	85	85	71	78	78
Tractor/Machinery Ownership (%)	45	24	23	19	25
Average non-farm income (PKR /month)	11729	21212	17032	8169	14815

* indicates average values

Mostly, the household head was responsible for decision making in terms of their farm (such as crop sowing and marketing). However, our data showed that other family members (including partners and siblings) also helped them to make decisions about cultivation and other farming activities (as shown in Table 11.1 in the Appendix). The average age of these

[16] The detailed descriptive statistics are given in Appendix 11.2.

[17] We followed the Federal Bureau of Statistics definition of smallholders (i.e. having 12.5 acres or less). However, 12 farms in our sample survey had 13 acres of land.

secondary decision makers was 35 years. We also note that about 6% of these secondary decision makers were women and the ratio was much higher in District Lahore (41%).
Data on cropping patterns show that about 21% of smallholders grew vegetables as major crops, 45% grew fruit, and 50% grew cereals. Whereas farmers within Sargodha and Muzaffargarh mainly focused on fruit crops (e.g. citrus and mango), farmers in Kasur and Lahore specialised in vegetables, along with cereals and floriculture.

Another distinguishing feature of the survey data is in relation to female participation in farming activities. Data showed that the ratio of females to males in family labour was 8% to 92%, whereas for hired labour this ratio was 18% to 82%, respectively. Table 7.2 provides a district-level comparison with regards to the proportion of females involved in farming activities. We note that, for the most part, the women's involvement was confined to sowing, hoeing and harvesting activities (which varied across the districts).

Table 7.2: Gender Based Labour Participation in Farming Practices (%)

Family Labour (Male)	92.6	93	89	97.7
Family Labour (Female)	7.4	7	11	2.3
Hired Labour (Male)	69.7	86	83	92.7
Hired Labour (Female)	30.3	14	17	7.3

In our study, we observed that farmers faced increased costs of inputs as depicted in Table 7.3. We noted that chemical costs (combining pesticides and fertilisers) contributed about 43% of total input costs (on average) followed by harvesting (25%), seeds (15%), ploughing (9%) and irrigation (8%). A district-level comparison showed that farmers in Kasur District experienced the highest cost per acre for harvesting, fertilisers and irrigation compared with other districts. However, depending on the nature of the crops (e.g. vegetables), harvesting costs varied significantly across different ago-climatic zones (see Figures 11.3 a&b in the Appendix). This was due to the fact that farmers in the Kasur District mostly grew vegetables such as chilli, onion, eggplant and potato which involved higher costs (they require hoeing and harvesting activities) because of a longer growing season in comparison to other crops (like wheat and rice). In addition, farmers also used intensive farming, such as tunnel cultivation, which may have resulted in higher costs for some inputs.

Table 7.3: Per Acre Input Cost in Different Districts

Inputs	Kasur	Lahore	Muzaffargarh	Sargodha	All Districts
Ploughing	8	7	9	15	9
Seed	14	13	18	20	15
Irrigation	7	9	6	6	8
Fertilisers	24	33	34	38	30
Pesticides	13	16	13	10	13
Harvesting	34	22	20	11	25

Survey results indicated that energy costs, fertiliser prices and decreases in price levels of produce sold had an important influence on profitability. The average profit margins per acre were about PKR 200,000, which varied across the crops significantly (See Table 11.5 in the appendix). We also questioned farmers about their satisfaction with the prices of inputs and, unsurprisingly, most of them were dissatisfied. Most of these factors were beyond the farmers' control and, in order to recover their profit margins, they needed to either find ways to reduce costs, improve farm productivity or receive higher prices for their produce.

7.1.1 Sources of Credit

Survey results showed that few farmers attempted to apply for credit. Across the four sample districts, only 19% of the smallholders had attempted to obtain additional finance, although there were notable variations across the four districts. The sampled farms in Kasur were most likely to seek credit – about 30% of them reported that they attempted to access credit in the past 12 months – followed by farmers from Sargodha, Muzaffargarh and Lahore at 20%, 14% and 10%, respectively.

Of those farmers who requested credit, less than half reported a successful outcome. Once again, there was a wide regional variation. Whereas smallholders in Sargodha district were less likely to apply for credit, those who did apply had a higher probability of success. Information asymmetry may be the cause of this problem in that farmers were not aware of different credit sources and credit providers were unable to assess the credit worthiness of the farmers.

Of the formal sources of credit, banks, microfinance institutions and dealers/commission agents were significant contributors (as shown in Figure 11.4 in the Appendix). Similarly, dealers and NGOs also contributed significantly, which indicates that formal institutions have begun to play a significant role in the development of Pakistan's agricultural sector. Informal sources of credit (including from friends and family) played a vital role in providing finance to some farmers.

Various reasons were cited by the farmers for not seeking agricultural credit for their farms. While a minority of them (39%) said they did not actually require credit, the three main obstacles to obtaining credit were high interest rates, the fact that interest-based lending was perceived as un-Islamic, and complicated loan processes. All of these factors can be targets for financial service innovation for an unmet market. In particular, there is scope for investigating microfinance based on Islamic banking principles. A public-private partnership may be suitable to develop this type of finance for smallholders.

7.1.2 Smallholders' Adoption of Modern Practices and Supply Chains

Our survey results revealed that, for the most part, these farmers had not adopted modern farming methods and practices. The only exception was new seed varieties that were adopted by 62% of farmers. Within the sample, grading of fruit and cereals was rare and new marketing practices were reported by only 7% of farmers. The introduction of improved irrigation methods was reported by only 8% of farmers.

Statistics on supply chains indicated that about 50% of the farmers used last year's produce as seed input and a majority of the remaining farmers bought it from local markets and village shops. Similarly, 60% of farmers bought fertilisers and pesticides from local shops or markets and of them, one-quarter bought from dealers. Likewise, farmers disposed of their produce via various outlets. The sample data indicated that one-third of the growers sold their output in the local markets. Only 14% took their vegetable crops to larger markets. However, this percentage was higher for those farmers who sold fruit.

7.2 Sources of Farm-Level Productivity

Our productivity analysis provides a detailed explanation of various sources of farm-level productivity. The decomposition of productivity into its various exhaustive measures (such as mix and scale efficiency) provides insights to identify areas that can help to enhance smallholders' productivity. Mix efficiency is a relatively new concept associated with scope economies, which occur through changes in inputs (e.g. capital-to-labour ratio) and output mixes (potato to cauliflower) in response to changes in input and output prices (See O'Donnell, 2012; Ahmad, 2014). In other words, mix efficiency also refers to changes in productivity through product diversification.

The estimates of technical efficiency showed that, on average, farmers could increase their production by 38% using the same input resources. Table 7.4 shows that farmers in Muzaffargarh district appeared to be most technically efficient with an average efficiency score of 66.7%, followed by Lahore district (63.4%), Sargodha district (62.4%) and Kasur district (61.8%). Furthermore, these differences were significant across various crops. We also noted that technical efficiency increased for the larger farm sizes, indicating that farmers with relatively large farms were able to perform better farming practice methods. Moreover, these estimates differed across the various crops. For instance, the results indicated that those smallholders growing tomatoes and onions in Kasur district outperformed growers from the three other districts. These productivity differentials across different crops and districts are indicative of the varying farming practices.

Table 7.4: Average Estimates of Components of Farm Productivity (Percent)

District	Technical efficiency	Mix efficiency	Scale efficiency	Residual mix efficiency
Kasur	61	72	69	56
Lahore	63	77	52	53
Muzaffargarh	61	76	76	59
Sargodha	62	59	67	29
Full Sample	63	70	68	47

Scale and mix efficiency analysis enabled us to comment on how farmers should adjust their scale and scope operations in response to changes in the market environment. Our estimates of mix efficiency indicated that farmers could improve productivity by 30% as a result of appropriate adjustments to input mixes.

Further analysis of productivity components revealed that there are substantial differences in best practice processes among the smallholders (See Table 11.4 in the appendix). For instance, there was a difference of 35% in technical efficiency estimates between the bottom 10% and the top 10% – a finding which suggested that large productivity gains could be attained through adopting best practice methods. This outcome can be achieved through education by training low-performing smallholders. Similarly, attention must be given to significant differentials due to incorrect use of inputs among farmers with regards to appropriate pricing policies and timely provision of these inputs. Scale differentials appeared to be the highest among these framers, which further necessitated optimal input utilisation to realise scale economies.

Crop-level analysis of mix efficiency indicated that cereal growers were less productive in terms of input mix compared with smallholders growing vegetables and fruit (See Table 11.5 in the appendix). For instance, input mix efficiency in vegetable-growing areas was higher than for fruit and cereals. Amongst the vegetable growers, eggplant and cauliflower growers seemed most likely to improve productivity levels through appropriate input usage, whereas mango growers were most efficient within the fruit-growing areas (i.e. citrus in comparison to mango). We noted that smallholders in the mango-growing area (Muzaffargarh district) also cultivated tomatoes and chillies, and this crop diversification helped them to have higher farm productivity levels. Adjustments in scale and scope operations need significant improvement if they are to result in an increase in agricultural productivity.

7.3 Determinants of Productivity and Profitability

In this section, following our decomposition of farm level productivity into its different sources, we analysed the impact of external factors of productivity and profitability of farms. We estimated various models to link productivity components with external factors, including farm and farmer characteristics, credit, awareness of modern cultivation practices, contacts with market and peer groups, and zonal (as well as crop) dummies to determine the impact of these factors on components of productivity such as technical efficiency, scale and scope economies.

The econometrics analysis showed that farmers with diversified crops (e.g. vegetables) had higher farm productivity and profitability – a result which corroborates with our earlier findings of scope economies. This relationship was also confirmed from our crop-wide analysis of per acre profit, which indicated that vegetables and fruit were more profitable in comparison to cereal crops. We also noted that some vegetables (tomato, bitter melon and chilli) had much higher profit margins in comparison to with fruits (e.g. grapefruit). This can also be attributed to crop diversification as we noted that farmers in these areas were growing multiple types of vegetables.

The empirical findings reveal that farmers who received credit earned higher profits per acre than those who did not receive credit. However, farm profit margins were considerably reduced for those smallholders who had taken expensive loans from commission agents. This suggests that access to credit tends to make farms more profitable; however, there is a caveat that the true direction of causality between credit and profitability may not be

guaranteed without panel data. Another interpretation could be that farmers with profitable businesses are seen by lenders as being more likely to repay their debts and are therefore granted credit.

This finding indicated that credit helped farmers to better manage their farming practices which, in turn, allowed them to achieve higher productivity and profitability levels. However, this seemed to be at the cost of foregone profits, particularly in the case where farmers are bound to sell their produce to the lenders at a higher commission. These results suggested that credit problems differed across regions and, therefore, a policy response needs to be customised on a regional basis. There is a far greater opportunity for initiating credit assistance schemes in regions where requests for credit are very low.

The evidence from our econometric analyses also suggested that vegetable and cereal growers were more likely to seek credit, while citrus and mango farmers were much less likely to apply for loans. This makes perfect sense because the inputs required for cereal and vegetable farms at the beginning of the cropping cycle are much higher in comparison to mango farms. It was also noted that farmers who had many supplier contacts were more likely to receive credit. This result could be interpreted as input suppliers lending to farmers in order for them to be able to purchase inputs such as pesticides and fertilisers.

Similarly, those farmers who had more contact with buyers, as well as those practicing innovative methods, were more profitable. Likewise, educated farmers having more experience were able to transform their farming practices into more profitable businesses.

In summary, the following relationships were discovered in the econometric analysis:

- Farmers with more links to supply-chain actors made a higher profit from selling their produce
- Famers who graded their fruit and vegetables earned significantly higher profits than those who did not
- Growing off-season vegetables yielded higher returns
- Using improved seed varieties significantly increased farmers' incomes
- Using efficient irrigation systems increased farm profits.

These results showed that practices with high profit potential were not being adopted and this could be the basis for an important policy initiative to rectify this situation.

7.4 Productivity Outcomes of Innovation and Extension Services

In this analysis of survey data, we showed that adopting technology and new methods of production (grading) as well as accessing new markets through distribution channels had a significant correlation with higher levels of profitability.

These three types of innovations were important to improve profitability levels of farmers both in and out of this sample. However, a complication emerged in that farmers who did not deploy these methods were not readily able to access information about how to perform these practices. Our results showed that the most profitable practices were those of which farmers were least aware.

To support these findings, we used logistic regression analysis to investigate the drivers of innovative practices. The results revealed that education was one of the important motives for practicing innovative farming methods. We noted that high levels of farming experience was also positively related to the adoption of improved technology, which indicated that learning-by-doing (from own and other's experience) led to increased productivity and profitability for farmers. These findings demonstrating the effects of adopting innovative farming practices suggest that policies, which focus on encouraging smallholders to introduce new methods may result in significant increases in farm productivity and profitability.

In addition to a mismatch between information and training provided to farmers and the most profitable practices identified above, we also noted that government extension services were not optimal from the farmers' perspective. In the survey, we questioned farmers about their level of satisfaction with the extension services. In all the districts, over one-half of the sample respondents were dissatisfied or highly dissatisfied with the extension services.

The dissemination of improved farming practices is a major topic of interest for agriculture policymakers. Typically, governments develop extension services in order to educate farmers about new farming methods; however, other sources of information such as media, input suppliers, buyers and other farmers are also significant. In the survey, we asked farmers about their awareness of sources of information on improved methods.

About one-third of farmers were aware of television and radio programs that provided information on farming practices. Many farmers had also visited demonstration farms and their proportion was similar to those who knew of farms in their area. When farmers were aware of demonstration farms located nearby, they tended to visit them to become better informed (See Figure 11.5 in the appendix).

A clear implication for formulating policy is to focus on disseminating information about profitable practices. In the survey, we questioned farmers as to what they considered were the factors that affect the profitability of their farms. Energy costs, fertiliser prices and decrease in sale price of produce were cited as factors that have an important bearing on profitability.

The low rate of advice received about profitable farm practices was identified from the data analysis in this survey. Information on seed gradation, produce gradation and irrigation methods were received by less than 15% of the farmers. It was possible that when farmers do receive advice, they did not receive it on the practices that had the most important influence on profitability. More analysis is required in this respect, but the clear implication is that information channels and extension services need to focus more on marketing and produce value-adding.

7.5 Market Supply Chain Issues

Our survey results also included farmers' satisfaction levels with the availability of inputs, their prices, product marketing and sale issues. Most of them were not satisfied with the availability or price of these inputs or the marketability of their products. The majority of

farmers relied on purchasing inputs from local markets or villages at higher prices because of limited access to market value chain (See Figure 11.6 a&b in the Appendix). The reasons they stated for buying inputs from local sellers were easy access and availability of those inputs on credit. However, this practice resulted in increased costs due to higher prices, as well as delayed delivery of these inputs (fertilisers, in particular). Most of the vegetable growers were dissatisfied with the effectiveness of pesticides and insecticides available to them from the local market.

Similarly, farmers are faced with output disposal issues such as remote market access, increased transportation costs, decreased product prices, delayed payment for their products, and post-harvest crop management issues such as crop storage (See Figure 11.7 in the appendix). For instance, half of the surveyed smallholders faced marketing and sale issues which resulted in high post-harvest losses. Likewise, more than 60% of the sampled farmers indicated they were concerned about decreased output prices, followed by high transportation cost (i.e. 58%).

Some notable facts regarding market value chain were as follows:

- About one half of vegetables grown in Kasur were sold in the local market (within five kilometres), followed by Muzaffargarh (40%) and Sargodha (13%).
- However, 28% of vegetables from Kasur district were sold in large markets (Lahore or Islamabad).
- About 45% of fruits from Muzaffargarh were taken to local markets (within 20 kilometres) and the remaining 55% are sold in large markets.
- On the other hand, in Sargodha about 60% of fruits were taken to local markets, with the remaining 40% being sent to large city markets.

Most of these factors were beyond the control of farmers. For this reason, to recover their profit margins, they need to either find ways to reduce costs, improve farm productivity or receive higher prices for their produce.

Livestock value chain and dairy sector:
Our survey sample showed that most of the farmers owned cattle to supplement their farm income.

We note the following:

- Like the horticultural sector, the dairy sector was dominated by smallholders
- On average, farmers stock three milk animals
- The average milk sale by household was 13 litres per day. Moreover, they also sold their animals (e.g. cows, goats) – mostly within the local market – to supplement their livelihood
- Livestock holders also revealed that many factors such as limited availability of fodder, lack of market access and unavailability of credit inhibited their expansion of livestock assets.

7.6 Focus-Group Interviews: Case study-District Kasur

A group of 20 farmers was consulted from some villages within District Kasur. All of these farmers were vegetable growers and mainly grew cauliflower, potatoes, colocasia (arvi) and

brinjal. In addition, they grew cereal crops, including rice, wheat and maize. Most of the farm land is clay soil or a mix of clay and sandy soil, which are suitable for growing vegetables. The average annual lease rate was PKR 40000 to PKR 50000 per acre. The majority of the farmers had joint land holdings and worked as a family unit.

We noted the following main issues faced by these smallholders:

- The majority of interviewees were worried about the timely availability of fertilisers and pesticides. One of the reasons they identified was the lack of money/finances to pay for these inputs.
- Farmers were concerned about increased irrigation and fertiliser costs in recent years, which have considerably eroded their profitability levels.
- Most of the farmers purchased fertilisers and other inputs (seeds and pesticides) from the village shop. To them, it was much easier and quicker to buy fertilisers on credit from the local shop rather than obtaining formal credit. However, this access to informal credit had been exploitative as they had to pay a much higher price for inputs.
- Lack of interaction with the agriculture department was common. A majority of farmers had never received any information/education from agricultural officers regarding application of seeds, fertilisers and pesticides. Most of the farmers were using uninformed methods to apply fertilisers and pesticides. They were not aware of the hazards associated with these chemicals and did not take appropriate precautionary measures while applying them.
- Most of the farmers also expressed their concern about the marketability of their crops. The majority of these farmers were constrained to either selling their products on their farm or to the local middleman.
- The increased electricity prices had multiplied their costs of production and, as a consequence, reduced profit margins. They also stated that they were not aware of marketing strategies to increase their profitability levels.

Farmers' views and suggestions:

- Non-payment issues and delay in payment for crops: Farmers were concerned with the government procurement rate because it was always different from the market rate.
- Issues in market access (other than infrastructure): Government should ensure timely availability of inputs (particularly fertilisers) at market rate.
- Innovation and extension services: Farmers wanted help from the agriculture department regarding the introduction of extension programs. Moreover, they were willing to adopt innovative methods and attend training programs on modern cultivation methods (e.g. dripping, tunnel farming) provided by government and other bodies.

We conducted an in-depth interview with one farmer who is applying new methods to his farming practices (such as tunnel farming) in order to achieve quality improvement of his produce. This smallholder had 34 years of farming experience and cultivated a total of 15.5 acres land (he owns 1.5 acres and leases 14.5 acres). He mostly grew bitter melon, cauliflower (both in summer and winter), eggplant, onion and green chillies. Consequently, he was able to mitigate financial losses through crop diversification. Despite his illiteracy he introduced innovations into his cultivation activities and was gradually shifting towards tunnel farming. He also graded his produce before taking it to the market, which fetched a

higher return for him. When compared with other farmers with an almost equivalent amount of land and who cultivated the same crops but practiced traditional cultivation methods, we noted there were significant increases in profits. Due to this practice of grading his produce, he established his reputation as someone who sold quality produce, which lured buyers to purchase his vegetable products at higher prices. Moreover, he was offered lower commission rates by agents to attract his product to their outlet. Another important finding from this follow-up interview revealed that about 6% of total revenue was paid as commission to dealers for the loan accepted from them. This tended to significantly reduce profitability levels.

While both the public and private sectors recognise opportunities to generate wealth, support food security and create export income through the horticultural sector, the challenge has been in working with smallholders, who are the largest contributors to agricultural production but are fragmented and costly to work with on a one-to-one basis. This dispersed and informal nature of the smallholder economy makes it difficult to efficiently provide credit access, training programs and coordinate supply-chain investments which usually depend on scale efficiencies. We identify a number of constraints that smallholders are facing in developing counties in general and Pakistan in particular. These include lack of innovative practices, limited access to credit, extension services and market access. These constraints are challenging, yet they provide an opportunity for policy innovation.

8 Impact

The horticultural sector has great potential to contribute the Pakistan's economy through value addition. However, it is currently facing many constraints which impede smallholders' productivity and profitability. The identification of these issues is imperative to develop economic strategies to ensure food security and pro-poor growth. In this way, it requires careful economic analysis to suggest evidence-based policy options.

This project developed new methods to measure and segregate farm-level productivity and profitability into its various drivers in a way that hasn't previously been done. The main advantage of this approach is that it only requires input and output quantities for the productivity analysis which suits agricultural data where input prices are often distorted. A novel feature of this approach is econometric estimation of mix efficiency, which has not been attempted previously. It allows researchers to measure productivity effects as a result of changes in input and output mixes. In addition, we also developed survey tools to measure the farmers' capabilities in their businesses and its relationship with productivity levels. All of these scientific advances will improve future research on agriculture in emerging economies. In addition to developing these new methods, we also shared this expertise with our collaborators in Pakistan which, in turn, led to a higher level of research capacity in those teams with whom we worked.

This SRA also helped to develop the capacity of local researchers and university graduates. We provided intensive two-day survey training to 10 PhD faculty members from five Pakistani universities, staff from Punjab Agriculture Department and graduates of these universities. Moreover, the involvement of faculty members in finalising the unique survey tool and engaging university graduates in data handling and analysis helped them to learn new methods of economic policy analysis.

The final presentation day and policy dialogue during April with different stakeholders in Islamabad provided an opportunity to share and discuss the impact of policy. Many international organisations (including IFPRI, FAO, USAID and NGOs) participated in the workshop and took a keen interest in the research findings. These study findings have already received attention from the Pakistan government and were part of a briefing given to the Prime Minister by Dr Azeem Khan in April 2016. As Pakistan develops a new agriculture strategy, we are pleased to report that our findings in relation to productivity, mix efficiency and crop diversification have been taken into consideration as part of the national agriculture strategy.

Our findings revealed a lot of waste and inefficiency in the use of farming inputs. Excessive use of fertilisers and chemicals is not only costly but also damaging to the waterways, farmland and to the farmers themselves. By providing better training to farmers, our study shows that they can improve farm productivity as well as sustainability. In the new SRA, we designed ways to test the effectiveness of training and extension services, including more efficient ways of using these farming inputs. If future training programs are supported with this evidence-based design, we will start to see more efficient use of fertilisers and chemicals by farmers so that the negative impact on farmland and the food chain will be minimised.

8.1 Communication and Dissemination Activities

The findings of this study has been disseminated through seminars, individual meetings with high officials from the Punjab Agriculture Department, representatives of international donors and NGOs who are involved in similar research in Pakistan. Policy briefs have been shared with ACIAR and other stakeholders. These findings have also been profiled in the ACIAR biannual newsletter. We have also presented the main findings of the project at an international conference (An abstract of the paper and three policy briefs are attached). The final report will also be made available on the UQ Business School website soon. We are also working on three main papers based on our above mentioned findings and plan to submit to highly-ranked academic journals including Journal of Development Economics.

9 Conclusion and Recommendations

9.1 Conclusions

Based on our empirical analysis the following inferences can be drawn:

- The examination of components of total factor productivity and the relationship between technical efficiency and various socioeconomic, institutional and market environment characteristics show that education, access to credit and extension services have significant influences on farm productivity.
- There is a need to reduce energy costs to increase the profitability levels, which will help to reduce rural poverty.
- The expansion of agro-markets in rural areas will improve the input side of supply chains. In addition, the adoption of improved technologies and practices will increase both productivity and profitability of smallholder farms.
- The lack of extension services and education about appropriate use of inputs impedes farm-level productivity. The data revealed that farm-level productivity is mainly affected by not adopting best management practices and the optimal mix of inputs.
- Some farm practices are highly correlated with improved farm productivity and profitability. However these practices are not being actively promoted in the smallholder sector. Farmers appear to have a preference for embracing new practices if they are able to observe those practices in action. If they are close to a demonstration farm they will use it and similarly, if a neighbour uses modern practices, they are also more likely to adopt them.
- While these aforementioned productive practices are very important for improving the profitability of farmers there is a complication that farmers are not readily able to access information about how to perform these practices. Our results show that the most profitable practices are those that farmers are least aware of. Using our evidence to prioritize the spread of more productive practices will make farm training and education services more effective in their use of limited funding resources.
- Even though most farmers do not apply for credit, they have indicated that they would like to do so if they had the opportunity to overcome barriers such as complex application processes, the need for collateral and high interest rates.
- Given that market-orientated practices such as grading and processing are associated with higher levels of profit we encourage the enabling and diffusing these practices through collaborative farming groups and cooperatives.

9.2 Recommendations

The evidence shows that policy interventions should be targeted to promote productive farm management practices through education and training programs. For instance, initiatives focused on farmers' education on how to make better use of inputs (e.g., fertilizers and seeds) and grading of their produce are clear pathways for improving productivity. The provision of credit and extension services should also be long-term policy strategies to improve farm productivity.

Encouraging improved practices and better supply chain strategies must be considered as important levers of positive change for farm-level productivity and farmer incomes. This can be achieved through:

- The introduction of best practices and promotion of new methods of cultivation and marketing.
- Input and output price policies that could have a positive impact on productivity gains. This would help farmers to improve decision-making processes in relation to crop diversification and realisation of better net returns.
- Encouraging financial service innovations in partnership with lenders who are less exploitative and who offer loans with fewer strings attached. The process of obtaining credit must be made simple and easy to understand and the terms of the finance must not be too financially onerous. A public-private partnership may be suitable to develop this type of financial service for smallholders.

Farmer education and training can have a significant impact on improving productivity levels, which underscores the importance of introducing cost-effective and wide-scale training programs. Our focus in this type of study would be how to:

- Establish efficient and transparent input and output supply chains to achieve higher farm-level productivity and profitability
- Formulate gender-specific policies to empower women in farming to achieve a sustainable rural livelihood through increased farm incomes.
- Provide extension services and access to other sources of information that could help smallholders to adopt productive farming practices.

The findings of our study show that the policy interventions on credit availability, extension services, marketing, and value addition strategies are important to improve smallholder farm performance. An in-depth analysis with experimental design and field testing is still required to investigate the impact of intervention strategies such as provision of extension services, credit facilities and collaborative marketing and technology adoption practices over time. In particular, we recommend a comprehensive analysis of the role of women in generating farm income and value-addition through food processing and marketing of farm produce to understand the impact of economic empowerment of women on farm productivity.

With this focus on particular forms of intervention the opportunity exists to determine the most effective delivery of these interventions to further extend the evidence base for policy investments. This will enable policy makers to direct limited funding resources to programs that will have the most positive impact for smallholders.

10 References

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10.2 List of publications produced by the project

Ahmad, S. and Steen, J. (2016). Small farmers' capabilities and farm level productivity: Empirical evidence from developing economies, paper presented in Asia Pacific Productivity Conference April 08-10, 2016, Nankai University, Tianjin, China.

Note: The abstract of the paper is attached in Appendix 3. In addition, three policy briefs are also attached in the appendix.

11 Appendices

Appendix 1: Research Methods and Sample Selection

Sample Design

We adopted a multi-stage sampling design to finalise the survey sample in different districts of Punjab. In the first stage (during our scoping study), we identified clusters of various vegetables, fruit and floriculture farming. We focused on four districts, namely: Lahore, Sargodha, Kasur and Muzaffargarh. These four districts are located in different agro-climatic zones and focus on varying farming practices. Sargodha is known for citrus; Kasur and Lahore for vegetables (e.g. cauliflower, potato and turmeric) and nursery planting (ornamental and other plants); and Muzaffargarh for mango, chilli, and tomato.

After identifying different clusters, we randomly selected villages based on an official list of mouzas obtained from agricultural offices. At the second stage, we selected mouzas within each district and cluster. Lastly, we used random sampling to select the farmers/household we would target to collect the desired information.

Figure 11.1: Map of Survey Areas

11.1 Determination of Sample Size

We used proportional sampling to determine the sample size from each district. This proportional sampling implies that there was oversampling in some areas that had a high concentration of a specific crop (e.g. cauliflower). Keeping in mind that there tends to be a 20% non-response rate, we also allocated additional villages in each agro-climatic zone.

The following scheme was applied to generate the sample from all four districts.

i) District Muzaffargarh

- The main focus was on farmers growing mango, tomato and chilli crops.
- A total sample of 250 households was collected from all tehsils in the district.
- Data from 100 households (10 per mouza from 10 mouzas) has been generated from tehsil Muzaffargarh.
- 150 farmers from each tehsil – Kot Addu (50), Ali Pur (50) and Jatoi (50) – were interviewed

ii) District Kasur

- A sample of 250 households was collected from all four tehsils with a focus on each type of horticultural crop, which included the following:
    - Nurseries (ornamental and other species)
    - Turmeric area in tehsil Pattoki and Kasur
    - Cauliflower area in Tehsil Kasur
    - Potato and onion (Tehsil Chunian, Pattoki and Kasur)

iii) Sargodha District

- A total of 250 sample households were selected.
- We mainly focused on citrus crops; however, data on vegetables and other crops were also taken into account.
- Data coverage from all four tehsils was confirmed to capture the crop diversity.

iv) Lahore District

- A total 100 sample farmers were selected for the study.
- Mostly vegetable growers were targeted in the sample.
- We mainly collected our sample from two large rural areas (Kahn Nau and Wahga border) because the rest of this area is covered by urban dwellings.

Table 11.1 below provides the details of sample size focused on major crops data.

Table 11.1: District Wise Sample Distribution

Kasur	250	Cauliflower, Turmeric, Potato, Chilli, Onion, Nursery, Cereal
Lahore	100	Mixed vegetables, Cereal, Orchards
Muzaffargarh	250	Mango, Tomato, Chilli, Cereals
Sargodha	260	Citrus, Mixed Vegetables, Cereals

Survey Instruments

A comprehensive survey instrument was developed in consultation with team members, as well as household survey design experts. This instrument was developed along the same lines as the University of Cambridge innovation survey, as adapted by the University of Queensland for horticultural purposes. We translated the questionnaire into the Urdu language to ensure that farmers and interviewers fully understood the questions in order to provide/record correct information on different topics included in the survey.

Survey Implementation

A group of 25 university graduates with agricultural sciences or social sciences degrees was selected for the field survey. These graduates belonged to the sampled districts and so they understood the local language. These enumerators were supervised by the faculty staff from five universities in Pakistan, including University of The Punjab, University of Sargodha, Bahauddin Zakriya University, Multan, University of Agriculture, Faisalabad, and

the International Islamic University, Islamabad. These enumerators attended a two-day intensive training course at the University of Sargodha so that they fully understood the survey questionnaire. At the end of the training period, they were also involved in a pilot survey.

Appendix 2: Sample Descriptive Statistics and Economics Interpretation

Table 11.2: Descriptive Statistics on Household and Farm Characteristics

Variable	Kasur	Lahore	Muzaffargarh	Sargodha	Total Sample
Farm Area (acres*)					
Bottom 10%	4	2	3	3	3
Bottom 25%	5.5	4	4	4	4
Median (50%)	8	6	7	6	7
Top 75%	11	9	10	10	10
Top 90%	12	10	12	10	12
Secondary Decision Maker					
Age (years)	35	32	36	39	35
Female (percent)	5	41	3	7	6
Education (%)	%	%	%	%	%
No education	33	86	24	---	66
Less than Primary	4	2	0	7	2
Less than Middle	13	2	10	13	5
Less than Matric	17	4	18	47	10
Less than Intermediate	8	4	24	27	10
Intermediate and Higher	25	2	24	7	8
Tractor/Machinery Ownership	45	24	23	19	25
Average Non-Farm Income (PKR /month)	11729	21212	17032	8169	14815

Note: * indicates the average value of each characteristic

Figure 11.2: Education Level of the Household Head

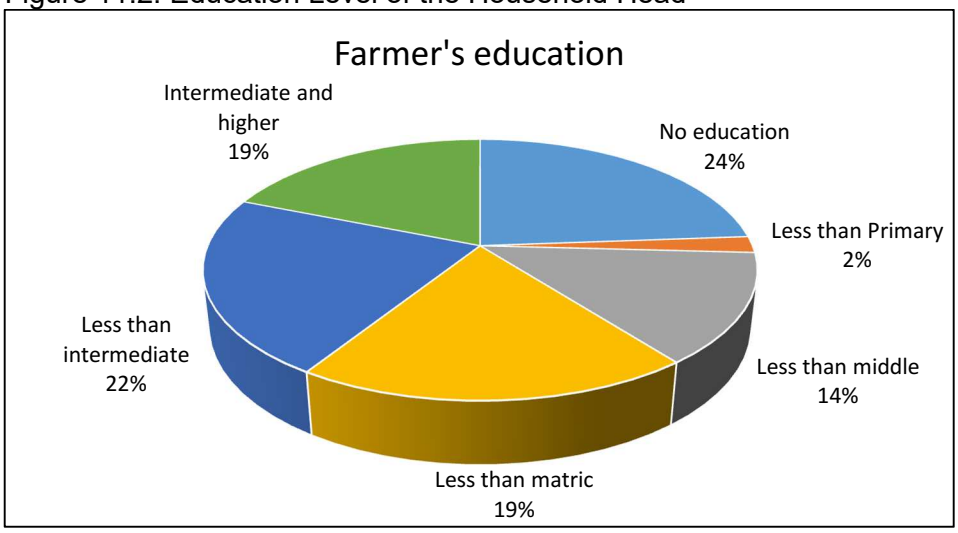


Figure: 11.3(a): Per Acre Input Costs (Full Sample)

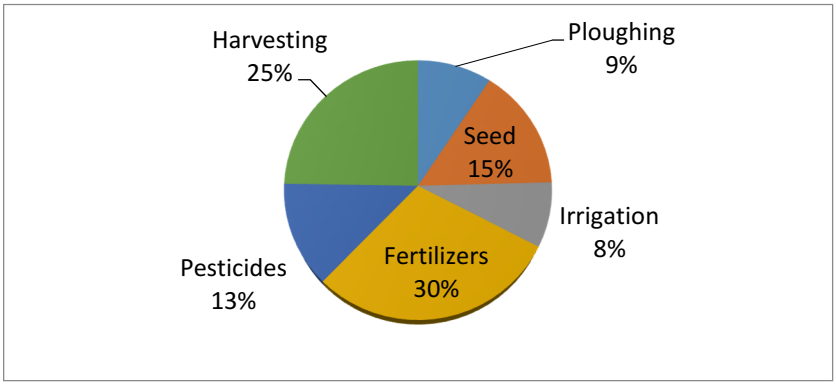
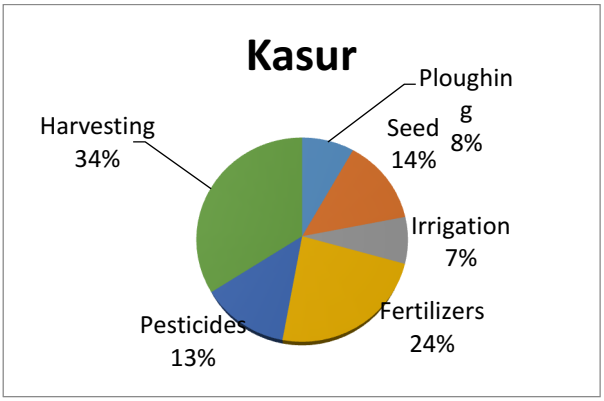
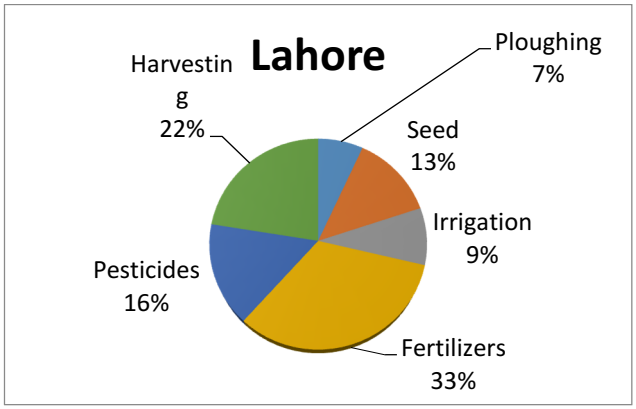
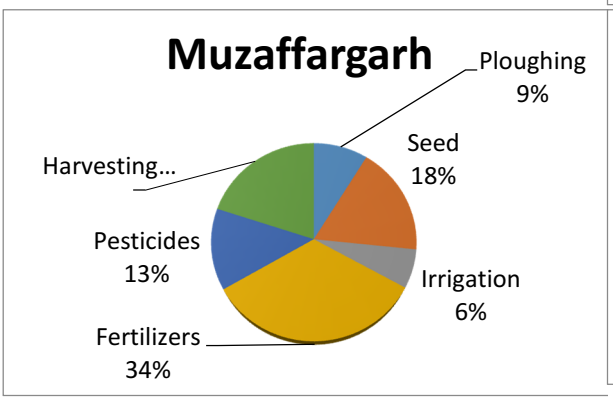


Figure 11.3(b): Per Acre Input Costs (District level)







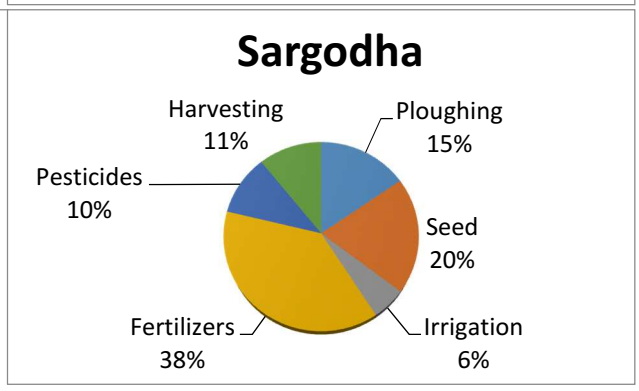


Figure 11.4: Farmers' Access to Sources of Agricultural Finance

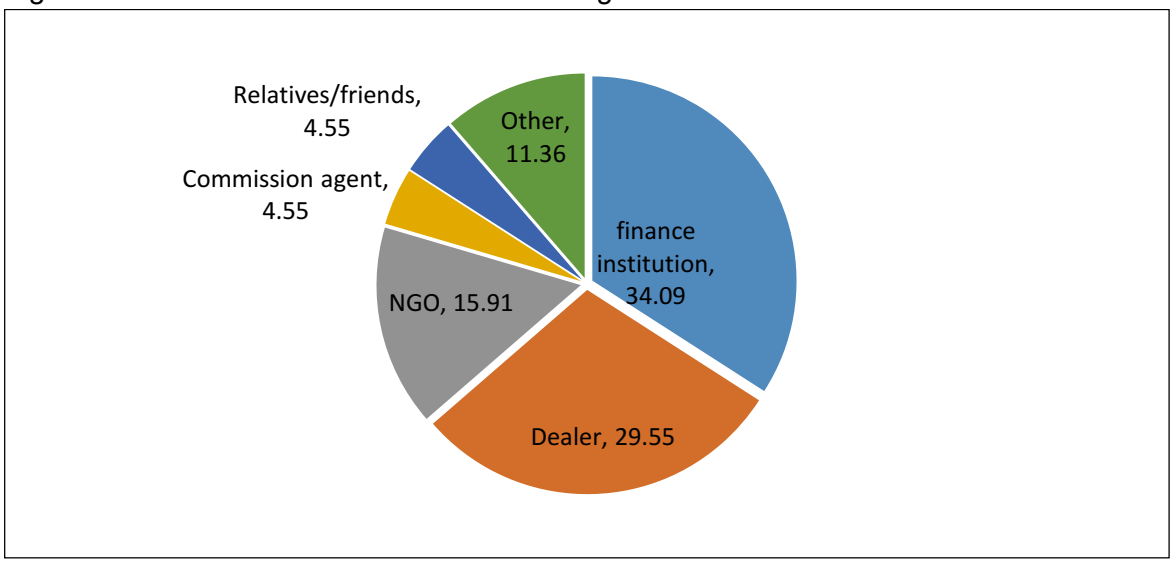


Table 11.4: Descriptive Statistics of Components of Farm Productivity

Quantiles	Technical efficiency	Mix efficiency	Scale efficiency	Residual mix efficiency
Bottom 10%	43	45	30	20
Bottom 25%	54	58	49	29
Median (50%)	65	72	75	47
Top 75%	72	84	91	65
Top 90%	78	93	99	77

Table 11.5 Cop Level Productivity Decomposition

Crop Description	Technical Efficiency	Mix Efficiency	Scale - Mix Efficiency	Residual Mix Efficiency	Profit Per Acre
Cereals					PKR
Rice	0.63	0.65	0.27	0.43	133149
Wheat	0.62	0.68	0.29	0.45	154230
Maize	0.63	0.69	0.34	0.48	161391
Vegetables& Spices					
Potatoes	0.63	0.79	0.40	0.63	148123
Tomatoes	0.62	0.75	0.57	0.64	820741
Chillies	0.61	0.75	0.39	0.53	356714
Cauliflower	0.61	0.82	0.47	0.63	133399
Bitter Mellon	0.63	0.77	0.38	0.53	355271
Egg Plant	0.58	0.81	0.30	0.53	249892
Turmeric	0.61	0.64	0.35	0.50	106984
Tobacco	0.64	0.72	0.30	0.44	171536
Fruits					
Citrus	0.63	0.68	0.31	0.43	284573
Mangoes	0.62	0.77	0.46	0.58	296031

Kino_Malta_Grapefruit	0.62	0.58	0.18	0.26	121774

Figure 11.5: Farmers' Awareness of Extension Services (Percent)

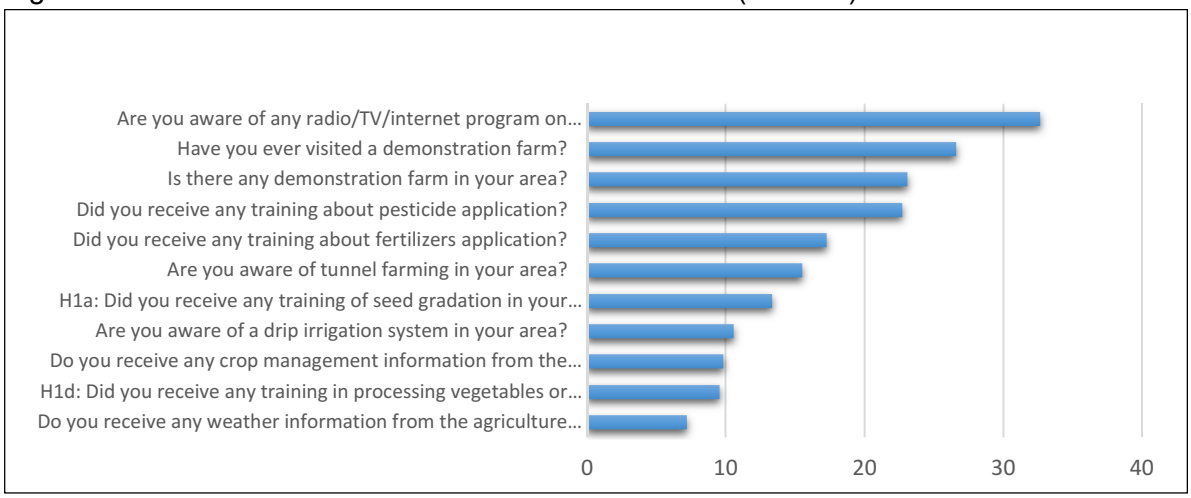


Figure 11.6(a): Sources of Fertilisers Purchase

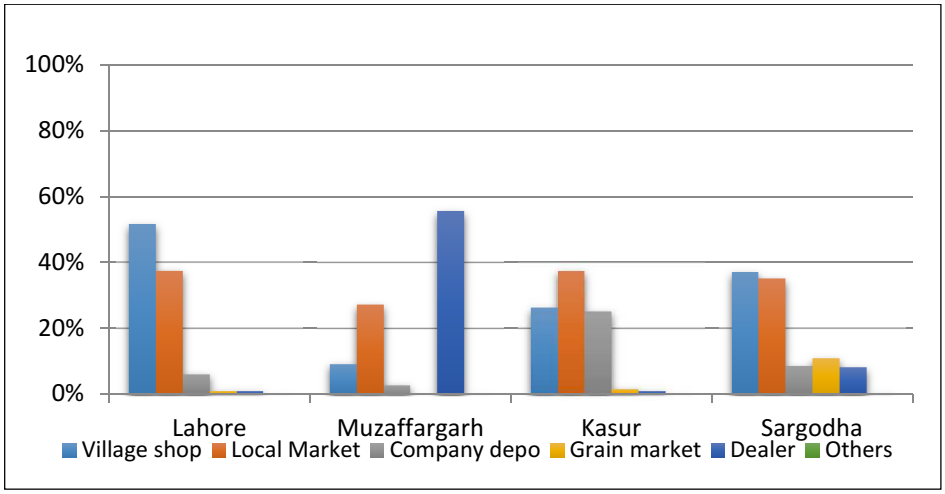


Figure 11.6(b): Sources of Pesticide Purchase

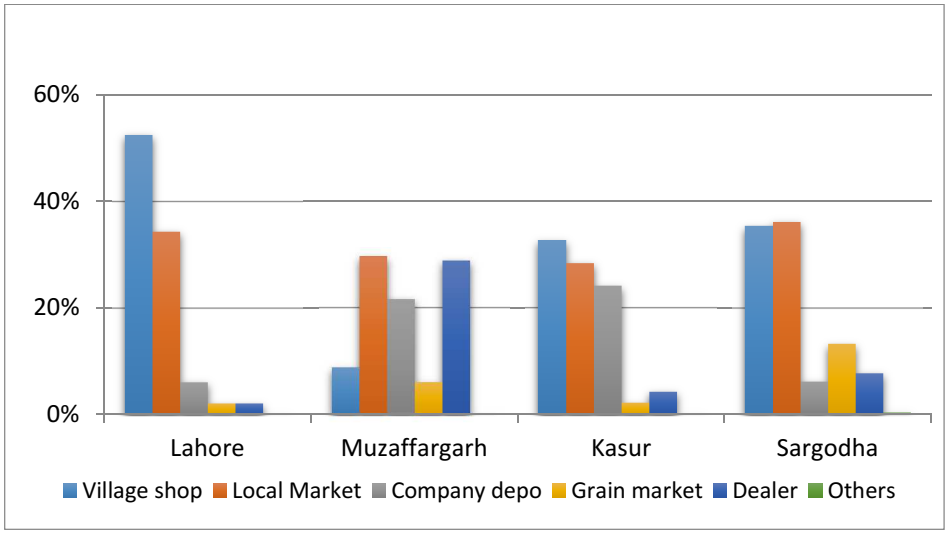
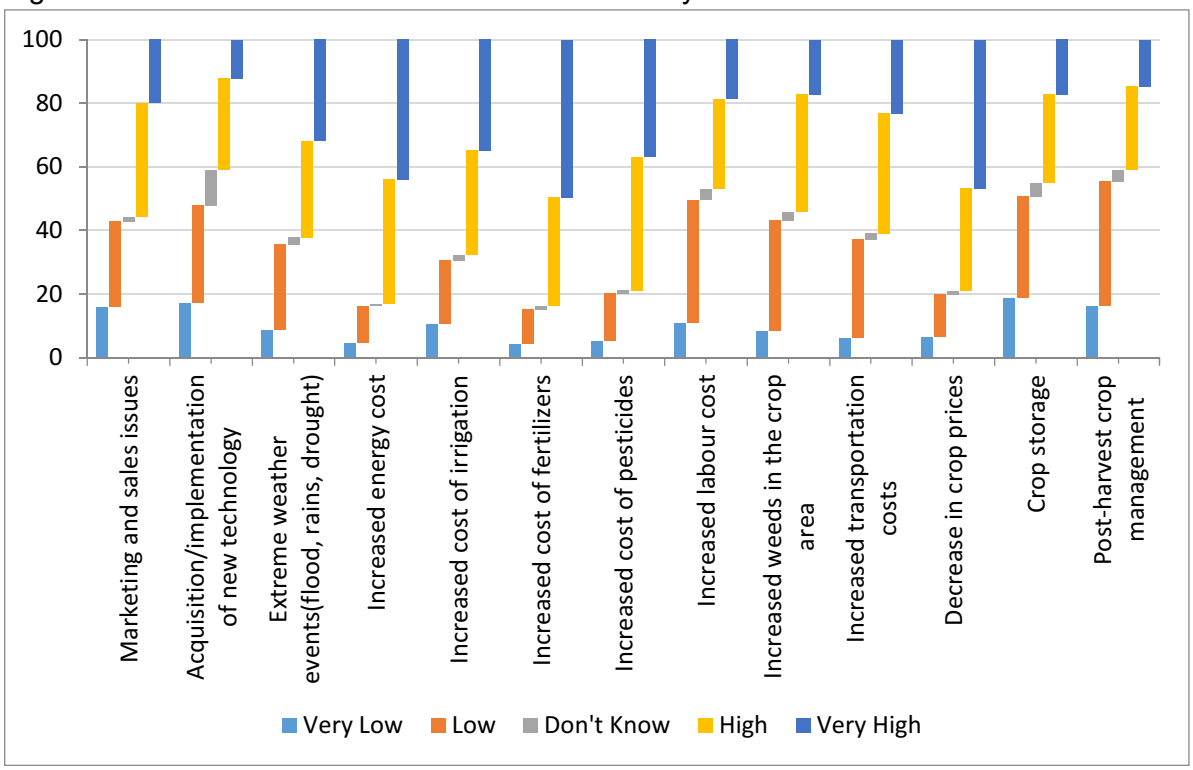


Figure 11.7: Farmers' Satisfaction on Value Chain System



Appendix 3: Abstract and Policy Briefs

Small farmer's capabilities and farm level productivity: Empirical evidence from developing economies

Shabbir Ahmad and John Steen
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Paper presented at Asia Pacific Productivity Conference, Tianjin University, Tianjin, China
9 July, 2016

Abstract

This paper proposes novel econometric methods to investigate the relationship between innovation, productivity and profitability of smallholders. More specifically, we aim to identify the factors affecting the capabilities of smallholders (particularly in the horticultural sector) that are likely to have a significant impact in pro-poor growth through enhanced productivity. The main objective of the proposed study is to measure small farmers capabilities by decomposing total factor productivity (TFP) into its various components such as managerial practices (technical efficiency), innovative practices (technology), and mix and scale effects, which are associated with scale and scope economies. Scope economies occur through changes in input and output mixes in response to changes in input and output prices; these are important for productivity because small growers cultivate a variety of crops by using varying input mixes. Particularly, we will estimate mix efficiency, which is a relatively a new concept. Mix efficiency is defined as the potential improvement in productivity when input or output mixes are changed. Any change in input mix (e.g., land to labour ratio) or output mix (e.g., crops to livestock) results in a change in productivity. We aim to explore the main factors affecting the capability development of farmers and what kind of policy measures can be adopted to improve these areas. We also determine the technological, institutional and capacity constraints that inhibit the development of smallholders' productivity.

We generated a unique dataset of 850 small farmers, which had been collected from different agro-climatic zones of Pakistan. Our survey data focused on the horticulture sector including mangoes, citrus, and vegetables. The empirical findings show that crop diversification increases the smallholder's productivity significantly. Moreover, financial constraints (such as credit availability), market access and lack of extension services appear to be the main factors impeding farm level productivity.

Key words: Agriculture sector, productivity, mix efficiency

Policy Brief 1

Smallholders' Productivity and Profitability in Pakistan: Evidence from Horticulture Survey

Motivation

Improvement in agricultural productivity and profitability has taken the centre-stage in discussions on food security and poverty alleviation in the developing countries like Pakistan (World Bank, 2008). Increased productivity ensures food security through greater utilization of resources in agriculture, as well as releasing productive inputs for use in other sectors of the economy (Shultz, 1953). From a policy point of view, the decision makers would like to know the factors impeding productivity growth and the degree of influence on profitability to better target interventions to achieve productivity growth and profit maximization objectives.

In informing possible interventions, it is important to explore whether productivity shortfall is the outcome of factors within the farm or outside the farm. For instance, if small farms are technically inefficient, that is the factor input combinations they use can be rearranged to achieve higher output levels with known technologies, then education and training programs (e.g., extension services) may be a desirable policy, compared to programs that encourage innovation and technological advancement. Access to explicit measures of farm productivity can help inform both public policy decisions on appropriate ways to facilitate productivity growth, as well as private individuals such as smallholder producers making better decisions on farm.

Moreover, the identification of characteristics of the production environment that affect the combination of agriculture inputs and outputs (such as market environment and knowledge about the use of technology) are important when identifying the sources of productivity and assessing whether agriculture sector payoffs can be increased through innovation or better access to input resources (e.g., fertilizers and credit facilities) or both.

Background

Agriculture is a key sector that has been identified as a priority area in the development plan of Pakistan to target pro-poor growth and achieve food security. The Pakistan Vision 2025 program and the Punjab Development Strategy Programme 2018 call for exploring various drivers of agricultural productivity to guide policy makers to formulate effective policies to deal with food insecurity and poverty issues.

This brief draws from a detailed analysis of horticulture sector productivity and its various sources that focussed on vegetables, mango and citrus sectors. The study used farm level survey data to estimate comprehensive measures of productivity, by decomposing the sources of productivity growth into those that affect resource allocation and profits. Hence the methodology was used to produce crop level estimates of profit and input costs and compare farm level returns for the selected crop enterprises.

Main Findings

- Farmers have experienced increased costs of inputs. These costs vary significantly across different activities as well as different agro-climatic zones. The increased cost

of inputs appears to have affected farm level profitability. A district level comparison shows that farmers in Kasur District experienced the highest cost per acre of harvesting, fertilizers and irrigation compared to other districts. Since farmers in the Kasur District mostly grow vegetables, viz., chillies, onion and potatoes, this may be one of the reasons behind the increased costs. In addition, farmers also use aggressive farming such as tunnel cultivation, which may have resulted in higher costs for some inputs.

- Based on our focus-group interviews, farmers are concerned over increased irrigation and fertilizer cost in recent years, which have eroded their profitability considerably. Our survey data also reveals that most of the farmers are either illiterate or have little education and thus lack the technical skills of input application (e.g., fertilizers). This, suggests the need for extension services to promote better use of the input resources.

- Vegetables and fruits are more profitable. Our crop-wise estimates of per acre profit show that vegetables are more profitable compared to fruits and cereals. Another important finding from a follow-up interview with one vegetable grower in Kasur reveals that about 6 percent of total revenue is paid as commission to dealers for the loan taken from them. This tends to significantly reduce the profitability.

- We also note that per acre yield of tomatoes, onions and peas differs significantly between Muzaffargarh and Kasur districts. Whether this is due to varying farming practices (e.g., aggressive farming) or other factors (such as output prices volatility) still needs to be explored. However, the insights from our qualitative survey data reveals that a large number of farmers express their concern about decreased prices of vegetables (e.g., potatoes).

- Farmers could produce same level of output by using 38 percent less input resources. Our productivity decomposition provides a detailed explanation of various drivers of farm level productivity. The estimates of technical efficiency based on the stochastic frontier analysis show that, on average, farmers could increase their production by 20 percent using the same input resources. Further, these differences are significant across agro-climatic zones. Farmers in Muzaffargarh district appear to be most technically efficient with an average score of 0.66, followed by Lahore district (0.63), Sargodha district (0.62) and Kasur district (0.61). The results also indicate that the growers of tomato, potato and onion in Kasur district out-perform growers from other agro-climatic zones.

  These technical inefficiency differentials across crops and agro-climatic zones are indicative of the varying farming practices. Our second stage analysis of production characteristics also shows that vegetable and fruit growers are more productive as compared to cereals and other crops. Moreover, these results show that education, access to extension services and access to credit facilities also improve farm-level productivity. Therefore, it may be stressed that farmers need training and education to enable them to optimally use inputs and technology to improve their productivity.

- Adjustment in scale and scope operations needs significant improvement to increase agriculture productivity. The decomposition of productivity into its various exhaustive measures such mix efficiency and scale efficiency was meant to provide further policy insights to identify areas that can help enhance smallholder productivity.

  Mix efficiency is relatively a new concept which is associated with scope economies, which occur through changes in input (e.g., capital to labour ratio) and output mixes (potato to cauliflower) in response to changes in input and output prices; these importantly motivate productivity because small growers cultivate a variety of crops by using varying input mixes. Scale mix efficiency analysis will enable us to comment how farmers are able to adjust their scale and scope operations in response to changes in the market environment. Our estimates of mix efficiency indicate that farmers could improve productivity by 30 percent with the appropriate use of input mixes. However, a further look at district level reveals that farmers in Our crop-level analysis of mix efficiency illustrates that tomato and onion growers in Muzaffargarh were efficient to make use of input resources as compared to famers in Kasur.

Policy Implications

- A considerable variation in input costs across farmers and districts indicates that farmers need more education and training to use appropriate amounts of inputs for various production activities. Moreover, market regulations regarding input and output prices could have helped realize more profits with decreased input costs and through increased farm level revenues.

- The examination of components of total factor productivity and the relationship between technical efficiency and various socioeconomic, institutional and market environment characteristics show that education, access to credit and extension services have significant influences on farm efficiency. The empirical results suggest that educating rural farmers about input use through the delivery of extension services and provision of streamlined credit facilities could have realized significant gains in productivity.

- The scale and mix efficiency appear to be the main drivers affecting the farm-level productivity. While the results of mix efficiency encourage farmers to account for the productivity losses due to incorrect use of input and output mixes, scale economies inform whether farmers are able to achieve the optimal scale of production with inputs change. The policies related to input and output prices could have larger impact on productivity gains. This would also be helpful to farmers in their decision making for crop diversification and realization of better net returns.

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Policy Brief 2

Does Credit Availability Impact on Productivity and Profitability of Smallholder Horticulure Farms in Pakistan?

Introduction

Access to credit at affordable cost enables growth of small businesses around the world. Firms and farms require working capital to invest in inputs and equipment. Therefore, lack of credit serves as a potential constraint for growth and profitability of firms and farms. Due to the time lag between planting and harvesting and seasonality of crops, the agriculture sector offers a special case where the availability of credit at the right time is critical for smoothing out the uneven cashflow of the farms.

Some previous studies have suggested that access to credit is indeed a problem for the farming community in Pakistan, but this research has been hampered by limited information on the nature and extent of problems faced by the smallholder producers (Ayaz et al., 2011; Ayaz and Hussain, 2011; Iqbal et al., 2003; Zahra et al., 2013).

Based on the data collected from nearly 850 smallholder farms operating in Kasur, Sargodha and Muzaffargarh districts, this study shows that even though most of the farms do not apply for credit, they have indicated that they would like to do so if they had the opportunity to overcome the barriers.

It is noteworthy that farmers who had access to credit earned much higher profits than those who were without it.

What proportion of smallholder farms are able to access credit?

Across the three sample districts, only one-fith of the smallholders in the survey smaple had attempted to obtain additional finance, although there was notable variations across the three districts. The sample farms in Kasur were most likely to seek credit with around 30 percent of them reporting attempts to access credit, followed by farms from Sargodha at 20 percent and then farms in Muzaffargarh at 14 percent and Lahore at 10 percent. These results suggest that credit problems differ across regions and therefore a policy response needs to be customized on a regional basis. There is a far greater opportunity for initiating credit assistance schemes in regions where the requests for credit are very low.

Of those farmers who requested credit, less than half of them reported a successful outcome. Again there was a wide regional variation. While smallholders in Sargodha district were less likely to apply for credit, those who did apply had higher probability of success. Information asymmetry may be the cause of the problem in that farmers are not aware of different credit sources and credit providers are unable to asess the credit worthiness of the farmers.

The evidence based on the econometric models suggests that vegetable and cereal growers are more likely to seek credit while mango farms are much less likely to apply for loans. This makes perfect sense since the inputs required to cereal and vetable farms a the beginning of the cropping cycle is much higher if compared with mango farms. It is also noted that farmers with many supplier contacts are more likely to receive credit. This could be intepreted as lending by input suppliers to farmers so they can are able to purchase such inputs as pesticides and fertilizers.

Where does credit come from?

Informal sources of credit including friends and family play a vital role in providing finance to the farmers. Of the formal sources of credit, banks, microfinance institutions and dealers/commission agents were significant contributors, which indicates that the formal institutions have begun to play a significant role in the development of Pakistan's agriculture sector. The evidence seems to suggest that the commission agents of agricultural inputs, e.g., fertilizer and seeds, give these inputs to farmers on loan. But, the terms of the loan can be exploitative because they vary from one farmer to another and the rates charged can be as high as 100 percent.

What are the obstacles for smallholders applying for credit?

Various reasons were cited by the farmers for not seeking agricultural credit for their farms. While a minority (39%) said they do not actually require credit, the three main obstacles to obtaining credit were high interest rates, interest-based lending that is perceived as un-Islamic and complicated loan processes. All of these factors can be targets for financial service innovation for an unmet market. In particular there is scope for micro-finance based on Islamic banking principles. A public-private partnership may be suitable to develop this type of finance for the smallholders.

How does credit affect farm profitability and productivity?

Empirical evidence based on econometric modelling and the survey data shows two important results. Firstly, farmers who received credit earned higher profits per acre than those who did not receive credit. However, the farm profit margins were considerably reduced for those who had taken expensive loans from the commission agents.

This suggests that access to credit tends to make farms more profitable but there is a caveat that the true direction of causality between credit and profitability may not be guaranteed without longitudinal (or panel) data. Another interpretation could be that the farmers who are profitable are seen by lenders as more likely to repay the debt and will therefore receive credit. The longitudinal data collection is required to confirm the causal relationship between credit and profitability.

A follow up interview with one of the vegetable farmers in Kasur district reveals that the hidden cost of borrowing from the commission agents could be exorbitantly high. Farmers who borrow from commission agents are bound to sell their produce to the outlets of the commission agents where they are paid much less than the market prices. More specifically, the said farmer had obtained PKR 150,000 interest-free loan from a commission agent, but he ended-up paying RKR 230,000 commission. This shows regional character of credit finance, which may have a different dimension in other districts.

Secondly, credit is correlated with higher levels of technical efficiency. This could mean that credit helps farmers to better manage their farming practices to realize higher productivity. However, this seems to be at the cost of foregone profits, particularly, when farmers are bound to sell their produce to the lenders at a higher commission. Again, the direction of causality cannot be confirmed due to want of the longitudinal data.

Policy Implications

While farmers who receive credit are more likely to have a higher level of profitability, less than 10 percent of the smallholders in the survey were receiving credit. To improve access to credit from this low base is a major policy lever for economic development in the country.

The policy makers may want to adopt two major strategies:

- Focus on credit schemes for grain and vegetable growers in regions where the farmers currently have a low level of credit-seeking.
-
- Encourage financial service innovations in partnership with the lenders who are less exploitative and those who offer loans without any strings attached. The hidden cost of many loans can be counter-productive and may fail to increase financial flows to the farmers. The process of obtaining credit must be made simple and easy to understand and the terms of the finance must not be too financially onerous.

Policy Brief 3

Farm Inputs, Extension Services and the Adoption of New Farming Practices

The adoption of technology and other innovations is the basis of economic growth. This is true for all industries and nations. For example, during the 20th century in the UK, total GDP increased nearly eight times but total hours worked actually declined. There is no other way to explain this growth except through new technologies that increase productivity.

The famous economist and the founder of innovation economics, Joseph Schumpeter, considered several forms of innovation and these are highly relevant in the context of smallholder producers in Pakistan (Schumpeter, 1937). New products and services are commonly recognised as innovations but new production methods are also a form of innovation. In addition, Schumpeter considered selling to new markets or sourcing inputs from new supply channels as other forms of innovation. Importantly, innovation can be completely novel or simply new to the business (an adoption of innovation from elsewhere).

In this analysis of survey data from nearly 850 smallholder producers from Pakistan, we show that adoption of technology, new methods of production (grading) and accessing new markets through distribution channels are significantly correlated with higher levels of profitability.

While these innovations are most important for improving the profitability of farmers in and out of sample, there is a complication that farmers who don't deploy these methods are not readily able to access information about how to perform these practices. Our results show that the most profitable practices are those that farmers are least aware of.

The clear implication for policy is to focus on the diffusion of profitable practices.

What practices are associated with higher farm profitability?

In the survey, we asked farmers about the factors that affect the profitability of their farms. Energy cost, fertilizer prices and decrease in sale price of produce were cited as factors that have an important bearing on profitability.

We also asked farmers about how satisfied they are with the prices of inputs and unsurprisingly, most of them were dissatisfied.

Most of these factors are beyond the control of farmers and to recover the profit margin they need to find ways to reduce costs, improve farm productivity or to get higher prices for their produce.

When we subjected the survey data to econometric analysis to model the relationship between farming practices and profit per acre, the following relationships were discovered.

- Famers who grade their fruit and vegetable produce earn significantly higher profit than those who do not grade them.
- Direct marketing strategies substantially increases profit of the farmers.

- Using improved seed varieties and efficient irrigation systems increases farm profits.

Our survey results also show that farmers are not frequently adopting the most profitable farming practices. The only exception is new seed varieties that are adopted by 53% of farmers. Grading of fruit and cereal was rare in the sample and new marketing practices were reported by only 7% of farmers. Surprisingly, the introduction of improved irrigation methods was reported by a very low 8% of farmers.

These results show that practices with high profit potential are not being adopted and this can be the basis for an important policy initiative to rectify this situation.

How do farmers find out about better farming practices?

The diffusion of improved farming practices is a major topic of interest for agriculture policy makers. Typically, governments develop extension services to educate farmers on new farming methods but other sources of information such as media, input suppliers, buyers and other farmers are also significant. In the survey we asked farmers about their awareness of sources of information about improved methods.

About one-third of farmers were aware of programs on television or radio that provided information on farming practices. This indicates that these programs have good penetration into the smallholder farmer groups in Punjab. Many farmers have also visited demonstration farms and their proportion is similar to those who knew of farms in their area. When farmers are aware of demonstration farms that are nearby they tend to visit them.

Farmers rarely received advice on the high profitability practices that we identified in the survey. Information on seed gradation, produce gradation and irrigation methods was being received by less than 15% of the farmers.

It is possible that when farmers so receive advice, they do not receive it on the practices that have the most important influence on profitability. More analysis is required here but the clear implication is that information channels and extension services need to focus more on marketing and produce value adding. Improving productivity through better irrigation and seed input is also important.

Are extension services effective?

In addition to a mismatch between the information and training that farmers are given and the most profitable practices identified above, we also note that government extension services are not optimal from the point of view of farmers. In the survey we asked farmers about their satisfaction level with the extension services. In all the districts, over one-half of the sample respondents were dissatisfied or highly dissatisfied with the extension services.

Policy conclusions and new strategy for extension services

The analysis of the farm survey data shows that some farm practices are highly correlated with improved farm profit, but promotion of these practices to other farmers is less than desirable.

Farmers appear to have a preference for seeing new practices and technologies in action. If they are close to a demonstration farm then they use it and similarly if a neighbour uses modern practices they are also likely to adopt them.

The extension services in their present form are highly ineffective. However, many farmers are using electronic media to improve their knowledge base. It is recommended that a pilot project of using SMS, TV and radio may be initiated to direct farmers to the demonstration sites or ‘lead adopter’ farmers.

Given that adding new parts to the value chain (removing intermediaries) and other market orientated practices such as grading are associated with higher profit, there is also support for the development of farmer groups that can do this marketing on behalf of farmers.