Department für Agrarökonomie
und Rurale Entwicklung
Georg-August Universität Göttingen

2017

Diskussionspapiere

Discussion Papers

To analyse the suitability of a set of social and economic indicators that assesses the impact on SI enhancing advanced technological inputs by farming households in Punjab Pakistan

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ISSN 1865-2697

Diskussionsbeitrag 1708

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Abstract

Increase in agricultural production in industrialized and developing countries are based on the adoption of new and improved technologies. Farming household's social and economic conditions greatly determines the adoption of new technologies. Particularly in developing countries majority of farming community comprises by small farming households. Pakistan is very interesting case in developing countries as its economy is based on agriculture and smallholder's production system is the salient characteristics of its farming community. The study in hand is conducted to examine the role of social and economic indicators which assesses the adoption of sustainable intensification-enhancing advance technologies in Pakistan. The study was conducted in Punjab province because it is the major contributor in agricultural GDP. The logit model is employ for the empirical findings of initial survey. A logit estimate shows that both social and economic indicators have statistically significant association with the adoption decision.

Keywords: Sustainable intensification, smallholders, adoption decision, and Punjab

1.Introduction

Sustainable development is the mechanism that essentially requires to meet the basic needs of people and to create opportunities for a better life (Bruntland Report). The important element to consider in sustainable development includes basic people needs, the socio-economic indicators, and the respective environment which determines the decision making process (Barkmann et al. 2013). The 1977 and 1990 "Farm Bills" describe sustainable agriculture as an integrated system of crops and livestock to satisfy peoples food and fibers needs, to sustain the farm economy, the efficient use of on-farm resources, for betterment of environment, and to enhance the quality of farming households and overall society (USDA, 2016).

There exist five school of thoughts for agriculture development; Business-as-usual optimists, Environmental pessimists, Industrialized world to the rescue, New modernists and, Sustainable intensification (SI) (Pretty, 1997). In agriculture SI is the production system in which farmers can enhance yield by the integrated use of wide range of

technologies from the existing unit of land and at the same time to protect the micro climate of farms from adverse environmental impacts (Garnett et al. 2012). The sustainable agricultural production system requires optimum incorporation of advance technologies, sustainable agriculture brings sustainable production of food and considered as first pillar of food security (Pretty and Bharucha, 2014). However, to enhance productivity and sustainability, the awareness of farmers under what conditions the use of agricultural technological inputs (e.g., fertilizer, pesticides and seeds) is desirable (Royal Society, 2009).

To define technology in agriculture production system is slightly intricate as it varies with nature of technology being adopted (Margaret and Kariuki, 2015). The past studies related to the adoption of technologies in agricultural production system takes technology into account as adoption of modern seed technologies, genetically modified organisms, the use of chemical fertilizers, soil conservations techniques, farmers field school training, extension contact under improved technology, advance mechanization, improved varieties, and adaptation to climate change. But most previous studies has not considered the adoption of technology as the use of SI enhancing advance crop care products such as fungicide, herbicides, insecticides, and seed treatment (Alene and Manyong, 2006; Mendola, 2007; Otsuki, 2010; Di Falco et al. 2011; Simtowe et al. 2012; Qaim and Kouser, 2013; Larson and Lilleor, 2014).

Agriculture in developing countries of South Asia is mainly categorized as small units of land, particularly in Pakistan where fifty eight percent of farms fall under the category of small farms operated by smallholders. The smallholders are at disadvantage when it comes to incorporate the advanced technological inputs due to socio-economic constraints (Thapa and Gaiha, 2011).

The socio-economic characteristics of farmers are important to determine the adoption decision of agricultural technologies, also farms and farmers specific attributes determines the sustained adoption decision of available technologies (Idrisa et al. 2010). The major socio-economic snags in smallholders production system includes; lack of authorized distributions of improved quality seeds, use of adulterated and inferior quality pesticides, lack of modern farming practices, hindrance in access to market, absence of specific cropping belts, absence of modern post-harvest technologies, high input prices, energy shortfall, complications in access to agricultural credit and water deficiencies are some peculiar socio-economic issues in Pakistan agriculture sector (Khan et al. 2013; Bilal et al. 2015).

Role of institutions in agricultural technology adoption in Pakistan

The developing countries such as Pakistan the technology adoption is generally slower and farmer's interest varies according to the feasibility of technologies (Ashraf et al. 2015). The institutions mainly the agricultural extension services contribute major role in technology adoption. In disseminating of modern technologies and modern ways of farming, government of Pakistan much rely on agricultural extension services. The institutional constraints include lack of knowledge capital and less numbers of extension workers, the services are limited to large famers, ignorance of smallholders and lack of communication between agriculture departments respectively (Saqib and Tachibana, 2014; Baloch and Thapa, 2016).

For the awareness of farmers about modern technologies electronic media plays essentials role, it expedites the famers existing knowledge to modern technology and keep them to latest information (Abbas et al. 2003). Among the medium of information to famers, the information and communication technology (ICT) now considered as vital for farming community. However, the effectiveness of ICT disseminates information to farmers, demands in-service training and capacity building programs for extension services providers (Aldosari et al. 2017).

Most of the studies have shown the association between socio-economic characteristics and the use of agricultural inputs mainly in Asia, Africa and Latin America (Yasin et al. 2003; Tijani and Sofoluwe, 2012; Garcia et al. 2012). But in context to Pakistan, there is no research has explicitly accounted for the set of social and economic indicators of smallholder agriculture system for the adoption of advanced quality input (e.g. fungicide, herbicides, insecticides, and seed treatment). This paper aims to contribute in the present literature by analysing the suitability of set of social and economic indicators that assess the adoption of SI enhancing advanced technological inputs, focusing on advance crop care products.

2. Data collection and sampling technique

The present study efforts to contribute to the existing literature by analyse the suitability of a set of social and economic indicators impacting on the adoption of SI enhancing advanced technological inputs in the sample area. We collected information about economic and socio-demographic attributes, land acreage, yield, off-farm income, farm assets ownership, manures application, family and hired labour, extension services and private firm's visits, household's size, age of respondents, education, and membership of local organization.

The field survey of the important districts of Punjab province conducted to collect the primary data, for this purpose a comprehensive questionnaire developed for getting the precise information about the farming household's specific attributes, farm specific attributes, socio-demographic attributes, and inputs specific attributes. At first stage, a reconnaissance survey was conducted for the development of questionnaire, the pilot test has significances in primary data based research; it helps in improvement in the quality of questionnaire. Then the number of respondents interviewed personally both categories of small farming households who incorporates the advanced quality inputs and vice versa as shown in table 1.

Table 1: Small farmer's distribution: adoption status and cropping zone

Cropping Zone	Adopters	Non-Adopters	Total
Mixed Cropping Zone	11	12	23
Wheat-Cotton Zone	7	15	22
Total	18	27	45

We employed Multi—stage random sampling technique about the household's survey to obtain primary data set. Two important districts with probability of selection made proportional to the area sown under main crops and the availability of advance technological inputs. This self-weighting sampling selection resulted in the selection of two districts in two important divisions namely, Faisalabad division and Multan division out of nine divisions from Punjab. The division of Faisalabad and Multan are predominantly considered as a Mixed-Cropping Zone and Cotton-Wheat Zone respectively. We randomly selected one district from each zone namely, district Jhang and district Vehari respectively, and then randomly selected two tehsils from each district. Five union councils (UC) selected at random from each tehsil, then from randomly selected UC 20 smallholders selected again at random from each UC. Thus, resulting total sample size will be between 320-400 smallholders. But for this pilot study we collected a sample of 45 households, comprising 23 households from Jhang district and 22 households from Vehari district.

3. Analytical Framework.

We model the SI enhancing advanced technologies crop-care products including fungicides, herbicides, insecticides, and seed treatment by employing an econometric approach. We mainly interested in the adoption status of these technologies and indicators which governs these adoptions. Logit analysis or logistic regressions from generalized linear model (GLM) family provides a solution, as given in Green, (2002).

$$\text{Prob}\,(Y=1|\text{x}) = \frac{e^{\text{x}'\beta}}{1+e^{\text{x}'\beta}} = \Lambda\,(\text{x}'\beta)$$

The independent or determining variables are the set of social and economic indicators, which are continuous or discrete, and the dependent variable is adoption status, which is a discrete variable.

Y= 1 if farming households using advanced technological inputs, Y = 0 if No.

x= economic and social indicators (listed below in table 2).

$$\text{Marginal effect} = \text{Prob}\left[\text{Y}=1\middle|\bar{\text{x}}_{(\text{d}),}\text{d}=1\right] - \text{Prob}\left[\text{Y}=1\middle|\bar{\text{x}}_{(\text{d}),}\text{d}=0\right]$$

Here d means a social or economic variable, and $\bar{x}_{(d),}$is a mean of all other independent variables. Which means the marginal effect is depend upon the value of social or economic variable which is tested in this study.

4. Results and Discussion

Descriptive statistics

The choice of variables incorporated in this study are consonant by the previous studies regarding technology adoption and socio-economic characteristics of developing countries of South Asia and Africa (Bauer and Karki, 2004; Hossain et al. 2006; Langat et al. 2013). Here we also interested to include the Household-level food insecurity and its significances on the adoption decision of SI enhancing advances technological inputs. We measured Hh-level food insecurity by using HFIAS (household food insecurity access scale), as the application of this method has already been tested in assessing Hh-level of food insecurity in developing countries of Asia and Africa (Kangmennaang et al. 2017; Ansari, 2010). We employ principal component analysis (PCA) for HFIAS and it yields two important components food-insecure component and severely food-insecure component, which we used in final regression analysis. Our analysis yielded a KMO value of 0.83, while the scale reliability coefficient tested by the Cronbach alpha statistic and value for the scale α = 0.91 for component analysis.

Important characteristics of smallholders in two important zones are presented in table 2. This illustrates that mean of land acreage, education, yield, off-farm income, number of private firm visits, farm machinery, family and hired labour, and household size higher in mixed-cropping zone, while manures application, number of milch animals, number of extension service visits, and age of respondents are higher in cotton-wheat zone. The average food insecurity is higher in cotton-wheat zone. The independent t-test for group mean comparison also employed, according to the test the mean of farm yield,

off-farm income, family labour, number of visit by private firms, and Hh size are statistically different in both cropping zone.

Table 3 shows important economic and socio-demographic attributes of both adopters and non-adopters, and an independent sample t-test is done to test differences between adoptions status. This shows that important economic characteristics of adoption status such as, average land acreage, yield, farm income, farm machinery, number of milch animals, and manures application are higher for smallholders who adopt, while off-farm income and food insecurity are higher for smallholders who do not adopt.

Table 2: Descriptive summary of variables for the adoption of SI enhancing advanced technological inputs with respect to cropping zones.

Variable	Mean	Std. Dev.	Mean	Std. Dev.	Diff. in mean at level of Sig.
	Mixed-Cropping Zone n=23		Cotton-Wheat Zone n=22		
Economic Indicators					
Area in acre	5	1.314	4.636	1.559	0.347
Total score (HFIAS)	6.043	4.395	6.136	6.519	0.359
Total farm yield in mounds	1495.087	1189.278	423.909	455.36	1047.646***
Total farm income in rupees	646800	463459	485581.8	343800.8	145671
Off-farm income in rupees	0.478	0.51	0.272	0.455	0.239**
Total number farm machinery	1.043	1.637	0.5	1.738	0.612
Total number of milch animals	1.434	1.199	1.454	1.056	0.108
Total num manure trolley/acre	4.913	2.81	6	3.532	-0.869
Socio-Demographic Indicators					
Total number family labour	2.608	1.405	1.818	1.401	0.944**
Total number hired labour	0.391	0.94	0.363	0.492	-0.027
Membership of local organizations(*dummy 1=yes, 0=No*)	0.217	0.421	0.136	0.351	0.007
Number of visit agri/ext/month	0.608	1.076	0.636	0.581	0.027
Number of visit/pvt/month	3.521	2.744	2.318	1.809	1.108*
Age of respondent in years	44.217	15.21	49.5	11.337	-4.677
HH size	8.608	4.075	7.318	2.801	1.555*
Education in years	6.608	4.687	6	5.061	0.28

Note: The level of significance is *** p<0.01, ** p<0.05, * p<0.1

As for as socio-demographic characteristics are concerned, the average number of hired labour, membership of local organization, number of extension and private firm visits, age of respondents, household size, and education are higher for adopters, while

family labour is higher in case of non-adopters. Only the mean of family labour, age of respondents, and Hh size is not statistically different according to t-test.

Econometric analysis (Economic indicators)

It was hypothesized that the economic indicators of smallholder's pertain to adoption status and suitable in providing the realistic view of the sample collected. For diagnostic tests we employed Hosmer-Lemeshow test to assess the model fit and it suggested that model was good fit, our model percentage correctly predicted was 93%. The coefficient of variable yield was positive and statistically significant at less than 0.01 % level, which means a percent increase in yield impact more likely to adopt the advance technological inputs then not to adopt but the marginal effect of the estimate is less. The finding is parallel with Idrisa et al. (2010) showed that adoption is associated with high yield as it raised the output and gross earnings.

Table 3: Descriptive summary of variables for the adopters and non-adopters

Variable	Mean	Std. Dev.	Mean	Std. Dev.	Diff. In Mean at level of Sig.
	Adopters n=18		Non-Adopters n=27		
Economic Indicators					
Area in acre	5.444	1.616	4.407	1.152	0.015
Totalscore (HFIAS)	2.222	2.579	8.666	5.392	0.000
Total yield in mounds	1552.667	1332.126	583.889	557.096	0.001
Total farm income in rupees	961961.1	371147.1	305329.6	138893.4	0.000
Off-farm income in rupees	0.333	0.485	0.407	0.5	0.000
Total number farm mach	1.722	2.295	0.148	0.601	0.001
Total no of milch animals	1.833	1.339	1.185	0.878	0.056
Total manure trolly/acre	6.444	3.433	4.777	2.9	0.086
Socio-Demographic Indicators					
Total number of family labour	1.888	1.278	2.444	1.527	0.250
Total number of hired labour	0.722	1.017	0.148	0.362	0.009
Membership of local organizations(*dummy 1=yes, 0=No*)	0.444	0.511	0	0	0.000
Number of visit agri/ext/month	1.111	1.078	0.296	0.465	0.001
Number of visit/pvt/month	4.666	2.057	1.777	1.846	0.000
Age of respondent in years	48.333	15.13	45.777	12.619	0.542
Hh size	8.388	4.552	7.703	2.714	0.530
Education in years	9.944	3.438	3.888	4.06	0.000

The implication of off-farm income was positive and statistically significant at less than 0.10 % level, which means the smallholders having other source of income apart

from farm income are more likely to adopt the advance crop care products or being rationale in decision process, they are more likely to invest the off-farm income to have the latest technology in their production system and due to this reason the off-farm income, citrus paribus, have very high probability of 23% of adopting the advance SI enhancing crop care products, this also in accordance with finding made by Hailu et al. (2014) in which they showed the adoption decision for sustainability enhancing farm inputs are the positive and significant function of off-farm income.

And similarly, the estimates of number of farm machinery impact the adoption status positively and statistically significant at less than 0.01 % level. The ownership of farm machinery enables smallholders in time and better land preparation, this capital asset also determines the adoption of advanced inputs so that the impact become high in obtaining better farm yield. The connection of adoption decision and farm machinery is also consonant with previous studies as Morris et al. (1999) showed that farm machinery percentage was higher for adopters.

The coefficient of family labour was significant but negative, which implies that a unit addition in family labour impact less likely to adopt the advanced technologies. One might possible explanation is that when additional family labour contributes to ongoing production activities decrease the likelihood of adoption because adoption requires investment to acquire the advanced technologies, off-farm income opportunities is desired in this case rather additional labour force . Similarly, coefficient of manures application was significant but negative, which implies that a unit addition in manures application impact less likely to adopt the advanced technologies. The one possible reason behind that due to socio-economic constraints, smallholders cannot afford advanced technologies or because of number livestock they own, yield more manure and they wisely using it as an alternative due their constraints. On other hand, they are doing best at the same time by deploying manures as organic fertilizer and as a soil conservation technique. The food insecure and severely food insecure household coefficient was very important to determine the adoption decision. Because of negative and significant coefficient, food insecure Hh and severely food insecure Hh, citrus paribus, has lesser probability of 12% and 10 % being as adopters of advance SI enhancing crop care products. The investigation is similar to those of Yasin et al. (2003) in which they showed a positive relationship between pesticides adoption and social status.

The results are consistent with the findings of the past studies. Regression results showed that the coefficients of yield, off-farm income, and number of farm machinery are

significant and have positive relationship with adoption decision while, coefficients of family labour, manures application, and food insecurity are also significant but have negative association. This validates our hypothesis that adoption decision regarding SI enhancing advanced technological inputs of smallholders has been determined by economic indicators. The log likelihood ratio test employed and it favors in the results depicted in Table 4. As already mentioned above we deal with household's data set. The problem of multicollinearity and heteroscedasticity is common in household's data set. We checked for multicollinearity we made pairwise correlations matrix and it showed no serious evidence and we made robust standard error calculation for logit model to address the heteroscedasticity.

Table 4: Logit estimates of economic indicators on the adoption of SI enhancing advanced crop-care products

Adoption Status	Coefficient	Robust. Std. Err.	Marginal Effects
Total yield in mounds	0.004***	0.001	0.000
Off-farm income	5.821*	3.267	0.226
Total family labor	-0.922**	0.417	-0.035
Total manure trolley	-0.576**	0.293	-0.022
Total number farm machinery	1.957***	0.653	.0761
Food insecure Hh	-3.259***	1.107	-0.126
Severely food insecure Hh	-2.615**	1.157	-0.101
Constant	-7.833***	2.718	
Log likelihood	-5.632		
R2	0.81		

Note: The level of significance is *** p<0.01, ** p<0.05, * p<0.1

Source: Authors' calculations.

Econometric analysis (Social Indicators)

The results of logit analysis of adoption status and social indicators are presented in table 5. Again to control for the heteroscedasticity, we made robust standard error calculation for logit model and to check for multicollinearity we made pairwise correlations matrix and found no serious evidence of multicollinearity.

The coefficient of smallholder's education was positive and statistically significant at 0.01 % level, which implies that adoption decision regarding SI enhancing advanced technological inputs of smallholders has been determined by their education. A unit increase in education enables smallholders more likely to adopt and vice versa. The results are consistent with previous studies regarding technologies adoption conducted by Nnadi and Nnadi, 2009; Langet et al. 2013. Education translates for better

understanding about technological development in agriculture. It certainly enhances the smallholder's abilities to think about the latest development and their management skills.

Similarly, age is also an important indicator which translates the farming experience, and experience enables farmers to adopt more likely. The coefficient of smallholder's age was positive and statistically significant at 0.01 % level and the finding is also consistent with past researches as shown by Margaret and Kariuki, 2015.

The number of contact made by smallholders with agricultural extension service was very important social indicators. It provides them with latest information on crop management practices, crop diseases, agricultural innovations, and encourage them to adopt advanced technologies. Due to this reason the number of contact made by smallholders with agricultural extension service, citrus paribus, have high probability of 20% of adopting the advance SI enhancing crop care products, this also in accordance with finding made by Handschuch and Wollni, 2013 in which they showed the adoption decision for sustainability enhancing farm inputs are the positive and significant function of extension contacts. The estimate of Hh size was not significant but positive. For diagnostic tests we employed Hosmer-Lemeshow test to assess the model fit and it suggested that model was good fit, our model percentage correctly predicted was 84%.

Table 5: Logit estimates of social indicators on the adoption of SI enhancing advanced crop-care products

Adoption Status	Coef.	Robust. Std. Err.	Marginal effects
Education in years	.648***	0.171	0.061
Age	.112**	0.048	0.010
Number of visit agri/ext/month	2.129**	0.94	0.201
Hh size	0.247	0.179	0.023
Constant	-13.503***	3.853	
Log likelihood = -13.15775	Pseudo R2 = 0.56		
Wald chi2 = 22.52	Prob > Chi2 = 0.000		

Note: Level of Sig. *** p<0.01, ** p<0.05, * p<0.1

Source: Authors' calculations.

The overall results confirms our hypothesis that social and economic indicators of smallholders plays pivotal role in smallholder's decision making process about the adoption of SI enhancing advanced crop-care products.

5. Conclusion

This article evaluates the impact of socio-economic variables on SI enhancing advanced technological inputs in rural Pakistan. The research based on reconnaissance survey

carried out to obtain farms and farmers specific attributes in Punjab province of Pakistan. The findings of the study are based on working hypothesis that adoptions status of advanced technologies govern by smallholder's socio-economic variables. We investigated the fundamental role of qualitative and quantitative socio-economic variables and results demonstrated that they significantly impacted the adoption decision of smallholders regarding SI enhancing advanced technological inputs.

We define the SI enhancing advanced technologies by focused on advanced crop-care products such as, fungicides, herbicides, pesticides, and seed treatment. In our research we considered smallholder's only, just to better understand the role of adoption and results revealed decisive difference among adopters and non-adopters. We concluded the defining role of socio-economic variables for the adoptions of advanced technological inputs.

Based on present empirical evidence we suggest policy makers to consider agriculture extension services, and educations on priority for effective technology adoption. Though, the results based on pilot study therefore, we are looking forward for the results of final survey to consolidate our findings. And in next stage we will employ treatment-effects models as smallholders are not randomly distributed to the adoption status.

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Georg-August-Universität Göttingen
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Diskussionspapiere
2000 bis 31. Mai 2006:
Institut für Rurale Entwicklung
Georg-August-Universität, Göttingen)
Ed. Winfried Manig (ISSN 1433-2868)

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Die Wurzeln der **Fakultät für Agrarwissenschaften** reichen in das 19. Jahrhundert zurück. Mit Ausgang des Wintersemesters 1951/52 wurde sie als siebente Fakultät an der Georgia-Augusta-Universität durch Ausgliederung bereits existierender landwirtschaftlicher Disziplinen aus der Mathematisch-Naturwissenschaftlichen Fakultät etabliert.

1969/70 wurde durch Zusammenschluss mehrerer bis dahin selbständiger Institute das **Institut für Agrarökonomie** gegründet. Im Jahr 2006 wurden das Institut für Agrarökonomie und das Institut für Rurale Entwicklung zum heutigen **Department für Agrarökonomie und Rurale Entwicklung** zusammengeführt.

Das Department für Agrarökonomie und Rurale Entwicklung besteht aus insgesamt neun Lehrstühlen zu den folgenden Themenschwerpunkten:

- Agrarpolitik
- Betriebswirtschaftslehre des Agribusiness
- Internationale Agrarökonomie
- Landwirtschaftliche Betriebslehre
- Landwirtschaftliche Marktlehre
- Marketing für Lebensmittel und Agrarprodukte
- Soziologie Ländlicher Räume
- Umwelt- und Ressourcenökonomik
- Welternährung und rurale Entwicklung

In der Lehre ist das Department für Agrarökonomie und Rurale Entwicklung führend für die Studienrichtung Wirtschafts- und Sozialwissenschaften des Landbaus sowie maßgeblich eingebunden in die Studienrichtungen Agribusiness und Ressourcenmanagement. Das Forschungsspektrum des Departments ist breit gefächert. Schwerpunkte liegen sowohl in der Grundlagenforschung als auch in angewandten Forschungsbereichen. Das Department bildet heute eine schlagkräftige Einheit mit international beachteten Forschungsleistungen.

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