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Determinants of recommended agronomic practices adoption among wheat producing smallholder farmers in Sekela District of West Gojjam Zone, Ethiopia

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Development of the Ethiopian economy is directly related to the transformation of the agricultural sector which is manifested with low utilization of recommended agronomic practices, improved farm inputs, and dependency on traditional farming and rainfall. As a result, low production and productivity of agriculture were prevalent over the last years. This study aims to identify the factors influencing adoption of recommended agronomic practices of wheat farming. Two-stage sampling method was applied to select 204 smallholder wheat producing farmers. Simple descriptive statistics and econometrics model such as multivariate probit model were used. The result of the model indicates that formal education level, family size, farm size, distance to the input market, use of chemical fertilizers and the use of credit have negatively and statistically significant effect on adoption decision while off-farm income, access of social media, cultivated land size, and attitude towards risk have positively and statistically significant effect on adoption decision of agronomic practices among wheat producing farmers. Moreover, early planting has a negative effect on distance to input market, farm size, and use of chemical fertilizers. The study recommended that government and other concerned body should develop the supply of inputs provision mechanism, credit, land, awareness creation through media.

Key words: Adoption of agronomic practices, multivariate probit model, and Ethiopia.

INTRODUCTION

Agriculture still offers the leading source of livelihood, and contributes a major phase to national income for most developing countries including Ethiopia. Statistics from ILO (2007) suggests about 60% of Africa labour force still derive their livelihood from agriculture, making it the largest employer of labour in most developing countries. However, the performance of the agricultural sector has been less impressive than expected in most developing countries. Agriculture is the core sector of most developing countries in general and in particular for the Ethiopian economy. It accounts for about 35.8% of the Gross Domestic Product (GDP) and also industry provides 22.2% of the country's GDP whereas service sector contributes 42% (World Fact Book, 2018) and 68% of employment opportunity for our country (World Bank, 2018). The sector is dominated by smallholder farmers,

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whereas about 56% of the farmers possess less than one hectare of land (CSA, 2017).

Despite its contribution to the GDP, employment creation, source of food and export earnings, agriculture productivity is very low. In this regard, the research system, along with the other stakeholders, has to play a major role in improving technologies required to enhance agricultural productivity in the country. Efforts have been underway by the national agricultural research system since its establishment in 1956 and a number of technologies have been released in the farming community. In spite of these efforts, productivity gains are not as such adequate in the country as compared to the potential (Degefu et al., 2017).

Low levels of adoption of recommended agronomic practices, technologies are among the major reasons contributing to low productivity (CSA, 2015). Wheat is among the most important staple food crops grown in Ethiopia. In CSA (2017/2018)'s main season, the total area under wheat production was 1,696,082.59 ha while the total production in quintal was 45,378,523.39 and yield quintal/ha was 26.75. It is also one of the most important cereal crops in Amhara National Regional States of Ethiopia, representing sources of food, cash and wheat straw for livestock feed (Ather Mahmood et al., 2006). Ethiopian Government aims to increase the extent and intensity of wheat production by expanding the area planted to the crop and improving crop productivity. To this end over 100 high yielding, high quality, rust resistant bread and durum wheat varieties have been made available along with their production packages suitable for different agro-ecologies. Therefore, the research system has always been grappling with rusts and made replacement varieties timely available (Dawit et al., 2017).

Goal of increasing wheat productivity and production will be realized only if farmers adopt various agricultural technologies developed through research institutions. Despite the release of several technologies, particularly of improved crop varieties, there has been limited use of improved technology by the majority of farmers (CSA, 2010). Some previous studies done on the area attest that such as unavailability of quality inputs at the right place and time is one of the key factors accounting for limited use of recommended agronomic practices, which further contribute to low productivity (Mekuria, 2013). Moreover, there is about 60% yield gap in wheat, which needs to be narrowed (Mahmood et al., 2013).The reasons for low or no adoption of new agricultural technologies may be technical, socioeconomic, and institution factors (Musah, 2017). Late planting of wheat, non-availability of improved inputs like seed, inefficient fertilizer use, weed infestation, shortage of irrigation water, drought in rain fed areas, soil degradation, and inefficient extension services were other factors for low productivity (Phillis, 2007). Although the analysis of adoption of technology in general and recommended agronomic practices in particular is important, there are limited empirical studies in Ethiopia, particularly on adoption of recommended agronomic practices and its determinants among wheat farming system in Sekela District of West gojjam zone, Ethiopia. Understanding the types of recommended agronomic practices and their determinants will contribute a lot for enhancing production and productivity of wheat among smallholder farmers in the study area.

METHODOLOGY

Description of study area

The study area is located in Amahara Regional State, the North western Ethiopia. This study was under taken in Sekela District. This district is located between 10°59.25′N latitude and 36°55.30′E longitude .The district is bounded with the Mecha District in the north, Yilmana Densa District in the northeast, Burie District in the south, Jabi Tehinan District in the Southeast, Awi zone in the west and the Quarit District in the east, at 460 km from Addis Ababa and 178 km from Bihar Dar. The area is the origin of River Abay. Based on Ethiopian (CSA, 2014) National Census, the district has a total population of 138,691 of whom 69,018 are men and 69,673 women; 6,779 are urban inhabitants. A total of 29,908 households were counted in this district, resulting in an average of 4.64 persons in a household, and 29,093 housing units for thirty two kebeles (lowest administrative unit).

Data sources and method of collections

To collect data, both primary and secondary sources were employed in this study.

Primary data

The structured questionnaire was used to collect primary date from sample respondent smallholder farmers. To collect relevant data, a questionnaire which consists of both open and closed ended questions were applied and administered to the target respondents. Then, training was given for enumerators before the data collection was started and then appropriate correction taken. Finally the data were collected from 204 respondents in the study area.

Secondary data

Secondary data were collected by reviewing and careful examination of related documents, research reports, published and unpublished writings, different journals, and internet websites. It was also collected from agricultural and land office and central statistics agency and other governmental concerned bodies.

Sampling techniques and data

The study was conducted based on cross-sectional data that were collected from 204 sample respondents among wheat producing smallholder farmers. Two-stage sampling techniques that involve simple random sampling methods were deployed to select wheat producer farmers. In the 1st stage, simple random sampling techniques were used to select five kebeles (lowest administrative units) among wheat growing kebeles. In second stage, simple random sampling proportion to their total population size was used to select households head from sample frame. As a result, a list of all wheat producer farmers in 2017/2018 production year was compiled with the help of the extension workers and leader of the respective kebeles. A total of 204 household head sample estimated based on sample size determination formula of Yamane (1967).

Analytical methods

Adoption of Recommended Agronomic Practices (RAPs) of particular technologies is not independent of other technological selections-on the same farm plot of land. Therefore multivariate Probit model (MVPM) were used because it accounts for error terms correlation (Priscilla et al., 2014). The MVPM simultaneously analyses the influence of a set of explanatory variables on each of the different agronomic practices, by allowing error terms to be freely correlated (Lin et al., 2005). Correlation between the different adoption decisions of RAPs may be due to technological positive correlation or negative correlation. If such correlation exists, estimates of simple Probit models would be biased and inefficient (Sied, 2015). Moreover, interdependence of technologies in both adoption and disadoption decisions could be tested by looking at the sign and significance of the off-diagonal elements of the variance-covariance matrix of MVPM explained by Teklewold et al. (2013) and Ndiritu et al. (2014)

Model specification of multivariate probit model

Specification assume that the decision to use recommended agronomic practices in improved wheat varieties adoption is simultaneously determined by vectors of demographic, socioeconomic, institutional and psychological factors. The interdependence between the statuses of adoption of recommended agronomic practices of adoption improved wheat varieties in 2017/18 production year in the study district is specified as:

$$\left.\begin{array}{l} Y^{*}i1 = X^{'}i1\beta1 + \mathcal{E}i1 \\ Y^{*}i2 = X^{'}i2\beta2 + \mathcal{E}i2 \\ Y^{*}i3 = X^{'}i3\beta3 + \mathcal{E}i3 \\ Y^{*}i4 = X^{'}i4\beta4 + \mathcal{E}i4 \\ Y^{*}i5 = X^{'}i5\beta5 + \mathcal{E}i5 \end{array}\right\} \text{Univariate probit} \Longrightarrow \quad Y^{*}ijm = X^{'}ijm\beta m + \mathcal{E}ijm \tag{1}$$

The number of latent equations corresponds with the number of observed equations

$$Yijm = \begin{cases} 1 if Y^{*}ijm > 0 \\ 0\ otherwise \end{cases}, \text{ m=EP, RP, SR, H, \&TP} \tag{2}$$

This shows that: combination of univariate probit models give multivariate probit model .Where: m represents recommended agronomic practices choice for household i(i=1,..,N) i.e.m=Early Planting (EP), Row Planting (RP), Seeding Rate (SR), Herbicide (HC), and Timely Planting (TP) which is facing a decision on whether or not to adopt the available agronomic practices on plot j. Y*ijm is a latent variable which captures the unobserved preferences for technology m (applicable if net benefit that is benefit-cost >0).This latent variable is assumed to be a linear combination of observed plot and household characteristics (Xijm), and unobserved chacteristics captured by the stochastic error term(εijm).βm is the vector of parameters to be estimated. In multivariate model, the adoption of several agronomic practices is possible, in case of error terms jointly follow a multivariate normal distribution (MVND) with zero conditional mean and Variance normalized to unity (Haile et al., n.d.) and (Mwebaze et al., 2017) where ($\mathcal{E}$EP, $\mathcal{E}$RP, $\mathcal{E}$SR, $\mathcal{E}$H &$\mathcal{E}$TP) ~MVND(0,Ω) and the symmetric covariance matrix.

The off-diagonal elements in the covariance matrix, which represent the unobserved correlation between the stochastic components of the different types of recommend agronomic practices. This assumption means that equation (B) gives a MVP model that jointly represents decisions to adopt a particular agronomic practice. This specification with non-zero off-diagonal elements allows for correlation across the error terms of several latent equations, which represent unobserved trait that affect the choice of alternative RAPs (Table 1).

RESULT AND DISCUSSION

Before running the model result appropriate model diagnostics test result were carried out and presented.

Multicollinearity test

The existence of Multicollinearity problems were checked among explanatory variables. The values of contingency coefficient (CC) for dummy variables and the value of variance inflation factor (VIF) for continuous variables were very low compared to their respective critical values (<0.75 for CC and <10 for VIF and tolerance was greater than 0.1 which is the inverse of VIF) that revealed the absence of a sever Multicollinearity problem among independent variables.

Heteroscedasticity test

Breusch-Pagan/Cook-Weisberg test was carried out for testing the existence of heteroscedasticity. The test result shows chi^2 value of 0.3918 was not significant implying there is no problem of heteroscedasticity on the model.

Multivariate probit model results

The chi-square (χ^2) distribution was used as the measure of overall significance of in Multivariate Probit Model (MVPM) estimation. As a result χ^2 (90) calculate greater than, the χ^2 (90) tabulated that is 122.61>69.93 at less than 5% significant level. So, this shows that, the variables included explaining well adoption decision of Recommended Agronomic Practices (RAP's) and fits the mvprobit model at less than 5% probability level. This implies that the joint null hypothesis of coefficients of all explanatory variables included in the model were zero should be rejected. Likelihood ratio test of rho21 = rho31 = rho41 = rho51 = rho32 = rho42 = rho52 = rho43 = rho53 = rho54 = 0: this implies null hypothesis (Ho), that is, there is no correlation for each equations error terms. HA: there is correlation for each equations error terms.

Table 1. Description of variables and expected hypothesis that were used in MVPM.

Variable	Unit	Nature	Descriptions	Expected sign
DV for RAPs:			Dependent variables for recommended agronomic practices adoption decision:	
Early planting	1 or 0	Dummy	1 for timely planting,0 otherwise	
Row planting	1 or 0	Dummy	1 for row planting 0, otherwise	
Seeding rate	1 or 0	Dummy	1 for recommended seed i.e kg/ha, 0 otherwise	
Herbicide	1 or 0	Dummy	1 for adopter ,0 otherwise	
Timely planting	1 or 0	Dummy	1 for timely tilling,0 otherwise	
IV			Independent variables	
Sex	1 or 0	Dummy	1for male,0 for female house hold head	-/+
Off income	Birr	Dummy	1 for off-farm, 0 other sources	+
Fedu.	Number of year	Continuous	year of formal education for household head in year	+
Excota	1 or 0	Dummy	1 for use of extension service, 0 otherwise	+
Useofcredit	1or 0	Dummy	use of credit 1,0 otherwise in Ethiopian birr	+
Farmsize	Hectare	Continous	Total land own by smallholder farmers.	+/-
Participation tech-evaluation	1or 0	Dummy	1 for Participation in technology evaluation ,0 otherwise	+
Family size	adult equivalent	Continous	Family size availability in small holder farmers in number.	+/-
tropical livestock	TLU	Continous	Number of livestock unit owned in the house hold.	+
HHexperi	Year	Continous	number of year house hold head use improved wheat varieties	+
DISTOMRT	Km	Continous	distance to impute market from small holder farmers residence	-
FPIWVS	Index	Perception	Small holder farmers' perception to the specific attributes of Recommended Agronomic practices of wheat	Favorable
Access oxen	1or 0	Dummy	1 for SHFs owns oxen ,0 other wise	+
AccessSM	1or 0	Dummy	1 for access to social media, 0 otherwise.	+
Wclaoship	1 or 0	Dummy	1 for well cultivated land ,0 otherwise	+/-
Risk	1 or 0	Dummy	1 if early adopter, 0 otherwise	+/-
Useche-ferti	Kilogram	Continous	User of chemical fertilizer by smallholder farmers.	+
Soil fertility status	1 or 0	Dummy	1 for fertile soil, 0 other wise	+

Since rho21 and rho41 were significant at 5 and 10% levels of significance (Table 2), we reject the Ho and accept the alternative hypothesis, meaning there is error terms correlation among each equation which implies the acceptance of the model.

The interaction between households' decision of choice rho21 and rho41 is positive and significant. This implies the households' decision to adopt rho21 does not alter the decision to adopt rho41 and the reverse is true. Moreover, this positive interaction will have a positive effect on activities done to promote row planting, early planting, and with the use of herbicide meaning they will take place at the same time by respondents. The joint probability of success showed that, if households are able to adopt all five agronomic practices (EP, RP, SR, HC & TP), their joint likelihood of adopting these technologies will be only 1% level of significance. This will justify simultaneous adoption of all the technologies is affordable for the smallholders. Moreover, the joint probabilities of failure in adopting all these five practices of the households are also 1% level of significance, implying that the households adopted at least one practice.

Formal education

The result of the model revealed that education of the household head has a negative influence on the participation in timely planting as opposed to the expected sign. Education is statistically significant at 1% probability level; as a unit increases in education every year, timely planting decreases by 0.068 holding constant other variables in the model. One more year in school for household head help increase his skill and minimize risk through diversification (by branching out income sources in off season). This leads to wastage of time to plough his land at the recommended time.

Table 2. Multivariate Probit model results.

Variable	Early planting	Row planting	Seeding rate	Herbicide	Timely planting
	Coeffi(St. error)	Coeffi(st.error)	Coeffi(st.error)	Coeffi(st.error)	Coeffi(st.error)
FEDUINYE	0.043(.033)	0.047(0.031)	-0.025(00.031)	-0.050(00.035)	-0.068(00.032**)
HHEXPERI	0.002(00.010)	0.007(00.010)	0.002(00.009)	-0.004(00.010)	-0.011(00.009)
FAMISI	-0.1003(00.068)	0.026(00.069)	-0.115(00.066*)	-0.057(00.073)	0.076(00.066)
SEXHH	-0.028(00.241)	-0.325(00.235)	0.152(00.232)	-0.026(00.245)	0.274(00.234)
TLU	0.082(00.076)	0.014(00.074)	0.078(00.072)	0.073(00.081)	0.034(00.072)
FARMSIZINHA	-0.201(00.118*)	-0.034(00.117)	-0.084(00.114)	0.192(0.121)	-0.160(00.115)
OFFFAIN	0.153(00.198)	0.484(00.192***)	-0.121(00.191)	0.157(00.209)	0.305(00.193)
AVAOXEN	-0.147(00.249)	-0.002(00.237)	-0.098(00.234)	0.110(00.260)	0.013(00.239)
EXCONTA	-0.0104(00.216)	0.038(00.208)	-0.121(00.204)	0.001(00.220)	-0.056(00.207)
DMRTKM	-0.073(00.018***)	0.013(00.017)	-0.033(00.017**)	0.011(00.018)	0.009(00.017)
USECHFKG	-0.001(00.001*)	0.0004(00.001)	-0.0004(00.001)	0.0005(00.001)	0.0017(00.001**)
USCREDIT	0.086(00.205)	-0.285(00.204)	-0.439(00.201**)	0.028(00.220)	-0.111(00.201)
PARTEVA	-0.012(00.227)	0.329(00.220)	0.347(00.217)	-0.073(00.235)	0.408(00.218**)
ACCESM	-0.108(00.215)	0.420(00.206**)	0.405(00.204**)	0.240(00.212)	0.0017(00.206)
WLANOSHIP	0.295(00.244)	0.410(00.235*)	0.160(00.236)	-0.647(00.243***)	-0.264(00.235)
ATITOWR	-0.095(00.206)	0.005(00.200)	0.128(00.198)	0.543(00.221**)	-0.156(00.199)
PHHIWV	-0.158(00.100)	-0.068(00.095)	0.027(00.095)	0.115(00.104)	-0.081(00.097)
SFS	0.2546(00.217)	0.031(00.209)	-0.063(00.208)	-0.119(00.228)	0.0213(00.213)
_cons	10.492019(00.611)	-10.021(00.578)	0.255(00.553)	-10.123(00.631)	-0.448(00.580)
rho21			0.237(0.106**)		
rho31			0.587		
rho41			0.204(0.118*)		
rho51			0.783		
rho32			0.184		
rho42			0.119		
rho52			0.722		
rho43			0.976		
rho53			0.506		
rho54			0.976		
Number of observation			204		
Wald chi2(90)			122.61		
Log likelihood			-608.857		
Prob > chi2			0.0127**		
Joint probability of success			0.000***		
Joint probability of failure			0.000***		

Likelihood ratio test of rho21 = rho31 = rho41 = rho51 = rho32 = rho42 = rho52 = rho43 = rho53 = rho54 = 0: chi2(10) = 12.274, Prob > chi2 = 0.2671. Coeffi (Std. Error) in this table denote the coefficient for each equations and their p-value.
Note: ***, **, and * shows 1, 5 and 10% level of significant respectively.
Source: Own survey (2018).

Family size

This variable is measured by adult equivalent (Stork et al., 1991 as cited by Getaneh, 2003), and it has negative contribution to recommended seeding rate in line with the expected sign at 10% probability level. As family size increases by one individual, adoption of seeding rate decreases by 0.115, keeping constant other variables. Family size increase means there is high demand for consumption. This leads to reduction in recommended seeding rate adoption.

Farm size in hectare

Farm size affects early planting negatively at 10% probability level. As farm size increases by one hectare, early planting decreases by 0.201 holding other variables constant. This implies that large farm size need plenty of time to cover vast area of land by seed at recommended planting time. That is why farm size in hectare and early planting have negative relationship.

Off-farm income

During slack periods many farmers earn additional income by engaging in various off-farm activities. This is believed to raise their financial position to acquire new inputs such as easy hire of labor because row planting is labor intensive activity. If off- farm income increases from zero to one birr it leads to increase in row planting of improved wheat varieties by 0.484 keeping other variables constant. Therefore, in this study, it is hypothesized that there is a positive correlation between the amount of off-farm income and row planting of improved wheat varieties at 5% probability level of significance and this relationship is in line with Mekuria (2013), that is access to off-farm employment had positively and significantly influence on the likelihood of adoption of improved maize seed production at 5% significant level. Hailu et al. (2014) said off-farm participation was positive in determining chemical fertilizer adoption decision.

Distance to the input market from farmers' residence

This variable has a negative influence on both early planting at 1% and seeding rate at 5% probability level of significance. A decrease in 1 km distance to the main market would increase the likelihood of participating in early planting and seeding rate by 0.073 and 0.033 respectively while holding all other variables constant. Hence, farmers nearest to the main market, infrastructure like main road and seasonal roads, use agricultural inputs both adequately and timely. Moreover, distance to main market is negatively correlated with participating because of the increased transaction costs associated with purchasing inputs. This agrees with the findings of Kidane (2001) that distance to the nearest market place has a negative influence on the extent of adoption of the farmers. Farmers who live in remote areas are reluctant to adopt improved agricultural inputs. This is possibly because they have limited access to modern agricultural inputs and market information. Ashenafi (2008) said market distance negatively influences triticale yield over Teff, wheat and barley; for Degefu et al. (2017) distance to the market negatively and significantly influenced the adoption of wheat technologies.

Use of chemical fertilizers

Use of chemical fertilizer is negatively correlated with early planting and positively correlated with timely planting at 1% probability level of significance for both. 1 kg decrease in use of chemical fertilizer increases early planting by 0.0018 other variables being kept constant. Logically chemical fertilizers could facilitate growth of plant as compared with plant without this input and lead to early maturation. So, farmers enforced early plant to persist maturation period of improved varieties as alternative to chemical fertilizers, and if use of chemical fertilizer increase by 1 kg timely planting increase by 0.00179 because farmers initiated to do more if they had got the input they want. Other variables hold constant, the later in line with Shemelis (2004) that is farmers who have better access to fertilizer credit has positive contribution to use modern agricultural inputs.

Use of credit

Credit has a negative contribution for adoption of seeding rate at 5% probability level of significance. Farmers who have access to credit can minimize the use of recommended seeding rate. Thus, it is expected that access to credit decreases the probability of adopting recommended seeding rate of improved wheat technologies. Moreover if credit increases from zero to one birr leads to decreased seeding rate by 0.439 amounts; other variables being equal (constant). This relationship is opposite to the expected sign. As access to credit increases, the household head will be established: new business venture to increase their income rather than adopting improved technology (particularly seeding rate); moreover nature is full of risk and uncertainty that is why farmers are enforced to start other business alternatives to reduce risk.

Participation in technology evaluation

Attending formal training such as field days, demonstration plots, and participating in formal agricultural training are expected to have a positive attitude for farmers to prepare their land timely. If participation in the above-mentioned activities increases from zero to one, timely planting increases by 0.408 ceteris paribus other variables. Training has positive contribution for land preparation at the required time by owners at 10% probability level of significant. The result is in line with Tesfaye and Alemu (2001), that is participating in on-farm demonstrations positively affect the adoption of improved varieties of bread and Tesfaye et al. (2014) report that field participation positively improved wheat technology adoption and is in line with the researcher prospect sign before.

Access to social media

Access to social media has positive influence on row planting and recommended seeding rate at 5% probability level of significance for both. If access of social media increases from zero to one (from non-adopters to adopters), row planting, and seeding rate of wheat increase by 0.420 and 0.405 respectively keeping constant other variables. From this result we can understand that: Radio, television ownership develop the ability to receive broadcast agricultural programs and are expected to influence farmers' awareness and adoption. This is in line with Mesfin (2009) that higher access to information could increase adoption of triticale and Berhe (2014) that access to social media affects positively smallholder farmers' adoption of both row planting and improved wheat seed technologies.

Well cultivated land ownership

Well cultivated land positively affects row planting of improved wheat varieties (IWVs) and negatively influences the use of herbicide at 10% probability level for both. If the farmers have well cultivated land (well smoothed soil) they will be encouraged to adopt row planting of IWVs because the seed will germinate by penetrating the loam soil and if land is cultivated (if increases from zero to one then row planting increases by 0.410 and use of herbicide decreases by 0.647, it will be free from weeds. As a result the use of herbicide would decrease. This is in line with Hailu et al. (2014) and Musah (2017) that early adopters have 15% greater probability of participating in contract farming than late adopters.

Attitude towards risk

This variable positively affects the use of herbicide at 1% probability level of significance. If attitude towards risk changes from laggard to early adopter, the use of herbicide will increase by 0.543. The result is consistent with Musah (2017)'s that early adopters have 15% greater probability of participating in contract farming than late adopters.

CONCLUSION AND RECOMMENDATIONS

As the regression result indicate, distance from input market, farm size, and use of chemical fertilizers influence early planting of wheat negatively whereas off-farm income, access of social media, and well cultivated land size influence row planting of wheat positively; family size, distance to the input market, use of credit affect recommended seeding rate negatively. Moreover well cultivated land affects negatively use of herbicide whereas attitude towards risk influences positively use of herbicide. Finally participating in technology evaluation affects positively timely planting and in similar manner timely planting is affected negatively by use of chemical fertilizers and formal education. It is suggested that concerned bodies have to consider the supply of inputs to address the input demand of targeted farmers at the right time, with the right price, for the right person, to the right place to enhance development. Moreover it is better to give stress for methods of cultivation, income and information sources to reduce constraints faced by smallholder farmers and to open more opportunity than before. In the same situation, it is better to develop farmers' participation in social media to create strong awareness among those smallholder farmers in the study area and smallholder farmers should be motivated to use hand weeding system because hand weeding facilitates growth of crops than the use of herbicide. Finally, experience share should be conducted among laggards with that of late majority, early majority, early adopter and innovators to develop strong awareness for risk averse.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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