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Risk Management Strategies and Pesticides Use in Vegetable Production: The Case of Smallholder Farmers in Kombolcha Woreda, East Hararge Zone, Oromia National Regional State, Ethiopia

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ABSTRACT
Vegetables have a special place in farming system because of the intensive nature of the crops. Kombolcha Woreda/district is one of the major vegetable producing areas in East Hararghe. So far, however, vegetable production risk management strategies in the Woreda have not been very well studied and documented. Therefore, in this study, the possible risk management strategies were analyzed based on data collected from 130 sample households. Use of pesticides, enterprise diversification, income diversification, sequential marketing and irrigation were found to be the most common strategies. Factors determining to use pesticides in managing vegetable production risks were analysed using double hurdle model. The first hurdle results (probit model regression) indicate that vegetable production experience, farm income, livestock size, non/off-farm income, and access to information are found to be factors affecting the decision to use pesticides while the second hurdle results (truncated regression) show that variables landholding, livestock size, non/off farm income and access to information are found to be determining the proportion of vegetable farm treated by pesticides. Experience sharing and discussion, creation of non/off farm work, means of enhancing farm income and access to information should be strengthened to facilitate the use pesticides.
Key words: risk management, vegetables, double hurdle model

1. INTRODUCTION

The agricultural sector greatly influences economic performance in Ethiopia. About 11.7 million smallholder households account for approximately 95 percent of agricultural GDP and 85 percent of employment. With a total area of about 1.13 million km^2 and about 51.3 million hectares of arable land, Ethiopia has tremendous potential for agricultural development. The agricultural sector accounts for roughly 43 percent of GDP, and 90 percent of exports (MoARD, 2010).

Ethiopian agriculture is dominated by subsistence, low input-low output; rain-fed farming system (MoARD, 2010). The low performance of agriculture can be attributed to many interrelated factors. These include recurrent drought, unreliable rainfall, land degradation, scarcity and fragmentation of land, crop pests and diseases, livestock diseases, scarcity of animal feed, low level of improved and suitable technologies, and poor marketing and service infrastructure (Girma, 2002; Belaineh, 2003).

On a daily basis, farmers are confronted with an ever-changing landscape of possible price, yield, and other outcomes that affect their financial returns and overall welfare. Limited use of institutional innovations like crop insurance and affordable credit in developing countries like Ethiopia, to shift part of the risks from the private to the public sector, makes risk management an important part of smallholder production decisions. Indeed, farmers take their decisions in a risky environment, the consequences of these decisions or events are often not known with certainty until long after those decisions occur. As a result, outcomes may be better or worse than expected. Hence, knowledge on how farmers make decisions within the context of risks is important in determining the strategies for agricultural development.

The agricultural production in Eastern Hararghe is generally characterized by a high degree of instability. This causes great fluctuations on crops yield on the one hand and large fluctuations in input and output prices on the other. The unstable farm income resulting from business and financial risks coupled with poor infrastructure in the area may affect production decisions, delay adoption of technology, prohibit long-term investment in agriculture and hence delay the agricultural development (Lonnie *et al.,* 1989; Tefera *et al*., 2003). In this context, understanding risk is a key element in helping producers make better decisions in risky situations, and also provides useful information to policy makers in assessing the effectiveness of different types of risk protection tools.

Within the agricultural sector, vegetable production plays an important and varied nutritional as well as socio-economic role (Ntow, 2008). Vegetables have a special place in farming system because of the intensive nature of the crops. They can give high yield per unit area of land compared to cereals and hence generate high income for the farmers because of high market value and profitability. They also have high nutritive value compared to cereals. However, there are quite a lot of complex production and technical constraints that limit the expansion of the sector in the country. These includes low genetic potential, lack of high yielding and high quality cultivars for domestic and export markets, poor management practices, low level of disease and insect pest control measures, inadequate quality seed supply, low level of post-harvest technology, weak research and technology dissemination (EARO, 2000). Many of the vegetables are low yielders, and they are highly perishable. Hence, undertaking research on vegetable production risks would help in identification of appropriate technologies that may minimize risk.

Kombolcha *Woreda* is one of the major vegetable producing areas in East Hararghe. So far, however, the various risks management strategies farm households use to withstand the adverse influence of vegetable production risks have not been very well studied and documented in the study area. In the absence of such type of studies, one of the basic concerns of smallholder farmers, the design and implementation of effective risk management strategies to increase farm productivity and ultimately to ensure food security in the area could be problematic. Therefore, in this study, the major risk management strategies in vegetable production were identified and the determinant of pesticides use as risk management strategy would be conducted.

2. METHODOLOGY

2.1. *Description of the Study Area*

Kombolcha *Woreda*, having an area of 446.61 km^2, is found in the northern part of East Hararghe zone of Oromia National Regional State. It is located about 514kms south east of Addis Ababa and 14kms North West of Harar town. Komblocha *Woreda* bordered by Haramaya and Jarso *woredas*, Harari Regional State and Dire Dawa Administrative council. Altitudinally, it extends between 1200 and 2460 masl. Of the 19 *Kebeles* (peasant associations) in the *woreda*, 7 (37%) are located in the lowlands (*Kola*) and the remaining 12 (63%) are located in the *Woina dega*. The annual rainfall of Kombolcha *Woreda* ranges from 600 mm to 900 mm (KWP, 2011). The *Woreda* has a total population of about 140,769 and more than 90% of the population resides in rural areas (CSA, 2008).

Crop-livestock mixed farming system is practiced in the *woreda*. The *woreda*'s farming economy is characterized by small and fragmented land holdings. The rain-fed production system is most dominant and is practiced by the majority of the farmers. However, horticultural crops are often produced using irrigation. Farmers produce different crops like sorghum, maize, wheat, haricot bean, and fruits and vegetables. The *woreda* is one of the major producers of vegetables including potato, onion, cabbage, beet root, tomato, and lettuce (Bezabih and Hadera, 2007).

2.2. *Method of Sampling*

In this study, Kombolcha *Woreda* was selected purposively since it has vegetable dominated-mixed farming systems. Then, a two stage sampling technique was used to select sample producers. Firstly, in consultation with the *Woreda* Agriculture and Rural Development Office, the vegetable producing *Kebeles* in the *woreda* were identified and categorized into *kola* and *woina dega* climatic zones. Then, a total of 6 *kebeles* were selected based on probability proportional to the number of *kebeles* in the two categories. Secondly, a total of 130 sample households were selected randomly based on the proportion to the size of household population from the selected *kebeles*.

2.3. *Method of Data Collection*

In this study, both primary and secondary data sources were used. To collect primary data, structured questionnaire was used. Secondary data was collected from different published and unpublished materials and websites.

2.4. *Method of Data Analysis*

2.4.1. *Descriptive statistics*

Descriptive statistics like mean, standard deviation, frequencies, ratios and tabular analysis were used to examine and understand the socioeconomic characteristics of sample households.

2.4.2. *Econometric model*

In this study, double hurdle model was used to analyze factors affecting the decision and the intensity to use pesticides in vegetable production as a risk management strategy.

So far, most of the studies conducted in analyzing the determinants of risk management strategies used dichotomous discrete choice models (Logit and Probit) where the dependent variable is a dummy that takes a value of one or zero depending on whether or not a farmer uses a risk management strategy. However, Uematsu and Mishra, (2011b) pointed out possible loss of information if a binary variable is used as the dependent variable. In particular, a binary variable does not capture the intensity at which a farmer adopts a risk management strategy after he/she decides to adopt it. The most common approach to deal with data that have too many zeros, yielding a censored dependent variable, is to use the standard Tobit model, originally formulated by James Tobin (Tobin, 1958). The model permits incorporation of all observations including those censored at zero, without considering the sources of the zeros (from non-participation decision or other socio-economic factors). This means Tobit model assumes that the same underlying process determines both the probability that the dependent variable is censored and the conditional expectation of the dependent variable given that it is not censored (Burke, 2009). In the context of this study, the same underlying process determines whether a farmer uses pesticides as a risk management strategy or not and the intensity at which the farmer uses pesticides given that he/she decides to adopt it. As a consequence, the marginal effect of a regressor on these two outcomes always obtains the same sign (Wooldridge, 2001).

However, Cragg (1971) proposed a more flexible double hurdle model in which these two outcomes (decision and intensity) are determined by separate processes (Burke, 2009). The double hurdle model is also more flexible than Heckman's two stage model (Heckman, 1979) as it allows for possibility of zero observations in both of the two outcomes (Wooldridge, 2001; Cameron and Trivedi, 2005). In such situation, it is more suitable to apply Cragg's double hurdle model in which a probit regression on decision to use pesticides (most common formal risk management strategy) followed by a truncated regression on the intensity to use (proportion of farm treated by pesticides) (Cragg, 1971).

Since the double hurdle model employs two separate processes to determine two outcomes, the model has two latent variables. Following notations in Mishra *et al*. (2009) and Blundell and Meghir (1987) and suppressing subscript for individual observations, the double hurdle model is empirically represented as follows.

$$Y_1^* = X_1\beta_1 + e_1 \quad (1)$$

$$Y_2^* = X_2\beta_2 + e_2 \quad (2)$$

Where, $Y_1 = \begin{cases} 1, & \text{if } Y_1^* > 0 \\ 0, & \text{if } Y_1^* \leq 0 \end{cases}$ and $Y_2 = \begin{cases} Y_2^*, & \text{if } Y_2^* > 0 \text{ and } Y_1^* > 0 \\ 0, & \text{otherwise} \end{cases}$

Where Y_1^* is the latent variable representing the decision of whether or not to use pesticides while Y_2^* is the other latent variable representing the intensity at which the pesticides (measured in terms of proportion of land under management) is used. Y_1 and Y_2 are observed counterparts of Y_1^* and Y_2^* respectively. X, β and e are vectors of independent variables, parameters to be estimated and the error term, respectively. Note that subscripts, 1 and 2, for X, β and e indicate that the two latent variables can be specified by different sets of independent variables and error terms.

The log-likelihood function for the version of Cragg's model that assumes the probit and truncated regressions to be uncorrelated is given below (equation 3). The double hurdle model obtains consistent estimates of β_1 and β_2 by maximizing this likelihood function:

$$L = \prod_{Y_2=0} \left[1 - \Phi(X_1\beta_1)\Phi\left(\frac{X_2\beta_2}{\sigma}\right)\right] \prod_{Y_2>o} \Phi(X_1\beta_1)\sigma^{-1}\varphi\left(\frac{Y_2 - X_2\beta_2}{\sigma}\right) \quad (3)$$

Where Φ and φ are the standard normal cumulative distribution function and density function, respectively (Burke, 2009). The first portion is the log-likelihood for a probit, while the second portion is the log-likelihood for a truncated regression, with truncation at zero. Therefore, the log-likelihood from the Cragg model is the sum of the log-likelihood from a probit and a truncated regression. However, the probit and truncated regression can be estimated separately.

2.5. *Definitions of Variables and Working Hypotheses*

Pesticides application as a risk management strategy is the dependent variable which is a dummy variable in decision to use and continuous variable in the intensity to use. The intensity to use pesticides in vegetable production was evaluated by dividing the area treated by pesticides to the total vegetable farm land. So, the proportion is between 0 and 1 inclusive. The ratio is easy for comparison since it is unit less.

The followings are explanatory variables which were expected to determine the use risk management strategies (pesticides application particularly).

Sex of the household head: This is a dummy variable assuming 1 if male and 0 if female household head. The variable was expected to have positive effect on risk management strategies. Generally, female headed households are economically weak relative to male headed households. Due to resource constraint female headed households are less likely to use risk management strategies (pesticides).

Age of the household head: this is a continuous variable. The expectation here was positive relationship between age of the household head and risk management strategies. According to Uematsu and Mishra, (2011b) older farmers are more likely to employ risk management tools, regardless of farming experience, simply because of shorter planning horizon and thus they are more reluctant to take on risks, especially if that could cause a financial adversity.

Family size: It is a continuous variable measured in terms of number of persons in a family. The large family households can smooth their consumption from diverse sources of income other than vegetable production and are less likely to apply risk management tools. Therefore, the family size of the farm household was expected to be negatively related with risk management strategies.

Education level of household head: It is a continuous variable and measured in years of schooling of the household head. Formal education was hypothesized to have positive influence on risk management strategies. Accordingly, those farmers who are more educated would have better knowhow about risk management strategies and apply more appropriate measures.

Vegetable production experience: This is a continuous variable and measured in terms of the number of years. It was expected to positively influence risk management strategies, respectively. According to Uematsu and Mishra, (2011a) farming experience, holding age constant, reflects learning effects in decision making on the premise that more experienced farmers are more familiar and comfortable with making complex decisions in the face of risk. Being raised on the farm has a positive effect on the use of risk management tools.

Landholding: is a continuous variable expressed in terms of hectares of farm land owned by the respondents. It was expected to be positively related to risk management strategies. Farms with large scale operation are likely to be exposed to greater amount of risks, and thus they are expected to make extensive use of risk management tools (Mishra and Goodwin, 1997). For example, diversification activities, one of risk management strategies, are concentrated on large farms (Weiss and Briglauer, 2000; Mishra and El-Osta, 2002; Benin *et al*., 2004; Fetien *et al*., 2009).

Number of farm plots: This variable is a continuous one and was expected to negatively influence risk management strategies. According to Belaineh, (2003) spatial diversification is one of the risk management strategies and it gives those farmers who are entitled to more plots an opportunity for enterprise diversification in space and time leading to better livelihoods. The numbers of plots are negatively related to risk management tools.

Farm income: This is a continuous variable expressed in terms of Birr which measures total income that the household earns from farm sources per year. According to Rees, (2009) those low income households do not respond shocks in the same way as higher farm income groups due to the fact that they do not afford the mechanisms provided by the market to help them deal with shocks. This implies that farm income determines the risk management strategies positively.

Livestock size (TLU): This is a continuous variable expressed in terms of tropical livestock unit (TLU) and was expected to negatively risk management strategies. Farms with higher livestock size are less likely to use vegetable production risk management tools simply because they do not need them as much as crop farms.

Off/non-farm income: The value of off/non-farm income earned by the sample households from wages and salaries is a continuous variable. According to Uematsu and Mishra, (2011a) working off-farm reduces managerial time available on the farm, and therefore, off-farm labor was expected to negatively correlate with risk management strategies.

Access to information: It is a dummy variable taking value 1 if a household have got information about vegetable production risks and management strategies from different sources such as extension agent and media and 0 otherwise. Access to information plays a significant role in creating awareness about risk management tools and enables the farmer to adopt the various risk management strategies.

Access to credit service: It is a dummy variable taking value 1 if a household have received formal credit from any financial institution and 0 otherwise. Access to credit may enables the farmers to get additional income in such a manner that enables the farmer to afford the risk management mechanisms provided by the market to help them deal with shocks.

Ecological zones: It is a dummy variable taking value 1 if a household lives in *Woina dega* and 0 otherwise.

Most areas of Kombolcha *Woreda* are *Woina dega* climatic zones while the rest of the areas are *Kola* climatic zones. It was also expected to be negatively related to risk management strategies. This is due to the fact that being exposed to relatively lower risks; *Woina dega* areas are less likely to adopt risk management tools.

3. RESULTS AND DISCUSSION

3.1. *Socioeconomic Characteristics of the Sample Households*

Socioeconomic characteristics of the sample households are presented in Table 1 and 2.

The majority (about 84%) of the respondents are male-headed households. In terms of the marital status of the household heads, majority (about 81%) of the sample respondents are married. The survey results also showed that 48.5% of the producers do not have formal education while 51.5% of sample respondents attended formal education (Table 1).

The average age of the sample household heads is about 35 years and the household heads have about 13 years of vegetable production experience (Table 2). With regard to household size, sample respondents in the *woreda* reported that they had a family size of about 5 persons per household. This is equal to an adult equivalent of 4.33. Large household size allows the household flexibility to pool resources for sharing risks and labor they need during peak season.

According to the survey, the average land holdings of the respondents in the *woreda* is less than a hectare (0.36 ha on average). Of these, an average of above 0.20 ha of the land is suitable for irrigation (is irrigable area). The landholdings of sample respondents in terms of the average number of plots are two.

The farm income is earned from different sources like sales of grains/pulses, chat/coffee, horticultural crops and sales of livestock and livestock products. The average annual farm income of the respondents was Birr 21,565.66 (Table 2). The survey shows that crop production is a major source of income for the majority of the producers.

Livestock production is limited by the shortage of grazing area and hence by critical shortage of feed. Average number of livestock for the sample households is 3.17 tropical livestock units (TLU) (Table 2).

Farmers also participate in non-farm and off-farm activities to generate supplementary income. Non-farm/off-farm income is the income derived from sources other than farming, like petty trade, handicraft, daily labor, remittances, aids and working on others farm. The average annual non/off-farm income of the sample households was about Birr 1201.26 (Table 2).

3.2. *Major Risk Management Strategies*

Risk management has become increasingly important in all aspects of the agriculture sector, including vegetables. Risk management strategies consist of a variety of responses which may reduce the probability of an unfavourable event occurring and/or reduce the adverse consequences if the event occurs. There are several strategies that farm operators can use to reduce the farm exposure to risks. The strategies can be classified into modern/formal and traditional risk management tools. The survey indicated that, because of unavailability of formal strategies, farmers in Kombolcha *Woreda* heavily rely on traditional risk management strategies which are suboptimal.

As the survey implied, the farmers in Kombolcha *Woreda* are employing sequential marketing, enterprise diversification, income diversification (off-farm work), irrigation and chemicals/pesticides to cope with risks.

The sequential marketing (spreading sales), making several sales of a commodity during a year, is commonly used by agricultural producers. Producers are forced to spread their marketing over the entire year because of the nature of their production. Farmers in the study area practice sequential marketing especially for potato and onion. They harvest in a piecemeal over the harvesting period. This strategy is used to minimize losses due to perishability and in cases where there is a storage problem.

According to the survey, farmers in Kombolcha *Woreda* are using pesticides/chemicals to manage vegetable production risks caused by pests/diseases and insect attack. According to Ntow, (2008) the pesticides comprised insecticides, fungicides and herbicides. The use of pesticides helps to reduce crop losses and to improve the yield of vegetables.

Farmers in the study area are also using diversification to reduce vegetable production risks. From the survey, two forms of diversification were identified and most of the farmers diversify enterprises and about 20% of the respondents diversify their income sources into off-farm and non-farm sources. Intercropping is the most common form of enterprise diversification. The result of the survey indicates that farmers intercrop for three major reasons: to increase soil fertility, better use of resource (land in this case since it is scarce) and for minimizing risk due to loss from another enterprise(s). According to Bezabih and Hadera (2007), the advantage of intercropping may also entail supplementary relationship which calls for physical support of one crop to the other crop and erosion control through providing continuous leaf cover over the ground surface.

In addition, farmers are using other traditional and crop specific methods. According to Klingele (1998), late blight is a common disease for potato and farmers often prefer the dryer belg season (March, April and May) for cultivation where there is lower incidence of diseases. The survey showed that farmers also treat their land with ash to protect the vegetables from diseases.

3.3. *Determinants of Use of Pesticides/Chemicals*

The double hurdle model was used to analyze the determinants of the decision and extent to use pesticides to manage vegetable production risks. Here the first step (hurdle) is probit analysis on the decision to use pesticides and the second stage is truncated regression on the proportionate area treated by pesticides. The proportionate area is easy to compare the amount of pesticides use of the large size vegetable farm owners relative to the small size farm owners. The results of the regression are given in Table 3.

The positive relationship between total size of *landholding* and the intensity to use pesticides indicates that farmers having relatively larger landholdings apply pesticides on most areas of their land. Economics of scale and cost effectiveness encourages pesticides use in larger landholdings than application of other physical and/or biological pest/diseases control methods in vegetable farms. This is especially true in weed management. The result is in line with the study which states that farms with large scale operation are likely to be exposed to greater amount of risks (Mishra and Goodwin, 1997), and thus they are expected to make extensive use of pesticides.

Vegetable production experience is positively and significantly affecting the decision to use pesticides as a risk management strategy. As experience in vegetable farming increases the households might understand the need of pesticides and effective control of pest/diseases by pesticides in vegetable production and decide to use. As indicated by the marginal effects, an increase in year of vegetable production experience will increase the probability to use pesticides by 2.52%.

The coefficient of *farm income* is positive and significant in deciding to use pesticides. This is the fact that as farm income increases the purchasing power of the farmer could increase so that the farmer can afford the pesticides and his risk bearing ability increases and applies pesticides to help him deal with pest/diseases risks faced.

The *livestock size* measured in TLU is negative and significant indicating that households with more number of animals are less likely to use pesticides in vegetable production. But the intensity to use the pesticides is positive and significant showing that the amount of pesticides increases as the livestock size increases. Farms with higher livestock size are less likely to purchase pesticides simply because they do not need them as much as crop farms. However, higher number of livestock owners may be more willing to use pesticides at a greater intensity if the pesticides are proven to be successful and compatible with the existing situation. This is because farmers with higher number of livestock can better afford to purchase pesticides by selling livestock and livestock products. As indicated by the marginal effects, an increase in livestock size will reduce the probability to use pesticides by 11.7% and increase the intensity to use pesticides by 4.5% on average.

The coefficient of *non/off farm income* is positive and significant indicating that the non/off farm income increases the decision to use pesticides. Similarly, the coefficient of non/off farm income is positive and significant to the intensity to use pesticides showing that the proportionate area treated by pesticides increases as the non/off farm income increases. The involvement in non/off farm activities may enable the farmer to get additional income in such a manner that enables the farmer to purchase pesticides. Therefore, off/non farm income helps to purchase pesticides and thus reduces vegetable production risks.

The estimated coefficient of *access to information* is positive and significant in the decision to use and the intensity to use pesticides implying that those who have access to information are likely to use pesticides in their vegetable farms. The reason is that those farmers who have relatively more information and knowhow about the importance and application of pesticides can use pesticides and apply in relatively large areas of their plots.

4. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

4.1. *Summary and Conclusions*

The objective of this study was to provide empirical findings of major risk management strategies in vegetable production in Kombolcha *Woreda*. In general, farmers in the *Woreda* are very less likely to use modern risk management strategies due to non-existence of the strategies. Pesticides use, enterprise diversification, income diversification (off-farm work), sequential marketing and irrigation are the most common strategies used by the farmers to manage vegetable production risks.

The factors determining to use pesticides in vegetable production were analyzed using double hurdle model. The double hurdle model results indicate that vegetable production experience, farm income, non/off farm income and access to information determine the decision to use pesticides positively while livestock size affects negatively. On the other hand, landholding, livestock size, non/off farm income and access to information are variables affecting the extent of use of pesticides (measured in terms of proportion of land treated by pesticides) positively and significantly.

4.2. *Recommendations*

Pesticides are used as a tool for farmers to reduce vegetable production risks particularly risks of pests and insects. In order to promote use of pesticides, it is suggested that:

1. Experience sharing and discussion is important between vegetable producers to increase the likelihood of pesticides application.
2. Creation of non/off farm work should be given due attention to increase the likelihood of using pesticides as a risk management mechanism.
3. Higher farm income enables farmers to apply pesticides in vegetable production. Therefore, increasing farm productivity and hence farm income by using advanced farming technology should be strengthened.
4. The households' access to information sources such as extension service, trainings, access to media, etc should be given due attention to increase the likelihood of using pesticides in vegetables production.

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Table 6: Summary statistics of the sample households (categorical variables)

Variables description	Number of farmers	Percent
Sex of household head		
Male	110	84.62
Female	20	15.38
Educational level of household head		
Illiterate	24	18.50
Adult education	39	30.00
6th grade and less	39	30.00
7th grade and above	28	21.50
Marital status of household head		
Single	5	3.84
Married	106	81.54
Divorced	10	7.69
Widowed	9	6.92

Source: Survey results, 2012

Table 7: Summary statistics of the sample households (continuous variables)

Variables description	Mean	Std. Deviation
Age of the household head (years)	35.88	10.41
Total land holding (hectares)	0.36	0.19
Total irrigable area (hectares)	0.20	0.14
Numbers of plots	2.15	1.24
Vegetable production experience (years)	13.43	0.92
Family size of the household (persons)	5.76	1.92
Family size of the household (adult equivalent)	4.33	1.56
Total farm income (birr)	21,565.66	20,948.04
Livestock size (TLU)	3.17	2.08
Nonfarm and off-farm income (birr)	1,201.26	4,003.50
Distance to nearest market (km)	7.41	7.15
Number of visit by extension agent (number)	10.93	15.07

Source: Survey results, 2012

Table 8: Parameter estimates of Cragg's double hurdle model for use of pesticides

Variables	Pesticides use decision			Pesticides use intensity		
	Coef.	Std. Err.	dy/dx	Coef.	Std. Err.	dy/dx
Sex	-1.04093	0.51689	-0.36319	-0.05782	0.08559	-0.05782
Age	-0.03141	0.02305	-0.01253	-0.00525	0.00481	-0.00525
Education	0.01225	0.04183	0.00489	-0.01039	0.00999	-0.01039
Land holding	0.66145	0.84338	0.26388	0.19316***	0.1691	0.19316
No. of plots	-0.02351	0.12857	-0.00938	-0.07441	0.02643	-0.07441
Veg. experience	0.06307***	0.02166	0.02516	0.00254	0.00512	0.00254
Family size	-0.04574	0.07986	-0.01825	0.00866	0.01656	0.00866
Farm income	0.00001*	7.17e-06	4.86e-06	1.84e-06	1.75e-06	1.84e-06
Livestock size	-0.2928***	0.09780	-0.11680	0.04501*	0.02469	0.04501
Non/off income	0.00006*	0.00004	0.00003	0.00001**	6.10e-06	0.00001
Access to info.	0.61048*	0.31609	0.23981	0.09142*	0.05284	0.09142
Access to credit	-0.11241	0.37302	-0.04481	-0.00669	0.08529	-0.00669
Agro-climate	-0.40447	0.58279	-0.15939	-0.02690	0.13331	-0.02690
Constant	2.99205**	1.30626		0.65665***	0.2219	
Sigma				0.14780***	0.01590	
Number of observations	130			52		
LR chi2 (13)	46.34			32.54		
Log likelihood	-66.78089			27.70851		

***, ** and * indicate significance at 1%, 5% and 10% levels, respectively.
dy/dx-denotes marginal effects