World Applied Sciences Journal 35 (7): 1021-1028, 2017
ISSN 1818-4952

DOI: 10.5829/idosi.wasj.2017.1021.1028

Determinants of Household Food Security in Punjab – Pakistan: A Binary Logistic Regression Analysis

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Abstract: The household food security has gained tremendous focus of policy makers and agriculturists in the recent past. Household food security is multi-dimensional phenomenon which cannot be measured with a single set of variables. A large range of socio-economic, farming characteristics and human development related variables have been found significantly influencing household food insecurity. Agriculture sector in Pakistan contributes at least one fifth to the GDP but still the country has alarming levels of household food insecurity. Current study has been conducted with the objective to explore the determinants of household food insecurity in Punjab province of Pakistan. A comprehensive data regarding household economic level, agricultural farming conditions and food security situation was collected on a structured questionnaire from 300 farming households by employing multi-stage cluster sampling technique. Food insecurity experience measurement technique was employed to categorize food secure and insecure households. Subsequently, econometric model of binary logistic regression was used to explore significant determinants of household food insecurity. The results showed that age and education of household head as well as family earners, household monthly expenditure, agricultural farm size, land rent, irrigated land, livestock heads and ownership of tractor were significant variables which negatively influenced household food insecurity. However, family size and household head's self-possession of agricultural land in contrast with family ownership appeared positively linked with household food insecurity. The findings of the study underlines that the opportunities of education and income may be enhanced for the farming community along with effective implementation of population control programs. Enhancement of asserts base and farm mechanization with due focus on tackling the issue of fragmentation of agricultural land is emphasized to reduce household food insecurity in Punjab province.

Key words: Food security · Logistic regression · Rural households · Pakistan

INTRODUCTION

Household food insecurity is a severe problem for millions of people in many countries. Achieving sufficient food supply is a necessary condition for being food secure but sustainability of food supply keeping in view the growing needs of the people is a real challenge for the policy makers and agriculturists. Food insecurity encompasses the condition of persistent hunger wherein people do not have enough to eat and undernutrition when they insufficiently consume specific nutrients in the diet. According to the 1996 World Food Summit, food security is all about the economic and physical access by all people and all times to sufficient and nutritious food as per their preferences for leading a health life [1]. It entails that food insecurity is simply absence of one or more of these conditions.

The concept of food security also involves the people's risks of not having access to required food. These risks may be related to household crop production, employment and income etc. Thus, insecure household cannot ensure adequate dietary needs of all the household members. Household food insecurity can be transitory or chronic in nature. Transitory food security could be caused by instability of food prices, crop production and employment however, chronic food

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security is associated with poverty [2]. Repeated spells of transitory food insecurity hit hard the households and make them chronically food insecure.

Food security is multi-dimensional phenomenon which cannot be measured with a single set of variables. Various indicators are needed to capture the existence of food insecurity at national, household and individual level. At national level, the supply and demand side indicators e.g. total production of food grains, their aggregate demand and net import from other countries are taken into consideration. However, household food security is the mostly assesses by calculating per capita daily calories intake. Anthropometric measurements i.e. size, shape and composition of human body are also important for reporting food insecurity at individual level. This information is basically the outcome of the nutrition and sanitation conditions which prevailed in the past and affected the individuals. Thus, a complete mix of factors affecting food security must include variable related to food availability, food access and food utilization [3].

Pakistan is world's 6th most populous country. It has an estimated population of 195.4 million and a huge annual population growth rate of 1.89 [4]. It is projected that Pakistan, if could not control its current population growth rate, will have its population doubled by 2045. Even though agriculture is one of the major sectors of the economy which contributes 19.8% to GDP and employs 43.3 % of labor force, Pakistan still has serious concern of food security both at the national and household level. No doubt, the total grain availability has increased many folds in Pakistan since its inception in 1947 but all the benefits from agricultural development have been thwarted by disproportionate increase in population [5].

According to National Nutritional Survey of Pakistan held in 2011, at least 58% of households were food insecure in Pakistan and each household incurred 50.8% of monthly income on food only. Similarly, 15% of children under 5 suffered from acute malnutrition and 22% of the same age were underweight [6]. Pakistan has been ranked 78th out of 113 countries on 2016 Global Food Security Index with overall score of 47.8. Its scores for affordability, availability and quality & safety are 43.3, 50.4 and 44.5 respectively [7]. Similarly, the hunger level in Pakistan has been described as 'serious' on 2016 Global Hunger Index with very high score of 33.4. According to the same index, 22% of Pakistan's population is undernourished, 10.5% children under five are affected by wasting, 45% children under five are stunted whereas mortality rate under five is 8.1% [8].

The objective of this study is to analyze the food security situation at the household level and explore its key determinants to propose possible solutions and policy suggestions to the issue of food insecurity in Pakistan. This article has been organized into four parts: First part gives the general introduction; part two is related to methodology and data analysis; Results and discussion are presented in part three; and finally part four presents the conclusions and policy recommendation of the study.

MATERIALS AND METHODS

The methodology of the article has been presented as sources of data, analytical model and research variables.

Sources of Data: Keeping in view the aim and objective of the study, a comprehensive structured questionnaire was developed. It was consisted of separate modules for household economic level, agricultural farm productivity, farm machinery, livestock information, land use and food security situation. Pre-testing of the questionnaire was done and necessary amendments and improvements were incorporated. Data was collected from 300 households by employing multi-stage cluster sampling technique. Punjab was selected out of four provinces of Pakistan i.e. Punjab, Sindh, Khyber-Pakhtunkhwa (KPK) and Baluchistan because it is the most important province which contains 52% of total population, 57% of total cultivated area and 69% of total cropped area of the country. Due to distinct difference of agricultural conditions within Punjab, total sample size was proportionately divided into four agro-ecological zones: irrigated, arid, Thal and marginal lands. Then, 18 respective districts and 28 sub-districts were proportionately selected within the agro-ecological zones whereas the villages were selected by using simple random sampling technique. All the data entry and data documentation was made by using EpiData version 3.1 and subsequently the data analysis was done by using IBM SPSS Statistics version 23.

Analytical Model: Data analysis has been divided into two stages. In the first stage all the households surveyed were bifurcated into food insecure and food secure households. In the second stage, binary logistic regression analysis was employed to explore the key determinants of food security.

Different methods have been used in the literature to measure the nature and extent of food security but none can be taken as gold standard which provides full assessment of issues of sustainability and vulnerability regarding food security [9]. The choice of appropriate method primarily depends on the particular aspect of food security that is being focused i.e. availability, access or utilization. The most common techniques used in the literature is calories intake or under-nourishment method but it carries a substantial error in 24 hours recalling by respondents of their meals and portion sizes and the enumerators require high level of skill to appropriately classify the food for calories calculation [10]. As the study primarily focusses on the access to food dimension of food security, food insecurity experience measurement technique has been employed to categorize food secure and insecure households [11] and [12]. The data was collection on direct and indirect questions from the household head because it was in charge and well aware of the food acquisition and food intake patterns of the household.

Conventionally, linear regression is used in most of the economic and social estimations but it may lead to unreasonable results especially when the dependent variable is dichotomous [13]. As the sample households are either food insecure or food secure, binary logistic regression technique was used for dependent variable. It means that event either occurs i.e. food insecure households (1) or does not occur i.e. food secure households (0). Basically, the logistic regression directly estimates the probability of a household to falls into one of two categories of a dichotomous dependent variable of food insecurity or food security based on one or more independent variables which can be either continuous or categorical.

Following [14] and [15], the commutative logistic model can be econometrically written as below:

$$P_i = E(Y = 1 \mid X_i) = \frac{1}{1 + e^{-(\beta_0 + \Sigma \beta_i X_i)}} \quad (1)$$

where P_i is the probability of a household to be food insecure based on given X_i; Y =1 means that the household is food insecure; X_i represents the i^{th} explanatory variable of food security; β_0 and β_i are regression coefficients; whereas e is the base of natural logarithm.

The equation (1) can be written as following:

$$P_i = \frac{1}{1 + e^{-Z_i}} = \frac{e}{1 + e} \quad (2)$$

where $Z_i = (\beta_0 + \Sigma \beta_i X_i)$. The equation (2) is known as the commutative logistic distribution function. If P_i is the probability a household to be food insecure then $1–P_i$ is probability of a household to be food secure. Here.

$$1 - P_i = \frac{1}{1 + e^{Z_i}} \quad (3)$$

Therefore, equation (3) can be written as;

$$\frac{P_i}{1 - P_i} = \frac{1 + e^{Z_i}}{1 + e^{-Z_i}} = e^{Z_i} \quad (4)$$

Now, $\frac{P_i}{1 - P_i}$ is called the odds ratio in favor of being food insecure or the ratio of probability of a household that it will be food insecure to the probability that it will be food secure. If the natural logarithm of equation (4) is taken, then

$$L_i = \ln\left(\frac{P_i}{1 - P_i}\right) = Z_i = \beta_o + X_1 + \beta_2 X_2 + ... + \beta_n X_n \quad (5)$$

L_i is the log of odds ratio and is called logit or logistic regression model for food insecurity. After incorporating the disturbance term μ_i to the above equation (5), the logit model will be as following.

$$L_i = \beta_o + \sum_{i=1}^{n} \beta_i X_i + \mu_i$$

The parameter β_o and $\beta_1, \beta_2 ... \beta_n$ in the above model are estimated by using maximum likelihood (ML) method.

Research Variables: The potential research variables or determinants of household food insecurity were identified on the basis of literature reviewed, findings of the previous research, experts as well as personal knowledge of the food insecurity situation in the Punjab province. Following variables were selected to be analyzed for prediction household food security in the logistic regression.

The family size (X_1) is deemed an important variable because food security directly associates with number of persons in a household and food availability. Age of the household head (X_2) could be potential variable because agricultural operations need physical efforts and experience that varies with the age. Similarly, the education of the household head (X_3) also matters a lot because level of education expands the knowledge of household heads and there are in better position to apply improved practices for agricultural production and earn

off-farm incomes which influences the household food security situation. The total on-farm and off-farm labor engagements are important indicators for assessing the labor availability and productivity of a household because number of family earners (X_4) in households could directly influence the food security situation. The house building materials (X_5) whether it is bricks with mud or bricks with cement may show the living condition with is important with respect to entitlement or access to food of a household. Household monthly expenditure (X_6) matters in the context of food security because expense on food items improves the food availability and expense of non-food items may improve the access to food.

The ownership of farm assets is crucial for rural farming community. The total farm area (X_7) is an indicator of total cultivated area and agricultural production from the farm. The small agricultural farmers usually undergo subsistence farming whereas the larger farmers tend to experience progressive and market oriented commercial farming which is linked with farm profitability and also influence household food security. The land title (X_8) whether farm land is owned by the farmer or it is jointly owned by the family elder etc can heavily influence the investment decisions on the agricultural farm and indirectly food security of the farming family. The fertility of land is assessed with the fact whether it is irrigated (X_9) or not and how much land rent (X_{10}) can be received if farm land is given on lease. Thus, productive potential of the agricultural farm influences the household food security. The possession of livestock (X_{11}) is important for the farming family because livestock is usually a source of milk and meat but ready cash for meeting the urgent family and farm needs and thus is linked with household food security. Similarly, the ownership of a tractor (X_{12}) is very important for agricultural production, harvesting and transportation of agricultural produce. Tractor can be used for irrigating the farm area and rented out for added income. The farm mechanization in the form of tractor is very important in context of farm production, farm income and household food security.

RESULTS AND DISCUSSIONS

Results and discussion have been presented as household food security status and binary logistic regression.

Household Food Security Status: The Table 1 presents the empirical results of bifurcation of households among food insecure and food secure households. It can be seen that the food security situation is not so good because less that two third of total households were found to be food secure. Out of a sample of 300 households from the selected districts of Punjab province, only 205 households (68.3%) were food secure and the rest of 95 households (31.7%) were categorized as food insecure.

Binary Logistic Regression: The most important factors responsible for the determination of household food security were identified by employing binary logistic regression. The results of binary logistic regress employed the maximum likelihood methods and ascertained the effects of participating variables (X_1 to X_{12}) on the likelihood that household were food insecure. The binary logistic regression was significant as $\chi^2(12) = 38.402$ and $\rho<0004$. The binary logistic regression model explained 31.2% (Nagelkerke R^2) of the variance in the household food insecurity. The results showed that the model correctly predicted 73.0% of the sample households. Similarly, the correct predictions of food insecurity (sensitivity) and food security (specificity) were found to be 45.3% and 85.9% respectively.

As per Table 2, it is observed that out of twelve variables supposed to influence the household food insecurity eleven variables except variable of house building material were found statistically significant. However, at least six sub-categories of three different variables (education of household head, monthly household expenditure, agricultural land rent) were also found to be statistical insignificant. Overall, the results showed that age of the household head, education of the household head, family size, family earners, household monthly expenditure, agricultural land rent, agricultural farm area, livestock heads, agricultural land title, ownership of a tractor and irrigated agricultural land were important variables for determination of household food insecurity in Punjab province.

The results of binary regression presented in the Table 2 show that the age of the household head is highly significant variable in relation to household food insecurity. It was revealed that likelihood of food insecurity deceased with increasing age but beyond certain age reverse relation was observed. Thus, the household heads with age category of 46 to 55 were most food secure in their life time and 18.4 percent less likely to be food insecure as compared with the reference category of below 35 years of age. Similarly, the education of the household had negative relationship with the likelihood of being food insecure. Specifically, household heads those had attained primary education were found to be 62.6 percent less likely to be food insecure as compared with horseheads who were illiterate. These results are in line with the findings of [16] conducted similar study in rural and peri-urban areas of Faisalabad, Pakistan.

Table 1: Food Security Status of Households in Punjab, Pakistan

Household category	Frequency	Percentage
Food Insecure	95	31.7
Food Secure	205	68.3
Total	300	100

Table 2: Results of Binary Logistic Regression

Variables	Estimated Coefficients	Standard Error	Odds ratio
Age of HH (Years)			
Up to 35[RC]			
36 to 45	-.321	.646	.725*
46 to 55	-.204	.430	.816*
56 and above	-.250	.377	.779**
Education of HH			
Illiterate [RC]			
Primary	-.984	.703	.374*
Middle	-.293	.596	.746*
Matric or above	.188	.631	1.207
Family size			
Up to 5 [RC]			
6 to 7	1.489	1.127	4.434*
8 to 9	.809	.944	2.246**
10 or more	.785	.939	2.192*
Family earners			
1[RC]			
2	-.204	.445	.816*
3 or more	-.409	.355	.664**
HH monthly expenditure (Rs)			
Up to 20, 000 [RC]			
20, 001 to 40, 000	.488	1.278	1.628
40, 001 to 60, 000	.234	1.082	1.263
60, 001 or above	-.381	1.085	.683**
Land rent (Rs)			
Up to 10, 000 [RC]			
10, 001 to 20, 000	-1.411	.719	4.100
20, 001 to 30, 000	-1.282	.669	3.603**
30, 001 to 40, 000	-.842	.573	2.321
40, 001 or above	-.406	.527	1.501
House building material	.487	.328	1.627*
Agricultural Farm area (acres)	-.164	.042	.849**
Agricultural land title	.706	.311	2.026*
Irrigated land	-.100	.532	.905*
Livestock heads	-.120	.043	.887*
Tractor ownership	-1.173	.368	3.232**

Note: ** is statistically significant at P<0.01; * is statistically significant at P<0.05;

Sample size is 300; Pearson Chi-square is ; -2Log likelihood ratio is ; Nagelkerke R^2 is ; Overall classification is ; Sensitivity is ; specificity is ; RC is Reference category

The family size was found to an important variable in the logistic regression model that appeared statistically significant in relation with response variable of household food insecurity. The positive relationship of family size with the household food insecurity and odd ratio in favor of probability of food insecurity indicated that the large families are more likely to be food insecure. More specifically, the family size with 6-7 members were found to be 4.434 times more food insecure as compared with reference category of less than 5 family members. Similarly, the odd ratios for family size of 8-9 and 10 or more indicated that likelihood of these household being food insecure increased 2.246 and 2.192 times respectively as compared reference category. Similar, results were reported by [17] in context with Ethiopia and [18] in North Central Nigeria.

The number of family earners found to have negative relationship with household food insecurity. If a household had more earing hands in addition to prime bread-winner then their likelihood of being food insecure tended to decrease. As per finding of this study, if a household had two family earners then it is 18.4 percent less likely to be food insecure as compared with the reference category of household where only one family earner was present. The same likelihood of being less food insecure further increased up to 33.6 and 14.2 percent in case of three or more family earners as compared with households having one or two family earners respectively. The variable of household monthly expenditure was found statistically significant only in case of expenditure category of Rs. 60, 001 or above. It was revealed that household incurring monthly expenditure of Rs. 60, 0001 or more was 31.7 percent less food insecure. [19] and [20] reported similar findings by analyzing pattern of food security in Logos and Kwara States of Nigeria respectively. Such results regarding family labor and food insecurity was in line with the finding of [21] in context with Nepal.

The productive capacity of agricultural land was observed to have highly significant relationship with household food insecurity. In this regard the variable of agricultural land rent and irrigated land yielded negative relationship with food insecurity. The results confirmed the hypothesis that the households having fertile agricultural land will have more production, land rent and irrigated land as compared with land where facility of irrigation is not available and land rent is relatively meagre. Specifically, the odd ratio in favor of food insecurity decreased 3.603 in case of land rent category Rs. 20, 001 to 30, 000 per year as compared with reference category of land rent below Rs. 10, 000 per year. Similarly, odd ratio in favor of food insecurity decreased 0.905 times with increase in one acre of irrigated land as compared with rain-fed agricultural land. Such results regarding influence of agricultural land productivity and food security confirmed the findings of [22] and [23].

The agricultural farm area was found to be highly significant in the binary logistic regression model and appeared to have negative relationship with food insecurity. The odd ratio revealed that if farm size is increased by one acre then likelihood of a household to be food insecure decreased by 15.1 percent. The possible rationale of such results is that the agricultural farmers with larger farms may have more diversified crops, higher chances of using modern farming techniques and increased production which altogether add to the farm profitability, income and better food security condition for the farming households. Similarly, the ownership of livestock heads by the household yielded negative relationship with the household food insecurity. The odd ratio revealed that the likelihood of a household to be food insecurity decreased 0.887 times with addition of one livestock head with the farming households. The hypothesis that the livestock not only provide milk and meat but is an easily liquefied asset in case of urgent need to the farming household was fully endorsed by the results of regression model. Similar finding regarding farm size and livestock were reported by [24] and [25] respectively.

The variable of tractor was found to have highly significant results. It revealed that households those possessed a tractor were 3.232 times less likelihood to be food insecure as compared with households those did not possess the tractors. The hypothesis of taking ownership of a tractor as an essential farm asserts and its association with household food security was highly relevant. However, the self-ownership of agricultural land title did not carry expected negative sign. The odds ratio indicated that household heads which self-owned their farm land were 2.026 times more food insecure as compared with jointly owned farm land. The possible justification of such results could be the custom of living in a joint family system. Households those jointly owned and cultivated joint family land could be less food insecure as compared with self- owned and self-cultivated smaller agricultural farms by the possibly nuclear family household head.

CONCLUSIONS

It can be concluded from the above results and discussion that the prevalence of household food insecurity is quite high in the farming communities of Punjab province despite the fact that they were involved with agricultural production. The binary logistic regression model indicated that the socio-economic characteristics and assets holding both at household and agricultural farm level were important determinants of household food insecurity. The significant results for variables of age and education of household head, earning hands in a household and household monthly expenditure showed negative relationship with household food insecurity. Thus, agricultural farming experience and education of the household heads is important for reducing household food insecurity. If more and more family members participate in the earning activities and resultantly they can incur better household spending which reduces household food insecurity.

Similarly, agricultural farm area, irrigated land, agricultural land rent, livestock heads and ownership of tractor also appeared negatively and significantly linked with household food insecurity. The larger farm size, farm with the facility of irrigation water and better land rent reduced household food insecurity. In the same vein, the ownership of livestock and tractors also contributed towards reducing household food insecurity. However, the positive link between family size household food insecurity underlined the issues of population and large dependency ratio in the rural farmers. The household head's self-title of agricultural land in contrast with family ownership appeared positively linked with household food insecurity and revealed the prevalence of relatively less food insecurity among traditional joint family system.

In view of above, it is suggested for the policy makers that facilities of education may be increased for the farming community in Punjab province. The farming households with larger agricultural farms have improved conditions of food security thus a detailed policy may be devised to cut down the cultural practice of agricultural land fragmentation. As the more family earners have less food insecurity thus establishment of agro-based industry around rural areas will increase the off-farm and part-time income earning opportunities of farming community. The population control programs may be effectively implemented in rural areas which result in decreased dependency ratio and better food security conditions. As a part of development planning, livestock sector and farm mechanization may also be promoted for betterment of farming community and reducing food insecurity.

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