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Original Article

Factors influencing adoption of crossbred cattle in different agro-ecological zones of Bangladesh

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A B S T R A C T

Crossbred cattle farming by small farm holders are one of the promising agricultural activities to enhance financial and nutritional status of the rural people of Bangladesh. Several factors influence the rural farmers to raise the crossbred cattle farming. Thus, the research investigates the demographic, socioeconomic and agro-ecological factors and farming assets and facilities of the small farm holders that influence the adoption of crossbreds. Multistage random sampling technique was used to random selection of 300 cattle households in four agro-ecological zones. Chi-square tests were carried out to assess the association between cattle breeds and levels of variables. Also, the binary logistic regression model was used to determine the effects of the factors. Age group, level of education, occupation, household income, farming experience and reception of extension services were significantly ($p<0.01$) associated with the adoption of crossbred cattle. Extension services (OR=128.82, 95%CI=27.74-598.2) and higher income group (OR=6.138, 95%CI=1.352-27.87) were significant and more likely to adopt crossbred cattle compared to no extension services and low-income group respectively. Secondary educated farmers were 3.64 times more likely (OR=3.642, 95%CI=1.24-10.67) and higher than secondary educated farmers were 7.58 times more likely (OR=7.579, 95%CI=2.45-23.40) to adopt crossbred cattle compared to illiterate or primary educated farmers. Industrial zone was more likely and other two zones were less likely to adoption of crossbred cattle compare to river basin zone. Youths should be trained and educated and also extension services should be provided to the farmers to raise crossbred cattle for increased milk production and household poverty alleviation.

Introduction

Cattle farming in rural Bangladesh are constituted mainly from smallholder farming system being managed in traditional ways. Smallholder dairy as well as cattle farming is becoming increasingly important and potential to poverty alleviation, food security, employment generation and improved family nutrition and income (Uddin *et al.*, 2012; Fogwe, 2015). Almost 73.9% of the total cattle are kept by small and landless farmers of the country and cattle development would definitely help livelihood improvement of the rural poor in addition to dairy and meat production (Huque and Khan, 2017). A large portion of smallholders rear indigenous cattle in the homestead for own consumption and some times for income generating purposes. Low productivity of indigenous cattle is attributable to the fact that these cattle are mostly subsisted on crop residues and natural greenery without any noteworthy supplementation of concentrates produce low amount of milk yield. Crossbred cows are more economical and provide higher yield than the indigenous one. Income level from milk yields of crossbred cows is 3.19 times higher than that of the indigenous cows (Islam *et al.*, 2010). The research institutes and universities in the country have carried out a lot of researches in developing improved breeds of cattle to solve the problem of low productivity, yet the adoption level of crossbred cattle has not been increasing remarkably. The reasons for this are due to a combination of factors like farmers' unfavorable socioeconomic disposition, inefficiency of extension activities, especially, in remote areas, deficiency of farming assets and management facilities. But, these unfavorable situations in the farm level must be minimized and

preference of crossbred cattle by the smallholder farmers is essential to increase the dairy production at national level.

There are several characteristics that determine a farmer adopt or not adopt crossbred cattle. Farmer adopts it whether those characteristics of farmers are better. These characteristics are the farmers' age, education, family size, land holdings, income, experience, herd size, extension services, etc. Age of farmers has a negative effect on adoption (Baidu-Forson, 1999) and that younger farmers have higher probabilities to adopt technology than older farmers (Läpple and Hennessy, 2014; Barham, 2004). Education may foster technology adoption (Bortmuly and Guswami, 2015), which is considered to enhance the general mentality and therefore to positively influence the attitudes of an individual towards adoption of technology (Ansah *et al.,* 2015). Higher income farmers are better adopters of improves technologies than lower income farmers (Kinnucan *et al.,* 1990). Jera and Ajayi (2008) analyzed such characteristics and ecological factors on farmer's decision to adopt the technology using a logit modeling approach. Also, Irungu *et al.* (1998) and Mekonnen *et al.* (2009) analyzed such factors those affecting adoption on smallholder dairy farms.

Understanding the effect of socioeconomic and farm characteristics, variations of agro-ecological zones, extension services on cattle breed would helpful for policy design and effective management of extension programs in the study area. The study will also generate valuable information to the researchers as well as extension workers, which can help to form effective national planning for the development in the dairy sector. Therefore, the present study was undertaken to investigate the demographic, socioeconomic, farming facilities and agro-ecological factors and determine their influence on adoption of crossbred cattle.

Materials and Methods

The study location

Four agro-ecological study locations were selected from all over the Bangladesh in order to economize time and labor. These were (i) Bramhaputra river basin and mid-region of the country (Mymensingh district), (ii) industrial zone having high employment opportunity (Gazipur district), (iii) rural plain land and northwest region of the country (Gaibandha district) and (iv) northern hill sites (Sherpur district). The major occupation of the people in these regions is farming and mixed farming predominantly practiced, with most farmers blending crops and livestock in the farming activities. Some of the farmers' major occupation is services, business and laborer, especially in the first and second zones and cattle is the subsidized farming.

Sampling procedure and data collection

Multistage sampling procedure was used to select farm households for this study. The four regions were considered as the four strata of the sampled population. During the first stage, one random sub-district called upazila from each of the regions was selected randomly. During the second stage, three villages from each upazila were randomly selected using simple random sampling technique. During the third stage, 25 households (approximately 10% of the population households) were selected from each village using simple random sampling technique. Finally, a total of 300 cattle farmers having at least a lactating cow from the selected villages were found to collect data in four agro-ecological zones. Prior to farm household sampling, an initial complete listing of all the farm households in the selected areas was obtained.

Primary data were collected through personal interview by a trained enumerator using a pre-tested semi-structured survey questionnaire from the selected households. Frequent supervision was made by the researchers to correct the likely errors on the spot. Data collection questionnaire was developed considering the earlier researchers and using extensive review of literature. Interviews were conducted mostly at the sites of the farmers' work places and in some cases at the farmers' home. If any data appeared to be inconsistent, the farmers were again communicated for correct answers. The data collection was started from July 2017 and ended in June 2018.

Variable definition, categorization and hypotheses

Breed of cattle is the dependent variable in this study, which is categorized into two levels crossbred or indigenous. Adoption of crossbred cattle representing the decision to adopt is modeled as a dummy variable that represents the probability of the household adopting crossbred or not. For the household who adopts crossbred cattle the variable takes on the value of one and value of zero for the household who does not adopt crossbred cattle. The most common related independent variables those are directly or indirectly influence the farming of crossbred cattle were used in this study. Farmers' demographic, socioeconomic and farming characteristics and the agro-ecological zones are the influencing independent variables those are described bellow.

1. Demographic variables: Age of the household head is a continuous variable and measured in years, which is expected to affect the technology adoption. It is hypothesized that there is an indirect relationship between age of household heads and dairy technology adoption. As the age of the household head increased, the probability of adoption decreased because they are inactive to participate in the new technology, most likely due to being more influenced by culture. Age was categorized as 0 if < 35 years, 1 if 35-49 years and 2 if > 49 years. Education plays an important role in the adoption of any innovated or new technology. Further, education is believed to improve the readiness of the household to accept new ideas and innovations, and get updated demand and supply price information, which in turn enhances producers' willingness to produce more and increase milk market entry decision and volume of sale. Therefore, the more educated the household head, the higher the likelihood to decide for dairy technology adoption. It is a continuous variable but it was converted to a dummy variable that took a value of 0 if the household head was illiterate or primary educated, 1 if the household head was educated at secondary level and 2 if he/she was educated at higher secondary or more. Family size or number of members in the households is a continuous variable. As cattle faming or dairying is labor intensive: dairy production, in general and marketable surplus of dairy products in particular, is a function of labor. Accordingly, household with more family members tended to have more labor and to adopt dairy technology than household with less family members, which in turn increased milk production and then milk market participation of the households. Family size was categorized as 0 if 1 to 4 members termed as small family, 1 if 5 to 8 members termed as medium family and 2 if more than 8 members termed as large family. Sex or gender is

expected to affect crossbred technology adoption and male farmer heads adopt technology more than female headed as they had more access and exposure to get the information about the technology. But a few numbers of female-headed farmers (less than 5%) were found in this study, which do not reflect the gender effect and hence this variable was excluded from the model.

2. Socioeconomic variables: Land holding is a continuous variable and measured in hectares. It is hypothesized that there is a direct relationship between the size of land held by farm households and technology adoption. Farmers with less land were expected not to be willing to adopt a dairy technology since they were thinking that the technology needs more land for forage production. Land holding is classified as 0 if land size up to 0.5 acres termed as landless farmers, 1 if 0.51 to 1.0 acres termed as marginal farmers, 2 if 1.01 to 2.5 acres termed as small farmers and 3 if land size > 2.5 acres termed as medium/large farmers (Quasem, 2011). Types of cattle farmers' occupation influence to take decision for adoption of crossbred cattle. The households having no enough income sources like crop cultivation or services or other business may be higher likelihood to decide for improved cattle farming than the households having enough sources. Farmers' occupation was categorized as 0 if cattle farming mainly, 1 if crop cultivation mainly in addition to cattle farming, 2 if service or business are major occupation and subsidized cattle farming and 3 if day laborer and cattle farming. Household income was hypothesized to directly influence farmers' attitudes towards adoption of crossbred cattle. Generally, farmers with higher incomes are more able to bear the additional costs that may accompany new technology adoption. On the other hand, we can argue that farmers with high income may ever have adopted technological package that has improved their income levels and once they are familiar with the multiplier effects of improved technologies, they may be better adopters of new technology than their low-income counterparts. Farmers' monthly household income was categorized as 0 if less than Tk.7000 termed as low income farmer, 1 if Tk.7000 to Tk.11999 termed as medium income farmer and 2 if Tk.12000 and more termed as higher income farmer.

3. Variables related to cattle farming assets: Herd size is a discrete variable and measured as the total number of cattle species kept by a household including calf and heifer. The main hypothesis is that farmers are in the first stage of the production process with fewer animals would show a greater desire to increase herd size to fulfill households' economic gains while farmers with larger herd sizes would be reluctant in their adoption decisions. It is expected the sign for the coefficient of this variable to be positive. Herd size was categorized as 0 if up to 3 cattle, 1 if 4-6 cattle and 2 if 7 or more cattle in the household. Involvement of number of family members is an important variable in the improved production or use of improved technologies. Also, cattle farming require one or more people for its management activities. Involvement of hired labor is not possible in most of the cases in smallholder cattle owners. Thus, family members involvement in part time basis in farming activities and number of members has a direct affect on technology adoption. Person involvement was classified as 0 if 1 person involved, 1 if 2 persons involved and 2 if 3 persons involved.

4. Variables related to farming facilities: Farming experience is measured as the number of years a farmer has been engaged in livestock production. It is a continuous variable and measured in years. It refers to the number of years that the smallholder farmer practiced farming activity after the technology transferred to the area. It is hypothesized that there is a direct relationship between the farming experience and dairy technology adoption. Farmers with high farming experience were expected to be willing to adopt a dairy technology since they were getting information about the advantages of dairy technology through different ways. Farming experience was classified as 0 if experience < 10 years, 1 if 10-24 years and 2 if experience > 24 years. Access to extension service influences the adoption of any technology for production. This variable indicates whether a farmer solicited any information from an extension agent or not. Farmers who are in frequent contacts with extension agents are expected to have relatively more information about new technologies in general. Also, a household head had access to extension service is more prone for technology adoption than those who had no access. Extension service widens the household's knowledge with regard to the use of improved cattle/dairy technology, which leads to adopt more. Adoption is not necessarily determined by number of visits, since farmer's decision to a large extent depends on the quality of information provided by the extension agent, risk attitudes of the recipient farmers, among others. This variable was measured as a dummy variable taking a value of one if the farm household had access to dairy production extension service and zero, otherwise.

5. Agro-ecological zones: Agro-ecological location affects the adoption of improved cattle farming, as all the locations are not equally facilitated for cattle farming. It is hypothesized that the selected zones were heterogeneous in respect to crossbred cattle farming. Agro-ecological zones were classified as 0 for river basin, 1 for industrial zone, 2 for resource poor rural plain land and 3 for hilly land.

Method of data analysis

Data were analyzed using Statistical Package for Social Sciences (SPSS) 20.0. Descriptive statistics and inferential tests were employed in this study. A characterization was done using contingency tables (cross tabulation) to compare the proportion of crossbred and indigenous cattle owners in respect of a particular characteristic. Chi-square tests were carried out to assess the association of adoption and with the levels of socioeconomic variables.

Modeling a relationship between the decision to adopt and not to adopt an improved technology with the observed factors requires the use of qualitative response models. In order to analyze the factors influencing the adoption of the technology by farmers, probability model do not allow the usage of an ordinary least square (OLS) technique as the dependent variables are qualitative in nature. Commonly used models of this type are probit (which assumes an underlying normal distribution) and logit models (which corresponds to a logistic distribution function). Both the logit and probit models yield similar parameter estimates and it is difficult to distinguish them statistically (Aldrich and Nelson, 1990). The logit model was used in this study since it is easier and simpler to interpret and thus has been widely applied in adoption studies Ng'ombe *et al.*, 2014; Akroush *et al.*, 2017). Binary Logit model was used which helps to describe the relationship between the outcome variable and a

set of explanatory variables. Binary Logit is preferred to others because it gives standard result for discrete choice estimation (Gujarati, 2003; Greene, 2007).

$$Logit\ (P_i) = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \ldots + \beta_n X_{ni} + e_i$$

Where: *Pi* is the probability that the i^{th} value of the dependent variable, X is the i^{th} value of the independent variable, e_i is the "error" variability of the dependent variable not explained by the independent variable; n is the number of independent variables.

$$Odds = P_i / (1 - P_i)$$

Odds ratio is the way to present the probability of an event. The odds of an event happening (adoption of crossbred cow) indicates the probability of that event will happen divided by the probability of that event will not happen. Thus, the Logit (natural log of odds) of the unknown binomial probabilities are modeled as a linear function of the X_i:

$$Logit\ (P_i) = Ln\ [P_i / (1 - P_i)] = \beta_0 + \sum \beta_j X_{ji}$$

The Logit model assumes that underlying stimulus index Logit (P_i) is a random variable, which predicts the probability of crossbred dairy adoption. P_i is the probability of adopting crossbred dairy cows, while ($1-P_i$) is the probability not adopting the technology.

Results and Discussion

Characteristics of smallholder farmers and association with cattle breeds

Socioeconomic characteristics of the cattle farmers like age, level of education, land holdings, occupation, household income, herd size, farming experience, etc. are influenced to adopt the cattle of improved breed and are presented in Table 1. Half of the farmers (50.3%) in the study areas were between the age of 35 and 49 years old with 60.8% having indigenous cattle. Another 29% aged below 35 years old of which major proportion had crossbred cattle. This means lower aged persons are interested to produce crossbred cattle for income generation. Their level of education was very low and only about 24% has higher secondary or more education of which only 13% belonged to indigenous cattle owners.

Table 1. Distribution of farmers according to their socioeconomic, farm and agro-ecological characteristics

Item	Number of farmers in different farm categories, n (%)			χ^2-statistic (p-value)
	Indigenous cattle (n=194)	Crossbred cattle (n=106)	Overall (n=300)	
Age				42.691 (0.001)
<35 years	32 (16.5)	55 (51.9)	87 (29.0)	
35-49 years	118 (60.8)	33 (31.1)	151 (50.3)	
>49 years	44 (22.7)	18 (17.0)	62 (20.7)	
Level of education				46.596 (0.001)
Primary or illiterate	116 (59.8)	27 (25.5)	143 (47.7)	
Secondary	53 (27.3)	31 (29.2)	84 (28.0)	
Higher secondary and above	25 (12.9)	48 (45.3)	73 (24.3)	
Land holdings				6.286 (0.099)
Landless (up to 0.5 acres)	70 (36.1)	34 (32.1)	104 (34.7)	
Marginal (0.51 to 1.0 acres)	46 (23.7)	39 (36.8)	85 (28.3)	
Small (1.01 to 2.5 acres)	54 (27.8)	21 (19.8)	75 (25.0)	
Medium (2.51 acres and more)	24 (12.4)	12 (11.3)	36 (12.0)	
Number of members in the family				1.970 (0.373)
2-4	60 (30.9)	28 (26.4)	88 (29.3)	
5-8	101 (52.1)	64 (60.4)	165 (55.0)	
> 8	33 (17.0)	14 (13.2)	47 (15.7)	
Persons involved in cattle farming				9.338 (0.025)
1	81 (41.7)	29 (27.4)	110 (36.7)	
2	64 (33.0)	34 (32.1)	98 (32.7)	
3	49 (25.3)	43 (40.5)	92 (30.7)	
Occupation				46.258 (0.001)
Mainly cattle farming	18 (9.3)	39 (36.8)	57 (19.0)	
Agriculture and livestock	92 (47.4)	36 (34.0)	128 (42.7)	
Service/ business and livestock	40 (20.6)	27 (25.5)	67 (22.3)	
Labor and livestock	44 (22.7)	4 (3.7)	48 (16.0)	
Household income (Tk. per month)				40.260 (0.001)
Low (Up to 7000)	88 (45.4)	16 (15.1)	104 (34.7)	
Medium (7000 to 12000)	80 (41.2)	47 (44.3)	127 (42.3)	
High (Above 12000)	26 (13.4)	43 (40.6)	69 (23.0)	
Herd size				
Up to 3	83 (42.8)	29 (27.3)	112 (37.3)	7.553 (0.023)
4-6	90 (46.4)	59 (55.7)	149 (49.7)	
7 and more	21 (10.8)	18 (17.0)	39 (13.0)	
Cattle farming experience				20.905 (0.001)
Below 10 years	21 (10.8)	34 (32.1)	55 (18.3)	
10—24 years	144 (74.2)	58 (54.7)	202 (67.3)	
Above 24 years	29 (15.0)	14 (13.2)	43 (14.3)	
Reception of extension services				145.271 (0.001)
No	184 (94.8)	31 (29.2)	215 (71.7)	
Yes	10 (5.2)	75 (70.8)	85 (28.3)	
Agro-ecological zones				15.464 ((0.001)
River basin	45 (23.2)	30 (28.3)	75 (25.0)	
Industrial zone	37 (19.1)	38 (35.9)	75 (25.0)	
Rural plain land	54 (27.8)	21 (19.8)	75 (25.0)	
Hilly land	58 (29.9)	17 (16.0	75 (25.0)	

Crop cultivation was their main economic activity (42.7%) while mainly the cattle farming activity were done by 19% of the farmers only of which more than double were belonged to crossbred cattle owners. The occupational groups who were service holders and laborers along with cattle owners were used indigenous cattle mainly. The results in Chi-square test reveal a significant relationship between farmer's age group, level of education and types of occupation with adoption or non-adoption of crossbred cattle ($p<0.01$).

The findings of the study reveal that farm experiences of two-third (67.3%) of the respondents ranged from 10 to 24 years, however the farming experience about 18.3% of the respondents covered 1 to 9 years while 14.3% of the respondents had been for 25 years and more. The results also revealed that higher proportion of respondents were adopters of crossbred cattle (32.1%) compared to indigenous (10.8%) who were experienced less than 10 years but reverse results were observed for higher experienced farmers. Extension services were received by 28.3% of the farmers of which 88.2% were crossbred cattle owners and remaining 11.8% were indigenous cattle owners. Major proportion of crossbred cattle owners were belonged to higher income group while major proportion of indigenous cattle owners were belonged to lower income group (Table 1) implies that low income farmers reared indigenous cattle which agrees with the findings of Quddus (2017).

Comparatively crossbred cattle were farming in industrial zone and indigenous cattle were farming in rural plain land and hilly land by higher proportion of farmers. Major proportion (42.7%) of farmers' main occupation was crop farming, crop farmers and laborers used to more indigenous cattle compared to crossbred and cattle farmers mainly used to more crossbred cattle compared to indigenous. Agro-ecological zones and farmer's occupation were significantly associated with cattle breeds. Whereas size of land holdings, household size, persons involved in cattle farming and herds' size were not significantly associated with cattle breeds. Most of the farmers (63%) belonged to landless and marginal farm holdings whereas only 37% farmers belonged to small, medium and large farm holdings. Most of the farmers' (55%) family member was 4 to 8 and herd size was 4 to 6 (49.7%).

Determinants of adoption of crossbred

Binary logistic regression was used to determine the factors influencing the adoption of crossbred cattle. This model explained between 58.2% (Cox and Snell R^2) and 77.6% (Nagelkerke R^2) of the variance in use of cattle breeds and overall percentage correctly classified 88.3% of the cases. Additionally, an insignificant value for the goodness-of-fit test (Hosmer and Lemeshow) of $\chi^{2\,(8)} = 5.049$, $p>0.05$ was obtained. The sign and values of β (coefficients) is shown in Table 2 which indicates the amount of decrease or increase of adoption level in terms of increase in the level of independent variables from lower level to upper level. The column exp(β) in Table 2 gives the exponential of expected value of β, which is the predicted change in odds for a unit increase in the corresponding explanatory variable.

Table 2. Results of maximum likelihood estimates in binary logistic regression model

Variables	Levels	β	S.E.	Wald	Sig.	Exp(β)	95% CI
Age	< 35 years			5.903	0.052		
	35 – 49 years	-1.014	0.509	3.963	0.047	0.363	0.134 - 0.984
	>49 years	-1.823	0.894	4.156	0.041	0.162	0.028 - 0.932
Education	Illiterate & primary			13.05	0.001		
	Secondary	1.293	0.548	5.555	0.018	3.642	1.243 - 10.67
	Higher secondary+	2.025	0.575	12.39	0.000	7.579	2.454 - 23.40
Landholdings	Landless			3.336	0.343		
	Marginal	-0.665	0.711	0.875	0.350	0.514	0.128 - 2.072
	Small	-1.452	0.864	2.827	0.093	0.234	0.043 - 1.272
	Medium	-0.585	1.010	0.336	0.562	0.557	0.077 - 4.031
Family size	1-4			0.609	0.737		
	5-8	-0.380	-0.529	0.516	0.472	0.684	0.243 - 1.928
	> 8	-0.067	0.676	0.010	0.921	0.935	0.248 - 3.520
Persons involved in cattle farming	1			2.747	0.253		
	2	0.869	0.563	2.382	0.123	2.384	0.791 - 7.185
	3	0.659	-0.556	1.404	0.236	1.933	0.650 - 5.752
Occupation	Mainly cattle farming			15.50	0.001		
	Crop and livestock	-0.540	0.730	0.549	0.459	0.582	0.139 - 2.434
	Service and livestock	-3.078	0.953	10.44	0.001	0.046	0.007 - 0.298
	Labor and livestock	-3.163	1.044	9.185	0.002	0.042	0.005 - 0.327
HH income	Low			5.528	0.063		
	Medium	0.742	0.550	1.822	0.177	2.100	0.715 - 6.168
	High	1.815	0.772	5.524	0.019	6.138	1.352 - 27.87
Herd size	Up to 3			6.026	0.049		
	4-6	-0.332	0.524	0.401	0.526	0.718	0.257 - 2.004
	7 and more	-2.347	0.986	5.667	0.017	0.096	0.014 - 0.661
Farming experience	Below 10 years			2.504	0.286		
	10-24 years	-0.837	0.567	2.181	0.140	0.433	0.143 - 1.315
	Above 24 years	-0.382	0.942	0.165	0.685	0.682	0.108 - 4.322
Extension services	No						
	Yes	4.858	0.783	38.45	0.000	128.82	27.74 - 598.2
Locations	River basin			3.503	0.320		
	Industrial zoon	0.059	0.710	0.007	0.933	1.061	0.264 - 4.266
	Resource poor area	-0.654	0.636	1.059	0.304	0.520	0.150 - 1.807
	Hilly land	-1.019	0.713	2.041	0.153	0.361	0.089 - 1.461

The negative values of β coefficients against age groups of the farmers imply that higher the age of farmers decreases with the adopting crossbred cattle. Based on the odds ratio 0.363 and 0.162, farmers of age group 35-49 years were 63.7% less likely and farmers of age group 50 years and more were 83.8% less likely to adopt crossbred cattle compared to farmers of age group less than 35 years. This finding is in line with the report of Dehinenet *et al.* (2014), which stated that the probability of adoption decreased with the increase of age of household heads. On the other hand, younger farmers have higher probabilities to adopt technology than older farmers (McBride *et al.,* 2004). Level of education has a significantly positive impact on farming of crossbred cattle; farmers having secondary education (β=1.293) are significantly (p=0.018) better users of crossbreds compared to illiterate or primary educated farmers. The odds ratios interpret that secondary educated and more than secondary educated farmers were respectively 3.642 and 7.579 times more likely to be adopting crossbreds compared to illiterate and primary educated farmers respectively. This result agrees with the findings of (Bortmuly and Guswami, 2015). Thus, it could be summarized that more educated and younger farmers are more likely to experience farming the crossbred cattle but older farmers may be more conservative in taking risk for crossbred cattle. Farmers having higher income (Tk.12000 and above per month) were positively (β=1.815) and significantly (p<0.05) associated with crossbred cattle owners i.e. farming of crossbred cattle was increased with the increase of household income. Its increase was double for medium income holders and 6 times for higher income holders (OR=6.138, 95%CI=1.352-27.87, Table 2) compared to low income holders (below Tk.7000 per month). High-income farmers are better adopters of improved technologies than low-income farmers because the high-income farmers possess additional financial risk-taking attitudes (Kinnucan *et al.,* 1990). Land holding has a negative impact on farming crossbred cattle. Marginal, small and medium farm holders were 48.6%, 76.6% and 44.3% respectively less likely to adopt crossbred cattle compared to landless farmers. Landless farmers are more likely to farming crossbred cattle compared to others because enough land is not required for cattle farming but they try to involve in services or business, otherwise in improved livestock farming for more income as a livelihood purpose.

Household size had insignificant negative effect on crossbred cattle farming. This means that small household sized farmers mostly adopted crossbred cattle. But households having family members more than 8 were 6.5% less likely (OR=0.935, 95%CI=0.248-3.520) to adopt crossbred cattle. Herd size had negative effect but persons involved in farming had positive effect on adoption of crossbred cattle. Farmers having 4 to 6 cattle were 28.2% less likely (OR=0.718, 95%CI=0.257-2.004) to crossbred cattle farming compared to 1 to 3 cattle. Two persons involved in cattle farming was 2.38 times more likely (OR=2.384, 95%CI=0.791-7.185) and 3 persons involved was 1.93 times more likely (OR=1.933, 95%CI=0.650-5.752) to crossbred cattle farming compared to a single person involved in crossbred cattle farming.

The farmers who had contact with extension agents or get extension services are significantly (p<0.01) higher adopters of crossbred cattle than the farmers having indigenous cattle. This result agrees with the findings of Dhraief *et al.,* (2019) who found that extension contact is to be significantly (p<0.10) and positively correlated with the adoption decision of livestock farmers. The higher value of coefficient and odds ratio interpret that mainly the crossbred cattle owners receive extension services. This result indicates the major roles of extension services on adoption of crossbred cattle at the smallholder farmers level in Bangladesh. Usually, farming experience in dairy or livestock has a positive relationship with adoption of improved technologies as farmers having longer years of experience may develop the confidence in handling the risk and skills. But the negative effect of farming experience in this study reveals because crossbred cattle were adopted by large number of farmers having experience less than 10 years.

The values of β coefficients reveal that there was a negative relationship among the four categories of occupation in this study implies that farmers whose main occupation was mainly cattle farming were more likely to adopt crossbred cattle. Livestock farmers along with crop farming were 41.8% less likely to adopt crossbred cattle compared to mainly cattle farmers as they rear intensively cultivate the crossbred cattle for the main source of household income. Farmers of industrial zone were more likely and rural plain land and hilly land were less likely to adopt crossbred cattle compared to river basin area. On the other hand, odds ratios of these three locations reveal that farmers in the industrial zone were 1.06 times more likely, rural plain land were 48% less likely and hilly land were 63.9% less likely to be adopting crossbred cattle compared to the farmers in river basin area.

Conclusion

Cattle farming activities may be increased by increasing educated members in the family and through improving training facilities for the youths. Farmers should be invested a better portion of their total income in the cattle farming and hence farmers should be motivated to invest and participate in this job. Younger farmers and extension service receivers were interested to crossbred cattle but farmers of low educated and lower income group were used to indigenous cattle farming. Government has taken policies for livestock and dairy development and extension workers and researchers are providing lot of facilities to the farmers. Still now, farmers' awareness and use of crossbred cattle is very low in the study area. Positively associated factors in this study had a probability of increasing the adoption of crossbred cattle. Thus, intensive extension service is very essential to motivate and transform knowledge to the livestock farmers for increasing crossbred cattle farming.

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