Determinants of livelihood choices: an empirical analysis from rural Bangladesh[1]

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ABSTRACT

The study identifies socio-economic determinants of livelihood choices of rural households in Bangladesh (4,195 households from 139 villages) by applying a multinomial logit model of occupational choice and a multivariate tobit model that allows for jointness in decision making. Results reveal that households choose multiple livelihood options. A number of socio-economic factors and resources at the household level as well as the state of rural infrastructure significantly determine households' choice of livelihood options. Overall, resource rich and educated households engage in diversified livelihoods and rural infrastructure promotes diversification of livelihoods. Female headed households fail to participate in any of the livelihood categories and consequently earn significantly lower income. Policy implications include investment in rural infrastructure, irrigation, rural electrification, education, livestock resources, as well as targeted approach for female headed households, e.g., creation of a hired labour market and skills/education programs for females.

1.   Introduction

'Eradication of poverty and hunger' has been the main theme of development in the 2000s. While this ambitious goal has yet to be achieved, progress in 'poverty reduction' has been impressive and widespread. The proportion of people living below the international poverty line (i.e., living under USD 1.25 a day) fell to 25.7% (or 1.4 billion persons) in 2005 from more than 50% in 1981 (1.9 billion persons) (Krishna, 2013). Nevertheless, there are still large numbers of people living in poverty in Sub-Saharan Africa (51%), South Asia (40%) and East Asia (17%)

(Krishna, 2013) with figures including two newly emerging economic powerhouses, i.e., India and China. Krishna (2013) further claims that policies which were successful in reducing poverty in the past have lost their effectiveness and that a business as usual scenario is unlikely to further reduce poverty.

Although agriculture is considered the main source of livelihood in rural areas of developing economies, the transformative potential of non-agricultural livelihood options has been increasingly recognized over the past three decades (e.g., Smith et al., 2001; Deininger and Olinte, 2001; Davis, 2004). Rural households diversify their livelihood activities to generate income and better cope with adverse factors and events that affect agriculture (e.g., Ellis, 2000; Barrett et al., 2001; Deininger and Olinte, 2001; Ellis and Freeman, 2004). The strategies households adopt when choosing among livelihood options are determined by a range of socio-economic factors (Tesfaye et al., 2011; Eneyew, 2012). While the relevant literature is growing because of its policy relevance, the number of relevant studies is still quite small (Ellis and Freeman, 2004).

Recent MDG analysis highlights Bangladesh's remarkable social and economic achievements in terms of per capita income growth, reduced population growth, the fall in child mortality, improved child nutrition, expansion of primary and secondary education, reduction of gender inequality in education, maintaining food production close to a self-sufficiency level, and sustained trends of income-poverty declines. In spite of this progress, the poverty incidence remains high; in 2010, 31.5% of the population (47 million people) were below the poverty line (Gimenez et al., 2013).

The analysis of rural livelihood choices is complex because households engage in a variety of economic activities. Much of the recent literature examining household and/or community livelihoods adapted Chambers and Conway's (1992) definition with livelihood comprising the capabilities, assets (stores, resources, claims and access) and activities

required for means of living. Taking this broad perspective, livelihood approaches place 'people and their priorities to choose activities as means of living' at the centre of development efforts. Reviewing the literature, Scoones (2009) identified 'livelihoods' as a mobile and flexible term, which can be related to locales (rural or urban livelihoods), occupations (farming, pastoral or fishing livelihoods), social difference (gendered, age-defined livelihoods), directions (livelihood pathways, trajectories), dynamic patterns (sustainable or resilient livelihoods) and much more. People thus make their living by combining a complex web of activities and interactions. Livelihoods perspectives are thus important for integrating insights beyond disciplinary or sectoral boundaries.

The earlier literature on livelihood analysis is skewed towards qualitative accounts that are mostly descriptive in nature (e.g., Toufique and Turton, 2002; Lindenberg, 2002; Smith et al., 2001; de Haan et al., 2000) and often restricted to a particular resource management system. Therefore, conclusions may be imprecise and hard to generalise. On the other hand, quantitative livelihoods analyses have tended to focus either on descriptive analysis (Ellis and Freeman, 2004; Sen, 2003) or made use of univariate limited dependent variable models (e.g., single equation Tobit, probit or logit models), (e.g., Abdulai and CroleRees, 2001; Woldenhanna and Oskam, 2001; Jansen, et al., 2006; Tesfaye et al., 2011). From such descriptive analysis (e.g., Ellis and Freeman, 2004; Sen, 2003), it is not possible to precisely identify what motivates a household to choose among various livelihood options. While this literature provides us with classificatory labels and some factual information it is not possible to identify the characteristics that most strongly affect the livelihood choices of rural households. Recently, Hatlebakk (2012) used a multinomial logit model to determine occupational choice and/or livelihood strategies in Malawi, which provided a more incisive and balanced assessment of the factors influencing livelihood choices. However, such univariate models still ignore jointness in the household decision making process.

In this study, we draw on insights from the broad based livelihoods literature but restrict our focus to occupation based activities such as agriculture (which includes all types of crop farming, livestock and fisheries, and land leasing/renting out), wage employment (i.e., exclusively selling labour off-farm in either agricultural or non-agricultural sector); and non-agriculture (including business, salaried profession, transportation, and other self-employment activities in non-agricultural sectors). We assume that households choose one or a combination of these available options to maximise utility subject to their capabilities and access to assets. In this framework choice of a particular option in its reduced form would depend on a large array of exogenous variables, which could be drawn from the livelihoods perspective including economic, social and infrastructure related factors.

With this focus, the objective is to identify the factors that influence the choice of or between multiple livelihoods as well as the intensity of involvement as reflected by the income earned from each activity. The paper proceeds as follows. Section 2 describes our analytical framework and the data we make use of. Section 3 presents the results. The final Section 4 concludes and draws out the policy implications.

2. Methodology

2.1 Modelling factors influencing livelihood choice: multinomial logit model and its limitation

A critical empirical question is how to define multiple livelihood options for the purpose of quantitative analysis. The commonly used measure in the occupation literature is a dummy variable for each option (Y_{ji}=1 if income for option j for household i is observed). In this formulation, choice behaviour is mostly represented by a reduced form multinomial logit model as follows (Brown et al., 1980, Cohen and House, 1993, Barrett et al., 2001):

$$p(Y_{ji}) = \exp(z_i'Y_j) / \sum \exp(z_i'Y_{jk}) \qquad i = 1,.......N; \qquad j = 1,..........J \qquad (1)$$

where, $p(Y_{ji})$ is the probability that household i is in livelihood option j that can take on any of the J possible values corresponding to a different option, z_i is a vector of exogenous variables affecting supply and demand decisions for the household's employment/participation in a particular option, γ_k is the vector of parameters corresponding to the kth option, N is the number of observations and J is the number of options. The parameters of this model can be estimated by maximum likelihood methods.

Although multinomial logit models have some advantages in examining livelihood diversity, there are two main concerns with letting dichotomous variables represent livelihood options. First, the zero-cutoff is problematic since a farming household will diversify income sources by choosing agricultural and non-agricultural options, simultaneously. The standard solutions are counts of minimum number of days or minimum proportion of income as a cut-off. For example, Hatlebakk (2012) introduced a minimum number of days threshold before an occupation counts. Important information is lost by such arbitrary cut-offs. A significant income may also be wrongly categorized. For example, a household may draw 35% of income from agricultural sources and 65% of income from non-agricultural sources. An arbitrary cut-off of 40% would place this household in the non-agricultural group, resulting in substantive loss of information. To avoid this loss, we use income from different options as measure of intensity of choice. Second, the dichotomous dependent variable fails to consider the variation within the 0-1 range (choose an option or not). However, when an option is chosen it is possible to measure the intensity of participation by using a continuous variable above zero by income earned or number of days of work. This is why we use income as dependent variable and multivariate Tobit model for estimation. In what follows, we first estimate a multinomial logit model of occupational/livelihood choice (i.e., Eq. 1) for setting the scene and shedding light on the motivations underlying livelihoods choice. Also the model provides rich information on factors influencing various occupational choices with

2.2 *Modelling factors influencing livelihood choice: multivariate Tobit model*

We postulate that the households follow sequential decisions; first 'whether to participate in a particular livelihood option or not'; and second, conditional on participation, 'what is the level or intensity of participation'? In such a case, a censored regression model is required. A Tobit model is the most suitable because it uses all observations, both those at the limit, usually zero (e.g., non-participants), and those above the limit (e.g., participants), to estimate a regression line as opposed to other techniques that use observations which are only above the limit value (McDonald and Moffit, 1980). The procedure also captures latent level of intensity of potential households who decide not to participate in a particular livelihood option.

Let the outcome function for participation in a particular livelihood option (measured as net income derived from the chosen category) be given by:

$$Y_i^* = \gamma' X_i + \mu_i \tag{2}$$

where X_i is the vector of regressors, γ is the vector of parameters to be estimated, and μ_i is the error term. For households participating in agricultural livelihood, Y_i^* equals the actual level of income (Y_i). For those who are not participating in agricultural livelihood Y_i^* is an index reflecting potential income such that:

$$
\begin{aligned}
Y_i \quad &= Y_i^* \quad && \text{if } \gamma' X_i + \mu_i > 0 \\
&= 0 \quad && \text{if } \gamma' X_i + \mu_i < 0
\end{aligned}
\tag{3}
$$

The advantage of the Tobit model as in Eq (3) is that it captures the decision to participate as well as the resulting outcome, whereas a probit model will provide information on the decision to participate only. Since we see that a substantial proportion of households

participated in either a combination of two or all three livelihood categories at the same time (Table 1), we postulate a multivariate Tobit model in order to capture this joint outcome:

$$Y_{1i}^* = \gamma^{'} X_{1i} + \mu_{1i}$$
$$Y_{1i} = Maximum\,(Y_{1i}^*, 0) \quad (the\,usual\,Tobit\,specification\,as\,in\,3).$$
$$Y_{2i}^* = \gamma^{'} X_{2i} + \mu_{2i}$$
$$Y_{2i} = Maximum\,(Y_{2i}^*, 0) \quad (the\,usual\,Tobit\,specification\,as\,in\,3). \tag{4}$$
$$Y_{3i}^* = \gamma^{'} X_{3i} + \mu_{3i}$$
$$Y_{3i} = Maximum\,(Y_{3i}^*, 0) \quad (the\,usual\,Tobit\,specification\,as\,in\,3).$$
$$\mu_{ii}, \mu_{2i}, \mu_{3i} \approx N[0,0,0, \sigma_1^2, \sigma_2^2, \sigma_3^3, \rho_{12}, \rho_{13}, \rho_{23}]$$

where Y_{1i}^* denotes income of the ith household who participated in agricultural livelihood; Y_{2i}^* denotes income of the ith household who participated in wage employment, and Y_{3i}^* denotes income of the ith household who participated in non-agricultural livelihood; ρ_{12} is the correlation between the error terms μ_{1i} and μ_{2i}, ρ_{13} is the correlation between the error terms μ_{1i} and μ_{3i}, and ρ_{23} is the correlation between the error terms μ_{2i} and μ_{3i} The distributions are independent if and only if $\rho_{12} = \rho_{13} = \rho_{23} = 0$.

This enables us to accommodate household's decision to choose a single or a combination of livelihood options at the same time. The other advantage of this multivariate approach, as opposed to the univariate approach (i.e., single equation Tobit/probit/logit models), is that it is more efficient because it not only nests individual univariate models but also enables us to demonstrate jointness of the decision making process by providing an estimate of the correlation between the error terms of the individual univariate models. Lansink et al. (2003) and Teklewold et al. (2013) used multivariate probit models for their research. Though their approach takes care of the potential correlation of disturbances arising from interrelationships of decisions of different choice, the impact of factors on the intensity of participation rates in different choices cannot be measured. We use multivariate Tobit to overcome.

The model is estimated with a program code developed by Barslund (2007). The procedure involves simulation using Halton draws to generate random numbers for evaluation of the multi-dimensional Normal integrals in the likelihood function. For each observation, a likelihood contribution is calculated for each replication. The simulated likelihood contribution is the average of the values derived from all replications. The simulated likelihood function for the sample as a whole is then maximized using a standard Maximum Likelihood procedure.

2.3   *Data and the study area*

Data for this study draw from a large health and socio-economic survey conducted in 1996 covering all villages of the Matlab thana (sub-district) in north-western Bangladesh. The dataset provides a rich description of the agricultural and non-agricultural profiles of the sample households and their asset portfolio, complete information on personal characteristics of householder members, as well as detailed information on infrastructural facilities in the study villages. The sample households were selected in two steps. First, a random sample of 2678 residential neighbourhoods (known as *Baris*) was selected from the entire thana. In the second step, households were sampled. If a *Bari* had just one household, it was always selected. In case of multi-household *Baris*, two households were selected at random from each *Bari*. This led to a total sample of 4368 households[2]. After purging this sample of potential outliers and/or missing essential information, the final sample contains a total of 4,195 households located in 139 villages.

2.4   *Variables used for empirical estimation of the models*

The empirical application focuses on the identification of socio-economic factors that affect household livelihood choice decisions. The key elements and implicit assumptions underlying the models are (based on Adbulai and CroleRees, 2001):

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[2] Further details on the survey data are available in Rahman et al., (2001).

The three livelihood categories considered in this study are: 'agricultural livelihood', 'wage employment', and 'non-agricultural livelihood'. A household can straddle more than one category. The dependent variables are based on whether households earned income from one or more than one of these options. Assigning households to each category is done ex-post and determined by the various sources of income earned. This approach is more accurate than considering only the main occupation of the household head as the choice, since the latter will exclude the possibility of head's as well as other members' involvement in a range of livelihood options. Therefore, the dependent variable takes positive income value if the household has chosen livelihood option j and 0 otherwise. The information presented in Table 1 demonstrates the matter clearly (discussed in detail in the results section).

The variables representing socio-economic characteristics of the households affecting livelihood choices are drawn from the existing literature. These are: female headed households, experience of the household head (proxied by age), education of the household head, maximum level of education attained by any member of the household, the value of household assets, farm operation size, and the value of livestock resources. Since the influence of individual socio-economic factors on each category of livelihood cannot be determined *a priori*, we included the same set of variables in each of the three livelihood

choice models. The justifications for including these variables, primarily focusing on the agricultural livelihood choice model, are as follows.

Rural women in Bangladesh, as elsewhere in Asia, play an important role in agriculture (Rahman, 2000). However, in most South Asian societies, a female is designated as head only if she is a widower or divorced. The dummy variable of female headship is included to capture its independent influence on livelihood choices and the intensity of participation (as explained above).

Perceiving the level of education as a binding constraint for household decision making is fairly common in the literature (e.g., Ahmed and Hossain, 1990; Rahman, 2003; Benin et al., 2004; Rahman, 2008; Eneyew, 2012). The education variable is used as a surrogate for a number of factors. At the technical level, access to information as well as capacity to understand technical aspects related to chosen livelihood categories, e.g., modern agricultural technology or specialized business activities is likely to affect livelihood choice. The influence of education is measured by two variables: (a) education level of the household head (completed years of schooling), and (b) maximum education (completed years of schooling) among adult members (aged 19 years and over). This is done in order to allow for centralized decision making in the household where the household head as well as other educated members of the family have a particular role in the choice among livelihood options.

Age of the household head is incorporated to account for the maturity of the head in his/her decision-making ability. Literature suggests that younger farmers are more oriented towards adopting modern agricultural technologies (e.g., Rahman, 2003) as well as non-agricultural livelihoods (e.g., Hatlebakk, 2012).

Land is the scarcest resource in Bangladesh and farm size largely determines the level and extent of income from agriculture. Land also serves as a surrogate for a large number of

factors as it is a major source of wealth and influences decision to choose crops (Ahmed and Hossain, 1990). The size-productivity relationship in Bangladesh varies across regions depending on the level of technological development and environmental opportunities. We included 'farm operation size' to test whether land endowment influences choice of livelihood.

Rural households in Bangladesh are not only land poor, but also resource poor. The household asset variable (which also includes value of all tools and equipment used for farm operations) is included to examine its potential influence on the choice of livelihood options.

Livestock, as a measure of wealth, have an ambiguous effect (Benin et al., 2004). Livestock ownership is expected to contribute positively to choice of agricultural livelihood through ensuring draught power for ploughing when needed (Rahman, 2008; Benin et al. 2004).

The four infrastructure variables at the village level included in the models are: index of the rural infrastructure[3], electricity connection, irrigation facilities, and proximity to district/regional headquarters. The justification of including electricity and irrigation infrastructure is that these two indicators are critically important with regard to access, use and adoption of modern agricultural technologies. Also, electricity connection may be critical in enabling engagement in non-agricultural activities (e.g., Gibson and Olivia, 2010). Proximity to regional and district headquarters are included in order to judge whether remoteness from a city

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[3] The index of rural infrastructure was constructed as the average time taken to reach existing infrastructural facilities. Eight elements of infrastructure facilities were used (i.e., primary markets, secondary markets and/or growth centres, post office, telephone office, thana headquarter, bus stop, boat station, and bank) which taken together encompass market infrastructure, key administrative and financial institutions and transport facilities. We have chosen time taken to reach these facilities to construct the index because this clearly demonstrates the quality of access which is important (Gibson and Olivia, 2010).

or town location has any independent influence on livelihood choice as literature suggests some influence (e.g., Gibson and Olivia, 2010).

3.   Results

3.1   *Comparison of livelihood categories of the households*

Table 1 compares the socio-economic characteristics of households classified by their choice of livelihood options. There is a high degree of overlap in the adoption of livelihood categories by households, implying jointness of choices. The total number of observations belonging to all three livelihood categories adds up to 5,556, which is 33% higher than the total sampled households of 4,195. This means that 33% of the households are engaged in at least two livelihood categories. However, if we consider only the household heads' main occupation[4] to categorize our dependent variables, the proportions do not add up to unity in any of the livelihood categories.

The three livelihood choice categories differ significantly with respect to their average earnings. They also differ significantly in terms of socioeconomic and infrastructural characteristics except proximity to district headquarter. With respect to infrastructural facilities, only 11% of the villages have electricity connection, whereas 95% of the villages have irrigation facilities because Matlab sub-district hosts the Meghna-Dhonagoda Flood Control, Drainage and Irrigation (FCD/I) project giving access of canal irrigation to a large number of villages. The average time taken to reach any of these eight elements of infrastructural facilities takes about three-quarter of an hour, implying good quality accessibility.

3.2   *Factors affecting livelihood/occupational choices: a multinomial logit model*

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[4] The questionnaire allowed recording a total of 99 types of specific main occupation for household head which shows the maximum range of possible occupational choices undertaken by these rural households in their pursuit of livelihood.

The results of the multinomial logit regressions with robust standard errors are reported in Table 2, using agriculture as the base category. The positive effect of the farm size category implies that not only agricultural livelihood is the preferred category for households with cropland; wage employment and non-agricultural livelihoods are also influenced by land size. This is in contrast with Hatlebakk (2012) who noted significant negative signs of total land area on the livelihood choices with farming as the base category. One reason for this contrast may be renting out of land to tenants by land-rich households and engaging themselves in non-agricultural activities that generate more income. However, the signs of the coefficient on farm size for more diversified livelihoods involving agriculture are consistent with the findings of Hatlebakk (2012) which implies that for households with land, agriculture only is the more likely livelihood choice. However, livestock resources (an important input in farming in Bangladesh) affect the preference for agriculture as reflected by negative coefficient for wage employment and non-agricultural livelihood.

Education (either head's or member's highest education) significantly influences non-agricultural livelihood options in addition to agricultural livelihoods whereas uneducated households had to contend with low paid wage employment as expected. The findings correspond with Hatlebakk (2012) whose 'casual livelihood' and 'wage and business' categories are equivalent to our wage employment and non-agricultural livelihood categories, respectively. Abdulai and CroleRees (2001) also concluded that educated household heads are more likely to participate in non-farm sector. Similarly, Barrett et al (2001) noted that households with low level of educational attainment often find it difficult to overcome the skills barrier for taking up non-farm livelihoods.

Older household heads are less likely to engage in wage employment or non-agricultural livelihoods, implying that younger heads are more likely to choose these options, also consistent with Hatlebakk (2012). Female headed households are less likely to engage in

any of the livelihood options, implying that male heads are more likely to choose/avail these options, thereby, confirming women's vulnerability in the job market.

Non-agricultural livelihoods are more common in regions with developed infrastructure and proximity to regional headquarters as suggested by the negative coefficients. In other words, the presence of developed rural infrastructure correlates with diversification. Barrett et al (2001) noted that participation in nonfarm activities decreases with distance from town suggesting the importance of physical market access for livelihood choice which conforms with our results. Similarly, Abdulai and CroleRees (2001) noted that households in remote areas are less likely to participate in the non-cropping sector.

Having analysed the determinants of livelihood/occupational choices using a multinomial logit model, we now extend our analysis to jointly determine the factors influencing livelihood choices and income derived from these choices using a multivariate Tobit model.

3.3   *Factors affecting livelihood choices and incomes: a multivariate Tobit analysis*

The results of the full information maximum likelihood estimation of the multivariate Tobit model are presented in Table 3. All level variables (including dependent variables) are specified as natural logs except the dummy variables. Therefore, these coefficients can be directly read as marginal effects or elasticities except for the dummy variables which shows effects for a discrete change from 0 to 1. This strategy has two advantages: (a) allowing non-linearity of the underlying income function which is linear in parameters only, and (b) avoiding the problem of outliers in level variables, e.g., income[5].

Prior to discussing the findings we explain model test results reported in the lower panel of Table 3. Globally, 80% of the estimated coefficients (29 out of 36 coefficients) were

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[5] For zero values of level variables (e.g., education), we used a scalar value of 10^{-4} to permit including these observations in the analysis (e.g., Asadullah and Rahman, 2009)

significantly different from zero at a 5% level. This supports the inclusion of the variables in the model. The Wald χ^2 test results, presented at the bottom panel (row 1) of Table 3, statistically validate that these variables contribute significantly as a group to the explanation of the determinants of households' livelihood choices. The key hypothesis of 'correlation of the disturbance term between the pair of equations is zero {i.e., $\rho_{jk} = 0$}' is rejected at the 1% level of significance for two pairs, justifying our multivariate Tobit specification. The Likelihood Ratio test result, presented at the bottom panel (last row) of Table 3, also statistically validates that household livelihood choices are strongly correlated.

It is clear from Table 3 that a number of socio-economic and infrastructure variables affect households' livelihood choice differentially.   . The likelihood of an agricultural livelihood and earning more from this source is significantly higher for households with younger heads, with higher education among its members (but not the household head), and/or with more assets and livestock resources. The lack of influence of the farm operation size is somewhat surprising. The reason may be dominance of occupational shifts where land-rich households use land as collateral (a preferred option of financial institutions for advancing loans in Bangladesh) to borrow loans in order to invest in non-agricultural livelihoods. The land poor households choose wage employment as reflected by negative significant coefficient, while agricultural livelihood may be an intermediate category.

The significance of household members' education proves existence of centralized decision making in choosing agricultural livelihood. Asadullah and Rahman (2009) also noted presence of centralized decision making in rice farming in Bangladesh. The influence of household resources on the choice of agricultural livelihood is quite high with a coefficient value or elasticity of 0.88. The implication is that a 10% increase in the value of household asset will increase the probability to choose agricultural livelihood and increase income earned

from this source by 8.8%. Similarly, a 10% increase in the value of livestock resources will raise income from agricultural livelihood by 8.2% and education by 4%.

The decision to choose wage employment as a livelihood option and income derived from this source is significantly higher for households with less education (of both head as well as any member of the household), low level of household assets and land resource. Tefera et al. (2004) noted that poorer households cannot undertake more profitable activities (e.g., business) due to lack of start-up capital and human capital (e.g., skilled labour) which is also implied from our results. Woldenhanna and Oskam (2001) noted that off-farm wage employment (i.e., wage employment) provides less income than off-farm self-employment (i.e., non-agricultural livelihood) which conforms with our results. For example, the mean income from wage employment is Tk. 3,003 which is significantly lower from non-agricultural livelihood estimated at Tk. 18,041 per household (p<0.01) (see Table 1).

On the other hand, the decision to choose non-agricultural livelihood and income derived from this source is significantly higher for households with relatively younger heads, higher education (of both head as well as any members of the household) but low level of household assets and livestock resources. Also, the magnitude of the influence of education on non-agricultural livelihood is very high (elasticity value of 1.67 for any member and 1.15 for head, respectively), thereby, confirming importance of education in enabling households to undertake remunerative activities. The result is consistent with Gibson and Olivia (2010) who noted that secondary level of schooling of the household head has a significant influence on non-farm earnings in rural Indonesia. The significance of both head's education as well as other members' education proves existence of centralized decision making in undertaking non-agricultural livelihood, which has important policy implications. However, one may also interpret this result as switching of households to non-agricultural livelihood as education increases, which is indicated in the occupational choice model (see Table 2).

Female headed households are totally disadvantaged as they fail to participate in any of the livelihood categories which is at contrast with Gibson and Olivia (2010) who did not find any influence of female headed households on income from non-farm economy in rural Indonesia. On the other hand, Hatlebakk (2012) indicated that female headed households are more likely to choose casual work or remain inactive, which conforms to our findings. Table 3 clearly shows vulnerability of female members as heads in rural Bangladesh to access various livelihood options which ultimately affect their earnings. . A comparison of the mean total income of female headed and male headed households confirm this finding. For example, the mean total income of the female headed households is estimated at Tk.13,557 which is significantly lower than the income of male headed households estimated at Tk.28,989 (p<0.01).

The impact of rural infrastructure on livelihood choice reveals an interesting story. The likelihood of choosing agricultural livelihood is significantly higher in villages where infrastructure is underdeveloped with no electricity but have irrigation facilities. These villages are located further away from district headquarter Chandpur but closer to regional headquarter, Comilla[6]. The scenario for households choosing wage employment is quite the opposite. Incidence of choosing wage employment as a livelihood option is higher in villages with developed infrastructure and irrigation access but no electricity and those located closer to both regional and district headquarters. Finally, the scenario for households choosing non-agricultural livelihood is similar to wage employment category but opposite to those choosing agricultural livelihood. The decision of households to choose non-agricultural livelihood is

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[6] These two proximity variables are measured in terms of travel cost required to reach the facilities. Therefore, a negative sign on the coefficient implies less cost and hence closer distance indicating positive influence on the dependent variable and vice-versa.

significantly higher in villages with developed infrastructure[7] and electricity but no irrigation. Proximity to regional and/or district headquarters have no influence which is somewhat surprising. In all the three models, influence of rural infrastructure is very prominent with elasticity values of 0.80 in agricultural livelihood, –2.36 in wage employment and –0.72 in non-agricultural livelihood models. The implication is that a 10% improvement in rural infrastructure will increase the probability of choosing wage employment and income derived from this source by 23.6% and for non-agricultural livelihood by 7.2% but reduce agricultural livelihood by 8.0%.

The overall implication is that with respect to rural infrastructure, the choice of agricultural livelihood largely depends on the existence of irrigation facilities and proximity to large markets (i.e., Comilla, the regional headquarter). Similarly, the choice of wage employment as a source of livelihood depends on the existence of irrigation, developed rural infrastructure (e.g., presence of secondary markets, transport links), and proximity to larger markets (i.e., both Chandpur, district headquarter as well as Comilla, regional headquarter). On the other hand, the choice of non-agricultural livelihood is largely dependent on the existence of developed rural infrastructure and electricity. Gibson and Olivia (2010) noted that non-farm earnings are significantly higher in villages that are close to the provincial capital, whereas we find that farm earnings are higher instead. With respect to electricity connection, Gibson and Olivia (2010) noted that villages with no blackouts (i.e., quality of connection) have a significantly positive influence on non-farm earnings, consistent with our findings, although we do not have data on quality of connection.

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[7] The rural infrastructure index is a measured in time to reach the facilities. Therefore, a negative sign on the coefficient implies shorter time to reach the facilities and hence developed infrastructure indicating positive influence on the dependent variable and vice-versa.

All the correlation coefficients of error terms between pairs of livelihood choice categories are negative indicating that the choice of one livelihood category decreases the likelihood of choosing another category. The effect is more prominent between wage employment and non-agricultural livelihood, which is expected, implying that households engaged in non-agricultural livelihood are less likely to choose wage employment which in turn provides substantially low level of income.

4.   Conclusions and policy implications

This study identifies the determinants of livelihood choices and income derived from such choices of the rural households in Bangladesh using a multinomial logit and a multivariate Tobit model. While the multinomial logit analysis enables identification of factors influencing choice of livelihood options, the multivariate Tobit model allows joint determination of multiple livelihood choices and income derived from such choices. The model diagnostics confirmed jointness of the decision on livelihood choice, thereby, justifying our use of the multivariate approach (Table 3).

The results reveal that a number of socio-economic factors as well as the state of rural infrastructure affect households' livelihood choice decisions. The multinomial choice model reveals that land rich households are less likely to combine agriculture with non-agricultural livelihoods. Education influences non-agricultural livelihood while livestock resources influence agricultural livelihood. State of rural infrastructure influences diversification of livelihoods. Results from the multivariate Tobit model reveals that resource rich and educated households with younger heads in villages with access to irrigation but underdeveloped infrastructure are more likely to choose agricultural livelihood. Proximity to regional headquarters also influences choice of agricultural livelihood. Wage employment is chosen by resource poor and uneducated households in villages with no access to irrigation but with developed infrastructure and closer to district or regional headquarters. On the other hand, non-

agricultural livelihood is chosen by younger heads, educated households, and those located in villages with electricity and developed rural infrastructure.

The broader implication of all these findings from both models is that apart from the household's socio-economic characteristics, investment in rural infrastructure could exert significant impact on households' livelihood choices. Furthermore, female headed households lose out totally as they fail to participate in any of the livelihood options[8].

The following policy implications can be drawn from this research. On one hand, measures to promote agricultural livelihood should be on investment targeted at the household level. These are: investment in education and building up assets and livestock resources. This is because education matters in raising productivity, boosting potential output and improving efficiency in Bangladesh (Asadullah and Rahman, 2009). Similarly, Rahman (2010a) noted that livestock resources and farm capital assets, which are also unequally distributed among the farming population, are essential in farming too and, therefore, should be promoted, which is consistent with our findings. In terms of infrastructural provision to promote agricultural livelihood, the undisputed importance of irrigation facilities as a precondition is clear.

On the other hand, measures to promote non-agricultural livelihood and earning from this source rest largely on investment in education and rural infrastructure. It is clear that rural electrification and improvement in eight elements of infrastructure are essential in influencing households' decision to choose non-agricultural livelihood. Gibson and Olivia (2010) also confirmed that two key types of infrastructure – roads and electricity – significantly improve both employment in and income from non-farm economy. Similarly, Abdulai and CroleRees (2001) emphasized governments to invest in improved infrastructure

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[8] These results are very similar to the estimates from univariate Tobit models which, however, cannot demonstrate jointness of the decision making process (results not shown).

to promote income diversification of poorer households. Our results also showed that education plays an important role in choosing non-agricultural livelihood and raises income from non-agricultural sources as education increases. Furthermore, investment in education will enable vulnerable households to move out of wage employment as a source of livelihood, a goal worth pursuing.

Furthermore, targeted intervention is needed for the female headed households to enable them to participate in any of these three livelihood categories. Rahman (2010b) advocated for creation of a hired labour market specifically for women which would enable them to participate in the production process and hence contribute positively towards agricultural growth as they significantly contribute to enhance agricultural productivity and efficiency. We further recommend that targeted intervention to improve education vis-à-vis skills of female headed households would enable them to take up non-agricultural livelihood which is more financially rewarding.

Realization of all these policy measures, although formidable and challenging, will play a synergistic role in improving households' participation in a range of livelihood categories. The key to promote growth in the non-agricultural sector in Bangladesh lies in investment in education, rural infrastructure and rural electrification.

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Table 1. Livelihood category comparisons and summary statistics of the variables.

Variables	Measurement	All households		Households engaged in agricultural livelihood		Households engaged in wage employment		Households engaged in non-agricultural livelihood		F-statistic of differences applying ANOVA
		Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	
Dependent variables										
Agricultural livelihood income	Taka	6503.18	11411.21	9692.31	13108.53	4559.50	673712	6158.49	11738.11	85.02***
Wage employment income	Taka	3002.61	11457.23	3054.71	10830.68	11706.27	20252.08	3261.67	3180.79	136.79***
Non-agricultural livelihood income	Taka	18041.12	31494.64	15589.77	29819.04	1026.86	1788.40	37974.15	36483.87	528.10***
Socio-economic variables										
Female headed household	Dummy (1 if head, 0 otherwise)	0.16	--	0.09	--	0.06	--	0.12	--	--
Main occupation of head is agriculture	Dummy (1 if yes, 0 otherwise)	0.28	--	0.42	--	0.34	--	0.16	--	--
Main occupation of head is wage labourer	Dummy (1 if yes, 0 otherwise)	0.12	--	0.12	--	0.40	--	0.04	--	--
Main occupation of head is non-agriculture	Dummy (1 if yes, 0 otherwise)	0.35	--	0.28	--	0.14	--	0.59	--	--
Age of household head	Years	48.49	13.69	49.07	13.24	47.47	12.88	47.12	12.86	13.72***
Education of head	Completed years of schooling	2.55	1.49	2.61	1.49	1.99	1.41	2.80	1.47	108.16***
Maximum education in the household	Completed years of schooling	5.82	3.83	6.29	3.65	4.10	3.15	6.48	3.88	170.70***
Household asset	Thousand Taka	310.61	2120.57	393.65	2669.82	171.83	1691.20	309.34	1916.70	3.69**
Farm operation size	Hectare	1.11	7.11	1.67	8.60	0.89	4.75	1.01	7.52	5.90***
Livestock resources	Thousand Taka	3.65	8.66	5.14	10.38	3.28	6.12	3.24	9.94	26.87***

Variables	Measurement	All households		Households engaged in agricultural livelihood		Households engaged in wage employment		Households engaged in non-agricultural livelihood		F-statistic of differences applying ANOVA
		Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	
Infrastructure variables										
Rural infrastructure	Hours	0.63	0.29	0.66	0.29	0.66	0.28	0.61	0.30	17.97***
Village has irrigation	Dummy (1 if facility is available, 0 otherwise)	0.95	--	0.97	--	0.97	--	0.92	--	--
Village has electricity	Dummy (1 if facility is available, 0 otherwise)	0.11	--	0.09	--	0.03	--	0.15	--	--
Proximity to regional headquarter, Comilla	Travel cost measured in Taka[a]	46.79	13.87	46.58	13.82	46.56	13.41	46.25	13.42	0.37
Proximity to district headquarter, Chandpur	Travel cost measured in Taka[a]	24.99	11.08	25.93	11.17	24.32	10.40	24.83	10.86	10.24***
Total observations		4195		2487		1076		1993		

Note: [a] = Exchange rate: US$1 = 42.7 Taka (approximately) during 1996–1997 (BBS, various issues)

*** = significant at 1 percent level ($p < 0.01$)

** = significant at 5 percent level ($p < 0.05$)

Variables are converted into natural logs in the models except for the dummy variables.

Table 2. Determinants of occupational choice of Bangladeshi rural households: a multinomial logit model.

Variables	Dependent variable: Livelihood choices versus Agricultural Livelihood (marginal effects)									
	Wage employment		Non-agricultural livelihood		Agricultural livelihood + Wage employment		Wage employment + non-agricultural livelihood		Agricultural + Non-agricultural livelihoods + wage employment	
	Coefficients	z-ratio	Coefficients	z-ratio	Coefficients	z-ratio	Coefficients	z-ratio	Coefficients	z-ratio
Socio-economic variables										
Female headed household	-0.0377***	-8.28	-0.0256*	-1.85	-0.1728***	-15.38	-0.0194**	-2.01	-0.1763***	-10.72
Age of household head	0.0113	1.18	-0.0463***	-2.60	-0.0006	-0.03	-0.0261**	-2.08	-0.1111***	-4.28
Education of head	-0.0132**	-2.43	0.0166*	1.72	-0.0749***	-6.50	0.0009	0.12	0.0277**	2.21
Maximum education in the household	-0.0200***	-5.00	-0.0041	-0.48	-0.0308***	-3.22	-0.0003	-0.05	0.0847***	6.82
Household asset	-0.0192***	-8.65	-0.0432***	-9.85	-0.0208***	-4.11	0.0036	1.07	0.0241***	4.38
Farm operation size	0.0077***	4.33	0.0279***	7.01	-0.0428***	-6.03	0.0015	0.37	-0.0243***	-2.95
Livestock resources	-0.0104***	-2.89	-0.0923***	-12.46	0.0326***	5.10	-0.0075*	-1.65	0.0331***	4.65
Infrastructure variables										
Rural infrastructure	0.0042	0.68	-0.0585***	-5.42	0.0135	0.95	-0.0207***	-2.58	0.0439***	2.95
Village has irrigation	0.0002	0.02	-0.1514***	-4.17	0.0469	1.46	0.0134	0.72	0.0447	1.24
Village has electricity	-0.0172	-1.56	0.1412***	5.38	-0.1129***	-5.99	0.0008	0.06	0.0072	0.29
Proximity to regional headquarter, Comilla	0.0138	1.45	0.0195	1.25	-0.0195	-1.46	-0.0160**	-2.24	-0.0084	-0.49
Proximity to district headquarter, Chandpur	-0.0069*	-1.69	-0.0229**	-2.45	-0.0089	-0.82	-0.0041	-0.56	0.0336***	2.58
Observations	261		717		815		233		1043	

Note: *** = significant at 1 percent level (p<0.01)
      ** = significant at 5 percent level (p<0.05)
      * = significant at 10 percent level (p<0.10)
      Number of observations for only 'agricultural livelihood' = 1126.
      All variables are in natural logs except dummy variables.
      For dummy variables, dy/dx shows discrete change from 0 to 1.

Table 3. Factors influencing livelihood choices and intensity of participation: a multivariate Tobit model

Variables	Agricultural livelihood		Wage employment		Non-agricultural livelihood	
	Coefficient	z-stat	Coefficient	z-stat	Coefficient	z-stat
Constant	2.3957	2.44**	-0.5208	-0.10	11.8831	4.79***
Socio-economic variables						
Female headed household	-0.6931***	-3.94	-12.455***	-8.70	-3.3977***	-7.30
Age of household head	-0.4496**	-2.13	0.0087	0.01	-2.8520***	-5.29
Education of head	-0.1186	-1.11	-2.7319***	-4.34	1.1471***	4.07
Maximum education in the household	0.3960***	4.15	-1.3289**	-2.48	1.6651***	6.57
Household asset	0.8826***	19.62	-1.7572***	-6.70	-0.2807**	2.46
Farm operation size	-0.1119	-0.20	-0.8341**	-2.48	0.1451	0.95
Livestock resources	0.8176***	13.24	-0.9809	-0.26	-0.9866***	-6.06
Infrastructure variables						
Rural infrastructure	0.8021***	6.45	-2.3611***	-3.06	-0.7189**	-2.27
Village has irrigation	0.9915***	3.21	7.2884***	2.96	-2.0099***	-2.65
Village has electricity	-0.5425**	-2.50	-4.4212***	-2.67	2.2146***	4.05
Proximity to regional headquarter, Comilla	-0.3371**	-2.24	-2.2287***	-2.67	-0.0022	-0.01
Proximity to district headquarter, Chandpur	0.4518***	4.31	-1.4839**	-2.51	0.1165	0.43
Model diagnostics						
Wald Chi-squared$_{(36,0.99)}$	1732.33***					
σ_1 (Agricultural livelihood)	3.8746***	75.85				
σ_2 (Wage employment)	14.9451***	25.87				
σ_3 (Non-agricultural livelihood)	9.2199***	54.36				
ρ_{12} (Agriculture and Wage employment)	-0.0313	-1.30				
ρ_{13} (Wage employment and Non-agriculture)	-0.1561***	-9.56				
ρ_{23} (Agriculture and Non-agriculture)	-0.8004***	-35.78				
LR test ($\rho_{12} = \rho_{13} = \rho_{23} = 0$)	871.38***					
Total observations	4195					

Note: *** = significant at 1 percent level (p<0.01)

**= significant at 5 percent level (p<0.05)

All variables are in natural logs except dummy variables, and therefore, the coefficients are marginal effects.

For dummy variables, dy/dx shows discrete change from 0 to 1.