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Farmers' usage of information and communication technologies for integrated farm management: An analytical study focusing on rural households of Bangladesh

Md. Masud Rana[1]

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A B S T R A C T
Agricultural farming consists of multiple components and information related to farm management is one of the crucial factors. Information and communication technologies (ICTs) provide reliable and need-based information effectively. This study focuses on investigating the extent of ICTs usage for integrated farm management and to clarify the underlying factors in Gauripur upazila (sub-district) under Mymensingh district of Bangladesh. To achieve the purpose of the study, data were collected from 75 randomly sampled farmers using a structured questionnaire. Both descriptive and inferential statistical techniques were applied to obtain the findings of the study. The findings of the study revealed that the highest proportion of the farmers (46%) tended to use ICTs to a moderate extent. The analytical findings from the study showed that among the socio-demographic attributes annual income, training received, access to information sources and knowledge level were significantly associated with the usage of ICTs by the farmers. The step-wise multiple regression analysis indicated that knowledge of ICT usage, annual income and access to information sources were the most influential factors affecting the usage of ICTs by the farmers. The policy implications of the study suggest paying more attention to increase the operational knowledge and access to ICTs with provision to hands-on training and economic incentives for rural poor farmers. The coordinated approach involving both public and private sectors can be effective to improve the extent of ICT usage for integrated farm management.

1. Introduction

Bangladesh is an agrarian country where agriculture sector plays a crucial role in economic development by contributing (11.6%) to the Gross Domestic Product (GDP) of the country (World Bank, 2021). The major proportion of the population (67%) belongs to the countryside and relies on agriculture for income and employment (BBS, 2018). Half of the total population (50%) is employed in this sector while about 70% of the total population depends overall on agriculture for their livelihood (The Daily Star, 2021). The agriculture sector in Bangladesh is dominated by marginal and smallholder farmers who account for 70% of the total crop production and the average farm size is less than 0.6 ha (Ministry of Agriculture, 2021). The productivity of rice and other crops is low compared to other countries and a notable yield gap exists because of following conventional farming system with lack of technical knowledge. Diversification in agricultural farming system is low since the same crop mainly rice is grown year after year in the same field with low access to improved technologies (BIDS, 2014). The agriculture sector is continuously facing a wide range of constraints like shrinkage of arable land, high rate of population growth, inadequate access to agricultural inputs (seed, fertilizer, feed, vaccines, farm machinery etc.) and risk factor due to climate change (The Daily Star, 2021). These constraints are continuously posing a serious threat to crop productivity, economic profitability and the socio-environmental sustainability of agriculture. The intensive farming system is based on high use of external inputs to maintain high rate of agricultural productivity. The intensive cultivation system may results in high productivity but is responsible for environmental degradation, deterioration of soil nutrients and reduction of beneficial soil microbes resulting in high cost

[1] Md. Masud Rana
Department of Agricultural Extension Education,
Bangladesh Agricultural University
Bangladesh

of production (Devendra & Thomas, 2002). The excessive use of agrochemicals negatively affects the microbial diversity and increases the vulnerability of rural poor farmers to climate change shocks (Ataikiru *et al*., 2019). Farmers' high dependency on mono-cropping system should be replaced with a sustainable farming approach. In this case, integrated farming system (IFS) has greater potential for effective management of farm resources to improve the livelihood of rural poor farmers (Gill *et al*., 2009).
Agricultural farming involves a high degree of uncertainty in terms of productivity and household income. So, the adoption of an appropriate strategy is so crucial to maintain farm productivity and income throughout the year. Integrated farming system is an approach that evolves the components like crop and livestock in a supplementary or elementary process (Behera & France, 2016; Behera *et al*., 2013). The integrated farming approach is based on low or minimum use of external inputs and enhances several beneficial processes like recycling of nutrients, soil reclamation, soil fertility enhancement and conservation of the natural ecosystem (Salton *et al*., 2014). Integrated farming systems with effective management approaches involve less risks as the benefit comes from diversified enterprises with environmental safety (Behera & France, 2016). Integrated farming practices can be a viable option for marginal and smallholder farmers to boost up the productivity of crop, livestock and fisheries (Behera *et al*., 2013).

The concept of information and communication technology (ICT) consists of multiple technological devices, tools or applications (e.g. cell phone, television, radio, computer, smartphone, internet, online applications like Facebook, YouTube, web portals etc.) are widely used with a view to communicating each other, dissemination, storage and management of useful information. Information and communication technology is so crucial for the conversion of conventional farming system to modernized one. Agricultural farming is a complicated process involving different stages and each stage involves several specific decisions or actions taken by the farmer. Easy access to useful farming related information enhances the decision making capacity of an individual farmer by improving knowledge and skills about new agricultural technologies (Mittal *et al*., 2010). The application of ICTs in the field of agriculture is referred to as e-agriculture. Now a days varieties types of ICT tools or devices are being used that have direct or indirect benefits for the overall development of agriculture sector (Venkatesh *et al*., 2012). The conventional information sources like radio, television and newspapers are unable to meet the rising demand of farmers related to crop cultivation, harvesting, processing, storage and marketing of farm products (Aker, 2011). The nature and extent of usage of ICTs in agriculture sector of Bangladesh is not satisfactory due to a wide range of constraints. The government of Bangladesh established Agriculture Information and Communication Centre (AICC) in 2009-10 with a view to providing information on weather forecasts, crop cultivation and management techniques (AIS, 2017). The latest initiative includes the establishment of Farmer Information and Advice Center (FIAC) under National Agricultural Technology Program (NATP) (IFAD, 2016).

From the comprehensive study of existing literature, it is found that worldwide a good number of studies have been conducted covering different aspects of ICT usage in agriculture. A study on factors affecting the using information and communication technologies (ICTs) by livestock farmers in the Eastern Cape province in South Africa was conducted by (Mdoda & Mdiya, 2022). The study reported that the use of ICTs by farmers was effective and was influenced by socio-economic and institutional factors. Bhusal *et al*., (2021) conducted a study on the role of ICT in agriculture sector in Nepal and revealed t hat farmers have low access to reliable and updated agricultural information sources. Chowhan & Ghosh (2020) conducted a study on the role of ICT in agriculture and its future scope in Bangladesh and found that farmers and extension staff have limited access, level of knowledge and capacity to use ICTs. Another study conducted by Khalak *et al*., (2018) on farmers' access to ICT-based media in receiving information and reported that the majority of the farmers had low access to ICT-based media in receiving farm information. Syiem & Raj (2015) accomplished a study on access and usage of ICTs by the tribal farmers in Meghalaya State of North-East India. The study revealed that farmers mostly used mobile phones compared to other ICT devices due to having beneficial impacts. Due to having a wide range of benefits, integrated farming practice becomes popular in developing countries like Bangladesh (Mamun *et al*., 2011). So, it is crucial to explore the nature and extent of ICT usage by rural farmers for integrated farm management. But, no study has been conducted focusing on the usage of ICTs for integrated farm management in Bangladesh. To

address the research gap, this study attempts to investigate the extent of ICT usage for integrated farm management and the underlying factors in Gauripur upazila (sub-district) under Mymensingh district of Bangladesh.

2. 2. Materials and Methods

2.1 The study location

The study was conducted in the Gauripur upazila (sub-district) under Mymensingh district of Bangladesh (Fig. 2). Gauripur upazila (sub-district) has an area of 274.07 sq. km. sub-division is located in between 24°38' and 24°50' north latitudes and in between 90°27' and 90°44' east longitudes. It is bounded by Purbadhala and Netrokona Sadar upazilas on the north, Ishwarganj upazila on the south, Kendua and Netrokona Sadar upazilas on the east, Mymensingh sadar and Phulpur upazilas on the west (Banglapedia, 2023). Gauripur upazila has a total population of 335,702 having population density of 1,200 /sq. km. with an average literacy rate of 57.90%. The proportion of the rural population (92.62%) is higher than that of the national average (68.49%) (BBS, 2022). The study area was selected because agriculture is the main source of income for the majority of the people (71.21%) belong to this locality. A wide range of crops like paddy, wheat, jute, mustard, vegetables and fruits are grown throughout the year. Farmers of this area are predominantly involved with farming of multiple components like crop, livestock and fisheries simultaneously to earn their livelihood (DAE, 2023).

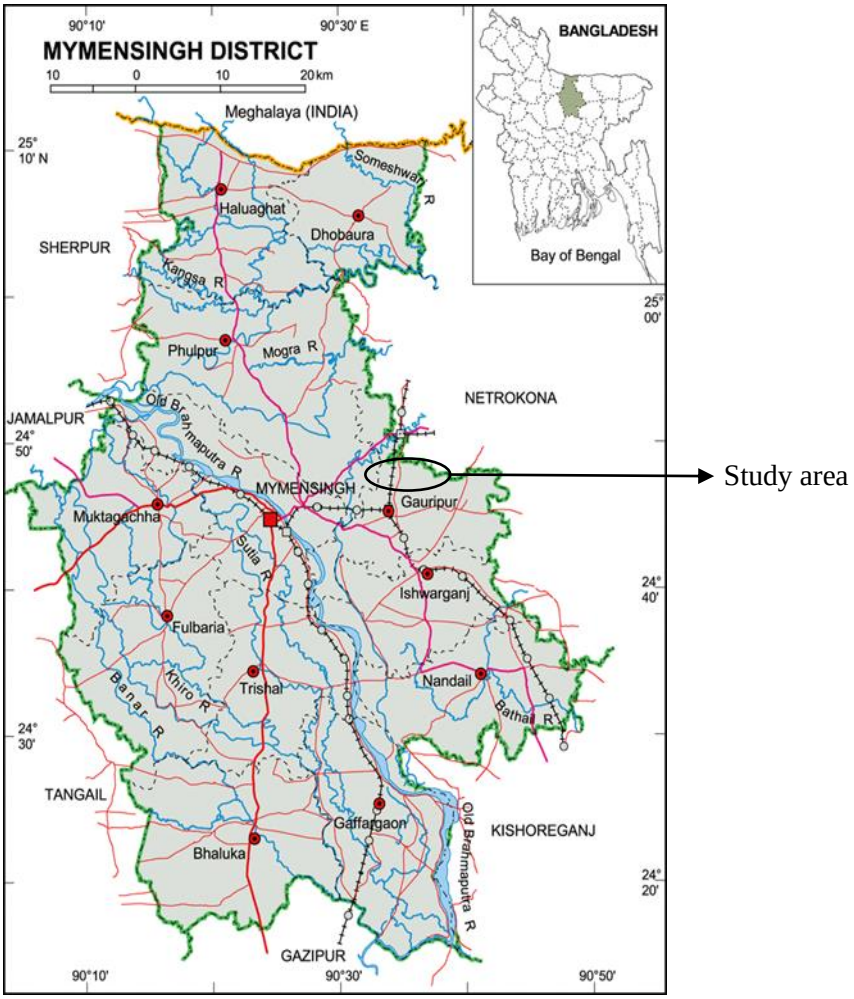

Figure 1. Map of Mymensingh district showing study area
(Source: Banglapedia, 2023)

2.2 Population and sampling design

The main focus of the study was to investigate the extent of ICTs usage for integrated farm management by the farmers of the study area. To have an in depth understanding about the nature of ICT usage, the farmers of the study area who were involved in integrated farming were considered as the population of the study. An updated list of farmers of the study area involved in integrated farming practices was collected from the local Upazila Agriculture Office. The population size of the study was 300 among them 75 farmers were randomly sampled to accomplish this study. The sample size was determined by using the following formula (Yamane, 1967) (Equation 1):

$$n=\frac{N}{1+Ne^2} \qquad (1)$$

Where, n = sample size, N = population size, and e = level of precision which indicates the degree of error or statistical variability

2.3 Methods of collecting data

This study follows a mixed-method research approach combining qualitative and quantitative techniques. To accomplish this research, data were collected by combining different methods such as individual survey, group discussion and field observation method. In case of survey method, a structured questionnaire was used as data collecting instrument which contained both open and closed forms of questions. The qualitative data were used to prepare the survey instrument and to verify the study findings. Data were collected from the household head of each farm family who were involved with integrated farming practices from the period of July to August 2022.

2.4 Measurement of variables

The socio-demographic attributes of farmers were selected based on the comprehensive literature review and consultation with resource personnel. Ten socio-demographic attributes of the respondents were considered in this study and these were also recognized as explanatory variables. Measurement of the socio-demographic attributes is mentioned in Table 1.

Table 1. Measurement of the independent variables

Socio-demographic attributes	Measurements	References
Age	Actual years	Parmar *et al*., (2018); Mdoda & Mdiya (2022)
Education	Year of schooling	Parmar *et al*., (2018); Mdoda & Mdiya (2022)
Household size	No. of family member	Mdoda & Mdiya (2022)
Farm size	Hectare (Ha)	Parmar *et al*., (2018)
Farming experience	Years	Parmar *et al*, (2018)
Annual income	Thousand ('000') BDT	Khalak *et al*., (2018); Syiem & Raj (2015)
Training received	Days	Khalak *et al*., (2018)
Organizational participation	Scale score	Khalak *et al*., (2018)
Access to information sources	Scale score	Mdoda & Mdiya (2022)
Knowledge of ICT usage	Scale score	Syiem & Raj (2015); Kabir (2015)

Farmers' extent of ICT usage was the main focus of the study. A four-point Likert scale was developed to measure the focus variable of the study (Likert, 1932). Twelve logically constructed statements considering patterns and extent of ICT usage were implied and asked each farmer against four possible responses such as high, moderate, low and not at all. The specific numeric value of 3, 2, 1 and 0 correspond to the four possible responses, respectively (Goswami & Paul, 2011). The score of each livelihood capital was measured by using the following formula:

Hence, ICT Usage Score (IUS)= $3\times H+2\times M+1\times L+0\times NA$

Where,
H = Total number of respondents expressing their opinion as 'high level of ICT usage'
M = Total number of respondents expressing their opinion as 'moderate level of ICT usage'
L= Total number of respondents expressing their opinion as 'low level of ICT usage'
NA = Total number of respondents expressing their opinion as 'not at all level of ICT usage'
So, the possible ICT usage score could vary from 0 to 36 where 0 indicates no usage of ICTs while 40 indicates high extent of ICTs usage by farmers.

2.5 Data processing and analysis

The survey data were properly edited, coded and analyzed by using the SPSS (Statistical Package for Social Sciences) software version 20. The socio-demographic attributes were computed with descriptive statistics like mean, standard deviation (SD) and percentage (%) (Fraenkel *et al*., 2012). To investigate the relationship between socio-demographic attributes and farmers' ICT usage, Pearson's Product Moment Correlation Co-efficient (r) was used (Ray & Mandal, 2004). In order to find out the factors affecting farmers' ICT usage, multiple linear regression and stepwise regression techniques were also applied.

3. Results and Discussion

3.1 Socio-demographic profile of the respondents

The socio-demographic profiles presented in Table 1 shows that the majority of the farmers (48%) belonged to the middle age category having primary (33.33%) to secondary (29.33%) level of educational qualification. The average household size was 5.24 which was higher than that of national average 4.0 (BBS, 2022). Farm size and annual income are the two important determining factors of social status for rural farmers. The study area mostly consists of smallholder farmers (57.33%) having medium annual household income (44%) which reflects the poor socio-economic condition of rural farmers in Bangladesh (BBS, 2022). As agriculture is the main source of livelihood, a notable portion of the respondents (49.33%) had high experience in farming activities. Training experience plays a vital role for the development of knowledge and skills of an individual (Obaniyi *et al*., 2014; Yassen *et al*., 2015).

Table 2. Distribution of the respondents according to their selected socio-economic attributes (n=75)

Socio-demographic attributes	Categories	Respondents		Mean	SD
		No.	Percentage (%)		
Age (21-72)	Young (18-35)	15	20.0	48.08	11.61
	Middle Aged (36-50)	36	48.0		
	Old (>50)	24	32.0		
Education (0-17)	No schooling (0)	16	21.33	6.24	4.69
	Primary (1-5)	25	33.33		
	Secondary (6-10)	22	29.33		
	Higher secondary (11-12)	7	9.33		
	Graduation or above (>12)	5	6.67		
Household Size (2-17)	Small (up to 4)	31	41.33	5.24	2.37
	Medium (5-7)	35	46.67		
	Large (above 7)	9	12.0		
Farm size (0.07-35)	Marginal (0.02-0.20)	15	20.0	1.59	6.71
	Small (0.21-1.0)	43	57.33		
	Medium (1.01-3.0)	14	18.67		
	Large (>3.0)	3	4.0		

Farming experience	Low (1-8)	12	16.0	18.75	9.08
	Medium (9-16)	26	34.67		
	High (>17)	37	49.33		
Annual Income	Low (up to 60)	13	17.33	145.64	138.47
	Medium (61-150)	33	44.0		
	High (> 150)	29	38.67		
Training received	No training (0)	32	42.67	2.31	5.51
	Short duration (1-3)	18	24.0		
	Moderate duration (4-6)	16	21.33		
	Long duration (>6)	9	12.0		
Organizational participation	Not participation (0)	29	38.67	0.87	1.16
	Low (1-2)	24	32.0		
	Moderate (3-4)	15	20.0		
	High (>4)	7	9.33		
Access to information sources	Low (1-12)	34	45.33	14.94	8.92
	Medium (13-24)	29	38.67		
	High (>24)	12	16.0		
Knowledge of ICT usage	Low (1-12)	16	21.33	17.63	4.82
	Medium (13-24)	45	60.0		
	High (>24)	14	18.67		

Notes: SD= Standard Deviation

But, a significant proportion of the respondents (42.67%) did not have the opportunity to participate in training compared to a relatively small portion (24%) had short duration training experience. The feature to take part in community-based organizations help in accumulation of social capital. It helps to develop a sense of bonding, bridging and linking social capital (mutual trust, togetherness, social networking etc.) (Islam et al., 2011). The farmers of the study area had a low tendency (32%) to participate in locally formed community-based organizations. Access to information sources and level of knowledge are important factors to determine farmers' extent of ICT usage in receiving farming information (Mdoda & Mdiya, 2022; Nyarko & Kozari, 2021). The farmers of the study area had low access (45.33%) to information sources with medium level of knowledge (60%) on using ICTs for integrated farm management. The findings are consistent with the study conducted by (Khalak *et al*., 2018) on farmers' access to ICT-based media in receiving farm information while Kabir (2015) reported that half of the respondents (50%) had medium level of knowledge of using ICTs for agricultural farming.

3.2 Extent of ICT usage by the farmers

Framers' extent of using ICTs was the main focus of the study. Based on the nature of ICT usage, farmers were distributed into three categories as shown in Figure 2. It is evident from the Figure that the highest portion of the farmers (46%) tended to use ICTs at a medium level while 19% of them tended to use ICTs at a high level. The study conducted by (Khalak *et al*., 2018) revealed that the majority of the farmers (81.2%) had low access to ICT-based media in receiving farming information. The investigation from our study found that farmers tend to use a wide variety of ICT devices and tools (e.g. cell phone, FM radio, television, smartphone, Facebook, YouTube, web pages and mobile apps developed by the government-

krishaker janala and *krishaker digital thikana*.) to receive necessary information related with integrated farming (e.g. vegetables-fruits-fish farming, poultry-fish farming, rice-duck farming, indigenous chicken-homestead vegetable cultivation, cereal crops cultivation-dairy farming etc.). The farmers reported that using a variety of ICT tools enable them to manage farm resources (e.g. land, labor, capital etc.) in a cost-effective manner. The incorporation of ICT tools enhance easy access to authentic farming information (e.g. weather forecast, availability of inputs, fertilizer requirement, pest and disease control, harvesting technique and marketing information) from trustworthy sources. Therefore, farmers can undertook these series of activities in appropriate time which results in better productivity and economic return. (Mdoda & Mdiya, 2022) reported that farmers of Eastern Cape province in South Africa used different ICT tools effectively that enhanced livestock productivity.

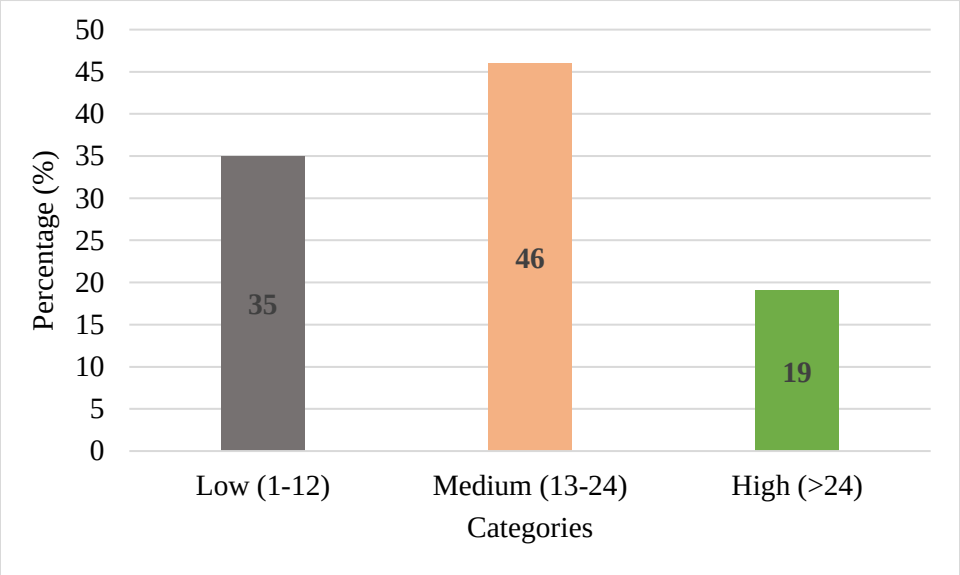

Figure 2. Distribution of farmers based on extent of ICT usage

Another study reported that farmers use ICTs for farm management decision located in Jorhat district of India (Lahan & Deka, 2019) while Syiem & Raj (2015) reported that the tribal farmers of Meghalaya State in India use mobile phone, radio and television mostly to receive agricultural farming information.

3.3 Correlation between farmers' socio-demographic attributes and usage of ICTs for integrated farm management

This section of the study aims to describe the association between farmers' socio-demographic attributes and the usage of ICTs for integrated farm management practices. To determine the correlation between the explanatory variables and focus variable, Pearson's product moment coefficient of correlation (r) was introduced.

Table 3. Summary of correlation between explanatory and focus variables

Focus variable	Farmers' socio-demographic attributes	Correlation coefficient (r) with 73 df
Farmers' usage of ICTs for integrated farm management	Age	-0.026
	Education	0.160
	Family size	0.076
	Farm area	-0.164
	Farming experience	-0.144
	Annual income	0.247*
	Training received	0.231*

	Organizational participation	-0.055
	Access to information sources	0.256*
	Knowledge of ICT usage	0.354**

Notes: *Significant at 0.05 level of probability (2- tailed) **Significant at 0.01 level of probability (2-tailed)

The findings presented in Table 3, clearly indicated that among the socio-demographic attributes annual income, training received, access to information sources and knowledge of ICT usage had significant and positive correlation with farmers' usage of ICTs for integrated farm management. The findings indicated that farmers with comparatively high annual income have better access to ICTs due to improve socio-economic conditions than the farmers with comparatively lower annual income. Because use of ICTs involves a good amount of economic investment related to price of ICT devices, cost related to internet connectivity, electricity and repairing of devices. Syiem & Raj (2015) reported that annual income had positive relation with accessibility and availability of ICTs for the tribal farmers in Meghalaya State of North-East India. Mukta *et al*., (2010) also reported that annual income had positive impacts on the cellphone using behavior of framers. Farmers' with training exposure have sufficient hands-on knowledge and skills in operational technique and handling procedures of ICTs compared to farmers having no training experience. Khalak *et al*., (2018) conducted a study on farmers access to ICT-based media and reported that training received on ICT have positive association with the use of ICT-based media in receiving agricultural information.

Furthermore, farmers' having access to information sources enabled them to know the usefulness of ICTs resulted in improving connectivity and networking through using ICTs. Mdoda & Mdiya (2022) showed that access to information services has positive impacts with the use of information and communication technologies (ICTs) by livestock farmers of the Eastern Cape province in South Africa. The findings are also consistent with the study conducted by Mukta *et al*., (2010). Lastly, farmers with adequate knowledge of ICT usage contributed in the formation of positive attitude with practical exposure that enhances the level of ICT usage than the farmers with lack of knowledge. Khalak *et al*., (2018) revealed that farmers' knowledge of ICT showed positive association with the use of ICT-based media in receiving agricultural information. So, these four attributes seem to have major contributions to the usage of ICTs by the farmers for integrated farm management. These findings are also consistent with the study conducted by (Chowhan & Ghosh, 2020) on the role of ICT in agriculture and its future scope in Bangladesh.

For detailed and in-depth understanding of the individual influence of the explanatory variables on the variations of farmers usage of ICTs for integrated farm management, a stepwise multiple regression analysis was implied. The findings of stepwise multiple regression are presented in Table 4.

Table 4. Summary of the stepwise multiple regression analysis (n = 75)

Model	Variables entered	Multiple R	Multiple R^2	Variation explained (percentage)	Significance level
Constant +X_{10}	Knowledge of ICT usage	0.404	0.163	16.3	0.001
Constant+X_{10}+ X_6	Annual income	0.473	0.223	6.0	0.025
Constant+X_{10}+ X_6+X_9	Access to information sources	0.521	0.271	4.8	0.028

The findings of Table 4 revealed that the model consists of three variables named knowledge of ICT usage, annual income and access to income sources. These three variables can (R^2=0.271) explain 27.1% of the variation in the farmers' usage of ICTs for integrated farm management. Among these three contributory variables, the first variable on knowledge of ICT usage (R^2=0.163) made the highest contribution (16.3%) in explaining the focus variable. The second contributory factor was annual income and it accounted for

6% in describing the variability of the focus variable. The third important factor was access to information sources and it was found to contribute 4.8% in explaining variation in the focus variable. The findings from the stepwise multiple regression disclosed that farmers with sufficient knowledge tended to use ICTs to a higher extent because of understanding the operational procedure and positive attitude towards using ICTs. The farmers with higher annual income had better access to ICTs than the farmers with lower income because access to ICTs involved a good sum of economic investment (e.g. price of devices, internet connectivity, the cost associated with smartphone applications or software and electricity charge). Farmers' with access to information sources had the opportunity to explore reliable information from authentic sources and were able to find other beneficial impacts from the usage of ICTs compared to the farmers with low access to information sources. These findings are consistent with the study on empowering farmers through e-agriculture in Bangladesh by Rashid *et al*., (2016).

4. Conclusion and Recommendations

In this era of technological advancement, information and communication technologies (ICTs) are widely used for smooth and efficient farm management (AIS, 2017). The analytical findings of the study discloses evidence on the extent of ICT usage for integrated farm management by the farmers of Gauripur upazila (sub-district) under Mymensingh district of Bangladesh. Specifically, it was revealed that the extent of ICT usage by the farmers was not comprehensive, as the majority of the farmers (46%) tended to use ICTs to a moderate extent. The socio-demographic attributes of annual income, training received, access to information sources and knowledge level had significant associations with the usage of ICTs by the farmers. Further investigation confirmed that multiple factors such as knowledge of ICT usage, annual income and access to information sources were found to be most significant in determining the extent of ICT usage by the farmers. Using of ICTs provides a wide range of benefits to the farmers through easy access to useful farming information (FAO, 2017).

Based on the analytical findings, this study suggests that government should pay attention to increase the level of knowledge and access to ICT facilities. Priority should be set up to assess the needs, conditions and interests of the farmers. As the majority of the farmers belongs to the countryside with poor socio-economic condition, there should be a provision of financial support to increase economic capacity of resource-poor farmers. The Department of Agricultural Extension (DAE) with the ministry of Information and Communication Technology (ICT) should arrange participatory training and workshop to increase technical knowledge and operational skills of farmers. Finally, emphasis should be given to raise awareness of farmers about the benefits of using ICTs by engaging the field staff of government (SAAO-Sub Assistant Agriculture Officer) and non-government organizations.

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