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Adoption of Modern Agricultural Technologies Transferred through Farmer Field Schools in Bangladesh

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Abstract: The adoption of modern agricultural technologies has received a lot of attention in both developed and developing countries. FFS is now being implemented and adopted all over the world and helps to improve intermediate outcomes related to adoption of modern agricultural technologies. However, the rate of adoption of these technologies is not as rapid as expected. To the contrary, the intention of farmers influenced the adoption of these technologies. The theory of planned behaviour (TPB) has provided a useful framework for explaining farmers' intention to adopt agricultural technologies transferred through FFS. Thus, this paper aims to assess farmers' intention to adopt modern technologies implementing the TPB. As per the results of a structural equation model, the three TPB constructs i.e., attitude, subjective norm, and perceived behavioural control are significantly related to intention. Furthermore, intention is found to be significantly and positively related to actual behaviour (adoption). The findings of the study expected to provide additional insights to policymakers and agricultural professionals as they create appropriate strategies to increase adoption of modern agricultural technologies in developing countries.

Keywords: Adoption, Theory of planned behaviour, Intention, Structural equation model

The world's population is increasing day by day. It is no longer possible to meet the needs of increasing numbers of population and to achieve food security by expanding areas under cultivation since the fertile land is not increasing over time. But this problem can only be solved effectively by increasing agricultural productivity of farm households. However, achieving agricultural productivity growth will not be possible without developing and disseminating yield-increasing technologies and application of these technologies by farm households (Challa and Tilahun 2014). The success of any technology depends on its dissemination among the potential users, which is ultimately measured by the level of adoption of that technology (Rashid et al 2019), while adoption of new farm technology can improve the economic status of a household (Dhani et al 2019). Observations indicated that despite visible benefits many technologies are not adopted by the farmers resulting yield gap between the farmers' field and the possible output of a specific technology (Mottaleb 2018). Farmer Field School (FFS) is a participatory extension approach through which a large number of agricultural technologies can be transferred to the farmers. The aim of FFS is to build farmers' capacity to analyse their production systems, identify their potential problems, test possible solutions and eventually motivate them to adopt the technologies most suitable to their farming system. Basically, the FFS program was implemented in many countries to empower farmers with scientific knowledge, skills, positive attitudes and suitable technology. It is one of the most effective group approaches in Bangladesh mainly implemented by the Department of Agricultural Extension (DAE) under the Ministry of Agriculture addressing a range of topics: from IPM to sustainable production systems, agro pastoralism, value chains, nutrition and life skills (FAO 2020). The FFSs worked smoothly during the execution period and the participating farmers had better understanding, adoption, and practice than non-FFS farmers (Bunyatta et al 2019). But technologies should be disseminated to non-FFS farmers as well. Despite an effective extension strategy, the effectiveness of FFS in influencing farmers' understanding and adoption of different technologies remains questionable (Roy et al 2014). This change in farmers' behaviour is a significant threat to adoption of modern agricultural technologies. The reason behind this is that there are some psychological factors which may influence the adoption of a new practice. The Theory of Planned Behaviour (TPB) has provided a useful framework for explaining the farmers' intention to adopt these technologies transferred through FFS. As per the TPB, adoption is inspired by intention, which is influenced by three psychological factors: attitude, subjective norm, and

perceived behavioural control (Fig. 1). Few studies focused directly on the adoption of modern agricultural technologies transferred through FFS, and most of the analyses ignored psychological factors. Thus, a research question arises, along with other factors, what psychological factors influence farmers to adopt agricultural technologies transferred through FFS.

The principles of TPB have been used in this study to define farmers' segments or typologies based on attitudes to predict behaviour and to analyse farmers' attitudes towards adopting modern agricultural technologies. In fact, attitudes are assumed to be causally related to rational behaviour when the decision-makers have control over decisions. However, this rational process is affected by both subjective norms and perceived behavioural control. In simple, a technology or a practice is judged for adoption by a farmer when build a positive attitude towards it, positive influence of the society around the individual about it (subjective norms), and have enough access to resources and the opportunities needed to adopt the technology or practice (perceived behavioural control). As per the TPB's theoretical foundation, the following hypotheses have been tested for the study:

H_1: There is a positive relationship between attitude towards behaviour and intention towards adoption of modern agricultural technologies (actual behaviour).

H_2: There is a positive relationship between subjective norms to perform the behaviour and intention towards adoption of modern agricultural technologies (actual behaviour).

H_3: There is a positive relationship between perceived behaviour control and intention towards adoption of modern agricultural technologies (actual behaviour).

H_4: There is a positive relationship between intention towards adoption and adoption of modern agricultural technologies (actual behaviour).

MATERIAL AND METHODS

The study was conducted at Kaliganj upazila (sub-district) in the northern part of Bangladesh, located between 25°54' and 26°04' north latitudes and between 89°07' and 89°22' east longitudes, where 52 Integrated Farm Management FFS (IFM-FFS) were implemented during 2013-2018. An experimental design was used in association with a cross-sectional survey. Using Cochran's (1977) sample size formula 182 FFS farmers were randomly selected from a population of 2600. As there was no list of non-FFS farmers and potential participants were hard to find, 156 non-FFS farmers were selected following snowball sampling procedure. Thus, a total of 338 farmers were selected as the sample for the study. Finally, ten technologies transferred through IFM-FFS were chosen based on judge rating. Data were collected by the researcher through face-to-face interviews using a pre-tested structured interview schedule from August to November, 2021. The interview schedule was formulated based on a series of activities, which include literature review, pilot study, and group discussions among academic experts, extension workers and researchers from various research institutes, extension agencies and universities. Questions related to the TPB were developed using a manual for constructing interview schedule based on the theory of planned behaviour (Francis et al 2004). Farmers' intention (INT) to adopt selected crop production technologies (INT_1, INT_2, INT_3, INT_4, INT_5, INT_6, INT_7, INT_8, INT_9 and INT_{10}) was measured with four degrees of intention towards adoption of the selected agricultural technologies ("currently use", "does not use, intends to use", "does not use, does not intend to use" and "does not use, does not apply") as used by Avemegah (2020). Ten statements on the instrument were used to directly measure attitude (ATT_1, ATT_2, ATT_3, ATT_4, ATT_5, ATT_6, ATT_7, ATT_8, ATT_9 and ATT_{10}). Farmers were asked if they agreed or disagreed with the statements about specific agricultural technologies. Four items (SN_1, SN_2, SN_3, SN_4) were used to measure farmers' subjective norms, which included the influence of the extension organization (DAE), important members of the community, and other farmers. However, five items of subjective norms were considered initially, but one was dropped out considering low value of Chronbach's alpha. Perceived Behavioural Control (PBC) was measured by five items (PBC_1, PBC_2, PBC_3, PBC_4, and PBC_5) that reflected farmers' confidence in their ability to adopt agricultural technologies on their farms. In total, 19 statements directly based on the TPB were used to create indices of each of the four constructs. Farmers' responses to these measurement items were captured on a 5-point Likert scale which ranged from 1 = strongly disagree to 5 = strongly agree, indicating the degree to which they agreed with the set of statements. On the other hand, adoption of the selected agricultural technologies was measured asking the respondents whether to adopt the technologies or not (coded: 1, 0).

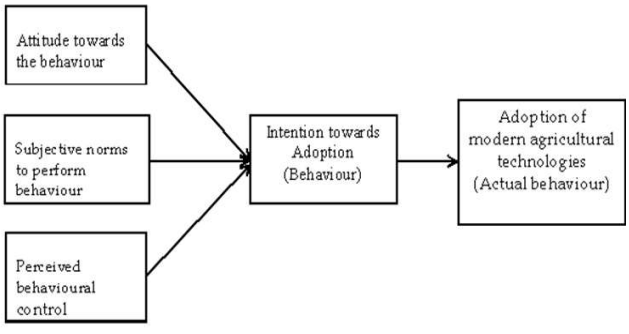


Fig. 1. Theory of planned behaviour (Source: Ajzen 1991)

Variables of the Model

Attitude: Attitude is defined as the degree to which a person perceives the behaviour based on favourable or unfavourable assessment of the behaviour. Since it lasts for a long time once it is formed, attitude often acts as a meaningful predictor of an individual's behavioural intention. In the context of this study, attitude refers to an individual farmer's positive or negative assessment of performing an action in relation to the adoption of modern agricultural technologies transferred through FFS methodology.

Subjective norms: In this study, subjective norms refer to the group norms influencing farmers' intention towards adoption of crop production technologies. For example, if a farmer perceives reference group-norm behaviour as good, the behaviour will be encouraged. Subjective norms were measured by whether the respondents agreed or disagreed that their colleague farmers and friends were increasingly using selective crop production technologies or which extension personnel motivated them, and whether it had an influence on them deciding to adopt the technologies or not.

Perceived behavioural control: Based on the theory of planned behaviour (TPB), perceived behaviour control is defined as an individual's confidence that he or she is capable of performing the behaviour. In this study, perceived behavioural control refers an external factor for a farmer's consciousness of the risks of adopting modern agricultural technologies that affects the actual behaviour (adoption) of farmers. Perceived behavioural control was measured by whether the respondents agreed or disagreed they had all the necessary skills and knowledge to engage in adopting modern crop production technologies.

Intention: This refers to the motivational factors that influence a given behaviour where the stronger the intention to perform the behaviour, the more likely the behaviour will be performed. It is defined as "indications of how hard people are willing to try, of how much of an effort they are planning to exert, in order to perform the behaviour." Farmers' intention to adopt selected agricultural technologies measured with the degree of intention towards adoption of these technologies.

Adoption: Adoption is a decision to make full use of an innovation as the best course of action available. When an individual takes up a new idea as the best course of action and implements it, the phenomenon is known as adoption. In the present study, adoption refers to a farmer's decision to use an agricultural technology and continue the use it in future.

Data analysis: In this study, SPSS (version 20) and STATA (version 14) software were used to analyse the data. To test the research hypotheses, a Structural Equation Modelling (SEM) was constructed using STATA (version 14). A reliability analysis was performed to investigate the consistency of the latent variable items.

Reliability: Chronbach's Alpha value was used to assess the reliability of the items of the TPB variables as it is the most frequently used indicator of internal consistency. Chronbach's alpha values ranged from 0.846 (very reliable) to 0.580 (almost reliable) for the variables. Chronbach's alpha, which assesses internal consistency and reliability, revealed the majority of variables of the model display good levels of internal consistency (Table 1).

Validity: To make sure the scale items for each structure were valid, experts in the design and interpretation of statistical surveys were asked to review them. As the conclusions of a study are regarded as statistically valid if they are reasonable, both the construction and statistical validity were considered in this paper.

Fit indices: Various goodness-of-fit indices are typically advised for determining how well the observed data match the model. The model fit was evaluated using Chi-square value (χ^2), Comparative Fit Index (CFI), Standardized Root Mean Square Residual (SRMR), and Root Mean Square

Table 1. An overview and operationalization of variables used in the model

Variable	Operationalization	Scale	Chronbach's alpha
Attitude	Attitudes towards intention to adopt modern agricultural technologies that were transferred through IFM-FFS.	1-5 Likert Scale	0.707
Subjective Norms (SN)	The reference group-norms influencing farmer intention towards adoption of crop production technologies.	1-5 Likert Scale	0.580
Perceived Behavioural Control (PBC)	An external factor for a farmer's consciousness of the risks of adopting modern agricultural technologies that affects the actual behaviour (adoption) of farmers. Perceived behavioural control was measured by whether respondents agreed or disagreed they had all the necessary skills and knowledge to engage in adopting modern crop production technologies.	1-5 Likert Scale	0.846
Intention	Farmers' intention to adopt selected crop production technologies means the degree of intention towards adoption of the technologies (Currently use; Does not use, intends to use; Does not use, does not intend to use; and Does not use, does not apply; Avemegah, 2020).	0-4 Likert Scale	0.604

error of Approximation (RMSEA). R-square was employed to measure the variation explained by the endogenous variable (i.e., intention). The models were estimated using maximum likelihood procedures.

RESULTS AND DISCUSSION

The average attitude score for the statement about ideal seedbed practice was high, followed by the statements about organic manure use, crop rotation practice, applying vermicompost and rouging (Table 2). On the contrary, the statement about using Guti urea for rice cultivation showed lowest attitude score, followed by the statements about controlling insect pests using light traps, employing air tight containers for seed preservation, transplanting seedling at proper age and line sowing. The majority of the items had an attitude score larger than the median (4.00), indicating that the majority of farmers had positive attitude towards intention to adopt the technologies. Subjective norms influenced by DAE personnel had the highest mean value, followed by similar farmers in the community, friends, and farmers from other Farmer Field Schools (FFSs). All items of the subjective norms' score were higher than that of median value (SN1:

Table 2. Descriptive statistics of TPB variables

Variable	Item	Mean	SD
Attitude	Practicing ideal seedbed improve seedling health	4.31	0.567
	Crop rotation decrease pest infestation	4.10	0.448
	Application of Guti urea in rice cultivation is not better than using prilled urea	3.21	0.941
	Vermicompost improves soil fertility	4.07	0.355
	Rouging helps to produce good quality seed	4.05	0.210
	Transplanting seedling in proper age helps in increasing yield	4.01	0.336
	Light trap is not helpful for controlling insect pest	3.28	0.786
	I think for better yield line sowing is a good practice	4.03	0.507
	I think for seed conservation using air tight container is not necessary	3.47	1.191
	Organic manure improves soil health	4.21	0.431
Subjective Norms (SN)	DAE personnel (AEO, SAPPO, and SAAO) often advise me to adopt crop production technologies transferred through IFM-FFS.	4.10	1.086
	Farmers that are similar to me already adopt crop production technologies transferred through IFM-FFS	2.80	0.965
	My friends think practicing crop production technologies transferred through IFM-FFS would be much better than previous state	2.25	0.620
	Farmers of other FFS would approve my practicing crop production technologies	2.12	0.539
Perceived Behavioural Control (PBC)	I have knowledge and ability to adopt crop production technologies transferred through IFM-FFS	3.37	1.063
	Crop production technologies transferred through IFM-FFS were easy for me	3.05	1.070
	I am confident that I can continue to practice crop production technologies transferred through IFM-FFS	2.81	1.016
	I can overcome any problems related to adopt practice crop production technologies transferred through IFM-FFS	2.74	0.984
	It is mostly up to me whether or not I practice crop production technologies transferred through IFM-FFS	3.60	0.985
Intention	Preparation of ideal seed bed for rice cultivation	2.85	0.395
	Use of air sealed container for seed storage	2.96	0.200
	Transplanting seedling at proper age	2.93	0.332
	Line sowing or proper spacing of seedlings	2.82	0.435
	Practicing rogueing for seed production	2.74	0.441
	Use of crop rotation	2.55	0.533
	Preparation and use of FYM	2.32	0.537
	Preparation and use of Vermicompost	2.04	0.483
	Application of Guti urea in rice cultivation	1.70	0.841
	Use of light trap	0.55	0.891

4.00; SN2 to SN4=2.00). This indicated that, in general, farmers' intentions to implement the technologies conformed to expected norms.

In terms of perceived behavioural control, the statement about whether or not farmers used agricultural production procedures had the highest mean score, followed by the statements about farmer' knowledge and ability, ease of practice, farmers' confidence, and overcoming any problems associated with adopting the technologies. The intention score was high in adopting air sealed container for seed storage followed by transplanting seedling at proper age, preparation of ideal seed bed for rice cultivation line sowing or proper spacing of seedlings and practicing rogueing for seed production. In contrast, farmers had expressed a low intention to adopt light traps for pest followed by the application of Guti urea in rice production, the usage of vermicompost and FYM, and the practice of crop rotation. The correlation matrix reveals that there are significant correlations between the variables (Table 3).

The findings of the structural equation model predicting intention and adoption of crop production technologies are shown in Figure 2. The fit indices revealed that the overall goodness-of-fit to the data was good (Table 4).

The method of estimation was significant in both the test of the targeted model against the saturated model (χ^2=3.073; p < .010) and the test of the baseline model against the saturated model (χ^2= 723.147; p < .001), indicating that there is a significant difference between observed variables and the theoretical model. However, χ^2 is not usually the deciding factor in determining model fit, as it does not always provide relevant information, and other measures of fit should be considered. Rather, multiple fit indices allow a more comprehensive assessment of model fit (Alavi et al 2020). The comparative fit index (CFI) of the model was 0.997 indicating good fit. The RMSEA provides values between 0 and 1, with values closer to zero indicating a better fit. According to this study, it was 0.078. Moreover, the model in this study builds a convincingly good fit, as indicated by the value of SRMR = 0.008, as the value of SRMR ≤0.08 is universally acknowledged as a good fit for the SEM model.

This study modelled attitude toward intention to adopt the technologies, subjective norms that perform intention to adopt the technologies, perceived behavioural control leads to intention to adopt the technologies, the intention towards adoption that treated as behaviour and adoption (actual behaviour) of the technologies. The attitude, subjective norms, and PBC all have positive and significant relationships with intention (behaviour). Intention has a favourable and significant relationship with adoption of modern agricultural technologies. These variables (attitude, subjective norms, and PBC) are also significantly and positively interrelated.

All of these findings support the hypotheses. As per Hypothesis H_1, a positive attitude predicts farmers' intention to adopt modern agricultural technologies. Farmers' attitude toward the behaviour, i.e., their favourable or negative personal judgment of adopting agricultural technologies, is undoubtedly the most important predictor of intention (β=0.170, p <0.01). This might be due to the fact that farmers intend to engage in the technologies because they are aware of the benefits that can be obtained through the use of effective interventions by the extension agencies. Farmers having expected subjective norms are also more likely to adopt modern agricultural technologies. As a result, the H_2 is accepted, implying that there is a positive association between subjective norms for performing the behaviour and intention to adopt modern agricultural technologies (β=0.055, p <0.01). This may be because the extension agencies, other farmers in the community, including friends

Table 4. Overall results of SEM

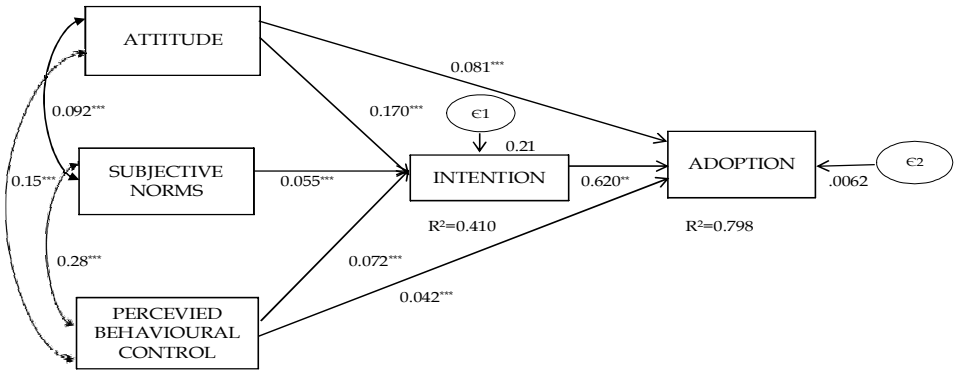
Path to	Path from	Coefficient (β)	Z value
Intention (R^2=0.410)	Attitude	0.170***	5.43
	Subjective norms	0.055***	3.44
	Perceived behavioural control	0.072***	5.38
Adoption (R^2=0.798)	Intention	0.620***	21.55
	Attitude	0.081***	4.65
	Perceived behavioural control	0.042***	5.95

Note: ** p < .05 level; *** p < .01 level.

Table 3. Descriptive statistics and correlations (N = 338)

Variables	Mean	SD	ATT	SN	PBC	INT	ADOP
1. Attitude towards the behaviour(ATT)	3.873	0.320	1.00				
2. Subjective norms to perform behaviour (SN)	3.89	0.621	0.463**	1.00			
3. Perceived behavioural control (PBC)	3.11	0.806	0.578**	0.566**	1.00		
4. Intention towards adoption (INT)	2.53	0.191	0.541**	0.480**	0.567**	1.00	
5. Adoption of modern agricultural technologies (ADOP)	0.555	0.176	0.622**	0.534**	0.659**	0.862**	1.00

** Correlation is significant at the 0.01 level, SD= Standard deviation



Significance Codes: *** = p < 0.01; ** = p < 0.05; * = p < 0.10.
Model fit: Chi^2_ms = 3.073; CFI = 0.997; RMSEA = 0.078; SRMR=0.008

Fig. 2. Structural Equation Modelling (SEM)

and neighbours, and farmers from other organizations exert constant pressure on farmers to adopt the technologies. The findings (Fig. 2) demonstrate a strong and positive relationship between perceived behavioural control and intention, supporting the H_3 and revealing that farmers' perception of their own capability affect their behavioural intention. Again, the H_4 is accepted since intention is positively and significantly associated to the adoption of modern agricultural technologies. Before performing any behaviour, intention is must and after determining their intentions, farmers are expected to take the opportunity to perform the actual behaviour (adoption). The inner model path coefficients of this study reveal that farmers' attitudes, subjective norms, and PBC are all important predictors of their intentions to adopt modern agricultural technologies, and that intention (behaviour) is a strong predictor of adoption (actual behaviour) of these technologies. Tama et al (2021) and Daxini et al (2018) observed similar result in their study. Van Dijk et al (2016) concluded statistically significant and positive effects of subjective norm on the intention to perform agro-environmental measures. In a different study, Bonke and Musshoff (2020) discovered positive and significant relationships between attitude to intention, as well as PBC and intention. The results obtained by Nguyen and Drakou (2021) showed that farmers' intention to adopt sustainable agricultural technologies is influenced by their perception of social pressure (SN) and their abilities to perform sustainable agriculture (PBC).

CONCLUSION

The findings indicate that farmers with favourable attitudes, expected subjective norms, and higher perceivable behavioural control were more likely than other farmers in the community to adopt agricultural technologies. Therefore, socio-psychological factors influencing the adoption, as outlined by TPB, may be considered while promoting the adoption of new technologies in the farming system. The findings of the study may be useful to the development of future research aimed at gaining a deeper understanding of psychological and other factors influencing technology adoption especially within the context of Bangladesh. This could lead to increased farm productivity and improved smallholder livelihoods in the country in a sustainable way. However, this study may have methodological shortcomings that create opportunities for future research.

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