FARMERS' ADOPTION OF NEW AGRICULTURAL TECHNOLOGY PROGRAMME IN HAMBANTOTA DISTRICT IN SRI LANKA: AN ANALYSIS OF CONSTRAINING FACTORS[1]

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ABSTRACT

This paper examines the major factors constraining the adoption of a newly introduced paddy improvement technology programme by farmers in the *Hambantota* district, as seen from the perspective of Agricultural extension officers. Further, the adoption pattern of those technological programmes by farmers was analyzed. A structured interview schedule was used to collect data from a purposively selected sample of 30 AI officers. Data was analyzed using the principal factor model with iteration and Varimax rotation, and simple linear regression analysis was done to explain any relationship between the adoption levels of farmers in each of the adoption stages. The results showed that a majority of AI officers perceived that only 40-60 per cent of farmers actually adopted the new technology programme. As for the percentage of farmers who proceeded to adopt each stage of the multi-stage process, the majority of the farmers in the community progressed to the awareness stage but only about 50 per cent of farmers continued until the final adoption stage was reached. Among the factors that could be cited as constraining the adoption: a lack of resources, incompatibility and complexity of new technology, and socio-economic and cultural constraints. Inadequacies in extension intervention, technical training and information were the main constraints that compromised the information and knowledge network. Moreover, the *Yaya 2* programme was hindered by environmental and economic barriers, poor educational competencies of farmers and weak information links with the other actors of the network. These findings suggest that there is an urgent need for researchers, policy makers and administrators of the extension service to consider these constraints seriously so as to overcome them to increase the adoption rate by farmers of the new paddy technology programme in *Hambantota*.

Keywords: Agricultural Technology, Adoption Stages, Adoption, Constraints

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1. Introduction

Technological change has been a major factor shaping agriculture in the last few decades. The rapid development of the agriculture sector may be attributed to technological innovations. Much of the agricultural innovation originated in developed countries and so some of the technologies are difficult to apply in developing countries. Though agricultural technologies are seen as an important route to poverty alleviation, the rate of adoption of these technologies has remained low in most of the developing countries (Mwangi & Kariuki, 2015; Bandira & Rasul, 2002). Nevertheless, the adoption of new technology remains a crucial requirement for the positive transformation of the agriculture sector. Therefore, the literature has focused on the individual adaptations of new technology and on farmers' learning behaviour as seen in many studies (Conley & Udry, 2010).

There exists a vast store of literature dealing with the factors that determine agricultural technology adoption (Katungi & Akankwasa, 2010; Akudugu et al., 2012; Loevinsohn et al., 2012; Adesina & Baidu-Forsen, 1995). Basically, literature on agriculture has highlighted two major driving factors behind successful agricultural technology adoption in developing countries. The availability and affordability of new agricultural technologies and farmers' expectations of long-term profitability promised by the new technology are two major determinants of technology adoption (Foster & Rosenzweig, 2010). Further, the factors that influence the adoption of modern agricultural technologies are categorized into three groups: economic factors, social factors and institutional factors. According to Akudugo (2012), the economic factors included farm size, cost of adoption, access to credit, expected benefits from the adoption and the off-farm income generation activities. The social factors included the age of farmers, the level of education and the gender. The institutional factors included access to extension services.

Technology dissemination is a key vehicle for technology adoption. Efficient dissemination of news about technology requires reliable information and technical guidance. Literature provides evidence of the importance of the technology dissemination process for invigorating the agriculture sector (OECD, 2001; Rogers, 2003).

Farmers who wish to keep abreast of new agricultural technology now have access to multiple sources of information. According to Rogers (1995), farmers may learn from their own experimentation, from agricultural extension services in the area, and from neighbouring farmers. In the case of developing countries, farmers often learn through the social learning approach. Further, traditional farmers were assumed to be passive recipients of knowledge that is provided to them by change agents. Those change agents in rural communities are the extension officers or sales agents representing producers of new technologies (Rogers, 1995).

The effect of social networks on technology adoption and the knowledge dissemination process has been discussed in previous literature. Uaiene et al. (2009) have claimed in their study that the social network enhances trust among actors of the network and promotes exchange of ideas and information. Learning through the social network is now a prominent feature of technology adoption in the rural agriculture sector in many developing countries. One of the most important models for social learning is the 'learning from others' model, where information about new technologies is transferred by word of mouth. This model emphasizes learning from others through collective experimentation, discussion and persuasion or through direct observation of neighbours' experiments (Foster & Rosenzweig, 1995). Despite this, social learning is considered to be a weak learning process. Further, diffusion rates of social learning will be slow if the individual farmer is unable to study his neighbours' experiences perfectly (Munshi, 2004; Stunding & Zilberman, 1999).

In view of the social aspects of the network, farmers can learn about new technologies and their practicability from their peer farmers in the network. Conley and Udry (2010) have explained the effect of farmer organizations on technology adoption. The literature describes both the positive and negative impacts of the social network on technology adoption (Katungi & Akankwasa, 2010; Foster & Rosenberg, 1995; Bandiera & Rasul, 2002). Moreover, Muwangi and Kariuki (2015), Genius et al. (2010), and Uaraeni et al. (2009) have explained the impact of the extension service on technology adoption in their studies. Availability and access to extension services was found to be a key aspect of technology adoption. Anyhow, only a limited number of studies have analyzed the role of the extension workers in the technology adoption process. This research gap might have crucial implications since the extension officers directly contact the farmer in the technology dissemination process. Further, much of the literature has explained the different factors that affect the individual decisions on technology adoption (Akudugo, 2012; Adesina & Baida-Forson, 1995; Ngoc Chi & Yamada, 2002). In addition, many studies have analyzed farmer perceptions regarding effectiveness of extension service on technology adoption (Agbarevo, 2013). Moreover, extension workers conduct awareness programmes and field demonstrations about new technology. Therefore, the perceptions of extension workers regarding how farmers adopt new technologies being introduced to them and the factors that affect technology adoption are deemed worthy of study. Further, this analysis would pinpoint the exact factors that drive the technology adoption. Additionally, drawing on an extensive review of the literature on adoption of agricultural technologies, analysing the perception of extension officers would be an alternative approach for determining the motivating factors behind the technology adoption process. Hence, the study will attempt to analyze the technology adoption pattern of paddy farmers in *Hambantota* district through the Agricultural extension officers' perception.

Though a number of studies have been conducted across the world on technology adoption and these have identified various factors that determine technology adoption, there is a dearth of literature on the specific factors that influence modern agricultural production technologies, especially among small scale paddy farmers in Sri Lanka. This is an acknowledged research gap that is going to be bridged through this study, which is based on the perception of AI officers in the *Hambantota* district in Sri Lanka.

1.1. Purpose and Objectives of the Study

The purpose of this study was to determine the factors influencing adoption of new agricultural technology by paddy farmers. In addition, the factors constraining farmers' adoption of new technology will be analyzed based on the perception of Agricultural Extension officers in *Hambantota* district. The study has mainly considered two paddy technological programmes. The specific objectives were:

1. To determine the percentage of paddy farmers who readily adopt the new technology as perceived by AI officers
2. To determine the level of adoption of the technology by farmers at each stage of adoption
3. To examine the factors which constrain farmers from adopting major paddy technology programmes

2. Literature Review

2.1. Technology Adoption

Adoption and diffusion are the processes governing the utilization of innovations. Diffusion can be interpreted as aggregate (widespread) adoption. There is a significant time lag between the invention of new technology and its adoption by farmers. Adoption behaviour of new technology may be affected by many factors. The vast literature on this topic mentions several different factors that influence technology adoption (Ngoc Chi & Yamada, 2002; Adebiyi & Okunlola, 2013; Adesina & Baidu-Forsen, 1995; Akudugo, 2012).

There are a number of factors that determine the extent of adoption of technology, such as attributes of the technology, objective of the farmer, characteristics of the change agent as well as the socio-economic, biological, and physical environment in which the technology is introduced. Socio-psychological traits of farmers such as their age, educational attainment, income, family size, tenure status, credit use, value system, and beliefs are positively related to adoption (Stunding & Zilberman, 1999). Apart from that, the personalities of extension officers in the area too can influence the farmers' adaptation. The credibility, good rapport with farmers, and communication ability of extension officers acting in combination with effectiveness of the technology transfer mechanism affect the adoption. In addition, the biophysical environment of the farming area such as infrastructure facilities and resources availability to the farm positively influence the farmers' social network.

Further, Rogers (2003) has drawn attention to an adoption category based on the innovation-decision period. The innovation-decision period is the length of time required to pass through the innovation-decision process. The time that elapses between awareness-knowledge of an innovation and the decision made to adopt it by an individual is measured in days, months, or years. Moreover, the innovation decision model of Rogers (1983) shows the stages through which the decision making process proceeds from first knowledge of an innovation to the decision made to adopt or reject it, to implement the new idea if accepted, and to confirm this decision (Rogers, 2003).

2.2. Technology Diffusion and Dissemination to Farmers

Diffusion can be interpreted as aggregate adoption (Stunding & Zilberman, 1999). Further, Rogers (1983) has defined Diffusion as the process by which an innovation is communicated through certain channels over a period among the members of a social system. An OECD (2001) study has defined diffusion as the process by which a new idea, practice or technology spreads in a given population. Similar to technology adoption, the characteristics of technologies, such as relative advantage, complexity, divisibility, and compatibility affect their diffusion (OECD, 2001). In respect of the technology diffusion process, Rogers in 1957 and other rural sociologists found in their studies that generally this process followed an S-shaped function of time.

Dissemination of information relating to technology among farmers is crucial for technology adoption. In general, farmers have conservative attitudes and need much time and information to be persuaded to adopt new technologies (OECD, 2001). Efficient promotion of new technology/ innovation requires reliable information and technical guidance. Therefore, demonstration plots and neighbouring farmers who have already converted are more persuasive to those who are debating whether to adopt new technology. Demonstration plots can provide practical information to guide farmers to make a smooth transition to new technology.

2.3. Determinants of Agricultural Technology Adoption

Foster and Rosenzweig (2010) mention that availability, affordability and farmers' expectations of long-term profitability of new technology are the major determinants in respect of technology adoption. Education level and income level of the farmers also affect the decision. An OECD (2001) study has identified further reasons for adopting new technologies. Progressive farmers who believe in science and technology adopt the new technologies more quickly than hidebound, non-progressive farmers. Similarly, educated and younger farmers also tend to adopt new technologies more readily compared to less educated and older farmers (Katungi & Akankwasa, 2010). Age of the farmer and size of the farm are other important determinants of technology adoption. Age was found to positively influence adoption of sorghum cultivation in Burkina Faso (Adesina & Baidu-Forson, 1995). According to Adesina and Baidu-Forson (1995), larger scale commercial farmers adopted new high-yielding maize varieties more readily than smallholders. Further, a few studies have classified these factors under different categories. For example, Akudugu *et al*. (2012) grouped the determinants of agricultural technology adoption into three categories, viz. Economic, social and institutional factors. Further, according to Loevinsohn et al. (2013), farmers' decisions about adopting new technology are determined by characteristics of the technology itself and the various restrictions and circumstances faced by farmers.

The OECD (2001) has identified the reasons for not adopting new technologies based on farmers' perceptions of technologies and farmers' attributes. Many farmers do not trust new technologies until they can see the demonstration field because they fear the risk of low yields. Particularly, conventional farmers do not like to change the methods based on their own experiences obtained through traditional farming experiences.

2.4. Effect of Knowledge and Information Network on Technology Adoption

More recently, economists have started to investigate how knowledge and information networks affect farmers' technology adoption. Their research findings have explained a range of potential externalities that have a bearing on technology adoption.

Social capital has been considered as the institutional factor which affects technology adoption (Akudugu *et al*., 2012). Technology adoption can be enhanced through the social network by building trust among actors of the network, allowing them to share ideas and exchange information among themselves. Particularly, farmers within a social network can learn from each other by discussing and observing new technology. Moreover, social networking can assist the individual to make decisions on technology adoption (Uaiene et al., 2009). Further, Uaiene (2009), Ostern and Thornton (2012), and Conley and Udry (2010) have explained the three major ways in which interactions between peer farmers can promote agricultural technology adoption: 1) individuals can profit by acting like friends/ neighbours; (2) individuals can gain knowledge of the benefits of technology from their friends; and (3) individuals can learn how to use new approaches from their peers.

Farmer organizations can serve as social capital in networks that provide official entitlement to the farmers as members of a farmer group and improve information sharing within the farmer group. Katungi and Akankwasa (2010) found that farmers who participated in farmer organizations engaged more in social learning about the technology and were therefore more likely to adopt the technologies. Although there are many positive impacts that social groups have on technology adoption, Foster and Rosenzweig (1995) have found there is some negative impact too due to the free riding behaviour of some actors of the social network. Based on both the positive and negative effects of social networks, Bandiera and Rasul in 2002 proposed an inverted U-shaped individual adoption curve, implying that network effects are positive at low rates of adoption, but negative at high rates of adoption.

2.5. Extension Services and Technology Adoption

The extension service is the key driving factor behind technology development in the agricultural sector in developing countries. Availability and access to extension services has also been found to be a key aspect in technology adoption (Mwangi & Kariuki, 2015). Akudugo (2012) has explained that access to extension services can counteract the negative effect of lack of formal education of farmers which hinders technology adoption. Thus, extension services create the platform for acquisition of the relevant information that promotes technology adoption. Moreover, information received through the extension services reduce the uncertainty about a new technology's performance, helping to make a positive change in the individual's decision on adoption. Therefore, access to extension services was also found to be positively related to the adoption of modern agricultural production technologies (Mwangi & Kariuki, 2015; Akudugo, 2012). Farmers usually become aware of new technologies through the extension officers in developing countries.

In addition, the extension agent acts as a link between the innovators of the technology and end users of that technology. Therefore, extension services help reduce the transaction cost associated with information sharing among the larger heterogeneous farming population (Genius et al., 2010). In developing countries, extension agents usually select a particular contact farmer who is recognized as the most influential agent to deliver new technology. Many authors have reported a positive relationship between extension services and technology adoption (Mwangi & Kariuki, 2015; Uaiene et al., 2009).

3. Methodology

The study was conducted in *Hambantota* district in Sri Lanka. Two major technological programmes that were considered in this study were named Farmer Field School (FFS) and *Yaya 2.* 30 Agricultural Instructors (AIs) were purposively selected for the data collection and semi-structured questionnaires were used using interview method. To determine the magnitude of the constraints as perceived by the AI officers, a five point Likert-type scale was used. The response options ranged from "not at all" to "a very great extent," scaled from -2 to +2.

Factor analysis using the principal factor model with Varimax rotation was used to determine major variables constraining the use of two improved paddy technologies. The loading under each factor represents a correlation between the identified constraint factors and has the same interpretation as any correlation coefficient. Simple linear regression analysis was done to explain any relationship between the adoption levels of farmers in each of the adoption stage.

3.1. Regression Analysis with the Level of Adoption with the Constraining Factor

The goal of regression analysis is to describe the relationship between two variables based on the observed data and to predict the value of the dependent variable based on the value of the independent variable. Even though regression analysis can make such predictions, this doesn't claim any causal relationship between the independent and dependent variables.

Regression analysis can measure how well the regression model fits with the data using the R, R^2, and adjusted R^2. *R* represents the multiple correlation coefficients and *R* can be considered to be one measure of the quality of the prediction of the dependent variable. The R^2 represents the value (call as the coefficient of determination), which is the proportion of variance in the dependent variable that can be explained by the independent variables (technically, it is the proportion of variation accounted for by the regression model above and beyond the mean model). Adjusted R-square is an adjustment of the R-squared that penalizes the addition of extraneous predictors to the model.

The statistical significance of the regression analysis will be measured using F and significance value of Anova table. The F-value is the Mean Square Regression divided by the Mean Square Residual. The p-value is compared to some alpha level in testing the null hypothesis that all of the model coefficients are 0. These values are used to answer the question "Do the independent variables reliably predict the dependent variable?" If the predicted p-value is smaller compared to typical value of 0.05, study can conclude that the independent variables reliably predict the dependent variable. If the p-value is greater than 0.05, it says that the independent variable does not show a statistically significant relationship with the dependent variable, or that the group of independent variables does not reliably predict the dependent variable.

The coefficient table use to predict the Y using x value in following table. The first coefficient, "(Constant)", is the intercept term. The regression equations are in following format:

$$Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4$$

Each of the other coefficients is b variables, or the slope of the line. For each 1-unit change in X, Y will change by b units.

3.2. Determining Relative Importance of Factors Constraining Technology Adoption

If two independent variables are measured in exactly the same units, it can assess the relative importance in their effect on Y using the coefficient value. Larger regression coefficient value represents the stronger effect on Y by independent variables. Often, explanatory variables are not all measured in the same units, making it difficult to assess relative importance. This problem can be overcome for quantitative variables by using standardized variables.

Two major technological programmes that were considered in this study were named Farmer Field School (FFS) and *Yaya 2*. To determine the level of constraints as perceived by Extension agents, five point Likert-type scales were used. The responses ranged from 'not at all' to 'a very great extent' along the scale. The FFS programme and *Yaya 2* Programme were used as the new paddy technology programmes in this study. Further, two major categories of variables were used for analysis. Eight variables were included under socio-economic and cultural constraints and six variables were included under the constraints associated with the knowledge and information network.

Factor analysis, using the principal factor model with iteration and Varimax rotation was used to determine major variables constraining the use of improved paddy technologies. The loading under each factor represents a correlation of the identified constraint factor. Kaiser´s criterion using factor loading above 0.5 was adopted in naming and interpreting the factor and constraint variables (Agwu & Anyanwu, 1999). Later, the simple linear regression analysis was done to explain any relationship between the adoption levels of farmers in each of the adoption stage. The study has converted the dependent variable into a binary variable: 1 for all stages in which at least a certain percentage of the farmers have reached a threshold level and 0 if not reach that level. Depending on the percentage of the adoption level at different stages of the study, different values were used as the threshold level.

4. Results and Discussion

4.1. Measurement of Adoption of New Technologies

Measurement of the rate of adoption of agricultural innovations is essential for ensuring effective knowledge transfer process by extension officers. The perceptions of AI officers concerning the percentage of farmers who adopt the given technology were measured. Table 01 shows the percentage of farmers who adopted new technology as perceived by AI officers.

TABLE 01
Farmers' Technology Adoption and Knowledge Dissemination Process

Percentage of Farmers who Effectively adopt New Technology and Share Information	Mean Response of AI Officers (Percentage)
Almost all farmers	0
80-100 % of farmers	3
60-80 % of farmers	10
40-60% of farmers	37
20-40 % of farmers	27
10-20 % of farmers	23
Only wise farmers	0

Source: Authors' own data (2015).

According to Table 01, nearly 37 per cent of AI officers have perceived that 40-60 per cent of farmers in the district effectively adopted the given technologies. None of AI officers had an experience of 100 per cent adaptation by farmers of the given technologies. Further, 27 per cent of AI officers in *Hambantota* district have perceived that only 10 per cent of farmers in their area have adopted the given technology due to several issues and constraints which are identified later in this study. The adoption rate of the farmers was greatly influenced by the socio-economic factors of the farming community. In addition, the effect of the knowledge and information network invariably influences the adoption rate of the farmers.

4.2. Stages of Adoption of New Technology

The adoption of agricultural technologies is a dynamic process and follows hierarchical or pyramidal stages, namely awareness, interest, evaluation, trial and adoption. George and Bohlem as cited by Ovwigho (2013) have explained those five steps in detail in their study.

Awareness simply means the individual's awareness about the existence of the innovation. When the individual wants more information about the new technology to assess if the innovation can help him, then that is interest. The evaluation stage implies the mental examination of the information gathered by the individual, who tries to determine whether it will really impact his work. In the trial stage, the individual tests the innovation to see if it actually measures up to his expectations. Finally, the individual reaches the adoption stage when he decides he really likes the innovation and wants to adopt the new technology and use it for his work. Though the individual could go through this adoption process steadily, some people are slower to transition between steps (Ovwigho, 2013).

The study intends to analyze each stage of the adoption process for two major technological programmes in *Hambantota* district and so the percentage of farmers passing through each stage as perceived by AI officers in the district will be recorded. After the initial awareness of new technology, extension offices in the areas will follow the progress of the farmers through each stage of adoption to get an idea about the individual adoption process. Based on that, Table 02 shows the percentage of farmers reaching each adoption stage as perceived by AI officers in the district.

TABLE 02
Percentage Distribution of Farmers by the Level of Adoption as Perceived by AI Officers

Adoption Stage	Percentage of Farmers	
	FFS Programme	*Yaya* 2 Programme
Unaware	0	0
Aware	80	83
Interest	60	76
Evaluation	57	71
Trial	54	64
Adoption	45	50
Discontinuance	16	9

Source: Authors' own data (2015).

The differences in farmer participation for each stage have been explained in previous literature. Onweremad and Njoku (2007) reported that low participation in some stages were caused by poor field contact between the extension agents and farmers. Efficacy of any agricultural extension is judged by the level of mass adoption by farmers and scientific practices among farmers.

4.3. Regression Analysis with the Level of Adoption with the Constraining Factor

The following Table 03 and 04 show the model summary of regression analysis of each adoption stage of both technological programmes. *FFS 1* and *Yaya 1* represent the eight independent variables under socio-economic and cultural constraints and *FFS 2* and *Yaya 2* represents the six independent variables under the constraints associated with the knowledge and information network.

TABLE 03
Model Summary of FFS Programme

Model	Threshold Adoption Level	R		R Square		Adjusted R Square	
Adoption Stage		FFS 1	FFS 2	FFS 1	FFS 2	FFS 1	FFS 2
Awareness	75 %	.718	.502	.515	.252	.330	.057
Interest	60 %	.607	.643	.369	.413	.129	.260
Evaluation	50%	.465	.438	.216	.192	-.083	-.019
Trail stage	50%	.473	.281	.224	.079	-.072	-.161
Adoption	40 %	.506	.555	.256	.308	-.028	.127
Discontinues	20%	.625	.494	.394	.244	.156	.047

Source: Authors' own data (2015).

TABLE 04
Model Summary of *Yaya* Programme

Model	Threshold Adoption Level	R		R Square		Adjusted R Square	
Adoption Stage		*Yaya* 1	*Yaya* 2	*Yaya* 1	*Yaya* 2	*Yaya* 1	*Yaya* 2
Awareness	75 %	.502	.408	.252	.167	-.033	-.051
Interest	60 %	.642	.444	.413	.197	.189	-.012
Evaluation	50%	.243	.472	.059	.223	-.299	.021
Trail stage	50%	.475	.464	.226	.215	-.069	.011
Adoption	40 %	.530	.511	.281	.261	.007	.068
Discontinues	20%	.506	.406	.256	.165	-.028	-.053

Source: Authors' own data (2015).

The threshold adoption level has mentioned in above table. Indicators of the above tables measure the quality of the prediction of the dependent variable. Anyhow, only few models shows significant values showing a good level of prediction and two models indicate poor level of prediction showing lowest value. (0.281 at trail stage of Table 03 and 0.243 at evaluation stage of Table 04). Further, following two tables (Table 05 and 06) show the statistical significance of the model at each stage using F value and significant value. Based on those tables the independent variables do not reliably predict the dependent variables of many models except awareness and Interest stages of FFS programme.

TABLE 05
Anova Table for FFS Programme

	F Value		Significance Level	
Adoption Stage	FFS 1	FFS 2	FFS 1	FFS 2
Awareness	2.789	1.294	.028	.299
Interest	1.198	2.696	.347	.039
Evaluation	.723	.909	.670	.506
Trail stage	.756	.329	.643	.915
Adoption	1.687	1.706	.160	.165
Discontinues	.901	1.237	.533	.324

Source: Authors' own data (2015).

TABLE 06
Anova Table for FFS Programme

Model	F Value		Significance Level	
Adoption Stage	*Yaya* 1	*Yaya* 2	*Yaya* 1	*Yaya* 2
Awareness	.885	.767	545	.603
Interest	1.843	.942	.125	.485
Evaluation	.165	1.101	.993	.392
Trail stage	.765	1.051	.636	.419
Adoption	1.025	1.354	.448	.275
Discontinues	.901	.759	.533	.609

Source: Authors' own data (2015).

The general form of the estimated model will be measured using the coefficient table and regression equation will be derived using the unstandardized coefficients. Unstandardized coefficients indicate how much the dependent variable varies with an independent variable when all other independent variables are held constant.

4.4. Prediction of Regression Equations

The following regression equations developed using the correlation coefficient of regression analysis. The following two equations are for the FFS programme:

Socio-economic and Cultural Constraints

1. Y(Awareness) = 1.130 + (-.092)V1 + (.057)V2 + (-.403)V3 + (-.034)V4 + (.014)V5 + (-.083)V6 + (-.108)V7 + (-.208)V8

(Where, V1-High cost of using new technologies, V2-Lack of adequate technical knowledge about new technologies, V3-Lack of resources to carry out necessary activities associated with new technologies, V4-Difficulty of integrating new technologies into the existing farming system, V5-Cultural incompatibility of technology adoption, V6-Complexity in carrying out associated practices related to new technologies in the field, V7-Environmental barriers against using new technologies, V8- Lack of adequate educational qualifications and experiences).

Constraints Associated with the Knowledge and Information Network

2. Y(Awareness) = 0.671 + (.011)V1 + (-.088)V2 + (.203)V3 + (.069)V4 + (.178)V5 + (.050)V6

(Where, V1-Unavailability of important information associated with new technologies, V2-Lack of influence of extension services and social learning, V3-Lack of technical training and meetings with technical specialist, V4-Poor information links and sharing with other actors of the network, V5-Lack of adequate information sources on new technologies, V6-Lack of trust in available information and information sources).

Based on the above two equations, the adoption level of the awareness stage are greatly affected by Lacking resources to carry out necessary activities associated with new technologies and Lacks adequate educational qualifications and experiences. Negative value of coefficient indicates that the adequate level of resources and qualified extension workers help increase the adoption level at awareness stage. In respect to constraints associates with the knowledge and information network, two major factors could be highlighted. Lacks technical training and meetings with technical specialist and Lacks adequate information sources on new technologies affect the adoption level at the awareness stage.

Following two equations shows the regression equation for *Yaya* programme:

Socio-economic and Cultural Constraints

1. Y(Awareness) = 0.627 + (-.042)V1 + (-.061)V2 + (-.084)V3 + (-.115)V4 + (.003)V5 + (.128)V6 + (-.080)V7 + (-.090)V8

Constraints Associated with the Knowledge and Information Network

2. Y (Awareness) = 0.458 + (-.193)V1 + (.096)V2 + (-.030)V3 + (-.080)V4 + (.108)V5 + (.033)V6

Similar to above explanation, following regression equations show the relative importance of constraining factors for FFS and *Yaya* programme for the rest of stages. The Table 05 shows the relatively importance of each factor which affecting to the adoption level of each stage.

Socio-economic and Cultural Constraints Affecting the FFS Programm (FFS 1)

1. Y(Interest) = .795 + (-.005)V1 + (-.032)V2 + (.121)V3 + (.054)V4 + (-.011)V5 + (-.054)V6 + (.132)V7 + (.003)V8
2. Y(Evaluation) = .770 + (-.035)V1 + (-.054)V2 + (.162)V3 + (-.036)V4 + (-.081)V5 + (-.050)V6 + (.010)V7 + (.102)V8
3. Y(Trail) = .471 + (.119)V1 + (.140)V2 + (-.019)V3 + (-.105)V4 + (-.113)V5 + (-.114)V6 + (-.054)V7 + (-.065)V8
4. Y(Adoption) = .323 + (.095)V1 + (.151)V2 + (.114)V3 + (.058)V4 + (-.197)V5 + (.012)V6 + (-.031)V7 + (-.167)V8
5. Y(Discontinues) = .401 + (-.259)V1 + (.083)V2 + (-.063)V3 + (.065)V4 + (.078)V5 + (-.092)V6 + (.131)V7 + (-.146)V8

Constraints Associated with the Knowledge and Information Network (FFS 2)

1. Y(Interest) = .219 + (-.144)V1 + (.242)V2 + (-.007)V3 + (-.080)V4 + (.006)V5 + (.224)V6
2. Y(Evaluation) = .888 + (.044)V1 + (.076)V2 + (-.101)V3 + (-.093)V4 + (-.103)V5 + (.038)V6
3. Y(Trail) = .663 + (.059)V1 + (-.017)V2 + (-.069)V3 + (-.048)V4 + (-.034)V5 + (.080)V6
4. Y(Adoption) = .541 + (-.090)V1 + (.132)V2 + (-.143)V3 + (.203)V4 + (.108)V5 + (.014)V6
5. Y(Discontinues) = .249 + (-.044)V1 + (.217)V2 + (-.063)V3 + (.042)V4 + (.154)V5 + (-.007)V6

In respect to above regression equations, Table 07 figured out the significant factors affecting the adoption of different stages of FFS Programmes**.**

TABLE 07
Significance Factors Affecting the Adoption Level at Different Stages of FFS Programme

	Significance Factor	
Adoption Stage	FFS 1	FFS 2
Awareness	Availability of resources to carry out necessary activities associated with new technologies, Adequate level of adequate educational qualifications and experiences	Lack of technical training and meetings with technical specialist Lack of adequate information sources on new technologies
Interest	Lack of resources to carry out necessary activities associated with new technologies, Environmental barriers against using new technologies	availability of important information associated with new technologies, Lack of influence of extension services and social learning, Lack of trust in available information and information sources
Evaluation	Lack of resources to carry out necessary activities associated with new technologies, Lack of adequate educational qualifications and experiences	Adequate technical training and meetings with technical specialist, Adequate information sources on new technologies
Trail stage	High cost of using new technologies; Lack of adequate technical knowledge about new technologies; Easy of integrating new technologies into the existing farming system; Cultural compatibility of technology adoption. Easiness of carrying out associated practices related to new technologies in the field.	Lack of trust in available information and information sources
Adoption	Lack of adequate technical knowledge about new technologies, Lack of resources to carry out necessary activities associated with new technologies, Cultural compatibility of technology adoption, adequate educational qualifications and experiences.	Lack of influence of extension services and social learning, sufficient technical training and meetings with technical specialist, Poor information links and sharing with other actors of the network, Lack of adequate information sources on new technologies
Discontinues	High cost of using new technologies, Environmental barriers against using new technologies, adequate educational qualifications and experiences.	Lack of influence of extension services and social learning, Lack of adequate information sources on new technologies.

FFS 1- Socio-economic and cultural constraints affect to FFS programm.
FFS 2 - Constraints associated with the knowledge and information network.
Source: Authors' own data (2015).

Socio-economic and Cultural Constraints Affecting the Yaya Programm (Yaya 1)

1. Y(Interest) = .570 + (.097)V1 + (-.026)V2 + (-.334)V3 + (-.079)V4 + (-.046)V5 + (.004)V6 + (-.039)V7 + (-.166)V8
2. Y(Evaluation) = .812 + (.025)V1 + (.058)V2 + (.019)V3 + (.035)V4 + (.020)V5 + (.053)V6 + (-.031)V7 + (.018)V8
3. Y(Trail) = .471 + (-.025)V1 + (-.128)V2 + (.210)V3 + (-.050)V4 + (-.107)V5 + (.043)V6 + (.096)V7 + (-.067)V8
4. Y(Adoption) = .525 + (-.057)V1 + (.005)V2 + (.166)V3 + (.108)V4 + (-.201)V5 + (.056)V6 + (-.142)V7 + (.055)V8
5. Y(Discontinues) = .426 + (-.087)V1 + (-.154)V2 + (-.042)V3 + (.065)V4 + (-.059)V5 + (.151)V6 + (-.024)V7 + (.044)V8

Constraints Associated with the Knowledge and Information Network for Yaya Programme (Yaya 2)

1. Y(Interest) = .487 + (.120)V1 + (-.124)V2 + (.115)V3 + (.137)V4 + (.136)V5 + (.131)V6
2. Y(Evaluation) = .926 + (.068)V1 + (-.132)V2 + (.024)V3 + (.062)V4 + (-.020)V5 + (.132)V6
3. Y(Trail) = .586 + (.156)V1 + (.117)V2 + (.076)V3 + (.100)V4 + (.031)V5 + (.190)V6
4. Y(Adoption) = .528 + (-.266)V1 + (-.190)V2 + (-.044)V3 + (-.067)V4 + (-.119)V5 + (-.043)V6
5. Y(Discontinues) = .299 + (-.049)V1 + (-.058)V2 + (-.127)V3 + (.025)V4 + (-.140)V5 + (.076)V6

In respect to above regression equations, Table 08 figured out the significant factors affecting the adoption of different stages of *Yaya* Programmes**.**

TABLE 08
Significance Factors Affecting the Adoption Level at Different Stages of *Yaya* Programme

	Significance Factor	
Adoption Stage	*Yaya* 1	*Yaya* 2
Awareness	Easiness of integrating new technologies into the existing farming system, Complexity in carrying out associated practices related to new technologies in the field.	Availability of important information associated with new technologies; Lack of adequate information sources on new technologies
Interest	Availability of resources to carry out necessary activities associated with new technologies, adequate educational qualifications and experiences	availability of important information associated with new technologies, great influence of extension services and social learning, and almost all variables
Evaluation	Lack of adequate technical knowledge about new technologies and small effect from all other factors	Great influence of extension services and social learning , trust in available information and information sources
Trail stage	adequate technical knowledge about new technologies, Lack of resources to carry out necessary activities associated with new technologies, Cultural compatibility of technology adoption	Unavailability of important information associated with new technologies, Lack of influence of extension services and social learning, Lack of trust in available information and information sources.
Adoption	Lack of resources to carry out necessary activities associated with new technologies, Difficulty of integrating new technologies into the existing farming system, Cultural compatibility of technology adoption, less Environmental barriers against using new technologies.	Availability of important information associated with new technologies, great influence of extension services and social learning, adequate information sources on new technologies
Discontinues	adequate technical knowledge about new technologies, Complexity in carrying out associated practices related to new technologies in the field	Sufficient technical training and meetings with technical specialist, adequate information sources on new technologies

Yaya 1 - Socio economic and cultural constraints affect to *Yaya* programm.
Yaya 2 - Constraints associated with the knowledge and information network for *Yaya* Programme.
Source: Authors' own data (2015).

5. Discussion and Limitations of the Study

The results of the study have some interesting research implications, of which some are supported by previous studies, while some new facts have emerged in the context of the Sri Lankan scenario. First, the study has shown the perceptions of AI officers concerning the attitudes of farmers who are thinking of adopting new technology. The majority of AI officers perceived that only 40-60 per cent of farmers in their areas effectively adopted a given technology. Anyhow, the adoption rates of new technologies by farmers heavily depend on internal and external determinants of the farmers' network. Irrespective of those factors, the literature also supports the fact that only 40-60 per cent of farmers in the community effectively adopt the given technology (Muange & Schwarze, 2014; Uaiene et al., 2009; Bandiera & Rasul, 2002).

Secondly, the study has shown the percentage distribution of farmers by level of adoption as perceived by AI officers. The seven stages of the adoption process have been described by Ovwigho (2013) and the study used these seven stages for the analysis. Almost all farmers become aware of new technological programmes that are introduced by extension officers. Following up to the subsequent stages, nearly 50 per cent of the farmers finally adapt to the FFS and *Yaya 2* programmes in *Hambantota* district. Importantly, 16 and 9 per cent of the farmers who adopted these two programmes have discontinued. The prevailing constraints and issues have affected the programmes leading to the discontinuation of the technology. Onweremad and Njoku (2007) have pinpointed the specific factors influencing the information network that are responsible for causing the differences in participation at each stage of adoption. Further, the literature has strongly supported the fact that farmers' age, experience, and educational qualification would cause differences in the distribution at each stage. The AI officers in the *Hambantota* district also supported the above findings and have emphasized the importance of personal qualifications of farmers for the variation in adoption at different stages. In addition, active involvement of AI officers in those technological programmes would positively affect the adaptation of farmers at the different stages.

Concerning the constraints affecting the adoption of technology by farmers, the study shows constraints under two major categories separately for the FFS and *Yaya 2* programmes. Socio-economic and cultural constraints which influence adaptation to the FFS programme have been identified. Lack of resources to adopt new technology, incompatibility, complexity of new technology and environmental barriers against adopting FFS programme have been identified by the study. As in the case of the FFS programme, Environmental and economic barriers, poor educational competency, inadequate resources and incompatibility of new technologies with prevailing conditions are the major constraints that were extracted by the study.

Just as in the case of socio-economic and cultural constraints, the constraints associated with the knowledge and information network which impact on the adoption of the FFS programme were also extracted. Inadequate extension intervention, poor technical training and inadequate information on new technologies were major constraints on adoption of FFS programmes. Concerning the *Yaya 2* programme, three major constraints were identified. Poor extension intervention, limited information access and weak information link with actors were the extracted constraints associated with the knowledge and information link.

The study has a few limitations in respect of its methodological approach. One is the Questionnaire used to measure the adoption of new agricultural technology based on the perception of AI officers who serve as the external influencing agent for adoption. Many of the previous studies have measured the technology adoption based on the farmers' perception. Therefore, the study has limitation of justify the research findings based on limited literature supports which has done using perception of external influencing agent such as extension officers. Moreover, the major data collection approach of the study was based on a field survey using a semi-structured questionnaire. AI officers in *Hambantota* district come under two administrative divisions and mainly work at field level. Therefore, practical problems were encountered during field level data collection. The pre-identified variables were analyzed using the factor loading techniques with Varimax rotation techniques used to extract major subgroups of variables. It is also possible that there might be other important variables that were neglected in this study. Previous literature has also given evidence of similar variables which influence the farmer adoption. Since the study was based on the individual perceptions of AIs in *Hambantota* district, it can only be said that those factors would depend on the subjective opinions of AI officers as well as the location and socio-economic characteristics of the farming community. Also, the results could be different with respect to the other determinants and country specific factors.

6. Conclusion

The results of this study have some interesting research implications. First, the study shows that the adoption of new paddy technology by farmers in *Hambantota* district varied from 40-60 per cent. The study was based on the collective perceptions of AI officers in the district since the major source of knowledge and information for the paddy farmers are the Agricultural extension officers and public extension services in *Hambantota* district. The results showed that distribution of farmers at each stage of adoption were different percentage wise for FFS and *Yaya 2* programmes. Another striking result was that awareness about new technology was high in *Hambantota* district in Sri Lanka implying effective information sharing between extension workers and farmers. Further, this study showed that at all stages of adoption there was active involvement of AI officers while a significant percentage of farmers discontinued the use of new technology after a period due to prevailing circumstances. Another key outcome of the results was in pinpointing the major constraints which influence the farmer adoption for FFS and *Yaya* 2 programmes. Those constraints were categorized under two headings; socio-economic and cultural constraints and constraints associated with the knowledge and information network in the district. These findings seem to suggest a few policy implications in the Sri Lankan context. Particularly, the constraints associated with the extension services might lead to a slight change in the extension approach that is currently being used in *Hambantota* district for the two technology programmes. Concerning the adoption stages, the success of the awareness stage has to be followed up until the adoption stage is reached through intervention at every stage of adoption by the extension officers. Finally, the study has categorized the constraints and barriers facing farmers in *Hambantota* district when adopting any new paddy technology programme. The study has provided strong evidence to prove that it is essential to overcome the constraints which hinder the adoption rate through the intervention of extension services. The study has also shown the need for immediate action to eliminate barriers such as the lack of resources to adopt new technology programmes by introducing certain policy reforms in the agricultural sector.

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