The Journal of Agricultural Sciences - Sri Lanka
Vol. 17, No 2, May 2022. Pp 280-296
http://doi.org/10.4038/jas.v17i2.9743

A Review on Factors Affecting Technology Adoption in Agricultural Sector

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Received:14th October 2021 / Accepted: 19th April 2022

ABSTRACT

Purpose: *Adoption of new technology in the agricultural sector is low. This is similar to the condition in many other sectors as well. Many studies have been conducted to find out reasons for this issue. While some studies have identified similar factors affecting the decision to adopt a technology, some studies revealed factors which were uniqe to their study. Therefore, identification and compilation of these factors will support future studies and researchers.*

Research Method: *An analysis of literature on technology adoption was conducted. Literature originated from numerous sources spanning almost 50 years were taken for the study. The factors identified by different studies were then compiled for this review paper.*

Findings: *The factors identified can be mainly categorized into three; (1) factors related to the user, such as farm size, income, prior experience, gender, education level, and age; (2) factors related to the technology, such as affordability, availability, compatibility, complexity, trialability and observability; (3) institutional factors, such as access to extension services, inputs, markets and credit facilities. The review findings reveal that adoption is a collective and interactive effect of some or all factors. Thus, identification of priority factors and a holistic approach need to be considered to ensure greater adoption.*

Originality/ Value: *This compilation will support practitioners in technology dissemination for proper identification of factors affecting technology adoption, and future research on technology adoption and diffusion.*

Keywords: *Adoption process, agriculture, factors affecting, technology adoption*

INTRODUCTION

Since the civilization of mankind, agriculture has come into the scope of food and livelihood. It provided many opportunities ever since for a person to become an entrepreneur. In the past when the world was moving towards industrialization, agriculture was considered as an unprofitable venture. But even today the situation is the same. But still, agriculture plays a major role in the livelihood of many people all over the world. Every day new technologies pertaining to agricultural development is popping up. Those are introduced to the farmers and other stakeholders for the improvement of their practices. But the adoption of those new technologies lies at a low rate (Simtowe *et al*. 2016; Yigezu *et al*. 2018; Ruzzante *et al*. 2021). When sought deep into the issue it reveals that the adoption process is affected by many factors (Simtowe *et al*. 2016; Ruzzante *et al*. 2021). Many theories and models have been developed to explain the adoption process. This review

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gives a compilation of these factors affecting technology adoption and analysis of different studies conducted on it. In order to do so, an analysis of literature on technology adoption was conducted. Literature originated from numerous sources such as research articles, technical reports, official websites, text books, spanning almost 50 years were taken and compiled. This compilation will support future researchers for literature and knowledge for the effective conduct of their research and technology dissemination process.

LITERATURE REVIEW

Agriculture can immensely support to reduce poverty while increasing income. At the same time, enhancement in agriculture will lead to uplift the food security. These improvements might have a tremendous effect on about 80% of the poor people living all around the world. These poor people are mostly residing in rural areas and many of them are working in the agriculture sector (The World Bank, 2019). The World Bank (2019) mentions that according to their studies, around 65% of the poor working adults are earning their income through agriculture and related activities. Thus development in agriculture will have an immense effect in ending poverty. At the same time, it will promote the spread of wealth and will provide food required for the increasing population. In 2019, agriculture contributed 3.5% to the global gross-domestic product (GDP) according to the statistics given by the World Bank Group (2021). The same report mentions that the highest contribution from agriculture to the GDP is reported from low income countries (23.9%) while the least is reported in high income earning countries (1.3%) in 2019. Therefore, agricultural development is considered as an apex and an essential strategy to boost the economy of a country (Eklund, 1983; Devi *et al*. 2014; Diiro and Sam 2015).

Each day, research generates novel technologies in the agricultural sector. These technical advancements are taking place around the world. Novel or improved technologies are considered as key role players in many sectors including agriculture (Ugochukwu and Phillips, 2018). The most important fact about these novel and improved technologies is that, how efficient they are in improving food production thus leading to ensuring food security. In the recent past, new technologies were emerging worldwide. Yet, the adoption of these new technologies is not guaranteed. But the real impact expected from introducing the novel technology will be visible only when adoption of the technology has taken place. Even if people get similarly aware on a particular technology, they will behave differently toward different technologies. Therefore, the time duration taken for adoption might vary depending on many factors, such as characteristics of the technology and of the adopter. But the rate of adoption and its diffusion will determine the extent of adoption that has taken place over time. Many researches have been conducted using different models considering different factors to detect the adoption and the influence of each and every factor taken for the study. Similarly, many studies have been conducted in medicine, information and communication technology, and education too, again using different models as well as factors to decide on technology acceptance and/or rejection (Ugochukwu and Phillips, 2018; Walisinghe *et al*. 2017).

With all these research and discussions, novel technologies are to be used as a remarkable tool to alleviate poverty and the economic development of a nation. Identifying the factors affecting the process and discussing different theories and models to describe the adoption will facilitate the proper execution of the required activities to achieve such goals. But the low rate of adoption is still considered a major limitation in all these sectors especially in developing countries (Silva and Broekel, 2016; Mwangi and Kariuki, 2015; Bandiera and Rasul, 2002). However, adoption of novel technologies still lies as a pivotal requirement in the development of the agriculture sector. Therefore, much emphasis is given to facilitate and ensure adoption of technologies.

Adoption of Technology

Many authors define adoption in different ways. In 2012, Loevinsohn *et al*., had defined the adoption to be as "the integration of a new technology into

existing practice and is usually proceeded by a period of 'trying' and some degree of adaptation". On the other hand, Bonabana-Wabbi (2002) had mentioned that Feder *et al*., (1985) had defined adoption as "a mental process an individual passes from first hearing about an innovation to final utilization of it". Feder *et al*., (1985) had given another definition for adoption, which is "the integration of an innovation into farmers' normal farming activities over an extended period". In all these definitions the actual practice and time factor are mentioned.

Although adoption is taken as a behavioural change, it might not be permanent. Discontinuation of adoption might also take place due to many reasons. Some of them are personal, institutional, and social. Another remarkable reason is that, a person might discontinue the adoption of a specific technology due to the availability of a superior technology that will be able to satisfy the consumer expectations at an elevated level (Dasgupta, 1989).

Feder *et al*., (1985) classified adoption into two categories, namely, "individual adoption" and "aggregate adoption". Feder *et al*., (1985) were referring to the individual adoption to be an adoption taking place at the farmers' level. The definition for this individual adoption is "the degree of use of a new technology in the long-run equilibrium when the farmer has full information about the new technology and its potentials". In aggregate adoption, diffusion and time factor are taken into consideration. Diffusion is thus defined as "the spread of a new technology within a region". Therefore, the aggregate adoption is analyzed by the aggregation of usage of particular novel technology, within a certain community, a specific geographical area or a specific population. Rogers (1983) describes the diffusion of technology where he says, "Diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system". Here in this definition too, the time factor is raised. Furthermore, this definition discusses a special communication process where the message is on the novel technology. In the collection of all these definitions and comments from various scientists, the summary of it is that the adoption of technology is a process that leads to the usage of new technology and it might spread to other people through the diffusion process. Sometimes the people might discontinue using this technology due to various reasons as well. Furthermore, the adoption process has many factors affecting it.

In a holistic manner, Melesse (2018) had summarized some paradigms introduced by many authors as below. The innovation-diffusion model, the adopters' perception, and the economic constraints models. The innovation diffusion model was based on one assumption. This assumption was defined as, "the technology is technically and culturally appropriate, but the problem of adoption is one of asymmetric information and with very high search cost". The adopters' perception paradigm describes features related to adopters. It suggests that the attributes of the technology perceived by the adopter will determine the adoption of the novel technology. This implies that even with all the required information that the first paradigm discusses is available, each person who receives the information will evaluate the technology in a different manner than the scientists (Kivlin and Fliegel, 1967). Therefore, it is very important to understand the technical information, process of dissemination of it as well as the comprehensive abilities of the end-user in generating new technologies. It is equally important in determining the information dissemination procedures as well. The economic constraint model, which is the third paradigm, discusses that the availability of required inputs in the short run will determine the adoption process. Such crucial inputs could be access to credit, land and labor (Aikens *et al*. 1975). This implies that even with all the information in hand and a complete understanding of it, lack of required resources will limit the adoption of the technology. But the use of these three paradigms together in modelling the technology adoption process is much explanatory and appropriate than using a single model (Melesse, 2018). The author also agrees with all these paradigms however, which are more effective in a collective approach. That will lead to all the factors mentioned in all three paradigms; i.e. the level of information reaching the farmer, perceived effectiveness of

the technology to the individual farmer and all the infrastructure and other capital resources required for the usage of the technology that are altogether affecting the adoption process.

Many authors have cited as well as described a number of theories in adopting the technologies. Some of these theories are given in Table 01.

Influences on Technology Adoption in Agriculture Sector

Many influencing factors, which affect the adoption of new technologies in the agriculture sector had been identified and discussed by many authors worldwide. Ugochukwu and Phillips (2018) had cited many authors to list factors falling into five categories, namely, 1. Personal, 2. Cultural, 3. Social, 4. Economic attributes, and 5. Characteristics of the technology.

They have also described the adoption process and many factors affecting them, including the size of the farm, land availability and ownership, access to credit, access to extension services, and availability of required labour. Furthermore, personal characteristics such as educational level, gender and other demographic features, and farmers' attitude on the risks associated with the technology were also listed as influential factors.

But, Melesse (2018) and Teklewold *et al.,* (2013), had grouped these factors into three categories, namely, "(1) Factors related to the characteristics of producers/farmers, (2) Factors related to the characteristics and relative performance of the technology, and (3) Program and institutional factors". The "Factors related to the characteristics of producers" included age, gender, level of education, prior experience on the technology introduced, wealth status, farm size and its characteristics (such as plot characteristics), availability of labor, acquisition of resources required (own resources, subsidies, grants, etc.) and tolerability of risks associated with the introduced technology. Some of these factors are similar to what has been listed by Ugochukwu and Phillips (2018). The "Factors related to the characteristics and performance of the technology" include factors such as income generation ability, the attitude towards the performance and other characteristics such as availability of technology as well as of the inputs, complexity of the technology in usage, profitability in comparison to similar technologies, and the payback period.

Table 01: Theories developed to explain technology adoption

No.	Theory	Reference
1.	Theory of Reasoned Action	Fishbein and Ajzen, 1975
2.	Technology Acceptance Model	Davis, 1989
3.	First modified version of Technology Acceptance Model	Davis *et al*., 1989
4.	Theory of Planned Behavior	Ajzen, 1991
5.	Igbaria's Model	Igbaria *et al*., 1994
6.	Decomposed Theory of Planned Behaviour	Taylor and Todd, 1995
7.	Theory of Diffusion of Innovation	Rogers, 1995
8.	Task-Technology Fit	Goodhue and Thompson, 1995
9.	The final version of Technology Acceptance Model	Venkatesh and Davis, 2000
10.	Technology Readiness	Parasuraman and Colby, 2001
11.	Unified Theory of Acceptance and Use of Technology	Venkatesh *et al*., 2003
12.	Integrated model of Technology Acceptance	Venkatesh and Bala, 2008
13.	Expectancy Livelihood Model	Petersen and Pedersen, 2010
14.	Motivational Model	Grellhesl, 2010
15.	Perceived Characteristics of Innovating Theory	Hameed *et al*., 2012
16.	Social Cognitive Theory	Rana and Dwivedi, 2015
17.	Uses and Gratification Theory	Chen, 2015
18.	Trans Theoretical model	LaMorte, 2019

Furthermore, Melesse (2018) and Teklewold *et al*., (2013) had also mentioned that the existing pattern of adoption in the locality and the susceptibility of the technology to environmental hazards also play a main role on the adoption process. The third category, which is the "Institutional factors" include factors such as access to awareness on the technology, the amount of information and the available quality of the information received. Additionally, availability and accessibility to raw materials and other inputs as well as markets, availability of credit, the ownership of land, and the availability of required infrastructure and other facilities were also mentioned. Support received through extension services were also identified as one key factor in technology adoption.

Other than the above factors, Shiferaw *et al*., (2009) had mentioned that the presence of favourable policies, supportive programs and institutional support also facilitate technology adoption. Availability of credit facilities and market linkages were also identified as having a positive impact on technology adoption.

Furthermore, some more studies have identified and categorized the affecting factors under different titles. Of them, Akudugu *et al*., (2012) had also categorized the factors into three groups, namely, economic factors, social factors and institutional factors. Similar to previous categories done by other authors, economic factors were comprised of the farm size, access to credit and expected returns by the use of the introduced technology. Additionally, Akudugu *et al*., (2012) had stated a fact called cost of adoption to affect the adoption process. This factor was not mentioned by any of the previous authors. The social factors mentioned by Akudugu *et al*., (2012) included similar factors listed under characteristics of the farmer by the other authors. Under this category, Akudugu *et al*., (2012) also mentioned factors such as age, educational level and gender. But only the access to the extension services was mentioned under the institutional factors. But of course, the other factors mentioned by other authors such as acquiring information, access to credit facilities, markets and subsidies can be highly related to the access to extension services.

On the other hand, Silva and Broekel (2016) stated two main factors which will affect the adoption process as "the availability and affordability of new agricultural technologies", and "farmers' expectations of long-term profitability promised by the new technology". Although these are mentioned as two key factors observed in developing countries, those can be further broken down into specific factors much similar to what is being discussed by previous authors.

Therefore, although the grouping might slightly deviate in different studies and according to different authors, all these reveal certain common groupings and common factors affecting the adoption process of agricultural innovations. Thus these identified main factors are discussed below under three categories; 1. Factors related to the user, 2. Factors related to the technology, and 3. Institutional factors.

1. Factors related to the user

These are factors of the person who will use the technology introduced. The person could be a farmer, processor or any other person who would be using the technology. Therefore, the author wishes to address these persons as users rather than farmers or any other.

Age

Age is a common factor discussed in many studies. The impact of age on technology adoption has controversial discussions. Different studies conducted on new agricultural technologies had revealed conflicting conclusions. While some findings revealed a negative relationship between age and technology adoption (Heinz 2013; Berkowsky *et al*. 2018; Chuchird *et al*. 2017), some studies revealed a positive relationship (Ullah *et al*. 2018; Chuang *et al*. 2020, Ha and Park, 2020).

For example, Melesse (2018) refers to age as one main factor that determines the technology adoption behaviour of a farmer. Here he expresses the age of the head of the household. Furthermore, age is considered to be influential

in accessing information as well to act based on the information received. Melesse (2018) also mentions that older farmers might have more experience than young farmers. Furthermore, the more you get older the more resources get accumulated. Thus, such facilitates adopting new technologies. On the contrary, the young farmers will laregely adopt the technologies due to increased educational levels than the older community. Thus, Melesse (2018) supports the fact of age, having a positive as well as a negative impact on technology adoption. When the adopters in the agriculture sector are depicted in a schematic diagram, the young generation generally falls into the first category where they are grouped as innovators. The innovativeness of younger farmers will lead to making favourable behavioural changes towards adopting the novel technologies. The most probable reason for this innovativeness could be the tech savvy behaviour of the younger generation. This behaviour will support in accessing more information on the new technologies much easily, and have a positive impact on the adoption process. Silva and Broekel (2016) also discusses about the age of the farmer and citing the work of Adesina and Baidu-Forson (1995) states that the age of the farmer was positively influencing the adoption of a new technology related to sorghum cultivation in Burkina Faso. This might be due to the higher levels of experience in older farmers which might have caused a positive effect on the adoption. With these contradictory findings, it seems that the impact of age on the adoption of technology will also depend on the technology itself.

Education

Many research had taken education as a factor in determining the technology adoption as well (Abu-Shanab, 2011; Riddell and Song, 2017; Paltasingh and Goyari, 2018). The status of education of the head of the household is one of the most common and priority factors in determining the adoption of a novel agricultural technology. Several studies had revealed a positive relationship between education with adoption of agricultural technologies. For example, factors affecting the adoption of an improved sorghum variety were studied by Egge *et al*., (2012) in the Somali Region of Ethiopia. The results had revealed that farmers with higher educational status were more probable to adopt the introduced variety. This relationship was revealed in many other studies as well (Heinz, 2013; Ullah *et al*. 2018; Ha and Park, 2020). The main reason for this positive relationship might be the ability of education to change the knowledge, attitude and skills of a farmer. Furthermore, it will enable a farmer to have elevated levels of analytical and problem solving abilities. It is also believed that education will facilitate critical thinking and efficient use of information received. When coupled with the age of a farmer, the young and more educated farmers are more prone to adopt the novel technologies than the old and less educated farmers (Senanayake and Rathnayaka, 2015; Melesse, 2018).

Gender

Gender had been seen as a prominent factor in technology adoption and many authors had discussed it. For example, Melesse (2018) had mentioned that although gender is a significant factor in determining the technology adoption as it is highly biased based on the socio-cultural aspects of the local society. For example, the society had made some stereotyping of male and female members of a family and the society. Thus gender will affect the decision making ability. Furthermore, the gender of the household head will play a main role. While female-headed households might have a negative impact on adopting a technology, male-headed households might have a positive impact. Differences in wealth distribution and assertiveness of female and male-headed families might be one of the reasons for the varying results in these technology adoptions.

However, other studies have revealed contradictory conclusions. For example, a study that Morris and Doss (1999) had conducted on introducing a new maize variety in Ghana, no significant relationship was identified between gender and the likeliness of adopting the new variety. The study had concluded saying that the technology adoption is more dependent on

access to resources than gender. But Morris and Doss (1999) had also mentioned that if use of an improved maize variety requires resources such as land and labour, the access to these inputs might vary depending on gender. More commonly men would have more access to these resources leading to higher adoption than women.

On the contrary, adoption of certain specific technologies might have a significant influence by gender. Furthermore, Omonona *et al.,* (2006), had stated that due to some social and cultural norms, males are considered as the household head and the primary decision makers. This also might cause differences in adoption. This fact was also confirmed by Mignouna *et al*., (2011). For example, in a study conducted in Nigeria on the introduction of cassava cultivation techniques, it was revealed that gender had a positive influence on the technology adoption (Obisesan, 2014). Therefore, this reveals that although gender is controversial in determining adoption, it is heavily correlated with other associated factors.

Availability of labour

In conducting agricultural activities, labour is a significant factor. In most cases, family labour is used in the agriculture sector. According to Melesse (2018) and Ullah *et al*., (2018), the availability of family labour for practising the novel technology plays a key role in the adoption of the technology. But the amount of labour requirement will depend on the type of technology introduced as well. This will also lead to variation in the adoption of novel technologies (Kinyangi, 2014; Udimal *et al*. 2017).

Size of farm

The size of the farm was also identified as one of the factors affecting the decision of adoption. But the level of the effect varied in different situations. Some studies revealed that the size of the farm is positively related to the adoption of the introduced technologies. For example, research carried out in the Central Highlands of Ethiopia to determine the factors affecting the adoption of an improved maize variety, revealed a positive correlation of the size of the farm with the adoption behaviour. Ogada *et al*., (2014) too had stated having a positive relationship of the size of farm in the adoption of joint cultivation of inorganic and improved maize varieties. Melesse (2018) also supports this argument. According to Melesse (2018) one of the main reasons for such positive relationship is that most farmers in Ethiopia grows different varieties of crops and at the same time it requires larger extents of land. This positive relationship is further supported by Adesina and Baidu-Forson (1995). According to their studies, the farmers with larger land extents had more readily adopted new high yielding maize varieties. It was also discussed by Silva and Broekel (2016) with relevance to rubber cultivations in Sri Lanka. Mwangi and Kariuki (2015) mention that one reason for this adoption is that farmers with a large land area can offer a part of their lands for trialling out the new varieties. But the farmers with less farm size are unable to do that due to scarcity of land. Furthermore, technologies such as mechanization or the involvement of machinery will cause elevated costs which will require larger cultivation extents to become profitable (Feder *et al.* 1985).

On the other hand, when considering an input-intensive technology, farmers with small farm sizes had shown a trend to adopt more. According to Yaron et.al. (1992), labour intensive or high density cultivations and greenhouses which tend to reduce land use will be more favoured by small landowners than large landowners. In animal husbandry, technologies such as zero grazing will also be more preferred to be adopted by small landowners (Harper *et al*. 1990).

Tenure status of the land

It is a common fact that humans would like to invest more on their own properties than on others'. The main reason behind this is that when the land is owned by the adopter him/herself, then, the owner can obtain all the earnings from the investment made. The past research revealed that the farmers tend to adopt good agricultural practices (GAPs) with increased efforts and resources be utilized, only on their own land, so that the benefits gained in the short run, as

well as the long run, will be enjoyed themselves (Senanayake and Rathnayaka, 2015). Owombo *et al*., (2015) also support this finding of having a positive effect on technology adoption in a study conducted in Nigeria.

Income status

Many authors had cited income status as one of the influencing factors in adoption. Accordingly, Udimal *et al*., (2017) and Kinyangi (2014) had mentioned that the respondents with higher annual income were adopting more of the novel technologies recommended for agriculture, revealing a significant positive correlation with adoption. Melesse (2018) also reports that when introducing a technology package for teff, barley, wheat and maize, a positive and strong relationship was observed with the annual income of the participant. This was also confirmed by Silva and Broekel (2016) in relevance to rubber cultivations in Sri Lanka.

Cost of production and income gained

Senanayake and Rathnayaka (2015) had mentioned that with the increasing cost of production of a technology, farmers were less interested in adopting the Good Agricultural Practices (GAP) in potato cultivations in Sri Lanka. Generally, it is believed that when the farmer receives an increased income, they would use appropriate technologies introduced to them. But, the study revealed that the long term benefits that will be gained by the application of GAPs were ignored when the required practices were associated with high cost. Udimal *et al*., (2017) also had confirmed a positive relationship with the technology adoption in a study conducted on improved rice varieties in Ghana.

Prior experience

When the farmers are already having experience on cultivations in their lands for a longer time, they might have a better understanding of the impact of the problem that the technology is addressing to. Furthermore, the long term experience will facilitate the farmers in making the best option. Therefore, it might have a positive relationship with positive factors of the technology. But negative experiences with similar technologies will affect negatively on the adoption of the introduced technology. Thus, the level of and proper awareness with regard to the technology introduced is a prominent issue in influencing the adoption of the technology. It is closely associated with the prior experience that the farmer has (Senanayake and Rathnayaka, 2015).

Progressiveness of farmer

According to Silva and Broekel (2016) farmers who are more progressive, will trust scientific development. This will lead to more adoption of novel technologies in a readily manner than farmers who are conservative and non-progressive.

2. Factors related to the technology

Not only the characteristics of the user, factors related to the technology, are also playing a main role in decision making. Loevinsohn *et al*., (2012), had stated that decisions that farmers make on adoption vary with the characteristics of the technology, other limitations/facilities and other situational conditions that a farmer faces. OECD (2001), states that the attitude and perception that a farmer holds towards a certain technology will determine the adoption of it. According to Silva and Broekel (2016), some farmers need confirmation of the information given to them. This could be fulfilled by conducting demonstrations of successful farmer fields which will enable the farmers to trust the technology. This will reduce the anticipation of risks affiliated with the adoption of a novel technology, which ultimately leads to the adoption of the technology.

Foster and Rosenzweig (1995) implies that "availability, affordability and farmers' expectations of the long-term profitability of

new technology" are the main factors affecting the adoption of a novel technology. Doss (2003) states that "trialability" or "a degree to which a potential adopter can try something out on a small scale first before adopting it completely" is another key factor related to technology that will determine technology adoption. Furthermore, some authors have described that the "relative advantage, compatibility, complexity, trialability, and observability" of the innovation are key pillars in the adoption process (Pankratz *et al*. 2002; Scott *et al*. 2008; Warner *et al*. 2019).

3. Institutional factors

Institutional factors are also discussed by many authors (Akudugu *et al*. 2012; Uaiene *et al*. 2009; Conley and Udry, 2010; Katungi and Akankwasa, 2010). Some of the main factors, are discussed below.

Social capital

Akudugu *et al*., (2012) had mentioned social capital as an institutional factor influencing the adoption behaviour of a particular technology. A social network will facilitate sharing experiences, information and views even on a novel technology. As farmers are adults, peer learning will also take place in a social network. Thus social networks will facilitate an individual in decision making in technology adoption as well (Uaiene *et al*. 2009). Furthermore, three methods were described on how these social networks can support technology adoption (Uaiene *et al*. 2009; Conley and Udry, 2010; and Oster and Thornton, 2012). Those are, "1. Individuals can profit by acting like friends/ neighbours; 2. Individuals can gain knowledge of the benefits of technology from their friends; 3. Individuals can learn how to use new approaches from their peers".

Community-based organizations essentially serve as social networks. Farmer organizations are such key organizations functioning in farming communities that provide membership as well as access to shared information among the group members. Furthermore, the farmers who are members of farmer organizations, mostly have access to information via social learning. This had also promoted technology adoption as well (Katungi and Akankwasa, 2010). Other than the positive effects of social networking, it might cause negative effects too. The presence of 'free riders" in community groups is identified as such a negative effect (Foster and Rosenzweig, 1995). Thus considering all these positive and negative effects, a U-shaped individual technology adoption curve was suggested by Bandiera and Rasul, in 2002. Under this adoption curve, it is predicted that social networking has positive effects when the adoption rates are low, but it has negative effects when the adoption rates are high.

Extension service

In all countries where agriculture is present, extension service plays a main role in the technology adoption process. Mostly the information related to agricultural technology is delivered to the stakeholders via extension service. Extension system provides many avenues for the stakeholders to participate in trainings, demonstrations and other activities which provide opportunities to obtain information regarding the novel technologies available and promoted. According to Melesse (2018), farmers with frequent contacts with the extension services were said to be more liable to adopt novel technologies than farmers who had less frequent contacts. This was proved by a research conducted in Ethiopia on introducing technologies related to wheat cultivation.

Silva and Broekel (2016) stated that in developing countries, the extension service is among the most prominent factors in favouring technology adoption in the agricultural sector. Mwangi and Kariuki (2015), also had identified that availability and access to extension services are key aspects in technology adoption. Illiterate farmers who lack formal education will have problem in obtaining information related to technology and thus leads to less adoption. This problem will be eliminated through proper extension services (Akudugu *et al*. 2012). Extension services thus form a platform for technology dissemination and a positive relationship with technology adoption. The information received via extension services

will reduce ambiguity and promote technology adoption (Mwangi and Kariuki, 2015; Akudugu *et al*. 2012).

Especially in developing countries, the main source of information for farmers is extension workers. Thus, they act as the connector between the end-user and the innovator. This will reduce the transaction cost involved in technology dissemination (Genius *et al*. 2010). Extension workers usually use elite farmers in the locality, to facilitate faster and efficient dissemination and promotion of technologies in developing countries. Thus a positive correlation between technology adoption and extension service is being depicted in many researches (Uaiene *et al.* 2009; Mwangi and Kariuki, 2015; Ullah *et al*. 2018).

According to a research carried out in the Hambantota district in Sri Lanka, Silva and Broekel (2016) had mentioned that the limitations in the extension services might tend to deviate from the approaches used in technology promotion. Furthermore, they have mentioned that the successful completion of the awareness stage should be followed up until the person reaches the adoption stage. This follow up process should be carried out by the extension worker. In addition to that, Sheikh *et al*., (2003) had mentioned according to a study conducted on introducing a "no-tillage" technology for farmers in Punjab in Pakistan, that the frequency of visits paid by the extension worker also had significantly affected the adoption of the introduced technology. At the same time, Walisinghe *et al.*, (2017) had mentioned that a similar situation exists in Sri Lanka too. The extension service in Sri Lanka is conducted by many state organizations as a free service to the farmers. The main aim is to promote novel technologies among relevant stakeholders to improve the effectiveness and efficiency of farming, which ultimately leads to developing the agricultural sector in the country. The prioritized attention of extension workers had been paddy farming in Sri Lanka. Therefore, the extension service is considered as a key factor in promoting technology adoption in paddy cultivation. Walisinghe *et al*., (2017) had also mentioned that further research and development programs aimed towards extension services and facilities will enhance the tendency of adoption and diffusion of novel technologies. Therefore, more concern should be paid in launching extension oriented programs to promote technology adoption in any country.

Market

Marketing is another common factor in determining the adoption of novel technologies. Distance to the markets is one factor related to marketing. The lesser the distance the lesser the cost of transportation. When distance increases, the information reach will also reduce. The findings of Melesse (2018) in Ethiopia describes that when technology packages were introduced to maize and teff, the households who were closer to the markets were having a higher tendency to adopt the technology than the households situated farther to the markets. Furthermore, "market pulled technology adoption" is much favoured. Bayissa (2014) also confirms these findings. The negative correlation between adoption and market distance was repeatedly discussed by many authors. For example, a study conducted on fertilizer use was also showing a negative relationship between adoption and distance to markets. In this study, it was clearly depicted that when the distance to the market decreases the cost of transportation for input supply was less. Thus the farmers can more easily purchase the inorganic fertilizer required for the cultivations. Thus it had reduced the use of organic fertilizer showing a negative correlation between using organic fertilizer and market distance (Gebresilassie and Bekele, 2015). Kinyangi (2014) also had confirmed the positive correlation of market access to elevate the technology adoption through a study conducted with smallholder farmers in Kenya.

Access to credit facilities

Many authors have discussed the importance of access to credit facilities in agricultural technology adoption (Yigezu *et al*. 2018; Kafle, 2011; Melesse, 2018). It is the basic source of financial capital, especially for small and medium

scale entrepreneurs. Many authors such as Kafle (2011), Ogada *et al*., (2014), Melesse (2018), Kinyangi (2014) and Udimal *et al*., (2017) have agreed with the fact that when farmers have access to credit facilities, there is a high tendency for them to adopt novel technologies . Furthermore, it is mentioned that these financial sources could be formal or/and informal sources. Access to any of such credit facilities will have a positive effect on the technology adoption process.

According to Athambawa *et al*., (2017), a study conducted in the Eastern province in Sri Lanka reveals that a major factor in having a low to medium level of adoption is due to lack of required finances. In this study, the rice millers were less interested in obtaining credit from banks and other financial institutions. The study revealed that the majority of the community in this area is Muslims who believe that the interest is prohibited in their religion thus resulting in obtaining less credit. Furthermore, the study had mentioned that government subsidy schemes and other support will mitigate this less financial issue. The findings also suggest that increased institutional support and government intervention would result in higher technology adoption.

Number of adopters present

Bandiera and Rasul (2002) mention an interesting fact that the number of adopters in the network affects the adoption process. Although it is commonly believed that social networking positively affects the adoption process, the social learning theories reveal that the relationship might have differences.

When there are many adopters in the locality, they will provide many details to facilitate further adoption and attract more incentives. This will lead to many free riders as well. Bandiera and Rasul (2002) predict a nonlinear relationship between the number of adopters in their network and the adoption of the technology. They propose an inverse-U shaped relationship, where, the adoption will be higher when the number of adopters present in the family and the network is few. The adoption will be less when there are many adopters in the network. The first rise might be due to the availability of information and the free riding effect. The latter reduction might be due to increased competition and limited consumers.

DISCUSSION

In consideration of all these factors and studies conducted by many authors the reviewer finds that many personal factors are affecting the adoption process. Most of these authors have taken and listed each factor separately while few have taken some factors together. But when the factors are sought deeply, they reveal that most of these factors are interconnected and are linked together. For example, the age, experience and education level. Older farmers have more experience in farming. They must have been exposed to many new technologies throughout their lifetime. Therefore, they might tend to adopt the technology much more easily than the young and less experienced farmers. On the contrary, the young farmer might have a higher educational background than the older farmers. Therefore, they might adopt the technology much readily than the older farmers. The risk-taking ability might differ with the age, education and experience in the sector.

Another example is, in taking gender issues most of these studies are conducted in African countries where the household head is the husband or a male member of the family. With the social norms and beliefs in those countries, women have a less decision making power. But even in these countries, some authors found that there is no relationship of adoption with gender.

With the characteristics of the technology, not being in favour of the farmers' expectations, adoption will never take place. Therefore this is one area that much focus is required. But in certain cases, the social network and the social influence might affect in adoption of even such technologies. Furthermore, even when the technology is very sound, but the information related to the technology revealed to the user and the access to additional information also might affect the adoption process as well.

One other remarkable factor is that the availability of necessary infrastructure and other required capital resources. Even with the technology being appropriate and the end-user is willing to adopt but the required financial capital is not present, then the adoption will get hindered.

In conclusion, many factors do affect technology adoption in the agriculture sector. They are either institutional factors or factors related to the user or technology. But when taken together, most of the individual characters are interrelated and interconnected. These factors have to be studied individually as well as with the relationships with other factors to determine the adoption process of a certain technological advancement. Therefore, it is recommended to further study and analyze the effect of these factors, for their influence on the technology adoption individually as well as collectively in the agricultural sector.

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