Chapter

Socio-Economic Dimensions of Adoption of Conservation Practices: What Is Needed to Be Done?

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Abstract

Promoting sustainable agricultural production requires farmers to adopt new technologies such as organic farming to increase the agricultural productivity, while conserving the environment. Adoption and diffusion of new technologies need a long process, as experienced in the past. There are social and economic factors, identified in the literature, and those could cause delays in farmers' use of new technologies. Hence, technology adoption and diffusion are important policy issues in agriculture. For that reason, this paper provides a literature review including factors influencing the adoption and diffusion of technology in agriculture and aims to contribute to the future studies and policies, especially focusing on the social capital or the social aspects, which are proven not to be analyzed by the previous studies comprehensively. The results show that interaction with neighbors and relatives, and membership in a group or organization, which represent the social aspects, has a positive influence on adoption and diffusion of new technologies. Hence, policy-makers should incorporate the social aspects when designing the policies, such as cost sharing programmes, to promote adoption and diffusion of new technologies.

Keywords: technology adoption, diffusion of innovations, conservation practices, sustainable agriculture, social capital

1. Introduction

Promoting sustainable agricultural production requires farmers to adopt new technologies to increase the agricultural productivity, while conserving the environment. Since the seminal study by Griliches, adoption of new technologies has been widely analyzed in the agricultural economics literature [1]. Technology adoption in agriculture is also analyzed in the rural sociology literature. The studies in rural sociology mostly focused on diffusion of new technologies in a region, whereas studies in agricultural economics focused on adoption of new technologies by an individual farmer. Initially, the focus of agricultural technology adoption was to increase the productivity of the farmers or the profitability, especially during the Green Revolution. Hence, profitability of the technology was found to be an important factor for adoption [1].

Previous studies incorporated factors related to technology, farm and farmer characteristics into the analysis to explain why a technology is adopted or not. Hence, starting with profitability of the new technology, many factors were identified in the literature influencing the farmers' use. Since the 90's environmental concerns becoming important, and recently the global warming, the focus of technology adoption has shifted mostly from productivity-increasing technologies to sustainable agricultural technologies and the conservation practices. Especially for the developed countries, the focus is more on conservation practices and technologies such as precision agriculture that would both increase profitability and conserve the environment. The 2030 Agenda for Sustainable Development has mainly focused on the global aims, which include demanding unprecedented actions and efforts across multiple interconnected social, economic and environmental issues. In this sense, science, technology and innovation have a big share to realize these aims. The contributions of technology with the innovations to the economies provide the opportunities to improve living standards through rise in productivity, fall in costs and prices, and contributions to

Factor category	+	—	D	A	N	Total	References
Age	3	2	1	0	0	6	[22, 24–27, 49]
Gender	3	0	0	0	0	3	[24, 26, 28]
Income	2	0	1	0	0	3	[17, 26, 29]
Off-farm income	4	0	1	0	0	5	[30–34]
Ownership and wealth	6	0	1	0	0	7	[10, 18, 22, 24, 26, 36]
Education	14	1	0	0	0	15	[7, 11, 18, 23, 24, 27, 37, 38, 42, 43, 50, 68]
Learning	6	0	2	1	0	9	[18, 28, 44–49, 69]
Information	9	0	0	0	0	9	[7, 15, 17, 25, 26, 38, 41, 50]
Social capital	3	0	0	3	0	6	[57, 59, 60, 61, 63, 64]
Norms	1	2	0	0	0	3	[57, 59, 66]
Neighborhoods	4	0	0	2	0	6	[22, 24, 25, 44, 46, 48]
Relatives	4	1	0	0	0	5	[25, 26, 28, 36, 61]
Contacts with extension agents	4	0	0	0	0	4	[27, 43, 60, 68]
Membership in a group and organization	3	0	0	1	0	4	[25, 27, 36, 61]
Experience	4	0	0	0	0	4	[41, 46, 50, 69]
Farm size	5	0	1	0	0	6	[11, 15, 27, 29, 37, 41]
Farm location	3	2	0	0	0	5	[6, 22, 25, 36, 60]
Characteristics of soil and land	3	0	0	2	0	5	[10, 36, 37, 59, 60]
Prices of inputs	3	0	0	0	0	3	[10, 19, 70]
Risk	3	1	1	1	0	6	[7, 11, 29, 45, 50, 61]
Credit accessibility	5	1	1	1	0	8	[17, 19, 26, 27, 29, 59, 60, 61]

+: affect positively.
-: affect negatively.
D: significance of the effect changes depending on situation.
A: the sign of the effect changes based on situation.
N: no information.

Table 1.
Factors influencing technology adoption in agriculture.

the real wages [2]. It also plays a crucial role in the field of agricultural development [3, 4]. Technology decreases the risk of diseases and pest and increases the productivity and developments in agriculture by providing more information about the crop and soil structure for the farmers [5–9]. Additionally, new technologies are shown as a solution to the impeding conditions in agriculture, such as water scarcity, drainage and pollution [10–13]. Not only for the crops and soils but also for communication and information, technology contributes to the agriculture by providing several communication infrastructures and digital portals, reducing human intervention and eliminating technology breaks [14]. All of the effects mentioned above are important factors for sustainable agriculture. However, in this respect, there are two important issues: the adoption and the diffusion of technology. In the field of agriculture, with the well-known study of Feder and Slade, there have been many studies about agricultural innovations and their adoption [15]. As it is understood from the definition of technology for adaptation by UNFCCC (2005), which is stated as 'the application of technology in order to reduce the vulnerability, or enhance the resilience, of a natural or human system to the impacts of climate change', technology adoption influencing agricultural productivity significantly is an important issue in the economic sense [16]. In parallel with the adaptation, the diffusion of technology in agricultural field has been approached in many studies [17–19] beginning with Griliches [1]. Some tools have also been used to predict the speed and level of adoption [20]. As a reason, technology should have been used and diffused to benefit from its advantages; however, to do that, profitability needs to be understood by adopters [21]. When analyzing these studies, it is seen that there are many factors affecting technology adoption and diffusion (see **Table 1**). The main object of this paper is to review the factors influencing the adoption and diffusion of technology in agriculture comprehensively and contribute to the future studies.

2. Methodology

While this review handles the factors influencing the adoption and diffusion of technology in agriculture, it specifically focuses on the social capital including norms, neighborhoods, relatives, contacts with extension agents and membership in a group or an organization. Accordingly, the literature from 1974 to 2018 was analyzed by taking the social capital as a base. Our paper consists of 78 reviews, which cover 56 articles in journals, 10 book chapters, 4 selected papers for presentation, 3 working papers, 3 reports, 1 conference and 1 discussion paper. Rather than examining a specific time period or a specific region, 44 empirical studies, which cover various time periods and places, were analyzed to find the factors influencing the adoption and diffusion of technology. The revealing 21 factors were collected under the three main titles: the characteristics of farmers, the characteristics of farms and external incentives or disincentives. The effects of factors analyzed were tabulated depending on their positivity, negativity and variability to ease the future studies.

3. Factors influencing technology adoption in agriculture

3.1 Characteristics of farmers

3.1.1 Age

In the decision-making process, age is another influencing factor because it affects attitudes and perspectives on the new technology. Many studies about the

effect of age on technology adoption indicate different results. The analysis of Case shows that if the age of the additional male household member is between 0 and 15, farmers more adopt the new technology but if it is above the age of 55, the adoption rate decreases [22]. Hua et al. support that idea with their study by showing that while farmers under the age of 50 are more likely to adopt one type of new technology, farmers over 60 have lesser tendency to the adoption [23]. However, for another kind of new technology, the same study also shows that there is no significant difference between farmers under the age of 40 and over 59. Hence its effect can be attributed to the type of technology. From a different perspective, Weir and Knight found that farmers tend to be more influenced by someone in the same age group; however, there is a significant difference in this point [24]. If the farmers are educated, they have been more affected by older people rather than being influenced by people in the same age group. In this sense, younger farmers are more likely to be educated because they have more role models than older farmers. Contrary to most studies, some studies assert that older farmers have more tendency to adopt new technology even earlier than younger farmers due to their extensive experience in farm, and increase in the age shows positive effect on the adoption [24–26]. The study of Abdulai et al. differentiates the effect of age on adoption by determining criteria rather than differentiating it as older and younger [27]. According to their studies, although an increase in age at the younger ages affects adoption positively, increase at the older ages affects adoption negatively.

3.1.2 Gender

Differences stemming from gender have been observed in many subjects, the adoption of new technology in the agricultural field also shows different results depending on the gender. The study of Weir and Knight demonstrates that people are influenced by the people of the same gender while trying the new inputs [24]. Although the percentage being influenced is different among males and females, it is clear that they have a tendency to copy what people of the same gender do. The findings in their study show that female-headed households and male-headed households are influenced by the households of the same gender by 53% and 94% respectively. The adoption rate of female and male households differs from each other. Bandiera and Rasul studied on the social networks and technology adoption in Mozambique, which is mentioned as sunflower adoption in the study, and concluded that female-headed households have more tendency to adopt [28]. Other findings by Deressa et al. support the effect of gender differences on the decisions of the farmer by showing more adoption of male-headed households to climate change such as conserving soil, changing crop varieties and planting trees [26].

3.1.3 Income

The rises and falls in income have an effect on the decisions of adoption because farmers may change their preferences according to their new income level. Using new agricultural products causes changes in income, and income is doubled when modern crop yields per acre are used rather than traditional technology [17]. However, the use of new agricultural products or technology also depends on income because it needs financial facilities. In regard to this issue, the study of Feder and O'Mara indicates that the larger landowners benefit from the innovations more than smaller farmers because of their different income levels [17]. While experiencing the innovation is too risky for smaller farmers and hence

they abstain from the adoption, when there is a fall or stability in the relative risk aversion with income, larger farmers allocate more land for new yields. They also suggest that income distribution that occurred with the different income levels is improved as the smaller farms switch to new technology. Correspondingly, the diffusion process is completed when the incomes of all farmers increase and thus it is possible to worsen income distribution in the initial stages until the smaller farmers participate in the adopters' ranks. From a different perspective, Feder shows that the larger farmers allocate relatively less land for the risky activity and associate income with risk aversion [29]. He asserts that, in the case of binding credit constraint, increasing farm size leads to decrease in the allocated land for the modern crop in the situation of increasing relative risk aversion with income. Then, the rise of relative risk aversion with income decreases the expected income per acre and this causes the improvement of income distribution via the introduction of modern crop. On this issue, Deressa et al. analyze the influence of farm income and non-farm income on adoption [26]. It is shown that when farming is the main source for the income, farmers have the tendency to make an investment on productivity, and farm income affects conserving soil and using different crop varieties. On the other hand, although non-farm income has a negative effect on these modern agricultural methods even if it is not significant, it has a positive effect on the possibility of planting trees and using irrigation as an adoption option. Both farm income and non-farm income also increase the possibility of changing planting dates.

3.1.4 Off-farm income

Off-farm income, as in income provided by farm, is also a significant factor for the adoption of technology because it contributes to the economic performance of the farm household [30]. It helps farmers to increase capital availability and financial resources to invest in new inputs, practices or technology [31, 32]. Hence, various studies indicate that off-farm income has a positive impact on the adoption of new technology [30, 31, 33]. However, this impact has shown differences depending on the technologies. Gedikoglu et al. assert that although there is a positive relationship between the adoption of capital-intensive technology and operator's off-farm employment, it cannot be supported for the relatively labour-intensive practice [32]. Fernandez-Cornejo et al. confirm that farms with labour-intensive enterprises less prefer off-farm work [30]. Moreover, the decisions taken by the operators to work off-farm have an influence on the decisions of their spouses and that decision for off-farm work has also a positive relationship with adoption. This relationship is not one-sided, there is a correlation because adoption also enables the off-farm work [34]. The study of Fernandez-Cornejo et al. indicates that the more off-farm income increases, the more the probability of adoption of technologies increases for better time management [30]. For lower off-farm income, it is seen that fall in the off-farm income directs farmers to adopt yield monitors. From another perspective, this study emphasizes that the increase in off-farm work activities leads to a decrease in the farm-level efficiency because of allocating less time for farm management. This situation affects the adoption of management-intensive technologies negatively. In this sense, the study by Goodwin and Bruer provides an explanation that because crop producers make seasonal production, they are more advantageous than livestock product producers who have to work year-round [35]. Although there are some factors influencing off-farm employment stated in the literature such as farm size and wages, the positive effect of off-farm work on the adoption of technologies is apparent [30, 32, 35].

3.1.5 Ownership and wealth

Incomes and livestock owned represent wealth in agriculture [26]. Therefore, most of the studies taking livestock and machinery as a measure for wealth show that as the household wealth increases, the farmers have more tendency to experience new agricultural products and adopt them [22, 36]. However, this relationship is not stable, it changes as less wealthy households adopt in time [18]. The study of Weir and Knight on adoption and diffusion of agricultural innovations draws a conclusion that a great majority of households are influenced more by richer households in the process of adoption decision and this factor is valid also for the adoption decisions of educated households [24]. In parallel with the effect of wealth, ownership has an impact on adoption. While the study of Deressa et al. shows the positive effect of livestock ownership on adoption methods [26], Kassie et al. emphasize its positive and significant effects on the adoption of improved seeds [36]. Land tenure is also evaluated as a factor within the scope of ownership. Kassie et al. who examined this issue in detail indicate that land tenure has an influence on adoption in terms of security because while better tenure security increases the probability on farmers' investments, worse security decreases the adoption of some agronomic practices on rented plots [36]. Additionally, being a tenant is also effective in the decision process because while tenants focus on short-term soil fertility by overusing chemical fertilizers, owners take a long-term decision about soil fertility on their plots, thus its effect in the short term is stated as ambiguous.

3.1.6 Education

As in most of other fields, education has an impact on technology adoption in agriculture. There have been many studies that show the positive effects and contributions of the education on technology adoption from different perspectives. First of all, education increases the decision-making efficiency of adoption [37] and improves the systematic and creative thinking skill for making innovative decisions [38, 39]. It helps the understanding of the effects and the results of the technology adoption [38]. Cotlear indicates that all three types of education, which are formal, nonformal and informal education, play a great role in the diffusion of innovations through the rise in farm productivity, explanation of the information and shaping of behaviors, beliefs and habits [40]. From a different perspective, education has a significant effect on the initial adoption of innovations [24] because it leads to decrease in adoption costs and uncertainty and hence the timing of adoption becomes shorter and the probability of early adoption increases [41]. Rise in productivity also has been seen as being related with high education because of its contribution on the information acquisition and the accessibility of improved technologies [42]. The study of Huffman indicates that benefiting from the available information totally depends on the education level of decision-makers [43]. He also states that education improves the skill to obtain and process information and accelerates the changes, and the production increases at the end of the process.

3.1.7 Learning

Learning is another element influencing technology adoption. Social learning has an important role in the farmers' decisions and knowledge diffusion, and the investments in learning about technology are related with the technology adoption [44]. Besley and Case explain the cause of the slow technology diffusion as the lack of learning its profitability [18]. In line with this idea, learning is explained as the fall in the likelihood of allocative error by obtaining more information about the

likelihood of output [45]. There have been many studies about the understanding of how learning comes true. A study conducted by Foster and Rosenzweig examines both learning by doing and learning from others [46]. Their study emphasizes that if the learning realizes with both neighbors' and own experiences, profitability occurs more rapidly. In this sense, while Krishnan and Patnam support the power of social learning in adoption, they claim that the effect of learning from farmers' own and farmers' neighbors' experiences on adoption is greater than the effect of learning from extension services, in their study [47]. Conley and Udry also assert that neighbors influence the behaviors of individuals in the lack of learning, and individuals may behave according to their preferences because of being subjected to an unknown thing [49]. Munshi states that when the technology performance depends on the latent characteristics of neighbors, social learning will be weaker [48]. As a reason, farmers take into account not only their own direct observations of realizations but also those learned by neighbors [49]. Even, Besley and Case provide the reason of early adoption as being forward looking by learning more about the new technology [18].

3.1.8 Information

There is an extensive literature about the effect of information on the adoption in agriculture because it is an important stage for the adoption and diffusion of technology. It has been considered that the resource allocation skills and efficiency of adoption decisions can be increased via information gathering [7]. However, this information-gathering process can be affected by the adopters' specific attitudes [50] and hence the differences in the interpretations of information lead to different adoption decisions [38]. In this sense, especially, uncertainty and the lack of information are the subjects, which are mostly touched on. Imperfect information and uncertainty have an influence on the adoption of the decision and information diffusion affects the adoption positively by reducing the uncertainty [50]. Fall in uncertainty also decreases the cost over time [17] and hence the farmers who have more information tend to adopt earlier more than other farmers who do not [15, 41] because they consider other options less valuable to wait [7]. However, information access is different for each farmer and adoption changes accordingly. Feder and Slade indicate that the resources used for obtaining information by larger farmers are more than those used by smaller farmers and this leads larger farmers to have more knowledge and adopt earlier [15]. From a different perspective, Wozniak states that information increases innovative ability and while having more information makes farmers innovators, having less information makes them operator [38]. As a source of information, agricultural extension services and private agricultural supply firms have an important role in the agricultural sector [41] but information obtained from agricultural extension services has been seen as more valuable than information obtained from private agricultural supply firms because while the private firms can provide service for profit of the firm, agricultural extension services exist for giving technical information [38]. He added that the diffusion of the information has influenced production and welfare positively.

3.1.9 Social capital

The concept of social capital, which was first mentioned by Hanifan, has been defined in many different ways since there is no consensus about the definition [51–54]. One of the most important differences differentiating this term with other kinds of capital has been seen as its existence in social relationship [55]. In this sense, one of the most accepted definitions about the social capital was made by

Smithson as 'social capital is a person's or group's sympathy toward another person or group that may produce a potential benefit, advantage, and preferential treatment for another person or group of persons beyond that expected in an exchange relationship' [56]. Thus, its measures have been generally taken as networks, trust and norms [57, 58]. Many studies about the social capital have shown that it also affects technology adoption in different ways [57, 59]. According to these studies, firstly, social capital enables farmers financially in the lack of credit accessibility [60, 61]. Secondly, social networks which are a part of social capital decrease the transaction costs [62] because the major driver of that costs is the lack of information and contract enforcement assistance [63]. In the same way, it fills the information gap leading to market inefficiency [64]. Social capital also contributes to the well-being of an agent by influencing that person's relationship with others [65]. All these effects cause the rise in production and adoption. On the other side, some studies about the influence of social capital on adoption indicate that social capital may also influence adoption negatively because it depends on technology [60]. However, the studies about its positive sides on the adoption are quite a few than its negative sides. By benefitting from the previous studies, the instruments of social capital, in this paper, have been taken as norms and networks including neighborhoods, relatives, contact with extension agents and membership in a group or organization.

3.1.9.1 Norms

As it is shown many times in the literature, individuals are affected by the opinions and decisions of others. Social norm, in this sense, is another factor that influences the likelihood of adoption. Läpple and Kelley examined this issue and suggested that the decision of adoption is made by not only farmers but also others [66]. It is found that belief-based subjective norms are a prominent motivation for farmers to convert their intentions in their study. Hunecke et al. studied on the topic of understanding the role of social capital in adoption decisions and concluded that norms affect the adoption of scheduling significantly and negatively [57].

3.1.9.2 Neighborhoods

One way to obtain information is from neighbors, and the effects of neighbors on adoption should not be overlooked to obtain unbiased and valid results because it influences both decisions and actions of farmers [22]. It is seen that if there is no opportunity for social information, individuals have to experience on their own but individual information does not compensate for the information gained from neighbors [48]. While more educated household heads or novice farmers have more tendency to learn using new inputs or obtain information from their neighbors [24, 44], farmers, who have the lower ability for information obtained from neighbors, have less reaction and slower adoption speed [44]. Also, if there is not a feasible environment, the person under the social pressure may prefer to act like a neighbor to improve the productivity [44, 46]. Neighbors contribute to farmers in terms of teaching input use and they take an active role in providing information with agricultural extension services [24, 46]. Not only for using input but also for changes in the use of inputs, neighbors are an important information source. The study of Conley and Udry (2010) emphasizes the strong relationship between changes in use of inputs and neighbors and indicates that if an information neighbor makes higher profits than expected by using more inputs, the farmers have a tendency to increase their input uses [44]. In this sense, the experience of the neighbors is one of the main points. According to the findings of Munshi, if the experiences of neighbors

cannot be observed well by the individuals, weak social learning and slow diffusion rate will occur [48]. Similarly, with this study, Foster and Rosenzweig indicate that profitability stemming from new technology increases with the individuals' own experiences and those of their neighbors; even an increase in the experience of neighbors approximately doubles the profitability according to the same increase in individuals' own experience [46]. The study also shows that decisions taken by neighbors play an important role in the decisions of farmers, future decisions taken by farmers are influenced by the past decisions of neighbors, and this shapes the planning decisions of farmers. Even this influence may outweigh the influence of extension services; Krishnan and Patnam assert that the influence of adoption by neighbors is approximately three times higher than the influence of extension agents [47]. Being approved by the society is another reason encouraging the farmer to adopt new agricultural technology [25]. In this sense, access to neighbors is an important factor in the adoption of new agricultural technology. Findings indicate that farmers who have access to neighbors have more tendency to adopt the new technology and adopt more quickly with information obtained [48, 59]. Wollni and Andersson state that if the neighbors are adopters, farmers become more disposed to adopt [25]. However, Munshi supports that even if an individual observes the decisions of neighbors well, that person may not obtain the same result with theirs because of the effect of different characteristics on performance [48]. On the other hand, although there are many benefits of the connection with neighbors, some farmers prefer to abstain from adoption because of the idea that the adoption also provides benefit to their neighbors' plots [25]. Nowak, whereas, defends the opinion that collective work is important to solve local resource management problems [67].

3.1.9.3 Relatives

When it is considered that the adoption decisions of farmers are affected by external factors, the effect of family on the decisions taken is inevitable. The findings of Bandiera and Rasul indicate that there is a strong correlation between adoption decisions and family [28]. As the number of relatives increases, the adoption possibility of households increases because of the opportunity for experiencing new technologies with lower risk; however, at the same time, great numbers of relatives lead to decrease in the work efficiency [36]. The factor that increases the probability of adoption can be shown as the labour supply provided by family and lower opportunity costs [25]. Deressa et al. confirm this positive relationship although the coefficients are not significant in their study and show that having more relatives in a local place affects adoption positively [26]. The study of Bandiera and Rasul examines the effect in terms of being the adopters of family members and concludes that increasing the number of adopters in the family increases the adoption probability of farmers [28]. However, this situation is found as valid just up to 10, then the marginal effect of the network is negative, so the relationship is shown in an inverse-U shape. Contrary to these studies, Wossen et al. show that compulsory sharing and strong loyalty among kin members have a negative effect on the adoption of farmers because they cause the free-riding behaviors [61].

3.1.9.4 Contacts with extension agents

As in mentioned in the effect of gathering information on adoption, the sources providing information also have an influence on the adoption; one of them is agricultural extension services. The study of Huffman who addresses the extension activity as an indicator of information availability indicates that there is a positive

and significant effect of the availability of information on the information gathering and processing it if adjustment is needed [43]. Also, agricultural extension services can substitute education in allocative efficiency. The information provided by the extension services helps the farmers in terms of understanding the process and using new technology; hence farmers who are in contact with agricultural extension services adopt the new technologies more [27]. The study of Husen et al. on this issue proves that when it is compared to the farmers without contact with agricultural extension services, the adoption of farmers having contacts with extension services increased by 28.85% for productivity-enhancing technologies [60]. From a different perspective, Huffman examines the role of human capital in the farm and off-farm work decisions in his study by including the effect of agricultural extension as an input [68]. His findings support that there is a positive relationship between the off-farm labour supply and the agricultural extension input because the extension services increase the productivity of farm and shorten the time for gathering information. This situation leads to shift in the demand of farmers for farm work and increases the farmers' days of off-farm work.

3.1.9.5 Membership in a group or an organization

Being a member of an organization or an institution is important in terms of accessing information and knowledge about new practices and technologies [25]. As shown in the literature, the better and easier access to information mostly has a positive effect on the adoption; hence the membership in an organization and institution also plays a role in the adoption. The study of Wollni and Anderson proves that membership in a farmer group, which provides assistance and information for farmers, increases the adoption of organic agriculture by 26% [25]. Wossen et al. examined this issue in detail, indicating that being a member of an association is not only important for gathering information but also for providing financial resources and having labour-exchange options [61]. As a reason, while membership in informal credit and saving associations helps farmers by solving liquidity problems, a member in labour-sharing arrangements may benefit from the opportunities of labour resources provided by those arrangements. These opportunities relax farmers and facilitate the adoption. The findings of their study show that these associations increase the adoption; when a farmer becomes a member of a local saving credit association, the likelihood of adoption of land management practices increases by 19.4%. Corresponding to the result of this study, Kassie et al. and Abdulai et al. confirm the positive relationship between being a member in an institution or association and adoption of new agricultural technologies or practices [27, 36]. On the other hand, the study of Wossen et al. emphasizes that the effect of this relationship depends on the type of institution or arrangement because it is found that being a member in funeral insurance arrangements or having a great number of relatives has a negative effect on the adoption of improved land management practices [61]. For the reason, funeral insurance arrangements direct farmers to make their social commitments and make money for funeral expenses, leading to abstaining from the agricultural innovation. The kinship also decreases the expectations from the adoption and so the likelihood of adoption because of the low incentives for collective sharing of benefits from adoption.

3.1.10 Experience

Although there are many beliefs and opinions about the new technology, these change with experience in time [18]. Especially in the adoption process, prior adoption experience has a significantly positive effect on adoption intensity [50].

The study of Wozniak shows that while uncertainty and the fixed costs of adoption obstruct early adoption, gaining experience increases the probability of being the early adopter of farmers because the more farmers gain experience, the more they cope with the difficulties of the adoption process [41]. Experience also affects the productivity positively [69]. Foster and Rosenzweig, who studied on the topic of learning by doing and learning from others, conclude that the experience of farmers and their neighbors allows them to take better decisions about the use of new technologies, and these decisions affect the profitability of adoption [46]. It is shown that experienced neighbors make more profit for farmers than inexperienced neighbors, and moreover, an increase in average experience of a farmer's neighbor affects the profitability of a farmer by approximately twice more than own experience. Conflictingly, although Wozniak supports the positive relationship between experience and the adoption time, he asserts that the relationship between experience and adoption shows differences because experience depreciates in a technological environment in time and hence the result may be biased in case of no any measurement for specific experience of adoption behavior [41].

3.2 Characteristics of farm

3.2.1 Farm size

The likelihood of adoption of new technologies has been also associated to farm size, in the literature, because the probability of adoption has changed significantly depending on farm size [37, 41]. One of the reasons for this difference has been shown as information accumulation. Feder and Slade emphasize that there is a positive relationship between the accumulation of information and farm size. The more farm size becomes large, the faster critical level of information is reached because larger farmers allocate more resources to get information [15]. All of these lead to the earlier adoption. Supportively, Wozniak and Rahm and Huffman confirm that larger producers have a relatively greater incentive to obtain information about innovations; hence they spend more time and more money for better quality information [37, 41]. This more allocation for information makes large-scale producers early adopters by allowing them to adjust the inputs according to the innovations. When profitability and costs of the inputs are taken into consideration, Torkamani and Shajari also support that the larger farms adopt new technologies more rapidly than smaller farms to prevent water cost and derive more profit [11]. In contrast with these studies, the study of Feder suggests that larger farmers tend to allocate relatively less land to the modern crop so as to not endanger their wealth because of the risk factor [29]. Besides all these, Abdulai et al. emphasize that farm size is not the only factor influencing adoption, cropping patterns and physical characteristics also have an effect on the adoption because while farm size has a positive and significant effect on one product, it may not have any significant effect on another product such as onion [27]. However, the effect of farm size on the selection of product for growing is also shown in their study in that while larger farmers tend to grow some kind of agricultural products such as onions and cabbage, smaller farmers tend to grow other products such as lettuce.

3.2.2 Farm location

When obtaining information about the new technology, the location of farm is important in terms of ease of accessibility and availability of information. While opportunities that stem from the farm location make adoption easier and shorten the adoption time, negative things caused by farm location make adoption difficult

and extend the time. The study of Khanna, which is one of the studies on this issue, handles the farm location as a main factor influencing adoption of soil testing [6]. It is shown that the more proximity of farmers to professional services increases, the more likelihood of soil testing adoption increases because most farmers trust the services provided by professional dealers. By confirming this relationship between farm location and adoption, the study of Kassie et al. indicates that the location has an effect on the investment decisions of farmers and hence being far from a village or a household that has more opportunities in terms of input and output decreases the likelihood of adoption of sustainable agricultural projects [36]. Case and Husen et al., who handle the subject in terms of accessibility to agricultural extensions, also emphasize that while proximity to agricultural centre affects adoption positively, parcel distance and being distant from their farm affect their adoption and farm management negatively [22, 60]. Due to these positive effects on adoption, it is shown that proximity to main market center provides better access to organic market outlets and hence their adoption becomes easier [25]. Eventually, when information is considered as positively related with the adoption, it is clearly seen that the accessibility to information, which means the closeness of farm location to the information sources, increases the likelihood of adoption.

3.2.3 Characteristics of soil and land

Many research studies conducted on technology adoption in agriculture prove that soil characteristics have a certain effect on the yield [37]. The study by Rahm and Huffman indicates that reduced tillage practices, which are used to measure adoption, influence the yield positively on the soils having poor characteristics [37]. Even, they expect to be dependent of per acre profitability on soil characteristics [10] because technologies decrease problems, which can stem from climatic conditions and natural events, by providing necessary conditions as required by the soil [37]. Larger and unfavorable fields for agriculture have more tendency to be equipped with modern technologies [10]. The probability of adoption changes depending on the soil characteristics and hence adoption shows the differences among farms [37]. Rahm and Huffman and Isham indicate that the probability of adoption under better soil conditions is higher [37, 59]. The benefits of reducing unfavorable conditions and improving soil characteristics provided by adoption affect the crop production value, input expenditures, productivity and sustainability significantly [36]. However, in this sense, the type of technology also causes differences in adoption. For instance, the study of Husen et al., examining the adoption of soil and water conservation practices (SWCs) and productivity-enhancing technologies (PETs), indicates that although land slope affects the adoption of SWC positively, it has a negative effect on the adoption of PET [60]. The adoption differences in terms of soil fertility, parcel distance and agricultural extension had also been observed in this study.

3.3 External incentives or disincentives

3.3.1 Prices of inputs

In the process of diffusion and adoption, the prices of inputs have an effect on the decisions of farmers. Dinar and Yaron suggest that past and future price expectations for inputs and outputs have importance in investment decisions for new equipment, which is mentioned in their study as irrigation equipment [70]. Moreover, the rise in these prices affects the use of modern technologies positively. In contrast to this study, the findings of Dinar et al. indicate the possibility

that although the price of cotton increases and thus the area allocated for cotton increases, the amount of farms equipped with modern technologies decreases in their study [10]. With these two opposite results, the study of Abdulai and Huffman concludes that the effect of price on the adoption and diffusion depends on the phases [19]. While the expected price of the new technology affects the diffusion process positively and significantly in the early adoption phase, it is shown that the price of new technology in the second phase does not have a significant effect on the adoption. The positive effect of the expected price can be shown by the result of its diminishing time and accelerating adoption effect, in their study.

3.3.2 Risk

Risk is one of the most commonly addressed issues about technology adoption in agriculture, in the literature. The study by Koundouri et al. indicates that risk has an important effect on the adoption decision process for a new technology [7]. They assert that farmers tend to invest in and adopt new technology more to avoid the production risk they encounter with the risk of extreme outcomes. In their study, it is shown that farmers who face adverse climatic conditions adopt new technologies to decrease the risk level. Uncertainty about the profitability, which is a risk factor, also increases the probability of farmers' adoption because the adoption of new technology decreases the production risk, risk premium and relative risk premium [7, 11]. If the producer is decisive in adopting, the adoption degree is also affected by the risk factors [50]. For instance, the larger farmers allocate relatively less land and hence smaller proportion of their incomes to risky activities, which means the higher input of fertilizer per acre [29]. In this sense, Hiebert suggests that while risk-preferring farmers tend to use more land and fertilizer for production than the risk-neutral farmers, risk-neutral farmers tend to use more inputs than risk-averting farmers [45]. Correspondingly, Wossen et al. assert that, in the adoption decision process, risk-averse households trust their social capitals in terms of adoption decision more than risk-loving households [61]. Networks and traditional sharing norms such as the social capital affect the risk-mitigating measures negatively [71]. On the other hand, Wossen et al. suggest that the relationship between social capital and risk aversion changes among households [61]. While some results show a significant and negative effect on risk aversion, some show a positive effect in their study.

3.3.3 Credit accessibility

No doubt that having a financial potential is necessary while experiencing an innovation. Financial assets also have an influence on adoption, and hence credit constraint leads to different adoption rates [17]. In the literature, there are many studies that show the importance of credit accessibility in the adoption. Access to credit facilitates investment because it provides the support for liquidity requirements [61]. Through this support, farmers may buy the inputs such as fertilizer and benefit from the facilities more easily; it also influences the change in planting dates and using irrigation systems positively [26]. By depending on its contributions to the agriculture, most studies indicate that credit availability encourage people to adopt, and increase the adoption by accelerating [19, 27, 59]. However, on the other hand, Husen et al. state that the effect of credit availability on adoption depends on the technology because they show that while credit access has a positive effect on the adoption of one of the technologies, it has a negative effect on the adoption of other technology in their study [60]. This negativity has been explained in that credit access may direct people to non-agricultural sectors for the investment. From

a different perspective, Abdulai and Huffman emphasize that if credit constraint can be substituted with another financial source such as household savings, the constraint does not influence the adoption [19]. Correspondingly, in the literature, traditional community networks, friends and relatives have been also considered as a financial source in case of lack of credit [29, 61]. Husen et al. confirm the positive financial effect of social capital on adoption by supporting this idea [60]. Relaxing effect of credit on the liquidity can be provided to a member in a credit or saving organization, these kinds of organizations relax the farmers in terms of cash constraints [61]. Abdulai et al. show that credit access has an effect not only on the investment but also on the crop choices because the farmers suffering from credit access have a liquidity problem and this directly affects the crop choices [27]. When considered from this aspect, smaller farmers who have limited credit have less advantage than larger farmers having better credit opportunities in terms of adoption [17]. Moreover, the study of Abdulai and Huffman indicates that, in the situation of credit constraint, if farmers just consider the current generation, higher adoption is expected in the middle-aged farmers; but if there is no credit constraint and farmers behave by considering future generations, higher adoption is expected in younger farmers [19].

4. Policy implications and future directions

As shown in the table, when the literature about the adoption and diffusion of technology in the agriculture is reviewed, it is clearly seen that while some factors have an exactly positive effect on adoption, some have negative effects and some are changeable depending on the situation. This review reveals the significant factors and makes the policies that may be implemented to expedite the technology adoption and diffusion more explicit.

When the knowledge of people is taken into consideration, the factors including education, learning and information play a big role in adoption. In this sense, governments should provide a good and an extensive extension service not only in central locations but also in remote locations because as it can be seen in the literature, being closer to opportunities increases the likelihood of adoption and diffusion. Removing the disadvantages of farmers who live in remote areas and providing accessibility to information will contribute to the adoption.

Some organizations and activities that strengthen social relations and facilitate communication among people also need to be set up regularly by governments because social capital is another significant part of the adoption and diffusion of technology. Encouraging farmers to be a member in a group or an organization develops social capital and this helps to obtain information and learning by others. Besides, when the effect of neighbors and relatives is considered, some key persons who can be trained and affect more people can be chosen by the government. These key persons who communicate with their immediate circles such as relatives and neighbors can produce a 'butterfly effect' and increase the adoption and diffusion of technology. In this sense, finding the key person on the farmers is important. For that reason, governments need to prepare specific and different programmes for households having different social identities. These aim-targeted plans will affect the tendency of farmers for adoption positively.

On the other hand, financial aid should be provided for farmers to ease technology use because the literature shows the dominant positive effect of ownership and wealth on adoption and diffusion of technology. Liquidity problem of farmers can be solved with special funds, credit facilities with low interest rate and subsidies provided for new investment and new crops. These opportunities both relax farmers and increase

the tendency of farmers to adopt the new technology. Undoubtedly, all of these are related to good and reliable governance; thus, if it exists, the adoption and diffusion of technology can be expedited.

Although education and learning are very big parts in the adoption and diffusion of technology in agriculture, it is necessary to do more detailed research on the dilemmas that 'Although communication and network are very effective on the adoption and diffusion, does learning by others without official agents cause mislearning and misuse of technology and hence to detract farmers from technology adoption or not?'

Future research may also analyze the effects of communication among relatives or neighbors of farmers on adoption because although they have mostly positive effects on adoption, there are also negative effects because of the idea of refusing to provide benefit for others. In brief, more precise results can be obtained about the effect of social capital on adoption and diffusion of technology by examining social relations in detail.

5. Conclusion

In these times when the competition among firms, sectors and countries is very strong, the importance of technology as a formula of long-run economic growth is great [72]. Technology contributes to the sectors in terms of real wages, increasing productivity and decreasing costs and prices [2]. These positive effects make it a big player in the agricultural sector for development [3]. Thus, the adoption and diffusion of technology in agriculture are very important to maintain continuity in production, increase production and generate more income.

In this paper, the factors influencing the adoption and diffusion of technology in agriculture had been analyzed and the results and policy that can be implemented were presented. The literature review includes 44 analyses and 21 factors on the adoption and diffusion of technology in agriculture. Analyses had been handled on a large scale rather than examining a specific time period or a specific region. For the section of characteristics of farmers, the results show that there is a predominantly positive relationship between income, off-farm income, ownership and wealth, education, learning, information, neighborhoods, relatives, contacts with extension agents, membership in a group or organization and experience with the adoption and diffusion of technology. General inference by looking at the effects of age, gender and norms cannot be made because although they have an effect on the adoption and diffusion of technology, the positivity and negativity vary by situation. For the section of the characteristics of farms, it is seen that both factors which cover the farm size and the closeness to the farm have positive effects on adoption. The following section, on external incentives and disincentives, indicates that prices of inputs and credit accessibility show a predominantly positive effect on the adoption and diffusion of technology in agriculture whereas the effect of risks changes. Although the factors examined reveal the main elements for the adoption and diffusion of technology in agriculture, future research may show more precise results for the uncertain factors depending on the situation.

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