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Adoption of Farmer Innovations Systems and Improved Agricultural Technologies: Reasons and Constraints

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Abstract

Many rice production interventions that involve the promotion of improved agricultural technologies have been rolled out, yet some of the farmers in Ghana still use indigenous farming practices and farmer innovation systems. This study, therefore, investigates, ranks and discusses the reasons why farmers prefer to use farmer innovations systems to improved agricultural technologies and vice versa. Kendall's Coefficient of Concordance was used to analyse primary data collected from rice farmers in Ghana. Some farmers prefer using their own innovations to improved agricultural technologies due to low production cost. Conversely, farmers adopted improved agricultural technologies because of the high rice yield. It is therefore recommended that, agricultural extension agents, researchers and NGOs should educate farmers for them to know the long run benefits of adopting technologies. Credit support system and contract farming concept should be promoted as these reduce some of the bottlenecks smallholder farmers face in adopting technologies. With these, farmers would be able to afford and be encouraged to adopt improved agricultural technologies to the latter, thereby improving rice productivity.

Keywords: adoption, constraints, innovations, productivity, technology

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INTRODUCTION

Ghana is still struggling to benefit from the "Green Revolution" which promoted high-yielding rice varieties, mineral fertilizer and pesticide applications. Over the years, research institutions and other stakeholder organizations have not relented in their efforts to developing scientifically improved technologies and making them available to rice farmers for adoption through agricultural extension agents (AEAs). These improved agricultural technologies (*IATs*) include improved varieties, mineral fertilizer, pesticides, row planting, transplanting, thinning, soil bunding, ploughing and harrowing. A study by Donkor et al. (2016) on rice yield found that row planting improves rice productivity. A study by Wiredu *et al.* (2010) observed that the adoption of New Rice for Africa (NERICA) and National Agricultural Research Stations (NARS) rice varieties which are *IATs* increases rice yield by 0.024Mt/Ha in Ghana. Additionally, a study by Abdul-Rahaman et al. (2021) revealed that farmers who adopted improved rice varieties obtained 76% improvement in rice productivity compared to non-adopters. In the same vein, uptake of improved rice seeds and chemical fertilizer application enhanced farmers' net revenue from rice and household income distribution (Addison et al., 2022). These are *IATs* that have contributed to the enhancement of agricultural productivity and farmers' welfare.

Though the emergence of *IATs* had led to dramatic results in agriculture development, there are a number of issues concerning their adoption. One such critical issue is the affordability of *IATs* to smallholders. On account of this and other issues, farmers sometimes mix indigenous farming practices (*IFPs*) with *IATs* to come out with farmer innovations systems (*FISs*). Assuming-Brempong *et al.* (2011) posit that adoption of improved varieties of rice especially the NERICA variety in Ghana is very low, especially in some areas of the country.

Meanwhile, this supply-driven concept of developing improved technologies is not yielding results satisfactorily, especially, in increasing rice yield significantly. During an interaction (during a preliminary survey) with farmers at Golinga in the Tolon district of the Northern Region, one of the farmers lamented that "policies are designed and implemented for the development of improved technologies with the notion that there is a farmer out there who will need them". Another farmer at Chinderi in the Volta Region of Ghana bemoaned that agricultural productivity-enhancing technologies are developed without conscious efforts of assessing whether they are demand driven or not. Many of the farmers may feel that their own farmer innovations are better and therefore, they fail to adopt externally developed *IATs*.

It is an open secret that irrespective of many developed rice productivity-enhancing agricultural technologies, the actual rice yield is still below the potential yield and varies across agro-ecological zones. Farmers in Ghana have the potential of achieving an average rice yield of 6.5Mt/ha but they only realize an average yield of 3.3Mt/ha in 2020 (MoFA, 2021). Many researchers have ascribed this low yield to rudimentary technologies used by farmers, incidence of diseases and pests as well as unavailability of certified seeds. Low adoption of the *IATs* is one of the causes of this low yield in Ghana. It can be hypothesized that production and socioeconomic factors prevent farmers from effective adoption of *IATs.* Therefore, the overarching objective of this study is to investigate, rank and discuss the reasons why some farmers adopt farmer innovations systems (*FISs*) and others adopt *IATs*. The study will also examine the constraints faced by farmers in adopting *IATs*.

Farmer Innovations Systems (FISs)

According to Tambo and Wunscher (2014), some farmers store seeds of crops in bicycle tubes, some use pepper and *neem*[1] (*Azadrata indica*) extract to treat seed before storage. There are various descriptions that have been given to farmer innovations. The most appropriate one for this study is conceptualized from World Bank's definition. According to World Bank (2011), farmer innovations are dynamically improved *IFPs* which are consciously developed or unconsciously discovered by local farmers with or without the main objective of improving agricultural productivity. In respect of farmer innovations to improve productivity, rice farmers in Ghana have over years engaged in selective combination of different varieties to produce uniquely high-yielding varieties. In other innovations, farmers have developed different types of storage practices such as storage of rice in pots, barns, etc. Farmer innovations can conveniently be referred to as local innovations. According to Prolinnova (2004), local (farmer) innovations are dynamically modified indigenous knowledge which emanates and grows within a social group through incorporating learning experiences from generation to generation. It also includes internalization of external knowledge into local settings. Farmer innovations include techniques or practices or processes which are not technical in nature. Wills (2012) stated that "whilst invention often concerns a single technique or technology, innovation frequently involves the combination of existing techniques or technologies in new ways in order to enhance their impact". They can be applied in everyday life of farming households.

Indigenous and local farmers are not only adopters of externally developed innovations but rather they are also innovators. The process and ability of developing or discovering or inventing an improved way of doing things is an innovation. With innovations, an organisation or individual can carve a niche and advance in the process of doing things. Innovations involve the adoption of new knowledge, technology or practice without assurance of expected outcomes or results. As such, innovators are risk lovers. Some innovators are initiators, others are not. Some of the local farmers are innovators and others are initiators of innovations. Farmer innovations are obtained through experience. Farmer innovations involve the use of new and more effective ideas or practices for agricultural production and marketing activities. The main aim of farmer innovations is the improvement of agricultural productivity for the betterment of indigenous farmers. Farmer innovations are supposed to be original, but sometimes they are not. They are those practices which have never been applied. Sometimes, indigenous farmers try to experiment certain newly discovered wild varieties of crops or try to domesticate wild animals. Farmers also use local material for soil moisture conservation, soil fertility management, weed control and pest and disease control. Through rice farming experience, many farmer innovations are applied by farmers to help them improve upon land preparation, seed planting or nursing, storage of rice, pest control and fertility enhancement.

Improved Agricultural Technologies (IATs)

Generally, technologies emerge from innovations. The definition of technology depends on the field. The universally accepted definition can be traced to the work of Rogers (2003). Rogers (2003: p. 13) defined technology as "a design for instrumental action that reduces the uncertainty in the cause-effect relationships involved in achieving the desired outcome". Rogers (2003: p. 259) explained that technology has a hardware component which is "the tool

[1] Neem is a medicinal tree which is very bitter.

that embodies the technology in the form of a material or physical object," and software[2] which is "the information base for the tool".

The concept of IATs emanated from farmer innovations. Researchers over the years observed innovative ways that farmers employed by combining and modifying IFPs for improved agricultural productivity. Some of the IATs stressed the need for specialized production, crop monocultures, mechanization (the use of modern farm machinery such as tractors, harvesters, threshers, etc.), development and use of improved seeds [high-yielding varieties (HYVs)], the use of pesticides and chemical fertilizers, and the construction and use of irrigation systems (Altieri, 1995 and Macmillan Reference, 2006). IATs can be effective when they are developed to suit the needs and priorities of the targeted local farmers.

Modern plant breeding of wheat started in the 1940s in Mexico through the Green Revolution. The intensive invention, introduction and promotion of IATs started in 1950s and this was done by hierarchical institutions led by the state and corporations (Buckland, 2004). In the 1960s, national modern rice breeding programmes were established in countries such as Japan, China, Taiwan and the Philippines (Buckland, 2004). The Green Revolution started in Asia and Latin America through the development of chemically responsive seeds and appropriate chemically improved input technologies. Through the Green Revolution, the public sector in Asia and Latin America established International Rice Research Institute (IRRI) in the 1960s in the Philippines, resulting in the development of many highly improved rice technologies (Buckland, 2004).

Agbanyo (2012) and Bloom *et al.* (2009) noted that though technologies play significant roles in improving agricultural yields, their developments are reflections of the interests of the sponsoring corporations and their supporting institutions. Most of these technologies are patented and their use requires constant purchase from their originators. The development of *IATs* seeks to achieve the known objective of firms, namely economic profit maximization. Simply, the use of *IATs* such as intensive tillage, monoculture, application of inorganic fertilizer, irrigation and agro-chemicals increase agricultural productivity and maximize economic benefits. These *IATs* are not mutually exclusive. The fundamental and direct reasons for the development of these technologies are to reduce drudgery, labour constraints and make plant nutrient readily available. For instance, irrigation as an improved agricultural technology aims at providing optimum quality water for crops all year round. Irrigation technology also supplements inadequate rainfall water for improved crop yield. Pesticides are applied to minimize crop damage by pests to economic threshold level.

METHODOLOGY

Study Area and Sampling Techniques

Ghana is divided into six agro-ecological zones namely, Sudan Savannah Zone (SSZ), Guinea Savannah Zone (GSZ), Forest Savannah Transition Zone (FSTZ), Semi-Deciduous Rain Forest Zone (SDRFZ), High Deciduous Rain Forest Zone (HDRFZ) and Coastal Savannah Zone (CSZ). Through stratified sampling technique, GSZ, FSTZ and CSZ were selected for the study. Primary data for 2015/16 cropping season in each of the study districts were collected. Using sample determination formula stated below, the number of rice farmers sampled for the study in GSZ, FSTZ and CSZ are 377, 359 and 171 respectively. This calculation was done

[2] Since software (as a technological innovation) has a low level of observability, its rate of adoption is quite slow (Sahin, 2006).

based on 8% imprecision. Through stratified sampling, Tolon, Kumbungu, Savelugu, Kasena-Nankana, West Mamprusi, Chereponi and Builsa South Districts were selected in GSZ and North Tongu, Ketu North, Krachi Nchumburu, Pru and Hohoe Districts were selected from FSTZ. Shai Osudoku, Ningo Prampram and Ashaiman Districts were included in CSZ. Systematic sampling technique was then used to select houses and one rice farmer was randomly selected from each house. In some of the communities, the enumerators visited rice farms and the rice farms were systematically selected and the owners interviewed. The study used a semi-structured questionnaire for collecting the data.

Method of Data Analysis

The adoption of technology depends on the constraints faced in making the adoption decision. The reasons for the choice of FISs and IATs as well as the constraints facing rice farmers in adopting the superior technologies thus (*IATs*) were identified through a literature review and a preliminary informal interview of 60 farmers. During actual data collection, these reasons and constraints were presented to rice farmers to rank according to the degree of importance.

The rankings of the constraints were done according to the degree of severity to which a rice farmer cannot adopt or fully adopt the superior technologies thus *IATs*. The rankings and the testing of the agreements among farmers' rankings were done with the help of Kendall's Coefficient of Concordance. Kendall's Coefficient of Concordance (*W)* is used to rank and test the null hypothesis that there is no agreement among the rankings by farmers against the alternate hypothesis that there is agreement.

Kendall's Coefficient of Concordance is used to measure the agreement among several (m) quantitative or semi-quantitative variables of interest. The mean ranks and the degree of agreement among the ranks estimated using equation 1.

$$W = \frac{12\left[\sum T^2 - \frac{(\sum T)^2}{n}\right]}{nm^2(n^2-1)}$$

Where:

T = sum of ranks factors being ranked, m = number of respondents, n = number of factors being ranked.

The two null hypotheses being tested are

H_0: Rice farmers do not agree to the rankings of reasons for the adoption of *IATs* to *FISs*.

H_0: Rice farmers do not agree to the rankings of constraints preventing them from adoption of *IATs*.

Decision: If $|Z_{calculate}| > |Z_{critical}|$, the null hypothesis is rejected in favour of the alternate that farmers agree to the rankings

SPSS version 20 was used for this analysis. The results were presented in tables and charts.

RESULTS AND DISCUSSIONS

Percentage Distribution of Technology Adoption

Figure 1 shows the percentage distribution of technology adoption. As shown in the figure, out of 907 farmers interviewed, 40.2% adopted *IATs* whereas 17.0% used their one farmer innovations. Those who used both *FISs* and *IATs* formed 20.8% of the respondents. This implies that majority of the farmers adopted *IATs* in rice production in Ghana. *IATs* such as fertilizer application, pesticides, improved riced varieties, ploughing, nursing and transplanting etc are now very common in Ghana. The problem has been the holistic adoption of the package. Irrespective of this, as significant as 21.9% of the farmers used none of these two but rather use their own *IFPs*. This should be a concern to all stakeholders in technology development and dissemination.

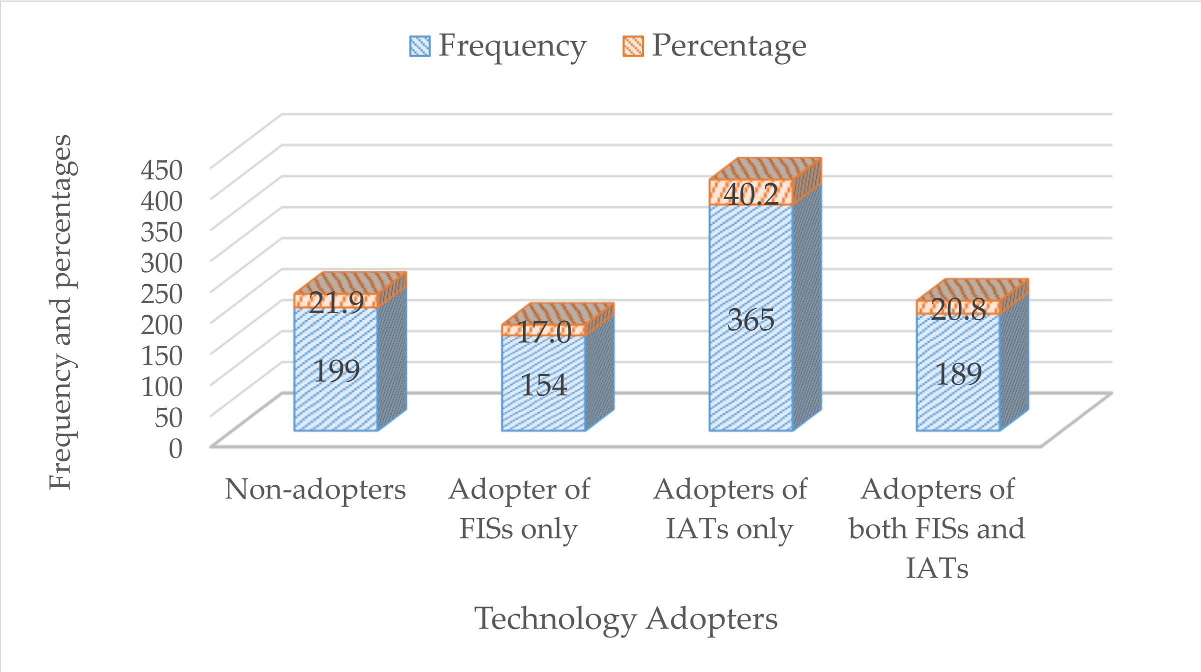


Figure 1: Percentage Distribution of Technology Adoption
Source: Analysis from field data (2017)

Mean Distribution of Variables among various adopters

In Table 1, the mean distributions of important variables are shown. It can be observed that averagely, adopters of *FISs* have the largest farm size of 2.8 acres followed by adopters of both FISs and *IATs* with a farm size of 2.7 acres. Non-adopters of any technology had the lowest farm size (2.4 acres). In terms of capital investment, adopters of *IATs* invested the highest amount of Gh¢1,081.20. It is not surprising to see that non-adopter invested the lowest amount of Gh¢285.50. This is because they do not use any technology that require big capital investment unlike adopters of *IATs* who need to spend money to buy fertilizer, pesticides, plough and harrow their field as well as purchase improved seeds etc.

Results from Table 1 suggest that farmers who are less educated and have big household sizes are more comfortable with the use of their *IFPs* and *FISs*. The reverse is true for adopters of *IATs*. Contrary to the expectation of the researcher, the study found out that older farmers adopted *IATs* as compare to younger farmers. Marfo *et al*. (2008) and Assuming-Brempong *et al*. (2011) identified formal education and extension contacts as principal factors influencing adoption of improved rice varieties. Consequently, the benefits of adoption of improved rice varieties are not fully realized in Ghana as majority of rice farmers are not educated. In order to increase exposure of farmers and improve upon the adoption of improved NERICA rice variety, Assuming-Brempong *et al.* (2011) recommended that efforts and resources should be invested in promotional activities. Education as a factor facilitates the understanding of people on the use of improved technologies. Farmers who have had formal education are likely to easily understand and assimilate the promotional activities on technology adoption. Therefore, level of education plays a key role in rice technology adoption.

The a priori expectation of the research is met as farmers who have access to extension contact, credit as well as engaged in contract farming and belong to farmer-based organization have adopted *IATs*. Agricultural extension agents having being doing well in the dissemination of IATs and hence this might be the reason for high adoption among those who have access to their services.

Table 1: Mean Distribution of Variables among various adopters

	Non-Adopters	**Adopters of *FISs***	**Adopters of *IATs***	**Adopters of both *FISs* and *IATs***
Farm size (acres)	2.4	2.8	2.6	2.7
Capital (Ghȼ)	285.5	646.2	1081.2	797.9
Age (years)	43.7	42.6	44.0	41.4
Household size	8.9	8.2	6.7	7.7
Education years	4.2	5.3	7.9	7.3
Rice farming experience (years)	15.8	15.2	13.8	11.9
Extension visits	0.9	2.0	3.2	3.4
Sex: Male	0.69	0.67	0.66	0.71
Contract Farming	0.06	0.21	0.54	0.36
FBO members	0.32	0.48	0.70	0.32
Credit access	0.13	0.21	0.45	0.42

Source: Analysis from field data (2017)

Rankings of the Reasons for the Adoption of FISs

People make choices based on certain reasons. This section presents and discusses the rankings of the reasons why farmers use or adopt *FISs*. Table 2 shows the results from the rankings and the testing of the agreements of the rankings using Kendall's Coefficient of Concordance. Thirteen reasons were analysed using Kendall's Coefficient of Concordance. Out of these, low production cost was ranked the most important reason why farmers choose to adopt *FISs*. The mean rank for low production cost is 4.45; the lowest thereby making it the principal reasons for the choice of *FISs* by farmers. Closely following the low cost of rice production is drought resistance nature of local rice varieties, which recorded a mean rank of 5.05. The easy understanding of *FISs* is the third reason why farmers adopt *FISs*. Through continual usage of *FISs*, farmers understand all the processes involved in cultivating rice using their own innovations. This is because *FISs* are not externally developed unlike *IATs*.

From Table 2, it is possible to discern the decreasing order of importance of the reasons why farmers adopt *FISs*. They are low production cost (4.45), drought resistant of local rice varieties (5.05), easy understanding of *FISs* (6.32), easy availability of local rice varieties (6.37), *FISs'* save water (6.40), *FISs* do not encourage weed growth (6.51), *FISs* maintain soil fertility (6.99), *FISs* are less labour intensive (7.17), *FISs* promote environmental sustainability (7.33), the use of *FISs* make farmers innovative (7.70), quality of paddy from *FISs* (8.76), *FISs* give higher rice yield (8.92) and higher value of paddy produced using *FISs* (9.04). Meanwhile, the least important reason why farmers adopt *FISs* is that paddy produced using *FISs* are highly priced. This implies that rice produced using *FISs* are local varieties which are lowly priced, have lower yield and are of less quality. It is therefore obvious from this research that *FISs* are much preferred by rice farmers principally because of low production cost.

From table 2, the test for the agreement of the rankings of the reasons why farmers adopt *FISs* is statistically significant at 1%, even though the estimated 12.8% agreement among farmers' rankings of the reasons is very low. The calculated chi-square value of 520.13 is greater than the critical chi-square value of 23.34, implying the null hypothesis that there is no agreement among farmers' rankings of the reasons is rejected in favour of the alternate.

Table 2 Rankings of the Reasons for the Adoption of *FISs*

Reasons for the choice of *FISs*	**Mean Rank**
Low cost of production	4.45
Local rice varieties are draught resistant	5.05
FISs are very easy and simple to understand alike *IATs* which are too complex to understand	6.32
Local rice seeds are readily available unlike improved and certified rice seeds which are not easily available	6.37
FISs are water saving	6.40
FISs reduce weeds unlike *IATs* which encourage weed growth	6.51
FISs maintain soil fertility	6.99
FISs are less labour intensive	7.17
FISs promote environmental sustainability unlike *IATs* which involve uprooting of tree stumps thereby causing soil erosion and desertification	7.33
FISs make farmers innovative and help keep indigenous farming innovations for future generations	7.70
Rice from *FISs* more quality that rice from *IATs*	8.76
FISs give higher rice yield than *IATs*	8.92
Rice from *FISs* are highly priced	9.04

*n=338, Kendall's Coefficient of Concordance = 12.80%, Chi-Square at 12 degree of freedom = 520.13, P-Value (Asymptotic significance) = 0.000****

Source: Analysis from the field (2017)

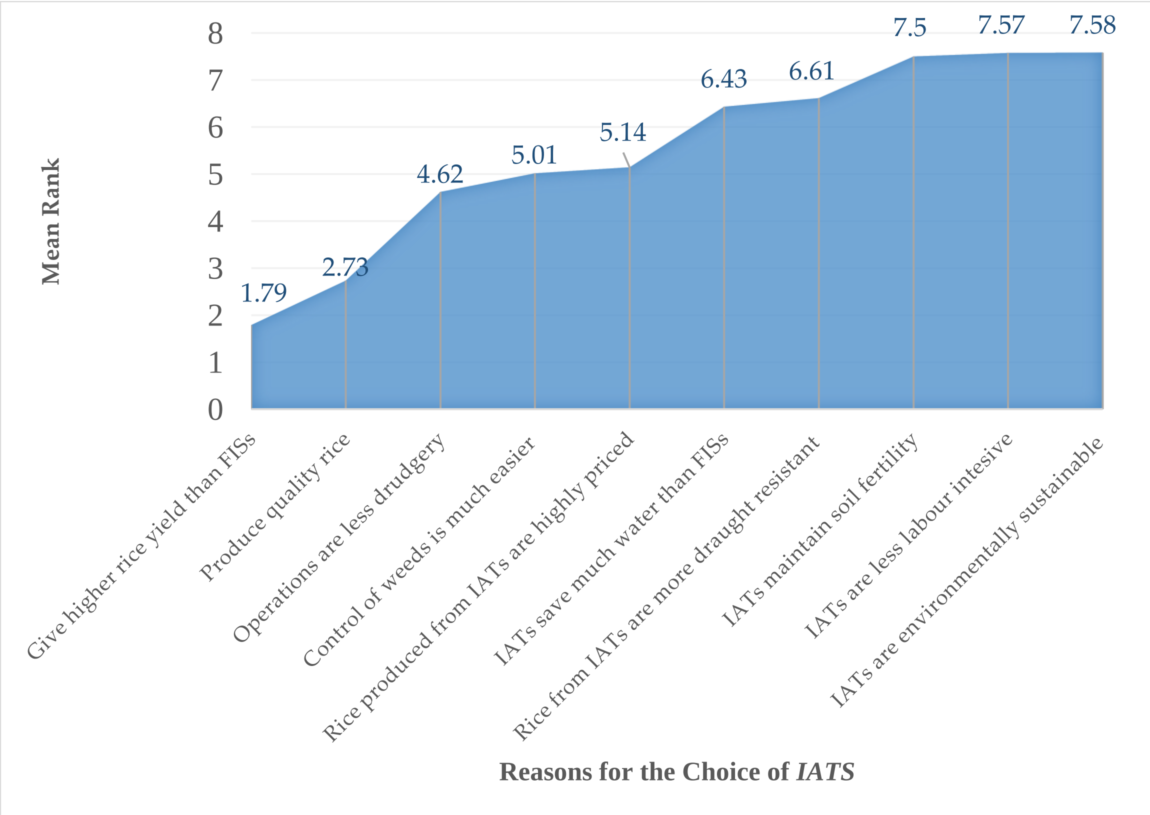
Rankings of the Reasons for the Adoption of IATs

The results of the rankings and testing of the agreements among farmers' rankings of the reasons for adopting *IATs* using Kendall's Coefficient of Concordance are illustrated by the area chart in figure 2. The lower the mean rank, the higher the reason for the choice of *IATs*.

From the figure, it is obvious that the most important reason farmers consider in adopting *IATs* is yield. They have actually realised that producing paddy using *IATs* gives higher yields than *FISs*. This is derived from the fact that it has the lowest mean rank value of 1.79. It is against this backdrop that Addison et al. (2022) indicated that agriculture productivity improvement is dependent on the uptake and utilization of agricultural technologies. The current findings also support the findings of Wiredu et al. (2015) that application of improved rice technological innovations increases rice productivity in Ghana.

The second, third, fourth, and in that order for the adoption of *IATs* are quality paddy (2.73), less drudgery farming operations (4.62), easy control of weeds (5.01), high price of paddy from

IATs (5.14), operations of *IATs* save much water (6.43), drought resistant of improved varieties (6.61), maintenance of soil fertility (7.50), less labour intensity (7.57) and improvement of environmental sustainability (7.58).



*n=498, Kendall's Coefficient of Concordance = 45.2%, Chi-Square at 9 degree of freedom = 2027.948, P-Value (Asymptotic significance) = 0.000****

Figure 2: Reasons for the Adoption of IATs

Source: Analysis from the field (2017)

As depicted in the area chart, farmers do not consider that *IATs* make the environment more sustainable and hence ranked it as the tenth most important reason. This is because some of the operations of *IATs* involve uprooting tree stumps, ploughing, harrowing and levelling of the field before planting. The application of pesticides and chemical fertilizers are examples of *IATs* that affect the environment. The less labour intensity of *IATs* is ranked ninth, implying it is a minor reason why farmers adopt *IATs*. It seems these findings depict the reality, since *IATs* involve planting in rows, dibbling or transplanting, which is slow and requires more labour.

Since the calculated chi-square value of 2027.948 is greater than the critical chi-square value of 19.02, it suggests that the testing of farmers' ranking of the reasons why they adopt *IATs* is statistically significant at 1% (probability value of 0.000). This implies that the null hypothesis that there is no agreement among farmers' ranking of the reasons for the adoption of *IATs* is rejected in favour of the alternative. The Kendall's Coefficient of Concordance is 45.20% implying there is 45.20% agreement among farmers' ranking of the reasons for the adoption of *IATs*.

Constraints Preventing Partial or Full Adoption of IATs

In farming, one or two factors can prevent a farmer from partial or full adoption of a technology. Some of these factors may be farmer characteristics, farm characteristics, or features of the technology itself. In order to do this analysis, thirteen constraints that prevent farmers from partial or full adoption of *IATs* were identified through literature review and preliminary interview. Farmers were then asked to rank these constraints, with a score from 1 to 13 indicating the most to the least pressing constraint that prevent them from partially or fully adopting *IATs*. The results of the rankings and the testing of the agreement among the rankings are illustrated in the bar chart of figure 3.

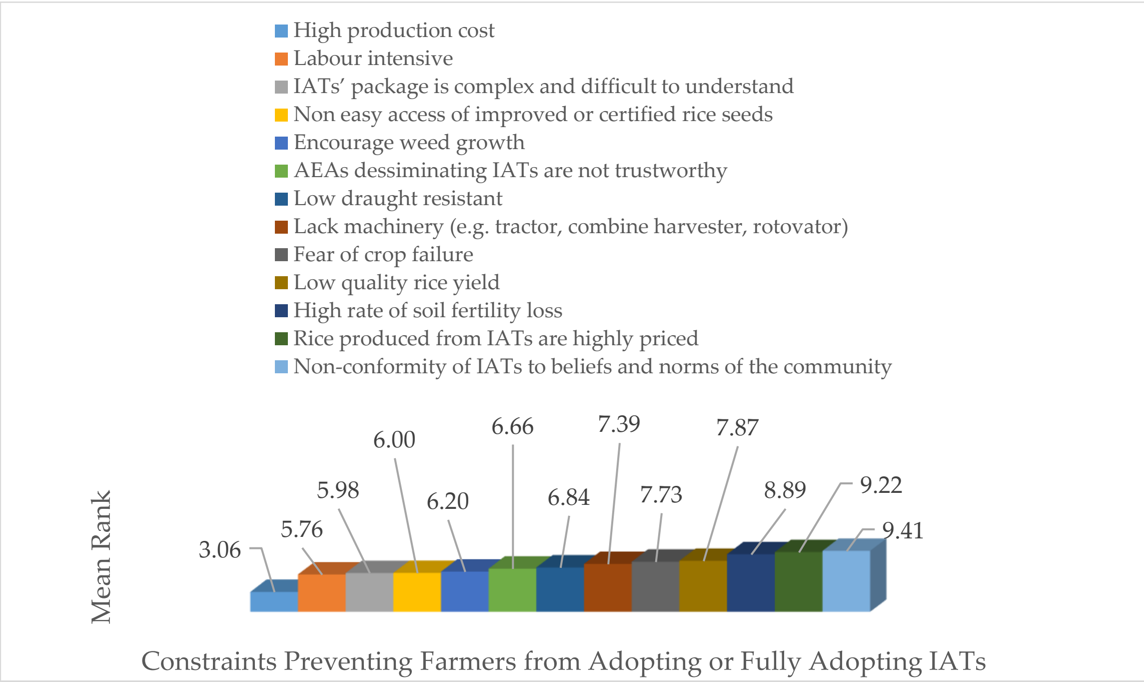
From figure 3, farmers unanimously ranked high production cost as the most pressing constraint that prevents them from fully adopting *IATs*. This is because it has the least mean ranked value of 3.06. The adoption of *IATs* require the intensification of farm inputs (using the required and appropriate quantity of improved or certified seeds, fertilizer, pesticides, labour) and hence highly capital intensive (Peterman *et al*., 2010). This suggests that the development of market-facilitated approaches to funding rice production should be intensified. It is important to note that production costs include the cost one needs to incur in acquiring appropriate land for technology. This confirmed the findings from Teklewold et al. (2020) that technology adoption increases with ownership of land in Uganda.

The second, third, fourth and fifth most pressing constraints limiting partial or full adoption of *IATs* are labour intensity of *IATs'* operations, complexity or uneasy understanding of *IATs*, difficulties in accessing improved and certified rice seeds and the encouragement of weed growth, since the estimated mean ranks are 5.76, 5.98, 6.00 and 6.20 respectively. As noted in the preceding section, the adoption of *IATs* calls for higher labour requirements especially dibbling, planting in rows, transplanting, etc; hence the justification for labour intensity being the second most pressing constraints. Another critical constraint affecting farmers' effectiveness in adopting *IATs* is poor access to improved or certified rice seeds for planting. This finding confirmed the finding of Peterman *et al*. (2010).

Also, farmers indicated that they do not want to adopt or they partially adopt *IATs* because of lack of trust in agricultural extension agents (AEAs), who are the technology disseminating agents. This lack of trust in AEAs is the sixth most pressing constraint, followed by low drought resistant of the improved rice seeds. As noted by Peterman *et al*. (2010), lack of information on *IATs* and neglect of duties by AEAs make it difficult for farmers to understand the intricacies involved in adopting *IATs*. Lack of trust in AEAs stems from the failure of AEAs in honouring their promises or appointments with farmers. This finding collaborates with the study by Donkoh et al. (2019) which explained that technologies such as harrowing and line planting require practical field visits and demonstrations for farmers to be trained on. Meanwhile, lack of logistics makes it difficult for agricultural extension agents to execute this technology thereby making farmers to conclude in this study that the former cannot be trusted in honouring the appointments and delivering their mandates.

The least constraint that limits the ability of farmers to partially or fully adopt *IATs* is nonconformity of *IATs* to traditional beliefs of their communities. This suggests that nonconformity of *IATs* to traditional beliefs of their communities is less of a problem for them in adopting *IATs*. They also ranked low price of *IATs'* rice and soil fertility loss caused by *IATs* as the second and third lowest pressing constraints preventing them from partially or fully adoption of *IATs*. Lack of farm machinery (tractors, rotovator, planters, combiner harvester etc) and the fear of crop failure were ranked eighth and ninth with mean ranks of 7.39 aand 7.73 respectively. The finding of the fear of crop failure is consistent with the work of Adato and Meinzen-Dick (2007), who indicated that production risk discourages the adoption of untried *IATs*.

From the inferential statistics, the calculated chi-square value of 1363.06 is greater than the critical chi-square value of 19.02. From the results, the probability values is 0.000 implying the test is statistically significant at 1% and hence a rejection of the null hypothesis in favour of the alternate that there is an agreement of the farmers' rankings of the constraints. From this result and the Kendall's Coefficient of Concordance value of 19.60%, there is therefore 19.60% agreement in the rankings of the constraints.



n=580, Kendall's Coefficient of Concordance = 19.60%, Chi-Square at 12 degree of freedom = 1363.06, P-Value (Asymptotic significance) = 0.000***

Figure 3: Constraints Preventing Partial or Full Adoption of IATs

Source: Analysis from the field (2017)

CONCLUSIONS

This study analyses the reasons for technology typology adoption and the constraints limiting the ability of farmers to partially or fully adopt *IATs*. From the results, the principal reason for the choice of *FISs* is low production cost. On the other hand, farmers adopt *IATs* because of high rice yield. Meanwhile, the most pressing constraint facing farmers in partially or fully adopting *IATs* is high cost of production. It is therefore recommended that, AEAs, researchers and NGOs should educate farmers for them to know the long run benefits of adopting *IATs*. Credit support system and contract farming concept should be promoted as these reduce some of the bottlenecks smallholder farmers face in adopting IATs. With these, farmers would be able to afford and be encouraged to adopt IATs to the latter, thereby improving rice productivity.

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