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# The Gap between Technology Awareness and Adoption in Sub-Saharan Africa

## A literature review for the DeSIRA project

**Cynthia Kazembe**


## Abstract

This paper reviews different studies on technology adoption in sub-Saharan Africa to understand the determinants of low adoption of improved technologies, with a special focus on Malawi. This will in turn help explain why there is a gap between awareness and adoption of agriculture technologies. As evidenced from the results of the FGDs conducted in Malawi in 2018, despite the visible benefits of the new technologies, farmers often do not adopt or take a long time to adopt them. This creates a gap between awareness of agriculture technologies and their adoption. The existing literature from sub-Saharan Saharan Africa, demonstrates that adoption, as a decision-making process, is affected by farmers' access to information, their financial and human capital, incentives and external programs, plus farmers' attitude to risk.


## Introduction

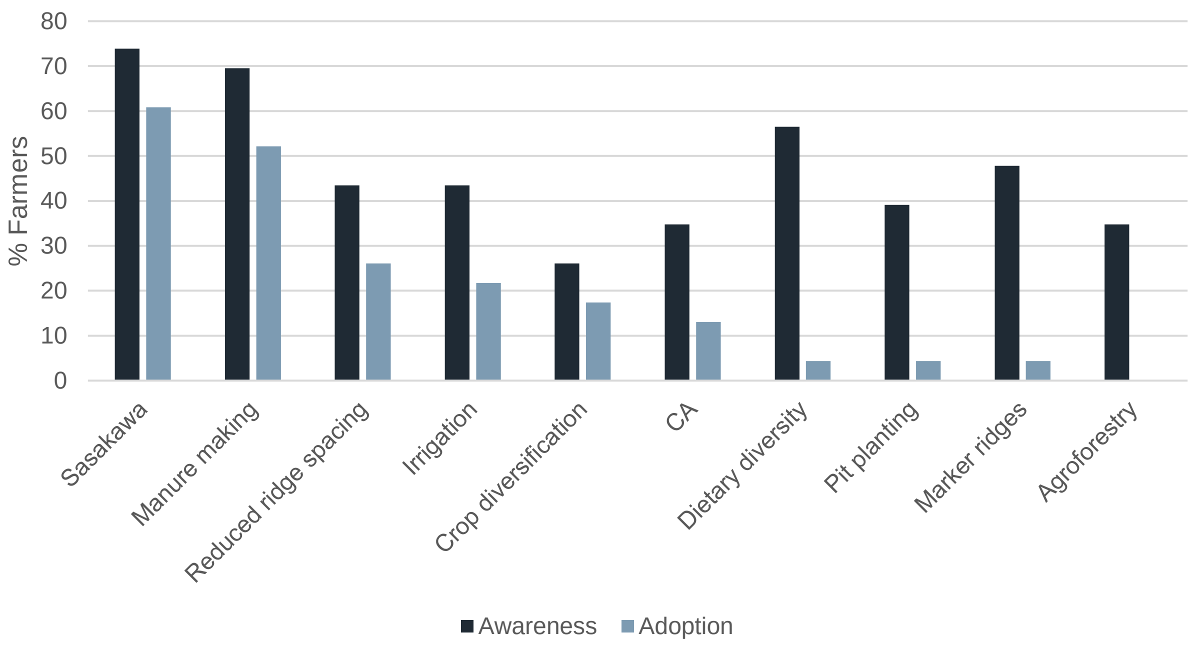
Agriculture is important for economic growth, enhancing food security, reducing poverty and rural development. With the rapid increase in population in many developing countries, the demand for food is increasing sharply while farming land is fragmented into smaller pieces because of the growing population. Increasing agricultural productivity is therefore crucial to meeting the growing demand for food. This can be achieved by using modern agricultural technologies (Challa 2013). Jain et al. 2009 defines agricultural technologies as all improved techniques and practices which affect agricultural output.

There have been many studies in the past looking at adoption of new technologies in developing countries. As evidenced from these studies, new agricultural technologies have slow and low adoption rates despite evidence that the technologies help to increase agricultural productivity (Bandiera and Rasul, 2002; Simtowe et al. 2011). A recent study by IFPRI looking at the status of agricultural extension services in Malawi, found that there is a large gap between farmers' awareness and adoption of agriculture technology. This adoption gap means a lot of farmers are aware of agricultural technologies but only a few adopt them. This paper, therefore, reviews different studies on technology adoption in sub-Saharan Africa to understand the determinants of low adoption of improved technologies. This will in turn help explain why there is a gap between awareness and adoption of agriculture technologies.

### *Agriculture technologies being promoted in Malawi and their acceptability*

In order to increase agricultural productivity, different technologies and practices are being promoted by the Ministry of Agriculture and Food Security (previously the Ministry of Irrigation and Water Development) in Malawi. Between 2016 and 2018, IFPRI conducted a study that was aimed at assessing and strengthening the pluralistic agricultural extension system in Malawi. In this study, focus group discussions (FGDs) were conducted with 22 communities in 8 districts of Malawi. The results showed that the most common agricultural practices and technologies that have been promoted in the communities sampled over the past 5 years include 10 main technologies (Figure 1). Other agricultural technologies promoted include use of hybrid maize varieties, home gardens, making basins, planting trees, mixed cropping, sustainable rice intensification, early cultivation and dietary diversity and food preparation. From this basket of technologies and practices, different communities consider only some as being valuable based on their need and suitability of the technology/practice.

**Figure 1:** Awareness and adoption of the most common agricultural technologies, 2016/17




**Source:** IFPRI Focus Group Discussions (2018)

The most common technology learned is *Sasakawa* maize planting, which is also described as *one-one planting*. Almost all communities and three-quarters of farmers have received information on this technology. It was seen that this technology was introduced a long time ago, but farmers took time to adopt it. *Sasakawa* involves planting one maize seed per planting station with 25 centimeters, or sometimes a foot, between planting stations. The *Sasakawa* method of maize planting is considered valuable because it gives higher yields on small areas of land. This technology goes together with the practice of reducing the ridge spacing. Before the 2000s, recommended ridge spacing was 90 cm between ridges. Now spacing of ridges at 75 cm is recommended. *Sasakawa* planting and reducing spacing of ridges ensures maximum productivity of land. Although the *Sasakawa* method of planting provides higher yields, many communities report low adoption. This is because the process of measuring the distance between planting stations is laborious, it requires hybrid maize varieties which are expensive, and it is believed that *Sasakawa* requires a lot of fertilizer

Another common technology that was considered valuable by the FGDs is manure-making. A majority of the communities indicated receipt of information on manure-making and that this technology was adopted very quickly after it was introduced. There are different types of manure that Malawian farmers have been taught to make including compost manure, *bokash* and *chimato*. Compost manure is made in two ways: in a pit and a heap. To make compost manure, farmers mix livestock dung, garbage or plants, soil and water. These are put in a pit or in a heap and covered for 14 days. *Bokash* and *chimato* manure are commonly referred to as fertilizer multiplication, which involves mixing dung, maize bran, ash and inorganic fertilizer. The main ingredient is the fertilizer. The FGDs showed there was no clear distinction between *bokash* and *chimato* manure. The challenge with manure-making is that carrying manure from the house to the fields prior to mixing is laborious. It is also difficult to find dung since many farmers do not own livestock. Despite these challenges, manure-making and application is widely adopted because inorganic fertilizer is expensive, so mixing manure with inorganic fertilizer is a cheaper alternative. In addition, fertilizer multiplication improves soil fertility and returns moisture in the soil.

Some communities also mentioned irrigation farming as being a valuable technology that they are practicing. This is because irrigation farming allows two cropping seasons in a year. Communities report realizing high yields with irrigation farming, enough food for the whole year and increased income from selling surplus harvests. The most common irrigation method practiced by the communities are using watering cans to sprinkle water on crops. Although this is commonly used technology, farmers complain that it is laborious. Most farmers mentioned that they cannot afford irrigation equipment like treadle pumps, while very few communities have large irrigation schemes that use canals to irrigate their fields. The concrete canals and water reservoirs for such schemes are typically constructed using grants from foreign organizations. Other valuable practices that ensure food security mentioned include crop diversification, early land preparation, and double row planting of soya and groundnuts and taking farming as a business.

The FGDs report that some technologies and practices learnt over the past five years were either adopted at low rates or adopted and then dis-adopted. Reasons for this range from the unsuitability of the technology or practice to the agro-ecology of the area to farmers’ lack of diligence. Examples of technologies or practices with low adoption rates include are, conservation agriculture, pit planting, dietary diversity and marker ridges.

Conservation agriculture (CA) was described as mulching and zero-tillage. People reported a number of challenges in adopting conservation agriculture. Firstly, mulching is considered laborious because people have to carry the mulch from elsewhere to the field, it also creates water logging in the field when there is too much rain, and lastly, they do not know the right amount of mulch to apply. Zero-tillage was reported to have low adoption because it is complex and makes weeding difficult.

Pit planting has very low adoption rates: in some areas, it was frequently dis-adopted because it is regarded as labor intensive; while in other areas, it resulted in water logging. Farmers also revealed that there was a contradiction in the details of how to implement pit planting. Farmers recall quite different measurements for the pit.

Finally, despite over half of farmers being aware of it, dietary diversity has very low adoption. Farmers argue that they cannot afford to grow all the six food groups on the small plots of land they farm. For the few farmers that adopted crop diversification, they are able to consume most of the food groups regularly.

## REVIEW OF LITERATURE ON AWARENESS AND ADOPTION OF AGRICULTURE TECHNOLOGY

### *Determinants of agriculture technology adoption*

#### ***Access to information and extension approach (Technology awareness)***

Awareness is a precondition for adoption of technologies, so partial awareness of technologies results in an adoption gap. In an important study, Diagne (2009) examines the reason for low adoption of agricultural technology in sub-Saharan Africa. The paper argues that low adoption of agricultural technologies can be explained by a lack of awareness of the technologies by a high proportion of the population; especially when the technology is relatively new. Diagne analysed the structure of the adoption gap resulting from lack of awareness of the improved rice variety called New Rice for Africa (NERICA). In this study, the adoption gap is measured as the difference between potential adoption and the mean observed adoption. The study estimated adoption gaps for new rice varieties of 21% in Cote-d'Ivoire, 41% in Guinea, 28% in Benin and 47% in Gambia. Diagne recommends conducting participatory variety trials as well as improving access to extension to bridge the adoption gap.

A similar study conducted by Simtowe et al. (2012) in Kenya, defined the adoption gap as the difference between the population mean potential adoption outcome and the mean actual (i.e. observed) outcome. The authors applied program evaluation techniques to data obtained from 414 farmers in rural Kenya to assess the patterns of adoption for improved pigeon pea varieties. The study found the sample adoption rate of improved pigeon pea to be 36% while the potential adoption rate was estimated at 48%: so, a 12% adoption gap results from farmers partial exposure of the improved pigeon pea varieties. According to this study, adoption of improved varieties of pigeon pea can be increased if farmers are fully exposed to the new varieties.

Sources of information available to farmers also play a huge role in technology awareness, hence adoption of technologies. A study by Fisher et al (2018) asks if farmer-to-farmer extension (F2FE) can help spread conservation agriculture (CA) practices to Malawian smallholder farmers in the long term. Using data for 180 lead farmers linked to 455 followers, they investigated how F2FE influences the awareness and adoption of the three CA principles (minimum soil disturbance, crop residue retention, and crop diversification). The study had four main conclusions. First, lead farmer motivation increases their effectiveness at diffusing CA practices to their followers. Second, both lead farmer familiarity with and adoption of CA matter to the spread of CA practices, but familiarity appears to be more important. Third, lead farmers play a more critical role in increasing awareness than adoption of the CA practices. Finally, F2FE is a complement rather than a substitute for other sources of agricultural extension in Malawi's pluralistic extension system and should support but not replace current systems.

Finally, Acheampong et al (2018) used cross-sectional data collected from 526 farmers in Ghana and employed a binary logit model to determine the role of awareness in their adoption of improved sweet potato varieties. The study results show that in addition to farm/farmer characteristics and institutional factors, awareness positively and significantly influenced adoption of improved sweet potato varieties. The authors recommended that since awareness creation and educating farmers on improved varieties encourages adoption, government and donor agencies to support extension services with resources for creating awareness. Furthermore, the media should be involved to help with the dissemination of improved varieties.

### Financial capital

Availability of finance plays a role in farmers' adoption of improved technologies, especially those that are capital intensive (Diiro 2013; Lambrecht et al. 2013; Simtowe et al. 2010). Simtowe et al. (2010) looked at how access to credit can increase adoption of improved groundnut varieties in Malawi. The study applied the Average Treatment Effect (ATE) framework to data obtained from a random cross-section sample of 594 farmers in Malawi to document the actual and potential adoption rates of improved groundnut varieties and their determinants, conditional on farmers' awareness of the technology. The paper found an adoption gap of 12% resulting from incomplete exposure of farmers to improved groundnut varieties. Furthermore, Simtowe et al. found that awareness of groundnut improved varieties is dependent on information access while adoption of them is largely driven by economic constraints. These findings illustrate there is an unmet demand for improved groundnuts varieties in Malawi and suggests that adoption rates can be increased by making farmers aware of the technologies and addressing constraints such as lack of access to credit.

Lambrecht et al. (2013) analyze the adoption of mineral fertilizer by modelling farmers' decision-making process in South Kivu province in the Democratic Republic of the Congo. The study finds that access to financial capital positively affect adoption, conditional on tryout. This significant positive effect of access to income on adoption shows that capital constraints matter for continued adoption of mineral fertilizer especially in a context of widespread poverty. This is consistent with previous studies by Liverpool and Winter-Nelson (2010), Feder and Umali, 1993; and Dercon and Christaensen (2011) which shows that household income and access to credit are key determinants of fertilizer adoption in Africa.

Finally, Diiro (2013) utilizes two waves of data collected in 2005/06 and 2009/10 to analyze the effects of off-farm income on adoption of improved maize seed and productivity of maize farming in Uganda. Using a random effects Tobit model, the results show a positive and significant effect of household off-farm income on adoption. For every one percent increase in income of the household, the probability of adopting improved maize varieties increase by 0.4 percent. The study also found that increases in income not only increase adoption but also increase the intensity of adoption. Among the adopters, a one percent increase in off-farm income resulted in a 0.3 percent increase in the area planted with improved maize seed. These results show that, like credit, off-farm income may increase adoption by providing farmers with capital for purchasing the improved maize varieties.

### Human capital

Empirical studies show mixed results regarding the effects of education on adoption of agricultural technologies. On the one hand, farmers' education level is known to positively influence their decision to adopt an improved technology. A number of studies (Mignouna *et al*., 2011; Lavison, 2013) show that farmers with high level of education are able to receive, process and use information relevant to the adoption of improved technologies. Ajewole (2010) analyzes the socio-economic factors influencing farmers' response to adoption and use intensity of commercially available organic fertilizer in Nigeria. Results from this study show that number of years spent in formal education positively influence adoption decisions. On the other hand, Kinunthia and Mabaya (2017) found that farmers' education negatively influences adoption of improved new seeds varieties in Tanzania. Using panel datasets based on the Living Standards Measurement Study-Integrated Surveys on Agriculture for the period 2005 to 2015, the study looks at the determinants of technology adoption and how this affects farmers' welfare in Uganda and Tanzania. The determinants of both countries include farm size, contact with government agencies, number of improved seed varieties and credit. However, there are determinants that are specific for each country. For example, education is found to negatively influence adoption of improved new seeds varieties in Tanzania only.

Another aspect of human capital is farmers' social networks. In a Malawian study, Beaman *et al.* (2018) notes that social relationships serve as a way through which farmers can learn and adopt new technologies. In their study, the authors used predictions from a threshold model of diffusion to target information to key individuals within villages to induce farmers to adopt pit planting. The results from this study show that many farmers need to learn from multiple sources before they can adopt the technology. Furthermore, they show it is possible to identify individuals in the network who can trigger the diffusion process. Therefore, with proper targeting, technology diffusion can be enhanced thereby increasing adoption of improved technologies.

**Incentives and external support**

Several studies conducted in southern Malawi (Amadu et al. 2020; Ward et al. 2018; Bell et al. 2018; and Holden et al. 2018) show that adoption of climate smart agriculture (CSA) technologies is constrained by a lack of financial incentives and external support. Amadu et al. (2020) developed a typology of farm level CSA practices to analyze CSA adoption using primary household survey data from a large USAID funded CSA project. They found that participation in the project strongly influenced adoption of all the CSA practices. This shows the importance of external support in adoption of resource intensive CSA practices among rural households.

Bell et al. (2018) highlights the importance of incentives in the adoption of CSA practices. The study was aimed at understanding how farmers decide to adopt specific practices of conservation agriculture (CA) in southern Malawi. The authors found that neighbors (peer effect) and incentives are the key determinants of adoption of CA in their sample. The use of dual agglomeration payments whereby farmers receive two payments if both their neighbors adopt CA was found to crowd-in peer effects. This implies that in the absence of peer effect, incentives are important to encourage initial adoption in the region. In addition, the study notes that decisions made in the presence of an incentive are structurally different than those made without incentives.

**Risks associated with technology adoption**

Risk plays an important role in agricultural production decision (Ramsey et al., 2016). Most smallholder farmers are risk-averse and so tend to adopt technologies that have lower risks (Meinzen-Dick et al., 2004). There is an extensive literature on how risk and uncertainty influences smallholder farmers' production and marketing decision dating back to the debate between Schultz (1964) and (Lipton, 1968). Schultz argued that farmers in developing countries are 'poor but efficient' while Lipton proposed that they adopt a 'survival algorithm' with severe aversion to downside risk. The latter can be modeled in terms of a maximin decision criterion, while the former implies farmers are risk neutral and maximize profits subject to resource constraints. Subsequent work by Antle (1983) and Anderson, Dillon and Hardarker (1977), and Rousmasset (1976) have shown how farmers' production and investment decisions can be modeled by attaching probability distributions for yields, prices and other stochastic variables to the outcomes of farmers' decisions. It is therefore important to incorporate risk in modeling the farmer's decision-making process because risk aversion operates like a friction to production and causes suboptimal levels of input use. This argument can also be extended to farmers making suboptimal decisions concerning uptake of seemingly beneficial technologies because of their risk aversion.

Mukasa (2018) investigates the role of production risks in adoption decisions of inorganic fertilizer, improved seeds, and pesticides by smallholder farmers in Tanzania and Uganda using nationally representative LSMS-ISA data. His findings suggest that adoption decisions are affected not only by expected production returns and volatility but also by the likelihood of exposure to downside risks and extreme output values. While expected mean production is one of the most important driver of technology adoption in both countries, production variance negatively also impacts the probability of adopting each of the three technologies. Furthermore, Tanzanian and Uganda smallholder farmers also weigh-up the risk of crop failure when making their input adoption decision. This suggests (i) an approach that considers the higher moments of production variable is important when examining smallholder farmers' adoption decision; and (ii) the variability of input costs is also one of the key factors discouraging input adoption, Flexible input voucher-based subsidies that adjust to variations in market prices might therefore have more impact on inorganic fertilizer and improved seed adoption than fixed subsidies per unit of input purchased.

Similarly, Juma et al. (2010) examined the effects of production risk on adoption of soil conserving and conditioning inputs (such as manure, chemical fertilizer and terraces) in Kenya. The authors adopted Antle's method of moments to generate the three moments of maize production which were later used as covariates in a pseudo-fixed effect probit model to examine their effects on farmers' adoption decisions. Higher probability of crop failure (downside risk) encouraged farmers to undertake terracing and apply manure more intensively but lowers the adoption and intensity of inorganic fertilizer use. So, the authors demonstrated that despite evidence of technology improving production, poor farm households in risky production environment are not willing to adopt them because there is high probability of yield variability and crop failure. This shows that productivity gains alone will not lead risk-averse smallholder farmers to adopt new technologies.

In an experimental study in South Africa, Brick and Visser (2015) founds that risk-averse individuals were more likely to opt into traditional agriculture (reflected as traditional seeds in the experiment) and were less likely to use modern farming inputs that require financing (e.g., high-yield varieties). The results of their framed experimented indicated that the provision of weather index insurance is not a panacea for promoting technology diffusion to small-scale farmers. A related randomized study in Ghana by Karlan *et al.* (2012) found that, while rainfall insurance results in both greater investments in agriculture and riskier production choices, the effect of the cash grant is relatively small.

In Malawi, Giné and Yang (2009) ran a randomized field experiment with approximately 800 maize and groundnut farmers in central Malawi to assess whether provision of insurance facilitates the uptake of loans to purchase high yielding seeds. Half the farmers in the sample were offered a loan without insurance, while the remaining farmers were offered loans bundled with rainfall insurance. While farmer's take-up of the basic loan without insurance was 33 percent take-up of the loan bundled with insurance was paradoxically lower by 13 percentage points. The authors suggest that the limited liability clause in the loan contract acted as *de facto* insurance to farmers. Take-up of the insured loan for improved seeds was also correlated with income, wealth and level of education.

Mapemba et al. (2019) looks at farmers' risk perceptions of conservation agriculture (CA) in Malawi. In this study, farmers were asked about their perceptions of crop losses due to waterlogging, pests, and drought if they adopted the three components of CA i.e. zero tillage, mulching and intercropping. Very few farmers perceive increased risk of crop damage due to waterlogging, pests and drought by practicing the individual components of CA. For example, introducing a new crop as an intercrop introduces pests to the field. Furthermore, farmers growing crops in termite prone plots may perceive mulching as being especially risky, as leaving residues in the field may increase termite pressure resulting in considerable crop damages. The study noted that decisions to adopt CA components are unique to individual farmers. Thus, farmers adopt CA components that respond to their characteristics and that of their farms.

Marketing risk is also potentially important. Although many Malawian farmers are net buyers rather than sellers of food crops (SAOS et al., 2008), high price variability exposes them to marketing risks that may bias them towards more inward-oriented production decisions. A series of studies have shown that double and triple hurdle models, which first model farmers' decision to participate in the market, and then how they buy and sell, is a useful way to model smallholder farmer marketing behavior, although it does not explicitly account for risk adversion in their marketing decisions (Burke et al. 2015; Ballemare and Barrett. 2006; Akter and Fatema. 2011).

## Conclusion

This paper has reviewed relevant literature on the factors that influence agriculture technology adoption in sub-Saharan Africa, with a special focus on Malawi. As seen from the results of the focus group discussions, farmers' perception of the technology plays a big role in its adoption.

The review highlights the importance of technology awareness, financial and human capital, incentives and risk in agricultural production decisions: Awareness of agriculture technologies encourages their adoption. However, various studies have found that awareness does not always translate into their adoption; Access to financial capital positively affects adoption, while increases in income not only increase adoption but also increase the intensity of adoption. Off-farm income may therefore increase adoption by providing farmers with capital for purchasing improved farm inputs; Farmers tend to learn from multiple sources before they adopt a new technology, making farmers' education an important factor in their decision to adopt it. Adoption is also affected by the availability of incentives which are important in encouraging initial adoption. Other factors that encourage farmers to adopt technologies include access to credit, off-farm income and farmers' social networks.

Risk is a major determinant when it comes to adoption of new technologies. Farmers' aversion to risks explains their technology adoption behavior. New technologies imply subjective and objective risks, such as uncertain yields with unfamiliar technologies and weather variability. Thus, lack of adoption or slow adoption of technologies should be expected when risks are high.

Finally, it should be noted that the determinants of adoption vary by technology. These include determinants like education and age, which have a positive effect on adoption of some technologies and a negative effect on the adoption of other technologies. It is therefore important to develop a comprehensive understanding of all the factors that help or constrain the adoption of new technologies. Policy makers and technology innovators should pay greater attention to the needs of farmers and their ability to adopt in order to develop technologies that will suit them.

## ABOUT THE AUTHOR

**Cynthia Kazembe** is a Research and Communications s with IFPRI Malawi.

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1201 Eye Street, NW, Washington, DC 20005 USA | T. +1-202-862-5600 | F. +1-202-862-5606 | Email: ifpri@cgiar.org | www.ifpri.org | www.ifpri.info