

**The Neglect of Marginalized Farmers in the Innovation-Decision Process: Precision Agriculture Adoption Attributes for Smallholder Farmers**

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## **Introduction and Theoretical Framework**

Precision agriculture (PA) adoption is a solution to food security (Mourhir et al., 2017). PA is a management strategy that enables farmers to use spatial and temporal data to improve production efficiency and quality, sustainability of agricultural practice, and cost minimization (Paustian & Theuvsen, 2017). However, some PA technologies were adopted fast, while others have lagged (Lowenberg-DeBoer & Erickson, 2019). PA adoption in marginalized smallholders is an important issue for global poverty reduction. The majority of the global small farms, if defined by land size, are in Asia and Africa (Lowder et al., 2014). They are the largest category of employment and small business group among the poor (Gatzweiler & Von Braun, 2016). However, poor people are willing to use and accept technologies that bring well-being (Rahman et al., 2017).

The lack of information is a barrier to adoption, and potential adopters can communicate with each other (Rogers, 2003, Strong, 2012; Wynn et al., 2013). The agricultural extension system plays an important role in providing PA information to producers. Kanter et al. (2019) reported adoption in smallholder farmer of PA technologies are due to the lack of extension services and information dissemination. Lee et al. (2021) found the absence of professional development for extension officers understanding of promoting PA adoption with farmers.

## **Purpose and Objectives**

The purpose of this study was to understand PA adoption strategies to assist agricultural extension systems develop strategies to improve PA smallholder farmer adoption. Specifically, the objectives were:

1. Identify the strategies for PA adoption by smallholder farmers.
2. Provide future research directions for agricultural extension systems to better provide strategies for PA adoption by smallholder farmers.

## **Methodology**

This study implemented a case study methodology to focus on a contemporary phenomenon in real life, in which boundaries between phenomenon and context are not clear (Yin 2009). This study analyzed the global search trends by using Google Trends with the search terms precision agriculture, smart agriculture, precision farming, smart farming, and climate-smart agriculture, and found that in the past 10 years, the search hotspots are in Asia and Africa, which are also the regions with the highest number of smallholder farmers in the world. Therefore, two studies, Xie et al. (2021), a seven-year study of smallholder farmers accessing and sharing the benefits of digital farming in China; and, Onyango et al. (2019), a study of PA practices to improve smallholder farmers' productivity using systematic reviews in Sub-Saharan Africa (SSA), are used as case studies in this study. To better depict the impact of PA on smallholder farmers globally, this study also incorporated Rotz et al.'s (2019) study on how to transform agricultural technologies in a way that supports the marginalized farmers in North America. Three studies found to be helpful in addressing question concerning the impact of PA on smallholders that requires more in-depth scholarly attention.

## **Result and Conclusions**

A lack of literature exists respective to marginalized smallholder farmer adoption of PA. There were three main categories of PA strategies used by smallholder farmers in both developed and developing countries gathered from the case study.

#### *PA information accessibility*

In developing countries, smallholder farmers received PA information indirectly. Formal and informal educational channels should be recognized and communicated to smallholder farmers to improve PA adoption (Kendall et al., 2021). Onyango et al. (2019) found there had been limited information on the use of PA offered to smallholder farmers in SSA. Besides, the government's recommendation on technologies does not recognize that there are differences between farms or regions. Xie et al. (2021) identified that PA information was not directly perceived by smallholder farmers; instead, they realized the use of PA by the outsourcing service. On the opposite, in the developed country like Canada, Rotz et al. (2019) indicated that smallholders could get PA information through the internet or PA providers directly. However, the problems smallholder farmers face was the increasingly economically oppressed by agri-tech companies, agri-food, and retail giants in the food system. This oppression may be exacerbated with the rise of agricultural data sharing.

#### *Production efficiency*

Xie et al. (2021) indicated that smallholder farmers could be involved in an organization (e.g., cooperatives) to increase their land operation efficiency in China. Onyango et al. (2019) summarized that smallholder farmers increased productivity by exploring local means and resources available to them in SSA. Establishing a local farmer organization seems to be a more practical solution for smallholder farmers in developing countries (Xie et al., 2021). In developed countries, the situation is just the opposite. Rotz et al. (2019) reported that many farmers sought to build and design equipment and sensor systems themselves through technologies because smallholder farmers would be able to control the end-product to reach the quality they preferred.

#### *Production cost reduction*

PA applications were targeted to lower production costs mainly on resources input (e.g., fertilizers) without considering labor costs in the developing countries. In contrast, PA technologies targeted overall costs included labor costs mainly in the developed country. Rotz et al. (2019) reported rising land costs had forced smallholder farmers to adopt technologies to reduce labor costs, especially displacing migrant laborers. PA smallholder farmers use of fertilizer applications was examined with Nigerian farmers (Jellason et al., 2021).

### **Recommendations and Educational Importance**

More global agricultural extension inquiries are needed to better understand smallholder farmer adoption of innovations to ensure they are not neglected in the innovation-decision process (Rogers, 2003). International agricultural extension practitioners should consider information accessibility, production efficiency, and production cost reduction adoption characteristics of smallholder farmers when developing PA technology promotion policies. Findings provide clarity that extension practitioners should be aware that there are various strategies can be used to deliver PA adoption to smallholder farmers, especially in the smallholder farmers of different context. Smallholder farmers are willing to adopt PA (Rahman et al., 2017), but need to acquire adequate information. To increase global food security under the multiplicity of changing climate and market variability requires the adoption of proven PA technologies to meet these extraordinary challenges (Olsovsky et al., 2021).

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