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An empirical analysis of the use of agricultural mobile applications among smallholder farmers in Myanmar

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Authors' Biography

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So Pyay is a currently doing her PhD at the University of Melbourne. Her thesis focuses on farmers decision making on fertiliser use and the acceptance of agricultural mobile apps to assist with fertiliser application in the context of a developing country, Myanmar. The study acts as a feasibility study with in-depth participation by farmers and develops a framework for a mobile based tool which is accepted by the smallholder farmers. She has previously worked as a researcher (social scientist) at the International Rice Research Institute (IRRI). She has experience in agricultural R&D in a developing country context, conducting survey and analysis.

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ABSTRACT

Mobile phone applications (apps) designed to assist smallholder farmers improve decision making have been revolutionizing the agriculture sector. These apps offer solutions to farmer information needs by providing weather information, crop market trends, pest and disease damage identification, and advice on pesticide and fertilizer use. They also facilitate interaction with fellow farmers, extension workers and other stakeholders in the value chain who are interested in information exchange. Much previous research has investigated the contribution of mobile apps to agricultural production. This study explored the agricultural mobile apps available in Myanmar, analyzed factors affecting their use and assessed the potential for farm-based decision support. Our findings indicate that when introducing mobile-based tools, focus should be given to younger, more educated farmers growing more specialized crops. The main constraints to adopt agricultural apps are lack of access to smartphone and/or internet (63%) and lack of digital knowledge (20%). However, smallholder farmers in Myanmar were optimistic and positive towards agricultural apps for effective utilization. We also found that majority of the surveyed farmers were familiar with information received through Facebook groups. Incorporating useful information and functions from an agricultural mobile app to a Facebook Page could have a more useful and sustainable impact.

Key words: mobile application; smallholder farmers; decision making; Myanmar

1. INTRODUCTION

In agriculture, access to relevant and timely information remains crucial for farmers. Farmers' access to up-to-date information such as weather, availability and market prices of farm inputs, and knowledge about innovative farm technologies can enhance farming productivity (Aldosari et al., 2017). With improvements in Information and Communication Technology (ICT), there is an increasing access to useful communication tools to help information delivery (Obong et al., 2018).

ICT tools such as mobile phones, in particular, are now an important resource to distribute information with potential to reach many farmers across rural settings (Santosham and Lindsey, 2015). Baumüller (2015) found that mobile phones are useful in providing timely information as well as the ability to store the information when farmers are selling their produce. Impacts on agricultural extension service delivery, including the amount, quality and speed of delivery, have improved significantly with mobile phone interventions (Fu and Akter, 2016). The benefits to farmers have been through greater knowledge and awareness of new information about agricultural practices. Furuholt and Matotay (2011) found that better access to market information that came with the use of mobile phones led to increased opportunities and reduced risks for rural farmers. A study based on data from 81 countries by Lio and Liu (2006) suggested that overall agricultural productivity has increased with the use of modern ICTs, which includes mobile phones and the internet. They found that adoption levels and the returns in developed countries were higher than those for developing countries, suggesting that increased use of ICTs could boost agricultural productivity in developing countries. According to Sanga et al. (2016) mobile phones and agricultural mobile apps can resolve deficiencies in agricultural extension service delivery systems when expanding outreach to remote areas.

Various agricultural mobile applications (apps) have been developed to provide farmers with information on weather (including flood and drought warnings), daily crop market trends and prices, pest and disease identification and advice on fertilizer use (Gichamba and Lukandu, 2012; Qiang et al., 2012; Romani et al., 2015; Woodill and Udell, 2012). Mobile apps are software programs that can operate on smartphones and tablets (Serrano et al., 2013). Daily weather updates and seasonal weather forecast are available to farmers through apps, which can help decisions about sowing, fertilizer and pesticide applications, and harvesting (Caine, 2015). In this paper, the term "agricultural mobile apps" is used to describe any mobile-based app that targets the needs of the agricultural sector and its stakeholders.

Mobile apps have become a preferred way of information dissemination compared to SMS texts with the widespread availability of smartphones (Kaske et al., 2018). In most cases, access to relevant information has a positive effect on farmers' decision-making ability (Taragola and Lierde, 2010) and facilitates interaction with fellow farmers, extension workers and other actors through exchange of information (Narine et al., 2019). Agricultural mobile apps such as Agrowdata (USA), Agrivi (Europe), Cocoalink (Ghana), Green Way (Myanmar), and The Agronomist's Diary (Russia) have been reported as useful to farmers (Meirmanova, 2019). Prior to 2011 only a few apps were widespread and financially self-sustainable, and the support for agricultural development was limited (World Bank, 2011). A study by Costopoulou et al. (2016) observed that the supply of agricultural mobile apps is still in its infancy because they have low ratings in reviews, indicating that they do not meet agricultural stakeholders' requirements. It has also been found that despite various initiatives for farm information and knowledge transfer using mobile apps, the outcomes are not satisfactory because of the poor use of these apps (Barakabitze et al., 2017; Khan et al., 2010; Patel, 2016; Qiang et al., 2012). There is a need to explore the factors linked with the use of agricultural mobile apps.

1.1 Agricultural mobile apps in Myanmar

The agricultural sector in Myanmar plays a vital role in the country's economy, contributing 38% of the country's GDP, accounting for 25-30% of total export earnings and employing more than 60% of the labor force (World Bank, 2017). However, the agricultural extension services are weak and under resourced (Haggblade et al., 2013) and practice a "traditional extension approach" focusing on individual contacts mainly with "progressive farmers" who are generally resourceful and easiest to reach. Many other smallholder farmers have limited and inadequate information about improved technology such as good quality seeds and fertilizers, crop management and farming techniques (Cho, 2013; Oo and Ando, 2012; Win et al., 2018).

In Myanmar, smallholder farmers dominate the agricultural sector with 80% of the farmers each owning less than 5 ha of land (Kyaw et al., 2018). For the purpose of this study, the term "smallholder farmers" is used for farmers who not only possess relatively small plots of land but are generally less well-resourced than commercial-scale farmers, practice farming as a main livelihood activity, depend mainly on family labor and/or may hire workers, and are often vulnerable in the supply chain (Ethical Trading Initiative, 2005). Hence, it is important that these smallholder farmers have easy access to information in a timely manner to improve their productivity.

Mobile phone usage in developing countries, such as Myanmar, is also expanding at a rapid pace. According to Telenor (2018), Myanmar was one of the world's fourth fastest growing telecommunication markets with mobile phone ownership estimated to be 80% of the total population. Internet used has also increased from 1% in 2001 to more than 30% in 2018 (McLaughlin, 2018). This provides opportunities for smallholder farmers in using mobile phones to obtain information in support of farm decision making and rural development (Chhachhar and Hassan, 2013). There are five agricultural mobile apps currently available in Myanmar.

The Green Way Agri-Livestock App is an agricultural and livestock app designed for use by farmers and others in the agricultural sector. The app includes information on farming practices, livestock management techniques, weather forecasts, daily crop market trends and prices, and contains a question and answer section where agricultural technicians can provide farmers with effective solutions to farmers' problems. The app creates linkages between farmers, agronomists and Department of Agriculture (DoA) extension officers to provide information for more than 60 crops. However, the app can only be used where internet connection is accessible. According to the official Greenway app website (http://www.en.greenwaymyanmar.org/) there were 100,588 active farmer users in 2019, of which 17% were women farmers and there were 2,873 technicians.

The Ooredoo Site Pyo has been developed by Ooredoo, one of the leading mobile operators in Myanmar (Ling et al., 2015). In March 2016, Ooredoo launched an agricultural smartphone app called Site Pyo, meaning “Cultivation” (GSMA, 2017) providing valuable information for Myanmar farmers about increasing crop yields. Ooredoo Site Pyo app is free to download and does not require internet connection, making it attractive to farmers and other users. It provides information on seed quality control, land preparation, fertilizer and water management, weed control, pests and diseases guidance, and harvesting and storage. It also provides weekly weather forecasts and sends out emergency alerts. The app is designed to be used in both Myanmar and English languages. According to a case study conducted by GSMA (2017), among farmers using the app 81% reported at least one type of on-farm decision changed, 64% changed pest and disease control practices and 31% changed harvesting or post-harvest practices. In their study, 44% of users reported the mobile phone as one of the main sources of information leading to changes in farm practices. However, there were no significant effects of the Site Pyo app on productivity or income levels. The app is only available for use with Ooredoo SIM card, which was a promotional strategy of the mobile operator.

The Golden Paddy app, also known as “Shwe Thee Nhan” in Myanmar, is a free web and mobile app developed by Impact Terra, an agricultural technology social enterprise which provides digital services to farmers (www.impactterra.com/golden-paddy). Like other agricultural apps, it provides weather forecasts and best farming practices with recent agricultural news. It also provides information on input and product prices and information about sellers and financial institutions. The service can be used offline and some aspects are offered through messages which direct to other functionalities.

The Htwet Toe app is another mobile app providing agricultural information to farmers. Htwet Toe means “higher yield” and is designed to help farmers increase their productivity and improve crop quality. It was developed by Village Link where a leading Myanmar agricultural cooperative, Myanma Awba Group, is a major stakeholder. Myanma Awba is also a well-known distributor of fertilizers and seeds throughout the country (Stads and Kam, 2007). Like the Green Way app, this app serves as a platform to connect with agricultural professionals, to ask questions and upload pictures through a live chat function. The app has been funded by the Dutch government to include more features such as yield predictions, seasonal weather forecasts and site-specific recommendations to support farmer decision making (Awba, 2018).

The Plant Protection (PP) mobile app has been developed by the Plant Protection Division of the Myanmar DoA. The app provides information specific to pest and disease management to promote the effective and safe use of pesticides on agricultural products. It contains information on integrated pest management for 25 crops, 187 insects and pests, 137 plant diseases, 30 different weed types and 12 rodents, as well as other useful information on different pesticides and use (www.ppdmyanmar.org/how-to-use-plant-protection-pp-mobile-application/).

All the apps require Android mobile phones and most of them require access to the internet which can incur some cost for the farmers, although the cost of downloading the app is free. The long-term sustainability of the apps can also be an issue as most of the apps are funded by individual projects. A list of the features in these apps is provided in Appendix Table A1. Features available in the agricultural mobile apps in Myanmar are summarized in Figure 1. The main uses are provision of information and means of communication for farmers with other interested parties.

Apart from apps designed to provide agricultural information, social media platforms such as Facebook have become very popular among participants in the agricultural value chain (farmers, input suppliers, retailers, and agricultural extension staff) as a place to interact and discuss agricultural and farming topics. For example, Myanma Awba, the largest manufacturer and distributor of agricultural technology such as fertilizers and seeds in Myanmar, hosts weekly discussions related to crop fertilizer management among Myanmar farmers. Currently the Myanma Awba Page has over 1.5M Facebook followers and has become an interactive forum for lively debates, solving farming related issues as well as a platform for exchanging knowledge and networking among industry stakeholders and farmers.

1.2 Research Objective

Studies focusing on mobile phone applications and use in agriculture have been undertaken in many countries (Aker and Fafchamps, 2013; Aldosari et al., 2017; Brugger, 2011; Costopoulou et al., 2016; Meirmanova, 2019; Misaki et al., 2018; Patel, 2016; Qiang et al., 2012). However, in Myanmar very little literature relates to perceptions and use of ICTs and no study has considered factors related to the use and adoption of mobile apps in the Myanmar agricultural sector. Given the low uptake of decision support tools/apps by farmers throughout the world (Kerr, 2004; McCown, 2002), this paper provides valuable context for discussing farmer perceptions and what factors need to be considered in developing and scaling up mobile applications. The present study considered the following research objectives:

1. Assess the smallholder farmers' use and perception of these agricultural mobile apps; and

2. Identify the socio-economic characteristics affecting the use of agricultural mobile apps by smallholder farmers in Myanmar.

1.3 Research Hypothesis

In this study, we hypothesized that;

1) Socio-economic factors are important for the use of agricultural mobile apps; and
2) Different socio-economic factors may have a causal relationship with the use of agricultural mobile apps.

The hypotheses were anchored around the key research questions of the socio-economic characteristics of smallholder farmers in Myanmar and how they influence the use of agricultural mobile apps.

The paper is structured as follows. In Section 2 we describe the methods of the study including the study area, data collection process, empirical modelling used for measuring the determinants of agricultural mobile apps and the explanatory variables used in the model. Section 3 presents the results and discussion followed by conclusions and recommendations in Section 4 and implications of research in Section 5.

2. METHODS

2.1 Study Area

The study area was the southern margin of the Central Dry Zone and Upper Bago Region of central Myanmar. This study was part of a project (ACIAR, 2016) assessing soil and crop fertility management for cereal crops with objectives to study smallholder fertilizer decisions and investigate the use of decision support tools to improve household incomes and local food security of small-scale farmers and their families. Project field trial sites were established in the Townships of Tatkon, Zeyarthiri and Taungoo (Figure 2). The present study was focused on the population of smallholders in these Townships surrounding the trial sites.

2.2 Data Collection

A household survey was conducted by interviewing 600 farmers from May to July 2018 in the Townships of Tatkon, Zeyarthiri and Taungoo in the Central Dry Zone of Myanmar Farquharson et al. (2019). A stratified systematic sampling technique (Cochran 1977) was used to randomly select the farmers across these Townships. Grids of 1000m x 1000m surrounding each trial site were overlaid within each Township. The purpose of the grid was to generate villages that would provide diverse contextual settings. Ten villages that fell within each grid and containing the highest population of farmers were selected from each township (total 30 villages). A ratio of 8:2 for male and female farmers were selected based on the male: female population ratio in the study area to investigate gender differences in access to mobile technology (Table 1).

Village farmer population lists were obtained from each Village Leader, who was consulted prior to the survey interviews. The first farmer to be interviewed was randomly selected to reduce the bias of household selection. If the farmer was not available at the time of the interview, or declined to participate, the next farmer on the list was selected. The selected farmers were contacted a day in advance and notified of the estimated time and place of the interview, which was either at the chief farmer's house or at Knowledge Transfer Centers. The criteria for respondent farmers included farmers who:

- Were the head of the household or household member who led the farm work;
- Were actively cultivating land either as a landowner or land tenant; and
- Expressed availability and willingness to participate in the survey.

A survey questionnaire was developed and structured to understand farmers' perceptions of agricultural mobile apps in aiding farm decision making and information sharing. Questions related to household demographics, farmland area, crop areas and types, information of farmers' access to mobile phones (smartphones), utilization and challenges. This was transcribed into the CommCare® mobile data collection app (Dimagi 2017; Ziegler 2017). Four agricultural graduates from Yezin Agricultural University (YAU) were hired as casual workers. They were trained and given access to the questionnaire for data collection.

A pilot survey (Lancaster et al. 2004) was conducted to test the flow and format of the questionnaire. Information on mobile use, knowledge and decisions were collected. GPS coordinates were recorded allowing measurement of the distance from individual farmer fields to the nearest market. Distance to market through the local road network was determined using the 'Distance to Nearest Hub' network analysis function in QGIS 2.18 (http://www.qgis.org). Nominal centers of farmer field polygons were the source points and destinations were the locations of the respective local markets in each Township. Farmer fields and market locations were connected by a road layer shapefile obtained from OpenStreetMap (https://www.openstreetmap.org) which was verified and corrected with reference to the researcher's ground knowledge and Google Earth images prior to the network analysis.

2.3 Empirical modelling of factors affecting the adoption of agricultural mobile apps

Binary and Multinomial Choice Models have been used to measure the adoption of technologies among farming communities (Khan et al., 2020; Mittal et al., 2010; Rahman and Fadol, 2013). In this study, the Probit regression model (Greene, 2003) was employed to consider factors relating to adoption of agricultural mobile apps. The dependent variable was binary, taking on values of zero or one if the farmer had not or had adopted a mobile phone app (Aldrich and Nelson, 1984). Previous studies have used Probit models to distinguish the factors influencing the decisions to adopt new technology (Adesina, 1996; Makokha et al., 2001). The Probit model is a statistical probability model having two categories in the dependent variable and based on the cumulative normal probability distribution (Liao, 1994). Based on Hübler and Hartje (2016) and Ma et al (2018), the decision to access smartphones and use of agricultural mobile app was modelled using a random utility framework as specified in models explaining smartphones and mobile phone apps. In this study, we assigned a numerical value 1 if the farmer was a user of any of the agricultural mobile apps, otherwise a value 0 was assigned.

Let A_i denote the difference between the utility from using an agricultural mobile app (A_{ia}) and the utility from not using (A_{in}) such that an individual *i* will choose to use the mobile app if $A_i^* = A_{ia} - A_{in} > 0$. Since the utilities cannot be observed directly, they are expressed as a function of observable components in the latent variable model below.

$$A_i^* = \beta Z_i + \mu_i \text{ with } A_i^* = 1 \text{ if } A_i^* > 0, 0 \text{ otherwise,}$$

where A_i is dummy variable for app use (1 for users, 0 for non-users); β is a vector of parameters to be estimated; Z_i is a vector of exogenous explanatory variables; and μ_i is the random error term, which is assumed to be normally distributed with a zero mean.

2.3.1 Description of explanatory variables used in the model

Factors influencing the use and adoption of mobile phones for agricultural information dissemination have been widely studied (Aldosari et al., 2017; Khan et al., 2020; Obong et al., 2018). In the absence of significant studies directly looking into the factors affecting mobile apps, we used mobile phones as a proxy to use apps. Socio-economic factors such as age, level of education and income were found to be crucial in adopting mobile phones for farm information (Dissanayeke and Wanigasundera, 2017; Mittal et al., 2010). Farmers of different age groups use a mobile phone to share and access various types of agricultural information, but this trend is more prevalent among younger farmers, most of whom are more educated (Rahman and Fadol, 2013). Jain and Hundal (2007) reported that the age group for highest use of mobile phones was 20 - 40 years and Richardson et al. (2000) found that people under 30 years of age were able to access wider services and functions of mobile phones. Islam and Grönlund (2011) observed that people with no formal literacy were still able to perform basic operations with phones and gain access to mobile interfaces by using signs and symbols on the phone. Nyamba and Mlozi (2012) found that the education level of farmers had no influence on the use of mobile phones for communication of agricultural information. On the other hand, Hartje (2017) and Ma et al. (2018) argued that education level contributed to mobile phone use as some functions with mobile phones and apps require a certain level of education or literacy for effective and efficient utilization. Income level influenced usage rate and access to information (Kalba, 2008). Similarly, Cole and Fernando (2012) revealed a positive relation between the benefits of mobile applications with wealth and education level of farmers. Blumenstock and Eagle (2010) found that mobile phone users are considerably wealthier, better educated, and more predominantly male than the general population. Farmers producing perishable products such as banana in rural areas were found to benefit from the mobile phone expansion compared to farmers closer to markets (Muto and Yamano, 2009).

Considering the literature (Hartje, 2017; Ma et al., 2018; Mittal et al., 2010), the availability of data and the context of the study, eight explanatory variables were selected for the current research (Table 2). These variables were age, education, gender, wealth indicating variables (crop income, off-farm income, degree of mechanization, and number of crops) and distance of field to market. The dependent variable was assumed to be directly influenced by the independent variables, either positively or negatively. The *a priori* expectations of how each explanatory variable might influence the use of agricultural mobile apps are shown in Table 3.

3. RESULTS AND DISCUSSIONS

3.1 Socio-demographic characteristics of respondents

The average values of the key variables used in the analysis are shown in Table 4. The mean age of farmers was 50 years which shows that most belonged to the middle and older aged groups. This was consistent with the findings from Harper et al. (2017), who reported the ageing of Myanmar’s farmer population and raised concerns over decline in young farmers, availability of labor and the sustainability of farming with an older farming population. Most of the farmers had only primary level education, the mean period of schooling was five years. Regarding income, average total crop income per season was USD 277 and average total off-farm income per month was USD 253. Off-farm activities include working for private or public firms, casual work, trading, transport business and owning a shop. The number of crops grown per household varied from a single crop up to a maximum of nine crops. With respect to mechanization, on average farmers owned two types of farming machinery such as sprayers and water pumps. Average distance from field to market was 11 kilometers.

3.2 Mobile phone ownership

Mobile phone ownership in the study area was high, 71% of farmers in the study area owned a mobile phone. Many farmers were also keeping up to date with technology, with 62% owning smartphones. Smartphones are defined here as mobile phones with internet access, as distinct from older (basic) mobile phones without internet access (Chang et al., 2009). However, the use of internet among the surveyed farmers remain relatively low at 38%. A higher proportion of male farmers were using mobile internet (41%) compared to female farmers (26%). The GSMA (2018) report also suggested that although there is an increase in the number of women owning mobile phones over the past few years, a significant gender gap remains in the usage of transformational services such as mobile internet. These results are given in Appendix Table A2. Among the farmers who use internet, 75% rated the internet connectivity as *“good”* in the study areas (Appendix Table A3).

3.3 Farmer perceptions on use of agricultural mobile apps for farm decision making

Farmer perceptions towards technology have a strong influence on adoption behavior (Meijer et al., 2015). Of the 600 farmers interviewed, only 22% were aware of agricultural mobile apps which could assist in farm decision making and 21% of farmers used them (Table 5). However, 73% of farmers responded that they are keen to follow the recommendations from mobile apps.

Among the farmers already using agricultural mobile apps, 85% stated that the mobile apps were useful and 70% would highly recommend other farmers to use apps, as additional information is useful for farm decision making. One farmer mentioned that mobile phones are very handy to receive market information easily and he no longer needed to travel to market for price information. Aker (2008) found that mobile phones reduced price dispersion across markets and lowered the variation in intra-annual price. Another farmer reported the importance of weather apps in forecasting weather to improve decisions on cultivation, harvesting and other management practices. Among the farmers who have not used any agricultural mobile apps, 60% would like to use the apps if there is good internet connectivity.

A majority of farmers (54%) were familiar with information received through Facebook groups while the remainder were aware of mobile apps such as Green Way (10%), Ooredoo Site Pyo (13%), Golden Paddy (14%) and others (Htwet Toe, PP 36%) (Appendix Table A4). Farmers considered “Facebook” as an agricultural mobile app where they can obtain agricultural information. Whitten-Woodring et al. (2020) reported that Facebook has the potential to influence decisions and has become a primary source of news in Myanmar. In

Myanmar, Facebook is also used as a search engine and has become an essential app on every phone, with many people using it on a daily basis (Leong, 2017). The Myanma Awba Facebook Page has over 1.5M followers and has become an interactive platform for exchanging knowledge and sharing information among farmers and stakeholders. Meirmanova (2019) described the Green Way app as a game-changer among agricultural apps in Myanmar for providing various up-to-date information to farmers including weather and climate change, crop prices and fertilizer/pesticide advice.

Although most farmers stated that mobile apps are useful, the intensity of mobile apps usage varied among farmers. From the study, 56% of the farmers used apps once a month, 20% only once a week, 19% every day and the remaining 6% rarely used the app (Appendix Table A5). Farmers attitude towards mobile applications were also addressed using a five-point scale *(1=highly unfavorable, 5=highly favorable)* (Albaum, 1997; Boone and Boone, 2012). The overall attitude towards mobile apps in the study area was positive with 56% being favorable towards apps as a means of obtaining information to improve farm decision making.

3.4 Constraints to adopt agricultural mobile phone apps

Of those respondents not keen to use apps, the main constraints included not having access to smartphone and/or internet (63%), lack of digital knowledge (20%), not interested (10%), money (4%) and age (3%) (Appendix Table A6). The cost of internet connection in Myanmar is US$1 per GB, and the daily minimum wage is US$3.60 per hour. One farmer reported that “*mobile apps are only useful when the person knows how to use it otherwise it takes up extra space in the phone*”. Farmers mentioned that training would be beneficial to effectively utilize the apps. Regarding issues in using the apps, lack of images, poor lighting when reading information on small screens especially in bright field conditions, and apps providing too many recommendations with the lack of site-specific information were mentioned by most farmers.

3.5 Determinants of agricultural mobile app use

A Probit model was tested to determine the factors associated with agricultural mobile app use. The estimated parameters and the marginal effects of the Probit model for app use are presented in Table 6 and more detail is provided in Appendix Tables A7 and A8. The marginal effects refers to the average individual (Leeper, 2018). The likelihood ratio test with the chi-square value of 118 with 8 degrees of freedom and an associated p-value of less than 0.001 indicates the model is said to fit the data significantly better than the more restrictive intercept only model. The factors which were positively significant for farmers' use of agricultural mobile apps included education level and degree of mechanization, while farmers' age, number of crops and market distance were negatively significant (Table 6).

Age: Age is an important factor affecting behavior and decision making. The age of a farmer represents knowledge and experience in the field (Harper et al., 2017). From these results, farmer age was highly significant in relation to the use of agricultural mobile apps. The negative value of the coefficient indicates a decrease in use of agricultural mobile apps with the increase in age of the farmer. The marginal effect suggests that older farmers have a lesser tendency (1.9% times) of using agricultural mobile apps compared to younger farmers (Ma et al., 2018).

Roy et al. (2018) suggested that older farmers tend to follow traditional knowledge and beliefs and do not rely on new ICTs. These results are consistent with Khan et al. (2020) and Rose et al. (2016) who also found a negative relationship between age and use of mobile tools.

Education: Many studies have reported that the education level of farmers plays an important role in the use of ICTs such as mobile phones (Hartje, 2017; Ma et al., 2018). The positive and statistically significant coefficient of the education variable was expected and this study indicates that marginally better educated farmers are 3.98% times more likely to use agricultural mobile apps. Islam and Grönlund (2011) observed that people with no formal literacy are still able to perform basic operations with phones such as calling, whereas in the case of agricultural mobile apps, where more functions are available, higher literacy is necessary. From this result, it can be concluded that better-educated individuals may be more knowledgeable and better skilled and, hence, more likely to adopt this type of ICT.

Gender: There was no significance difference in gender on the use of agricultural mobile apps, as the mobile phone use among female farmers has been increasing. The stereotypical view of women having a negative attitude towards technology use has changed across time (Buccheri et al., 2011). Sainz et al. (2016) also stated that males did not show a more positive attitude towards technology use than females.

Crop income and off-farm income: There were no significant effects for agricultural mobile app used associated with crop income or off-farm income. This is mainly because farmers already own a phone and most agricultural mobile apps are free to download. In Myanmar, “Zapya” app which is a free peer-to-peer file sharing app via Bluetooth, is widely used for app distribution and installation (Said et al., 2018). However, it can be argued some agricultural mobile apps require the use of internet and affordability can be an issue.

Number of crops: The negative significance for number of crops indicates that more specialized farmers tends to use agricultural mobile apps. Apps focusing on a single crop that are simple and easy to use are known to attract more users (Mir and Quadri, 2009; Rose et al., 2016). Hence it is better for apps to start simple and focused by specializing in fewer crops than to commence with complex services providing recommendations for many crops.

Degree of mechanization: The degree of mechanization has a positive and significant effect suggesting that better mechanized farmers are 3.6% more likely to use agricultural mobile apps.

Distance: Market distance was found to be negatively significant suggesting that farmers further away from markets are less likely to use apps. The distance to the market can also be regarded as a proxy for the strength of internet connection as broadband coverage is mainly available in public locations.

4. CONCLUSIONS AND RECOMMENDATIONS

Access to quick and reliable information will help improve farm decisions. Agricultural mobile apps can convey necessary information to farmers in a timely manner. However, low uptake by farmers has been a challenge. In our study, we found that only 21% of the farmers were currently using agricultural mobile apps with a majority (56%) only opening them once a month. The main reasons for such low use of mobile apps for farm decision making were lack of awareness and knowledge, along with the high cost of internet. However, farmers are optimistic about agricultural mobile apps with over 70% of the farmers willing to use them. The positive attitude towards agricultural mobile apps and negative usage level of most respondents in the study seems a challenge in introducing mobile-based agricultural support tools.

On the other hand, we found that a majority of surveyed farmers (54%) were familiar with information received through Facebook groups. Since Facebook has established trust and the majority of the smallholder farmers are using it, incorporating useful information and functions from an agricultural mobile app to a Facebook Page would have a more useful and sustainable impact, at the same time eliminating the issues such as lack of awareness, lack of use, and long term servicing and sustainability.

Specific policies are possible to improve accessibility and affordability of internet regardless of socio-economic status and expanding broadband coverage with targeted public sector support. Mobile operators in Myanmar have rolled out packages such as “Myanmar’s Cheapest Facebook Pack”, “Unlimited Facebook”, “Social Pack Promo” which provide access to apps such as Facebook at a relatively low cost. Hence, delivering agricultural information through Facebook can also solve the constraint of expensive internet. In addition, a Facebook app would be available in local language and therefore reach a greater number of people.

In order to analyze the socioeconomic factors, we employed the binary Probit model to a large set of survey data. Our empirical results demonstrated that socio-economic factors such as age (negatively), education (positively), degree of mechanization (positively), number of crops (negatively) and market distance (negatively) were found to affect the use of agricultural mobile apps. Hence, it is suggested that when introducing mobile-based agricultural support tools, focus should be given to younger, educated farmers with more specialized crops as early adopters. Education appears to be a barrier to large scale adoption of apps by farmers as most of these farmers only have primary level education. There is a higher proportion of female farmers without any formal education compared to males. Literacy intervention programs and training to ensure that more women farmers are literate and to provide digital skills for adapting and utilizing ICT remain important. Studies on farm typology can be useful to further distinguish specific farmer groups to target training and participation in the use as such group will have better possibilities and potential for adoption than others.

However, these empirical results reported should be considered in the light of some limitations in the explanatory variables used and including mobile phone use-related attributes (skills of using mobile phone, digital literacy, duration of phone ownership) would be useful. Moreover, the scope of the study is limited to smallholder farmers and the results may not apply to large scale commercial farmers.

5. IMPLICATIONS FOR RESEARCH

This study provides valuable context for discussion of important factors needing to be considered in developing and scaling up agricultural mobile apps to assist farmers with day-to-day farm decisions. This information is important as many agricultural mobile apps have been developed to date and are continuing to be developed for decision support to farmers, when these apps are not widely being utilized by farmers. The study suggests although the current usage remains low, farmers in Myanmar have a positive attitude towards agricultural mobile apps to obtain information. When introducing agricultural mobile apps younger, more educated farmers growing more specialized crops should be targeted. Having reviewed the existing agricultural mobile apps and the information system platforms in Myanmar, we found that Facebook was widely used by farmers. Incorporating features and functions into existing social media platform such as Facebook should be promoted and encouraged as it may have a more useful and sustainable impact compared to setting up new mobile apps and DSTs which may not last long without a 3rd party input to maintain the app. We expect that our study results will benefit international, private and public sector organizations in developing and scaling up agricultural mobile apps to be effectively utilized by farmers.

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FIGURE LEGEND/TABLE CAPTION

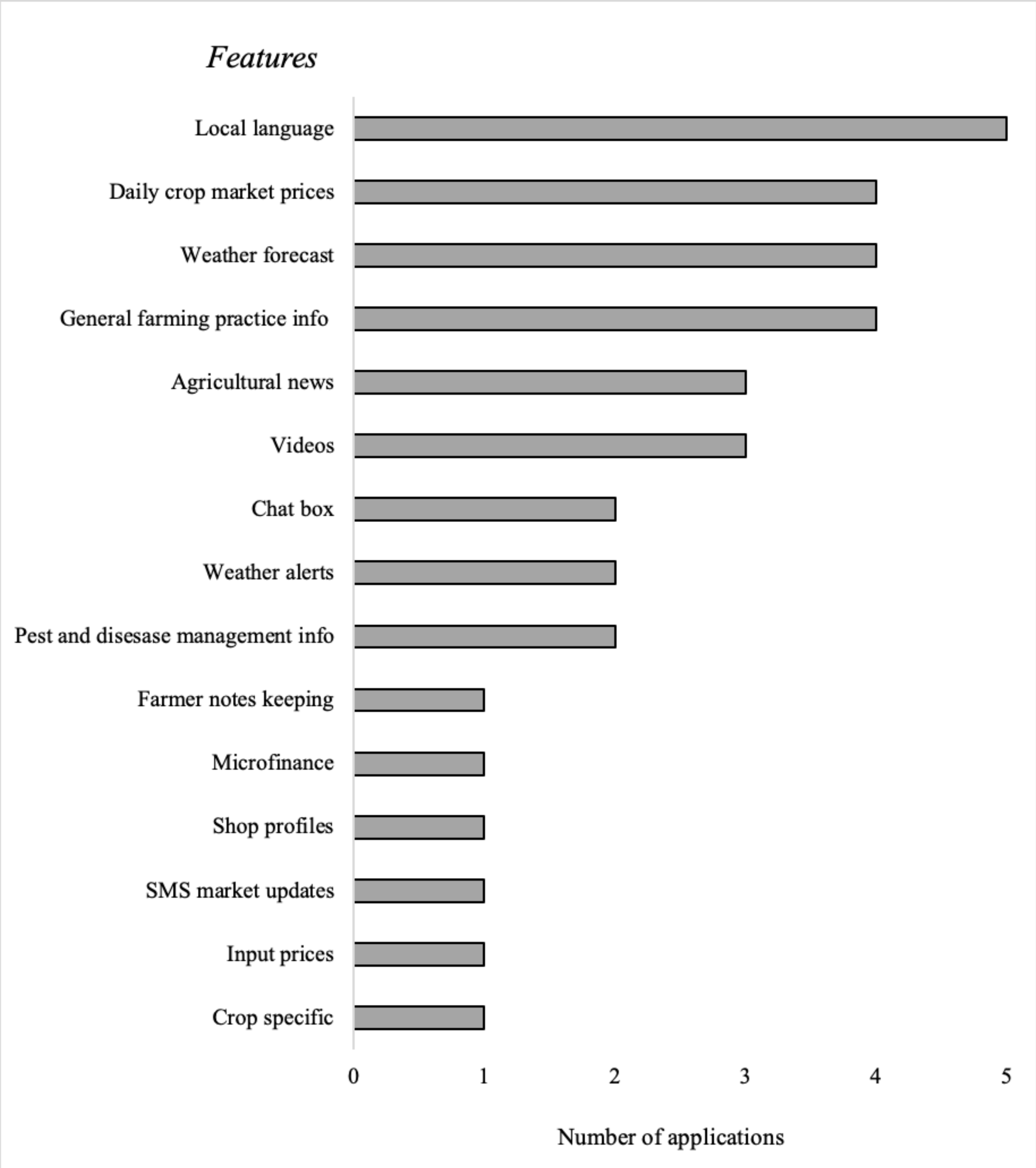
FIGURES

Figure 1: Features available in the agricultural mobile apps in Myanmar

Figure 2: Study area and Townships in central Myanmar

TABLES

APPENDIX



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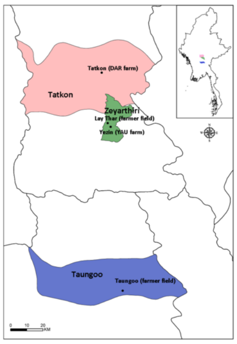

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Table 1: Sample size determination

	Tatkon	*Zeyarthiri*	*Taungoo*	*Total*
Township populations of farmers	14,879	7,399 Male 5,832 Female 1,562	12,536	34,814
Total farmers within the grid	4,300	3,261	2,388	9,949
Sample Size	258	196	146	600
Male sample size	208	149	112	469
Female sample size	50	47	34	131

Table 2: Description of the explanatory variables in the analysis

Variables	Description	Definition
Dependent variable		
Use of agri-mobile apps	Dummy, 1=user, 0=non-user	The use of agricultural mobile apps by farmers in Myanmar
Explanatory variables		
Age	Continuous (Years)	Age of the respondent in years
Education	Continuous (Years)	Education of the respondent categorized as No formal education 0 Primary school 1 to 5 years Middle school 6 to 9 years High school 10 to 11 years Tertiary education 12 to 16 years Graduate 17 years or >
Gender	1=female, 0=male	Sex of the respondent; male or female
Crop income	Continuous (USD/season)	Total income received from cultivated crops per season in MMK[a] converted to USD
Off-farm income	Continuous (USD/month)	Total income received by the family per year from non-farm related activities in MMK[a] converted to USD
Number of crops	Continuous (Number)	Total number of crops grown by the respondent within a year
Degree of mechanization	Continuous (Number)	Sum of all types of machinery such as tractors, threshers, sprayers and water pumps at household level
Distance	Continuous (Km)	Distance from the individual farmers field to the nearest market measured in km

[a] MMK = Myanmar Kyats, we used the exchange rate of 1USD = 1300 MMK when the survey was carried out

Table 3: Expected signs of explanatory variables on the use of agricultural mobile apps

Variables	Sign (+/-)	Rationale
Age	(-)	Older farmer less likely to use agricultural mobile apps
Education	(+)	Farmers with higher education levels more likely to use agricultural mobile apps
Gender	(+)	Men more likely to use agricultural mobile apps
Crop income	(+)	Farmer with higher crop income more likely to use agricultural mobile apps
Off-farm income	(±)	Farmers with higher off-farm income can more afford to use agricultural mobile apps Alternatively, they might not have time to utilize with 2 or more jobs
Number of crops	(±)	Farmers cultivating more crops more likely to use agricultural mobile apps if they require more information. Alternatively, farmers specializing on a fewer crops likely to use more apps
Degree of mechanization	(+)	Farmers possessing mechanization more likely to use agricultural mobile apps
Distance	(-)	Farmers further away from market more likely to use the app as they have less opportunity for extension staff to visit and less access to information

Table 4: Respondent socio-demographic characteristics (n=600)

Variables	Mean	SD	Minimum	Maximum
Human capital indicators				
- Age (years)	50	13	18	86
- Education (years)	5	3	0	17
Wealth and income indicators				
- Crop income (USD/season)	277	289	0	2,215
- Off-farm income (USD/month)	253	639	0	3,195
- Number of crops	2	1	1	9
- Degree of mechanization	2	2	0	12
Access to market indicators				
- *Distance (km)*	11	5	2	21

Table 5: Farmer perceptions about agricultural mobile apps

	Question	Response (%)
All *(n=600)*	Awareness of mobile apps that can help farm decisions	22
	Use of agricultural mobile app	21
	Keen to follow the recommendations from mobile apps	73
Users *(n=123)*	Are the apps useful?	85
	Any issues with apps?	19
	Recommend to other farmers?	70
Non-user *(n=477)*	Want to start using?	60

Table 6: Probit model results of factors affecting app use

Variables	Coefficient	P >|z|	Marginal Effect
Age	-5.773e-02	2.13e-12 ***	-1.9549e-02***
Education	1.159e-01	5.07e-05 ***	3.9242e-02 ***
Gender	2.635e-01	0.19366	8.5034e-02
Crop income	1.542e-08	0.43771	5.2199e-09
Off-farm income	3.890e-04	0.32005	1.3173e-04
Number of crops	-1.390e-01	0.03530 *	-4.7071e-02*
Degree of mechanization	1.084e-01	0.03791 *	3.6703e-02*
Market Distance	-2.965e-05	0.07114 *	-1.0041e-05*
Constant	1.462e+00	0.00389 **	
Summary statistics			
Chi square value X^2	118		
d.f.	8		
p-value	1.040446e-21		
Observations	372		

* statistically significant at 5%, ** statistically significant at 1%, *** statistically significant at 0.1%