Adoption of Digital Agro-Advisory Services Among Smallholder Farmers: Patterns of the Innovation-Decision Process

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Various digital agricultural advisory services have been developed to effectively exchange agriculture related information, skill and knowledge with the farmers. However, innovation and readiness of such technology does not guarantee that it will be adopted by the farmers. This study focuses on understanding farmers' adoption of digital agro-advisory while exploring factors that influence the patterns of adoption and non-adoption. A mixed-method research was conducted with 50 farmers of Kageshwori Manohara Municipality of Bagmati province, Nepal, who were also the users of mobile-based agriculture application, namely GeoKrishi. The innovation-decision process of the diffusion innovation theory was used as an analytical lens for data interpretation. The study findings show that there were three categories of farmers in terms of their adoption decision i.e., passive rejecters, active rejecters and active adopters. These decisions were influenced by factors such as digital literacy, farmer's agricultural needs, communication channel, farmer's social network, socio-economic and household dynamics and technological cluster. The study further argues that such innovations need to incorporate information that not just aligns with the needs of any farmers but should also be based on the local context.

Keywords: Agriculture extension, agro-advisory, digital farming, ICT for agriculture, smallholder farmer

Introduction

Agricultural extension is regarded as the bridge connecting farmers with evidence-based research and education which allows for the transfer of information, skills and new technologies (Ghimire et al., 2021). Extension services thus facilitates farmers to make informed decisions, leading to improved productivity, income, livelihood (Oakley & Garforth, 1985), and more recently towards sustainable agriculture (Allahyari & Sadeghzadeh, 2020). Along with public institutions, different NGOs/INGOs, private companies, and service providers have been extending such services to the farmers, making it more pluralistic in approach (Babu & Sah, 2019; Blum et al., 2020; Ghimire et al., 2021). However, extension services have not been effective in reaching out to the farmers due to unmet actual needs (Fuglie et al., 2020), lack of accessibility and infrastructural limitations (Bell, 2015), limited capacity and management problems (Birner & Anderson, 2007; Bell, 2015). Development of advanced information and communication technology (ICT) has changed the modus operandi for almost every sector of work including agricultural extension (Davis & Alex, 2020). Along with traditional ICT tools such as radio, television and newspaper, new mediums such as internet, videos, messages, mobile applications or 'apps' have been developed and has become an integral means of communication between farmers and other stakeholders for advisory services (Davis & Alex, 2020; Christoplos, 2010).

Such ICT tools could be a means to improve information accessibility to farmers and forge stronger connections between all the actors involved (Bell, 2015). Despite limited infrastructural development, there is an exponential use of mobile-phones in developing countries (Aker et al., 2016). Mobile-phone is one of the most common ICT devices used in Nepal, with 93 percent of the households having at least one mobile (MoH et al., 2017). In addition, the Digital Framework of 2019 asserts that the mobile

penetration among Nepali population was hundred percent and internet penetration was 63 percent. According to Magar (2020), mobile-phones have the capability of reaching more than 90 percent of the household, as around 90.1 percent rural households possess at least one mobile-phone (MoH et al., 2017). Despite having a hundred percent rate of mobile-phone sets, not every individual owns a mobile phone due to socio-economic barriers.

Several mobile-based applications developed by both public and private service providers have mushroomed in the country. Lately, KrishiGuru, GeoKrishi and SmartKrishi have more than 100,000 downloads. The Agriculture Development Strategy (2015-2035) of Nepal also promotes the role of mobile apps to disseminate agro-advisory. In general, most apps like, SmartKrishi, KrishiGuru, NARC Krishi focus on package of practices, weather and climate forecast, harvesting, storage, news, e-books and expert consultations (Magar, 2020; Thapa et al., 2020; Paudel et al., 2018) and has Nepali language as the primary language. Apart from above mentioned features, some apps like GeoKrishi and KrishiGhar also emphasize location specific advisory (Magar, 2020; Thapa et al., 2020; Paudel et al., 2018). Additionally, agriculture related television programs and radio programs also exist, with some apps that provide guidance on business planning with offline options. However, it is important to understand that availability and accessibility is not the only salient factor that motivates farmers to adopt such apps (Kassem et al., 2020). In terms of using a new technology, when a farmer is aware of new information and has taken interest, it is crucial to evaluate farmers' views and experiences about using such innovation (Oakley & Garforth, 1985). Only when concerned stakeholders understand their viewpoint can they customize such applications according to farmers' need and context, after which adoption could be more likely. Bell (2015) concurs that farmers can diagnose their problems with sufficient expertise, can collect data and price information, can

negotiate directly with the input suppliers, access financial credit, exchange feedback, and use it for record keeping through such mobile services. Similarly, while there are various applications for farmers in Nepal, it is essential to understand what farmers think about such innovation. The main intention of agriculture extension as suggested by Oakley & Garforth (1985) is to work with the farmers, with different needs. Thus, it is necessary that it actually serves farmers needs rather than supplying farmers with new technology just because it is ready to be used (McCampbell et al., 2023; Kassem et al., 2020). It is within this context that the current paper has focused on understanding smallholder farmer's patterns of innovation-decision process on adoption of digital agro-advisory services (DAAS).

Literature Review
History of agriculture extension
The exact date or year as to when agriculture extension was introduced for the first time in the world is not known. Its origin differs from researcher to researcher in terms of year and place. According to Swason & Rajalahti (2010) it was the potato famine that instigated the need of such services in Ireland in 1845. Birkhaeuser et al. (1991) assert that the execution of extension dates back to World War II. Some claim that the universities in the United Kingdom introduced extension for the first time in 1867. Many developing countries had started adopting agriculture extension programs formally after the second world war (Birkhaeuser et al., 1991). In the context of Nepal, agricultural extension was introduced in 1951 under the Ministry of Agriculture and Livestock Development (MoALD) (Dahal et al., 2020; Thapa et al., 2020).

Different approaches are used for agricultural extension such as Technology Transfer Extension model, Participatory Extension Approach, Market Oriented Extension Approach and Non-formal

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education or Extension Approach (Swanson & Rajalahti, 2010). Amidst the agricultural extension models in the world, present approaches in Nepal include of Conventional Educational approach, Pocket Package approach, Projectization approach, Farmer's Group Approach, Farmer's Field School Approach and Partnership Approach (Ghimire et al., 2021;Babu & Sah, 2019; Global Sustainable Research and Development Center, 2018; Sharma, 2014). Most countries are shifting from technology transfer methods towards more participatory, inclusive and market-oriented techniques (Davis, 2020). However, it has not been able to deliver optimally (Paudel et al., 2018). Updated and real-time information does not reach farmers because of inadequate infrastructure such as roads, market centers, transport and lack of proper assessment (Ghimire et al., 2021; Thapa et al., 2020; Dhital, 2017). Its ineffectiveness in delivering quality agro-advisory to the farmers is evident in its low coverage, which is 15 percent, with extension agent to farmers' household ratio being 1:1333 in 2005 (Lamichhane et al., 2022; Paudel et al., 2018) and 1:1399 according to the Agriculture Development Strategy 2015 in Nepal (MoAD, 2015). Diversity in farmers' access to extension services is presented by Berry (2012), whereas, FAO recommended extension to farmer ratio in 2000 was considered to be 1:800 (Owolabi & Yekinni, 2022). As a result, many farmers do not have access to quality extension services.

Concept of ICT for agriculture extension

In traditional extension service, an agent was required to be trained and sent to farmers to disseminate information. With the development of new technologies, radio, television, and the internet were used. According to Aker et al. (2016) and Jensen (2007), mobile-phone is changing the scenario and making information circulation comparatively economical as it lets farmers, extension agents and traders to explore more information without having to travel, allowing farmers to enhance their bargaining power with

the traders or any other actors. Ninety-five percent of the world population has access to mobile broadband networks with eighty-five percent coverage in the developing countries as estimated by ITU (2022). Expanding coverage of mobile-phone usage in developing countries, has led to the transition from conventional ICT mediums such as TV and radio towards more contemporary ICT tools namely computers and mobile-phones (Aker et al., 2016; Bell, 2015). These contemporary ICT tools make exchange of information possible through voice or audio, Short Message Service (SMS), mobile-based applications or 'apps', and also websites (Aker et al., 2016).

Consequently, Veeraraghavan et al. (2007) underline that computers or kiosks as ICT tools for agricultural extension have high maintenance cost, whereas more convenient, and comparatively less costly for the farmers is via mobile-based service like SMS. Similarly, Aker et al. (2016) states that mobile-phones with its low cost of communication has the capacity to bring about tremendous changes in agro-advisory. In addition to market information, the introduction of DAAS such as Avaaj Otalo, a voice application gave smallholder farmers in India direct access to authorized agriculture experts for pest or disease management which decreased their dependence on other farmers and input dealers for such information, leading farmers towards better input decision and increased yield (Cole & Fernando, 2020; Patel et al., 2010). The introduction of smart-mobile apps has provided even more advanced, need-based options to the users where all the required information is accessible in one touch (Sivakumar et al., 2022; Barh & Balakrishnan, 2018).

Traditional ICT instruments such as radio and television have been widely used as agricultural extension tools for technology transfer in Nepal (Magar, 2020). Recently, the Agriculture Information and Training Center (AITC) of the Nepal Government operates the Kisan Call Center and provides SMS services to farmers (Paudel et al., 2018). Similarly, with transformational development

in technology, various mobile-based apps such as SmartKrishi, GeoKrishi (Paudel et al., 2018; Magar, 2020), and many others like KrishiGuru, SuperKrishak, KhetiFarm, HamroKrishi, PokharaKrishi have been developed in the country. Project for Agriculture Commercialization (PACT) and Agriculture Management Information System (AMIS) have been initiated under the Ministry of Agriculture Development (MoAD) and it encourages the use of such applications and is working to improve access for the farmers (Paudel et al., 2018). Nepal Digital Framework 2019 also stresses on improving agriculture related government mobile apps like NARC Krishi app and Bhumi Sushasaan application (MoCIT, 2019).

Challenges and opportunities for Digital Agro-Advisory Services

One of the most prominent barriers that limits an individual's adoption of agriculture advisory is the digital divide (Aker et al., 2016; Keniston & Kumar, 2003). Not every farmer is able to afford a smartphone or have internet access. Even if they could afford it, not everyone will be able to navigate through such applications. Similarly,the primary language used in the app may be a hindrance to many farmers. These factors will widen the gap between people who can and cannot use it. Those who cannot use it will be left behind, when that is not at all the intention of such services. To address such challenges, spoken interface or audio could be an integrated function in the ICT tool for the illiterate farmers to listen to and send a recorded audio in exchange (Medhi et al., 2011).

Nevertheless, ICT tools are expected to minimize gap related to agricultural extension such as lack of proper infrastructure, poor accessibility and low coverage, insufficient technical and communication knowledge and skills (Bell, 2015), through its versatile features and consequently improve people's livelihood (Aker et al., 2016; Bell, 2015). Aker et al. (2016) considers mobile-phones with its low cost of communication to have the capacity to bring about tremendous changes in agro-advisory services. Jensen

(2007), highlights the importance of mobile-phone to get market information which could save time and lead to reduction in price dispersion, decrease in wastage, and increase profit. Additionally, smartphone apps allows two-way communication possible (Gaur & Tiwari, 2022; Sivakumar et al., 2022). On one hand, farmers can attain appropriate information and resolve farm-based problems without complications, receive updated weather forecasts, up-to-date market rates, details on latest technology, knowledge on government policies and schemes, financial services, training and also videos from where they can watch and learn. On the other hand, they can also put forward their confusions and discuss with experts through the application. It is also considered to be cost effective, timely and prompt even in developing countries as compared to spending on hiring, training and mobilizing extension workers (Sivakumar et al., 2022).

While many studies endorse the use of digital agro-extension, it is equally important to assess farmers viewpoint and understand their readiness, needs and its use before its execution in a large scale so that appropriate changes can be made, and such technology is adopted favourably and used sustainably (McCampbell et al., 2023). For instance, McCampbell et al.(2023) studied capability of Rwandan banana farmers to use a phone-based application i.e. 'BxW- App' which was introduced for the prevention and control of banana Xanthomanas Wilt disease (BxW). The study highlighted the gap between availability of technology and capability of users to use it. With only three percent of farmers owning a smartphone, the results maintained the importance of using traditional ICT tools such as radio along with new innovation so that farmers who cannot use the application can still have access and are not left behind. The study provided a crucial insight on the importance of incorporating traditional options along with new technology to create alternative opportunities for the farmers. Sivakumar et al. (2022) evaluated twenty-five different applications operated in India and suggested

the need of incorporating regional language for more inclusivity, improvement on user interface, such as more pictorial illustrations, fixing errors on time, and need to update technological innovations in the agricultural sector more regularly. Such evaluations play an important role as it provides insight on actual user experiences and their needs which can be further improved by app developers, community-based organisations and policy makers. While many authors suggest limitless possibilities that an ICT tool can create to extend agro-advisory services to the farmers, it is also imperative to understand the drawbacks it can bring with it, which needs to be considered while planning to implement such services as made evident by numerous researchers.

Methodology

This study is exploratory in nature as it focuses on understanding the challenges and opportunities that smallholder farmer's face during the process of adopting a new innovation, i.e digital agro-advisory services. Concurrent mixed-method design (Kroll & Neri, 2009; Leavy 2017; Creswell & Clark, 2018) was used as qualitative and quantitative data were simultaneously collected. A structured questionnaire with close-ended and open-ended questions were prepared in Survey CTO – a digital data collection software. Collected data was then cleaned, sorted, and analyzed separately but were triangulated and merged later. Quantitative data was separated in SPSS and excel for descriptive statistics, whereas qualitative data from the survey was transcribed as necessary and coded and analyzed using Nvivo. Use of mobile devices by the participants during the survey was encouraged to assess farmers' digital literacy and confidence. Likewise, pictures and photo query features were also considered to understand farmers' ability to use digital devices. The study has incorporated the Innovation-decision process under diffusion of innovation theory (Rogers, 2003) as an analytical and

theoretical framework to understand farmer's decision-making process of adopting DAAS.

Study Site and Sample

Kageshwori Manohara Municipality located in Kathmandu District of Bagmati Province in Nepal was purposely chosen as the study site because the sampling procedure illustrated the majority of the active users of GeoKrishi app to be in this site (see Table 1). Major agricultural production included paddy, wheat, seasonal and unseasonal vegetables mainly tomato. The total number of households in the municipality is 26,166 and the literacy rate of the area is 96.16 percent (Kageshwori Manohara Municipality, 2022). Out of the total 73,648 registered users in Nepal as of August, 2022, 1136 were registered in Kathmandu, but only 68 users were considered to be active users by GeoKrishi, which is 5.98 percent only. Based on the information provided by GeoKrishi, all active users of Kageshwori Manohara were contacted. However only 23 active users could participate in the study due to their time unavailability, no response while phone call from some, and 2 specifically suggested that they did not use the app anymore.

Table 1: Number of Active Geokrishi Users in Different Municipalities of Kathmandu

Budhanilkantha	1	Gokarneshwor	4	Shankarapur	4
Chandragiri	9	Kageshwori Manohara	31	Kathmandu Metropolitan	8
Dakshinkali	3	Nagarjun	3	Tarakeshwor	5

Source: GeoKrishi, 2023

A total of 50 farmers have been selected based on criterion sampling. It includes 23 active users of GeoKrishi and 27 not active users but those who had attended GeoKrishi training. According to GeoKrishi, active users are those farmers who have used the

application at least 3-4 times a month and have made crop related queries. A total of 96 percent out of the 50 study participants had received GeoKrishi training while the remaining 4 percent had not received any training but were informed about GeoKrishi by their friends. This reflects that all the participants were aware and had knowledge about the mobile app. Criterion, purposive and cluster-based sampling resulted in the selection of the given site.

Innovation-Decision Process: A Theoretical Lens

According to Rogers (2003) the diffusion of innovation is 'a process in which an innovation is communicated through certain channels over time among the members of a social system.' It is basically a course of action for a new idea, practice, or technology to be exchanged through various means (Zhang et al., 2015). In this regard, Rogers (2003) asserts that any innovation is likely to be either accepted or rejected resulting in some kind of externality to a social change. Five stages of the innovation-decision process from the stage of getting knowledge about a new technology to actually confirming their adoption has been proposed. The five stages include Knowledge, Persuasion, Decision, Implementation, and Confirmation. According to the theory, even if an individual knows about a new idea, practice, or a product, and is aware about its advantages, the individuals do not use or adopt it that easily. Various factors influence people's behaviour before considering adoption of an innovation. In this context, the diffusion of innovation theory provides a framework to understand factors that influence adoption of an innovation. The innovation under study is the DAAS. This theory typically focuses on the diffusion of an innovation from top-down approach. However, in this study, the data are presented and analyzed from innovators' side of diffusion as well as farmers' own initiatives to adopt new innovation.

Results

Respondents' Characteristics

Out of the 50 respondents, 42 percent were male and 58 percent were females, aged between 27 to 63 years. All the participants had attained some level of education with the majority of respondents having primary (48 %), SLC/SEE (34 %) and secondary (18 %) level education. All the respondents were involved in agriculture either as a main occupation (86 %) or as a secondary occupation (14 %). Out of which 68 percent were involved in vegetable farming, 4 percent in cereal crop farming only and remaining 28 percent grew both cereals and vegetables. Forty percent of the respondents were engaged in livestock rearing such as goats, chickens, and cows. Out of which slightly less than half of them were doing it for commercial purposes. Fifty-four percent of respondents owned land in Kageshwori which ranged from minimum of 0.6 to 8 ropanis, and 46 percent had ancestral land in their village but were leasing land in Kageshwori for settlement as well as for agricultural purposes. In global comparison, smallholders are mostly considered as those who roughly cultivate around 2 ha of land (Lowder et al., 2021; Shiva, 2016), which means that the study respondents were all smallholder farmers as they owned less than 0.5 ha of agricultural land.

Status of Agricultural Extension

Most frequently used channels for agro-advisory included neighbors (78 %), followed by agro-vet (70 %), digital channels like YouTube (68 %) and agriculture related mobile-based app (68 %). Respondents also used public institutions such as Municipality and Agricultural Knowledge Center, technical extension agents like the Junior Technicians or Junior Technical Assistants (JT/JTA, Agro-vet and Agriculture suppliers), community-based platforms (farmers group and cooperatives), interpersonal networks (family and relatives) and other digital platforms (radio, television, mobile-

phone call, Kisan call center, SMS, Internet search engine, Zoom/Google Meet, and Facebook). Majority had used Municipality (34 %) over the AKC (8 %). Out of those who had received extension services from the Municipality, around 82 percent had received it between 1 to 3 times in the past year, remaining 12 percent received it 4-10 times while another 6 percent accessed it above 10 times. Out of those who had received Municipality service, around 47 percent had also visited the office. Some had visited the Municipality for soil testing, and to get information on training and upcoming distribution of seeds. The ward and its Facebook page was also considered as a source of information on agriculture through which farmers received authorized government notices and information about training and seed distribution. In addition, the NARC office had also provided a few participants with seeds for rice and corn.

Almost all the JT/JTA in the study site were employed by the private sector to extend agro-advisory to the farmers. Other agents included cooperative or agro-vet based JT/JTA, and agriculture suppliers. The most popular technical agents were agro-vets as 70 percent of the respondents received agro-advisory from them, followed by JT/JTA (30 %) and other farm suppliers (18 %). Respondents mostly contracted agrovets when there was disease, pest or insect problem in their farm for diagnosis. Often they would take the sample to get recommendations on appropriate pesticide use. Out of the respondents who had received agro-advisory from agro-vets, 46 percent received it more than 10 times in the past year and 54 percent received it 10 times or less. Few respondents also found it convenient to visit a nearby cooperative rather than commuting far to reach other institutions. Some respondents shared that they could receive information from the cooperative and also share information that they received from other sources like JTA, Municipality and AKC to the cooperative members. Cooperatives often organized training according to the queries and needs shared in cooperative

meetings. Likewise, cooperatives could also call JTAs for the farmers and conduct various training on tomato farming, cucumber farming and soil treatment as requested by cooperative members. Training on mobile applications like GeoKrishi was also conducted through cooperatives. Apart from these sources, labor exchange, also known as parma jane, khetalo, mela jane, saghaune in Kageshwori, was a source of agro-information as it provided some farmers with an opportunity to observe and learn from other farmers.

Figure 1: Use of various agricultural extension channels by farmers (in %)
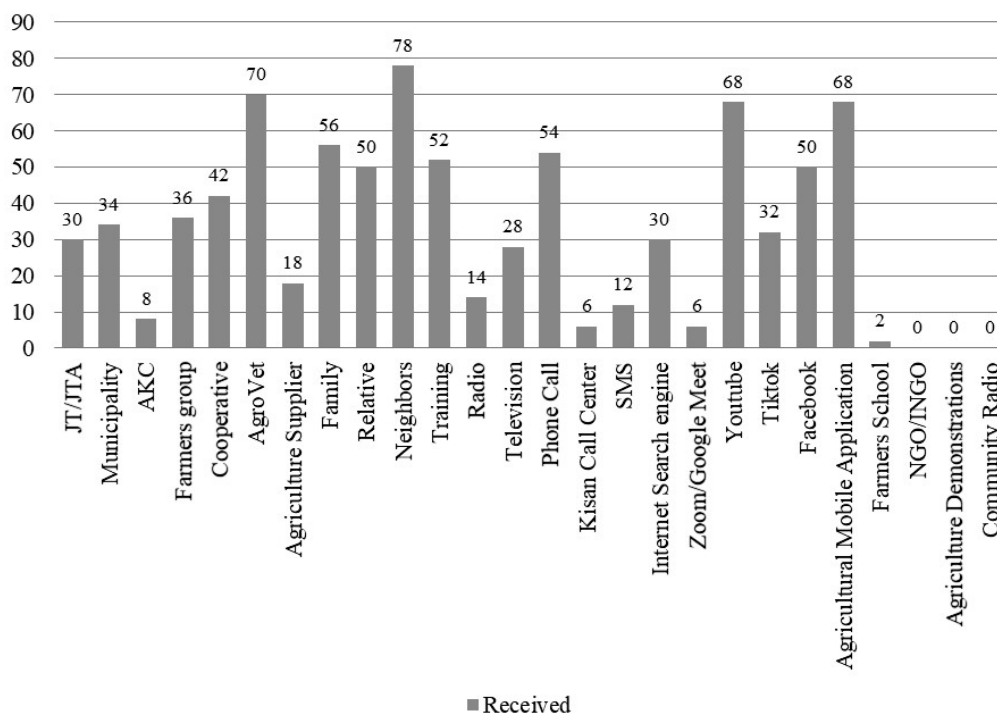
Digital ownership and accessibility

Every household had at least 2 mobile-phones, owned mostly by adult household members. Major function of a mobile-phone was to make phone calls. Apart from that, they also used YouTube, Facebook, TikTok, Viber, WhatsApp, Google, SMS, and agriculture and non-agriculture related applications, news updates, games and business purposes. Some respondents shared

that their children in the household started using mobile-phones to study since Covid-19. Ninety-two percent had a smartphone, whereas 8 percent had a simple phone. The cost of mobile-phones ranged from minimum NRs. 900 to maximum NRs. 69,999. While the majority of respondents bought mobile-phones by themselves, mostly women farmers said that it was their husband who bought the device for them to use (see Figure 2).

Figure 2: Respondent's capacity to buy mobile-phone
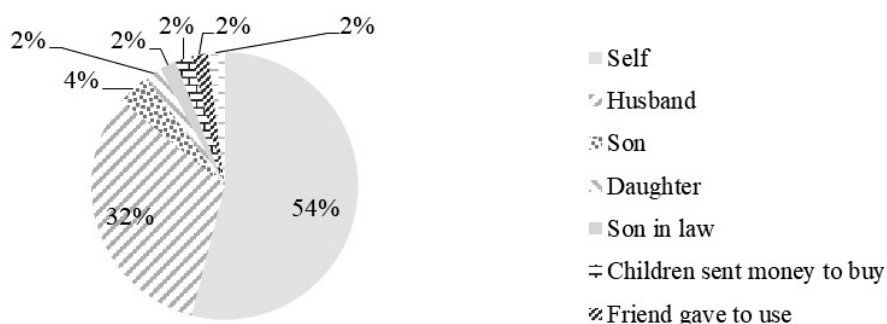
Almost two-third respondents did not share their phone with anyone and considered their phone to be personal, while the rest of the respondents shared it with their spouse, sons and daughters. Seventy percent used Nepal telecom as their mobile network, 12 percent used Ncell and 18 percent used both Nepal telecom and Ncell. Accordingly, 78 percent used wi-fi to use the internet, 20 percent used both wi-fi and mobile data, and the remaining 2 percent used mobile data only.

Use of Digital Platform for Agriculture Extension

Numerous digital platforms provided agro-advisory to the farmers including of conventional mediums such as Radio (14 %), television (28 %), mobile-phone call (54 %), and innovative digital platforms such as Kisan Call Center (6 %), Zoom/Google meet (6 %), SMS (12 %), Internet search engine (30 %), TikTok (32 %), Facebook (50 %), YouTube (68 %), and agriculture related mobile apps (68 %). Almost one-third of the respondents used YouTube and mobile

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apps for 10 or less than 10 times in the past year. Likewise, slightly more than one-third used it more than 10 times in the last year (See Figure 3). Many farmers also called one of the largest agro-market in Nepal – the Kalimati Bazaar to get market price information. Few farmers had also received information on availability of subsidies and seasonal mini-kits from the agriculture section/department of the Municipality, AKC and Ward office, either through phone calls or Facebook posts.

Figure 3: Use of Digital Platforms for Agro-Advisory (In %)
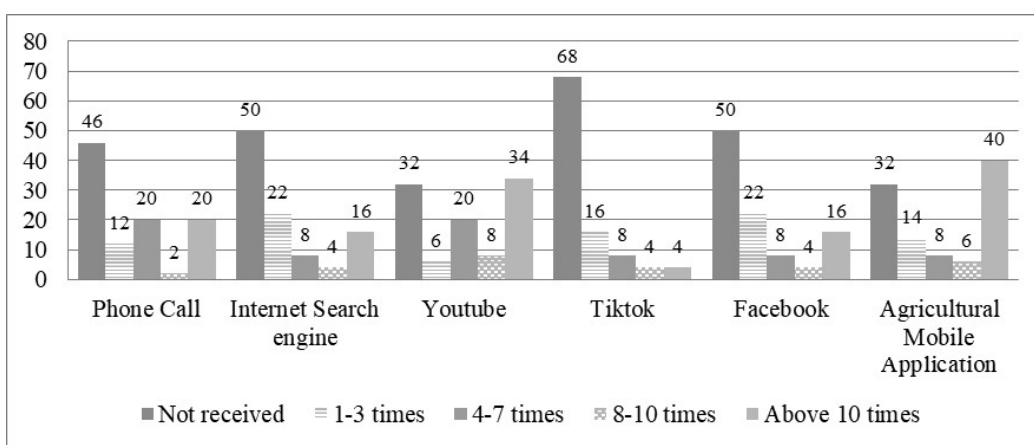
Regarding mobile app use, 76 percent had used GeoKrishi only, 3 percent had used SmartKrishi, and 15 percent had used both GeoKrishi and SmartKrishi, while the remaining had already stopped using such applications. These applications have been in existence in Nepal since 2020 and 2018 respectively. In addition to these two apps, around 6 percent had also used HamroPatro, KrishiChautari and an Indian agriculture app whose name the respondent could not recall. Among the few mobile-based apps that the farmers were using, GeoKrishi was the only service provider that had conducted various training programs through Municipality, Ward, Cooperatives and Farmer's Group. Majority of the respondents suggested that they got to know about the app through farmer's groups (32 %), Municipality (24 %), cooperative (22 %), Facebook (4 %), YouTube (2 %) and

other sources (18 %). Few respondents received the information from 2 sources, including Municipality and either neighbor, Facebook, or farmer's group. Out of the total respondents, 56 percent of GeoKrishi users who had been continuously using the app had used it for a minimum of 8 months to maximum of 3 years since the training. Another 12 percent used it for a minimum of 1-2 days to 2 years after the training and discontinued using it. The remaining 32 percent did not use the app after the training. In order to understand the factors influencing respondents to make such decisions on adoption of an innovation, the data has been further analyzed through Roger's 5 stages of the innovation-decision process (Rogers, 2003).

Discussion

Knowledge Stage

This stage allows individuals to get exposed to the existence of a new innovation and how it functions. During this stage, the communication channel plays a significant role. GeoKrishi customized one-day training to the farmers by networking with the Municipality, Ward, Cooperatives and Farmer's Group as they considered that the authority of these stakeholders would influence the decision of farmers regarding adoption of the app. During the training, farmers were given information about the app, process of downloading the app, how to use the app and various available features on the app (see Table 2).

Table 2: Overview of features available in GeoKrishi

Overview of Features available in GeoKrishi	
Type of crop and livestock information	Yes
Total number of crop	50
Total number of livestock	7
Pre-planting information	Crops Planning (Expected expenditure, Choosing a breed, Crop Production Calendar, Land choice, Soil Testing, Weather Information according to the crop

During planting information	Nursey Information, Land Preparation, Sapling transfer, Crop Care, according to the crop
Harvest information	Crop harvesting (Right time and how to harvest) according to the crop
Post-harvest information	After Harvesting (For Local and Other Market) according to the crop
Pest control and management information	Information on different kind of diseases and insects according to the crop
other farm management operations	Automated Work Calendar, Fertilizer Calculator, Farmers Diary - where a farmer can note pesticides/insecticides or organic fertilizer that they have used. And suggests noting such information will be necessary when they have to get a GAP certification. They can also note their expenditure and manage accordingly,
Weather feature	Yes - Daily and hourly
Text	Yes
Videos	Yes
Audio voice	Yes
Pictures	Yes
Photo sending option	Yes. Can send it to consullt about crop health or animal health with the experts
Call toll free	Not a toll free number but help Desk Phone Number is provided
Expert Consultation	Yes
Connect with other extension providers	Yes
Personal/customized messaging features	Yes
Calculation features	Yes Automated fertilizer calculator according to the crop chosen, expected Income, expenditure and profit according to the land size
Market information	Yes Kalimati market price list for various crops, vegetables and fruits, masala They can also add expected produce
Source of Market information	Yes Kalimati Bazaar
Market buying feature	Yes
Type of products available in buy feature	Yes
Market selling feature	Yes Provided list of market names and their contact number
E-Community meetings	Yes
Agriculture news	Yes
Government agriculture service notice board	Yes
Information on Loan	Yes
Information on Insurance	Yes
Information on importance of farming	Yes
Notifications	Yes
Information on Climate friendly Agriculture	Yes (Added recently)

Source: GeoKrishi application, 2023 (as compiled by authors)

Application features included registering the farm, farm size, market rate for the product, weather information, crop-cycle management practices with the option of auto notification according to the crop chosen, pest and disease management through message, photo query exchange option, and search options. At this point, farmers were communicated about the innovation of the app and its purpose to cater to the needs of

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the farmers. However, awareness about an innovation does not assure that the respondents would adopt it. Various factors play a role and have some level of influence on the favorable or unfavorable perception that individuals make about the innovation which will then convince them to use it (Rogers, 2003). This is evident from the data that shows that some farmers who had not received any training became active users, while many who had received the training did not continue using the app. The channel through which one receives the information about an innovation is crucial as active users who did not receive any training were informally made aware by their neighbors who saw the benefit of using the app and started disseminating the knowledge in their neighborhood. This leads to the second level of the innovation-decision process which is the persuasion stage.

Persuasion Stage

In this stage, respondents form different perceptions about the product and thus move from knowing to feeling, where individuals start forming an attitude and opinion towards the innovation which either encourages or discourages them to try a new product. Out of 96 percent of respondents who had received the training, 44 percent did not form a positive view of the app and thought that the training did not support them to use the app. Farmers asserted that the major reason for them to use the app would be the ability to access information that is relevant to their farm needs. Despite, initial attitude towards the app, many farmers tried the app because they were primarily involved in farming and that they perceived they could get new updated information on agricultural practices. Farmers also assumed that they could learn more and share it with other farmers. Similarly, a handful of farmers started using it to get market price information. Likewise, few farmers thought they could use the app to exchange farm problems like pests or other diseases with the experts through message or photo sharing option

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and also receive proper solutions to it. Apart from these reasons, one participant was also motivated to use it because it would save their time, and another respondent shared they could get relevant agriculture notices through the app.

When a new technology is introduced to an individual, they are uncertain about the risks of using it. So they sometimes seek reassurance from others who have already used it to see if they are on the same page as others and are not the only ones taking the risk (Rogers, 2003). Despite respondents having knowledge and information about the app through initial training, not every respondent felt that the training was the major source of persuasion to use the app. Only about 10 percent of the farmers suggested that attending the training persuaded them to use it, whereas many farmers were further persuaded by their friends, neighbors, cooperatives, and farmer's groups. Formal and informal channels of communication and network created an environment for reaffirming and encouraging the farmers to use the app. The perceptions that farmers developed about the app, after initial trial, backed their decision to either try or not try the app, leading to the decision stage.

Decision Stage

Consequently, after being aware about the app, 68 percent of the respondents decided to try using the app, while 32 percent passively rejected it. Among 32 percent of those who decided not to use the app, few revealed they could not properly remember, recall or understand exactly what was taught during one-day training. Some also suggested that the service providers never followed-up with them, which resulted in further lack of interest. This highlights the significant role that a change agent like service provider can play during the persuasion stage that ultimately results in adopters decision-making (Rogers, 2003). Similarly, few were not aware about having to take their smartphone along

with them for the training which resulted in farmers feeling disconnected during the session. Few respondents did not use the app because they could not read, write or type. Some respondent who had turned auto-notification on during the download, shared how frequent notification pop-ups made him delete the app as most notifications were not relevant to his needs. Likewise, some considered alternative digital mediums such as the internet as a broader search engine to be more applicable to their needs than the given applications. Apart from that, few of the respondents revealed that their children deleted the app to free the space to download games, after which they did not re-download it.

Hence, there were 3 categories of farmers that were identified in this stage according to their adoption decision. First category of farmers are those who decided to passively reject using the app after training (32 %), second category included those who actively rejected it after downloading and using the app for a while (12 %) and third category who adopted the app (56 %). Consequently, to understand how farmers decide to adopt the app, the implementation stage is necessary as Rogers (2003) believed that farmers were deciding mentally on the adoption of such apps till the decision stage but when they start to actually use the app, it leads to the implementation stage of the innovation-decision process.
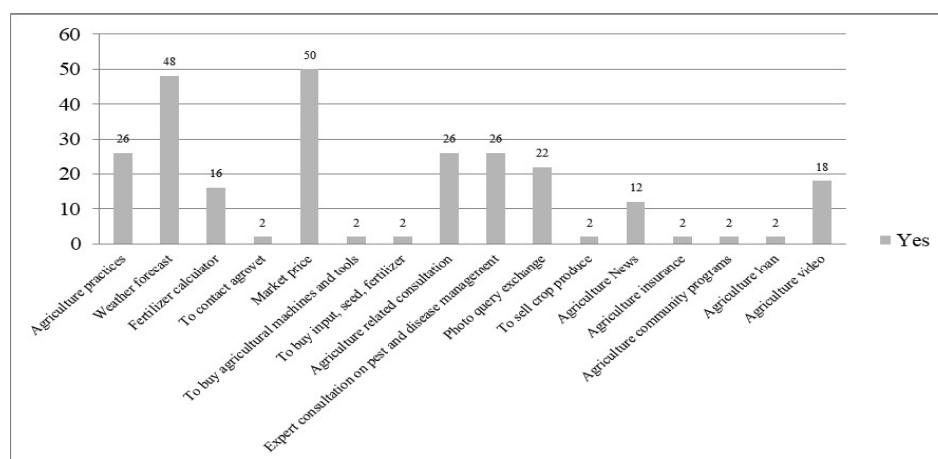
Implementation Stage

Rogers (2003) believed that deciding to adopt any new innovation and actually bringing it to practice are two different things. Putting an innovation to use requires behavior change and active participation in part from the users. This stage also determines whether the innovation is further internalized or is terminated. Respondents who used GeoKrishi, 85 percent used it for less than 30 minutes and 15 percent used it between 30 minutes to 1 hour while nobody has used it for more than an hour. Based on the app use data, 48 percent of respondents had used the app for

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crop information while 4 percent used it to get advice on livestock farming. Respondents who used the app to get information on livestock, all of them sought information on feed management. Other than that, 1 respondent looked for details on the choice of breed, cattle management and market organization and another used it for health and disease management. Similarly, those who used the app for crop or vegetable farming used it mostly for pest and disease management (38 %) followed by crop care (32 %), crop farming cycle such as for sapling transfer (26 %), crop planning (22 %), soil preparation (22 %), nursery management (18 %), crop harvesting (16 %), fertilizer and bag preparation (16 %), seed planting (14 %), crop processing (12 %), seed sowing (12 %), and plant tilling (8 %). Information on both local market and market outside locality was also searched by 18 percent and 10 percent respectively. Additionally, 12 percent of respondents also used it to know about the estimated budget for crop farming. Similarly, when respondents were asked about other features individually, most of them used the app to check market price, weather forecast, agricultural practices, agriculture consultation, pest and disease consultation, and query with experts.

Out of those respondents who used the app to check the market rate, 88 percent had used it more than 20 times since they started using the app and 12 percent had used it less than 15 times. Few also mentioned that they checked the price almost daily through the app. Similarly, in terms of weather forecast, around 80 percent had used it more than 20 times and around 20 percent had used it less than 10 times. Likewise, of those who have used it to consult with experts, around 8 percent have used it more than 10 times and the rest 92 percent have used it less than 20 times, mostly 5 times. Regarding the query exchange through photos, all of them had used it less than 10 times. Farmers took photos of the problem via the app and sent it to the experts, after

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which they would receive a reply within one day but sometimes it also took several days. Some also used the app to watch videos related to agriculture, calculate appropriate amounts of fertilizer, and agricultural news (see Figure 4). Accordingly, the app assisted few to know about agro-vet, how to sell their product, and get information on insurance, loan and community programs.

Figure 4: Mobile application features used by respondents (in %)

Once implementation of an innovation starts, individuals gradually come across different challenges related to its use but they figure out a way to solve such problems as suggested by Rogers (2003). Correspondingly, there were different challenges that the respondents faced while using the app such as difficulty in typing (28 %), skepticism on not being able to register initially (7 %), inability to log in (14 %), and insufficient information or unreliable (25 %) such as inability to get timely information, weather information not according to the area, differences in the name of pesticide that's available in their locality. Few also expressed it would be better if there were refresher training as one day training was not enough. Most of the respondents usually turned to their children for help when they faced difficulties while using the app, while some contacted GeoKrishi as they had their contact number. Apart from that, some of them asked for help from their husband, friend

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or neighbor. During this stage, respondents are now more aware of the challenges that they might encounter and ways to solve the problem faced (Rogers, 2003). While some problems are internal to individuals such as digital literacy, individual need, some are household specific such as shared mobile, inadequate space storage as a result of multiple phone users, other problems are external such as issues of mobile network, electricity, internet connection. Likewise, cost of smartphones, recharge card for mobile data, and internet subscription are few reasons that affect farmers' use of the app. This shows that innovation alone does not lead to adoption, but other interrelated variables which Rogers (2003) refer to as technology clusters also play an important role for its use.

Confirmation Stage

This stage allows individuals to strengthen the decision that they have made earlier by figuring out the advantages and disadvantages of using the app, which comes only after using the innovation. Thus, satisfaction measures among the respondents who have used the mobile app have been used. Around 93 percent out of the 28 (56 %) farmers who used the app reconfirmed that they would use it in the future as well. Some were willing to use it because their main occupation was agriculture and that they seek new and updated information. Some expressed that they would continue because of their need for information on agricultural practices and techniques. Most suggested the importance of getting updated market price, weather information, pest and disease management, and consultation with the agriculture experts. One respondent also shared that he would keep using the app as he can share information learnt from it to other farmers in the cooperative. On the contrary, around 7 percent of those farmers who adopted it reverted their decision of using it as one of them had decided to discontinue farming but would use it again if she gets back to farming. Similarly, another respondent shared that she gets more relevant information from other sources like

YouTube. Interestingly, those who discontinued using the app, also shared that they are willing to use the app again if they get relevant information, and training to use the app again. Out of 28 active users, around 14 percent were more than satisfied, 46 percent were very satisfied, and approximately 39 percent were satisfied with the app. Despite being vocal about the challenges of using the app, and discontinuance of the app, all 28 respondents indicated satisfaction with the app.

Out of 16 respondents who passively rejected the app without trying it, 43.75 percent expressed their keenness to use it in the future if they were given the training again. Some believed that with the changing digital world, it is imperative to move with technological advancements, whereas few were willing to use it to learn new information that they did not already know about. Few who rejected the app, believed that they were only using traditional methods of farming, as a result, the advanced agricultural application as termed by the respondents, would not be relevant to their needs. This reflects that the user's decision to adopt an innovation does not mean they cannot change that decision. To understand respondent's interest in using the app, their willingness to pay to use the app was asked which resulted in 48 percent responding positively to pay for the app as they thought that the app was beneficial.

Conclusion

Digital agro-advisory is considered as an innovation that could change the way farmers had been receiving extension services, from farmer-to-extension ratio, to digitalized source of advisory services and its potential to save time, resources, money, and improve livelihood of farmers through timely market price information, weather forecasts, and crop and livestock management information. Despite various factors that hinder the adoption of agro-advisory, this paper highlights the significant role that service

providers play mainly during the persuasion stage, along with the communication channel used for persuasion, and repeated follow-up sessions to update farmers with the new information provided through the app. Similar to McCampbell et al.(2023), this paper also suggests that multiple approaches of extension should be practiced as pluralistic extension services provide farmers with more choice and decision-making opportunities. Farmers were not only using the conventional extension services but were also gradually being inclined towards the latest digital technologies. Adoption of digital mediums were partially influenced by training as in the case of GeoKrishi, but many farmers also used other e-platforms such as TikTok, YouTube, Facebook and Messenger for exchange of agricultural information. Moreover, for the adoption of the new technologies and innovation in agro-advisory, agents and stakeholders belonging to a trusted source such as the municipality, cooperatives, local agro-vets, neighbours and family members were imperative.

As evident from other studies as well, mostly the farmers who adopted the app owned a smartphone, had an internet connection, were able to read, type and were capable of navigating through the app. They used it to get information according to their agricultural needs which also provided different opportunities for the farmers in planning and managing their farming activities, enhancing their negotiation power with the traders according to the daily market price available in the app and facilitated farmers to exchange their farm queries with the experts without having to travel. However, limitations of the app included inappropriate weather information or name of the pesticide which would hinder effective planning and execution of farming activities. This study further infers that service providers and policy makers should emphasize customized training programs with refresher training and follow-up training to ensure that farmers understand the process

and have the capability of using such innovations. Along with this, it is important that mobile-based applications go hand-in-hand with other channels that are being used in the local area, so that farmers who cannot use digital technologies still have access to agro-advisory. A systems approach to bringing about desirable change needs strategic engagement of various stakeholders throughout the agro-advisory chain and farmers' social network. Furthermore, to enhance adoption of new innovation, the information on the application and expert consultations should strive to be more reliable, timely and local context specific.

To better understand the type of farmers based on their adoption pattern, further empirical evidence on the actual impact, benefit, and drawbacks of using DAAS should be generated. It is also crucial to dig deeper and investigate why there are many passive rejecters that show less interest in the new innovation, if digital agro-advisory is to be prioritized in the future. If policy-makers are to take DAAS seriously for productivity and sustainability of farming as stated in the strategic papers, then it would be fruitful to pursue further studies to understand ways through which DAAS could be made more smallholder farmer-friendly, cost-effective, convenient, and trust-worthy.

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