UTILITY OF AGRICULTURAL MOBILE APPS AMONG INDIAN RURAL FARMERS

BY

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DISSERTATION

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ABSTRACT

Availability and accessibility of accurate and timely information are crucial in any field, including the knowledge-intensive agriculture sector. Yet this is very challenging in developing countries such as India. The problem of information deficiency is particularly pronounced in case of rural, small and marginal farmers. Eighty percent of the Indian farmers are small and marginal farmers; those with landholdings of less than 1.4 hectares. The current channels of accessing this information are through the mass media channels like television and interpersonal channels like extension officers. The effectiveness of these mediums of communication is often constrained by the lack of sufficient resources, skilled staff, and logistical issues. These can be overcome with more efficient utilization of information and communication technologies, including smartphone applications (apps) which can provide farmers with accurate and timely information.

The usage of mobile phone and its applications (apps) is still in development and early stages of adoption in India especially among the rural farming community, and there is a lack of serious studies attempting to understand the adoption of innovation/technology and research on user experience. Hence, the focus of my research is to identify the information needs of farmers and test current agricultural mobile apps intended for Indian crop farmers for usability (ease of use) and functionality (content, features, & information needs). Towards this, I conducted three studies: studying global agricultural apps, evaluating an agricultural app developed for Indian farmers with usability experts in the United States, and finally inspecting the same app with rural farmers in India.

The first study focused on understanding the characteristics of good agricultural mobile applications that are suitable for farmers and the information needs of farmers globally. To address this objective, I examined usability (ease of use) and functionality (content) characteristics of free mobile phone apps intended for global crop farmers. Eleven apps on the Google Play Store were selected for the analysis. The most essential information needs of farmers were selected from agricultural and rural development literature. Results indicated that the most prevalent usability characteristics were app performance, ease of use, navigation, and gestural design. The most frequently observed functionalities were soil management, seed and crop varieties, production and cultivation techniques, fertilizers, pest and disease management, weed control, and weather information.

Using the above findings, an agricultural app titled *NaPanta* was selected to study with usability experts in the United States (study 2) and with rural farmers in India (study 3). The two most common usability inspection methods, cognitive walkthrough and heuristic evaluation, were used to test the app with the experts (n=18) and a semi-structured questionnaire was used to conduct surveys with farmers (n=53). A mixed-method approach was used to collect and analyze the data both qualitatively and quantitatively to get a comprehensive understanding of the findings. Results from study 2 identified 90 usability problems with 25 themes and two categories: (i) general usability problems and (ii) app-specific usability problems. Findings from study 3 indicated 108 concerns grouped into 45 themes and four categories. Along with the two categories from the expert studies, two other categories: (iii) information needs and (iv) app usage and development directions emerged from user studies.

Testing and treating soil to improve fertility, available seed varieties and their sowing times, information and awareness on natural farming methods (less expensive and alternatives to conventional farming), and preventive methods for diseases in crops are among the major information needs for rural farmers. Providing accurate and up-to-date information in a simple and clear local language is the key characteristic for an app. Development of special apps that (i)

exclusively market farmers' produce directly in connection to consumers and (ii) enable the farmers to network with agricultural researchers and fellow farmers are among the top app development directions. Insights from these studies are expected to assist future app developers, agricultural researchers, and government officers to understand and help farmers better.

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their love and encouragement throughout our education, in spite of coming from a very humble background from a remote village in India where getting a doctoral degree especially for a girl is even beyond dreams. My brother is the first person to obtain a PhD degree (he received his PhD in Statistics from University of Michigan, Ann Arbor) and I will be the first woman to get a PhD degree from our village, which speaks volumes about the freedom and trust our parents have invested in us in spite of us being the first-generation college students in our family. I think it to be their achievement!

To Amma, Naanna, Annayya

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CHAPTER 1: INTRODUCTION

This section begins with briefly explaining why studying farmers in India is important, what are their information needs, and existing ways of obtaining that information and problems associated with those current pathways. This will be followed by discussing better and more efficient ways of disseminating information to farmers with the help of emerging smartphone usage in India. The section will end with presenting research questions and objectives of the study followed by a short overview of the dissertation with a brief introduction to each chapter.

Background and Motivation

New methods of providing farmers and other rural stakeholders vital information to increase harvests and improve livelihoods and incomes are frequently created. However, availability and accessibility of this information at the necessary time is challenging in developing countries including India. India is the world's second-largest populous country and agriculture is the main source of livelihood for about 58 percent of Indian population with about 80 percent being rural households with small and marginal landholdings (India Brand Equity Foundation, 2017; World Bank Group, 2018; Food and Agriculture Organization of the United Nations, n.d; U.S. Census Bureau Current Population, n.d.). In other words, small and marginal Indian farmers play a vital role in meeting the growing agricultural and food needs of the nation and the world, in turn, they help to improve the nation's economy.

Agriculture is a knowledge-intensive sector with large and complex information requirements. Crop farmers too have a variety of information needs at every stage of the agricultural life cycle starting from information on soil management, seed varieties, and cultivation techniques to market information and post-harvest management. In addition to these general information needs, farmers also need information and awareness on government schemes and policies, especially during natural disasters. Lack of information on these issues brings many new and difficult challenges to crop farmers in India (Rao, 2007; Goyal, 2010; Babu, et al., 2012; Bachhav, 2012; Nakasone, Torero, & Minten, 2014; Mittal & Mehar, 2016).

The major problem of information deficiency is faced mainly by rural, small, and marginal farmers. With dozens of major languages and thousands of dialects in India, it is very challenging and difficult to reach and communicate with rural Indian residents, especially due to geographic and language barriers (Parikh, et al., 2007; Rajan, 2011; FarmGuide, 2017; Wasan & Jain, 2017; Languages of India, 2019). The current channels of accessing information are through the mass media outlets like limited television and personal networks, such as conversations with government officials. The effectiveness of this communication is often constrained by the lack of sufficient resources, skilled staff, and other logistics. These methods of information dissemination are costly and time-consuming. However, these processes can be improved by leveraging information and communication technologies (ICT) including smartphone applications which can provide farmers with accurate and timely information at a lower price or sometimes at free of cost (Adhiguru, Birthal, & Kumar, 2009; Nakasone, Torero, & Minten, 2014; Rana, & Sontakki, 2017).

Mobile phone usage is rapidly emerging in India, including the proliferation of smartphones and their vast libraries of applications. Recent reports estimate there will be more than 800 million smartphone users by the year 2022 (Aggarwal, Choudhary, & Mehrotra, 2018; Bhattacharya, 2018). This rapid rate of smartphone penetration offers developers opportunities to design third-party applications that expand the functionality and usability of smartphones.

Recently, smartphone applications are increasingly used as platforms for different purposes—from simply sending messages to friends and family to operating secure healthcare information exchange systems between doctors and the communities they serve. Mobile applications play a vital role in agriculture and rural development for their ability to disseminate science-based information to farmers when they need it most (Brugger, 2011; Qiang et al., 2012; Duncombe, 2016; Ahmed et al., 2018).

Many agricultural mobile apps aim to facilitate information exchange between experts and farmers. To date, however, there is a dearth of studies that have analyzed usability (performance and design) and functionality (content and features) of agricultural mobile applications intended for Indian crop farmers. App developers often give more importance to the usability than the functionality of an app even though research has shown that one of the important and motivational factors of using an agricultural app is better and timely information provided to the user (Patel & Patel, 2016; Rana, & Sontakki, 2017). Hence, an efficient and cost-effective way of evaluating an app would be to perform usability analysis with experts such as heuristic evaluation (Nielsen & Molich, 1990) and cognitive walkthrough (Wharton, et al., 1994) and to perform functionality analysis with users (Tselios, Avouris, & Komis, 2008; Sivaji, et al., 2013; Pliakoura, Beligiannis, & Kontogeorgos, 2018). More details on heuristic evaluation and cognitive walkthrough are discussed in Chapter 4. Such an approach would yield results helping app developers to gain understanding from both expert and user perspectives to deliver more usable and user-friendly agricultural mobile apps. This enables local and national governments and scientists to disseminate agricultural information and latest updates to farmers to help them improve and produce profitable agricultural outcomes which would lead to a better way of life.

Objective & Research Questions

The main aim of this study was to understand the usability of agriculture-related smartphone applications from the experts' point of view and the functionality of these apps from the users' perspective. This study will be among the first to perform the functionality test of an agricultural mobile application with the Indian farmers. In doing so, this study will uncover the farmers' major information needs and expectations from an agricultural mobile app. In turn, it will offer great insights to agricultural app developers on how to be more responsive to the farmers' needs.

The questions this study attempted to address include:

1. What differences and/or similarities exist between expert and user views of the selected app?
2. What are rural Indian farmers' major information needs and are there any differences in the information needs identified from the literature to the information needs of participated farmers?
3. What are the current attitudes and values of crop farmers in using smartphones and mobile applications?
    i. What are the major barriers in using smartphones and their applications?
    ii. What are the important attributes of a mobile application to make them more useful for the rural community?

To achieve the objective and to answer the research questions, I conducted three studies: the first study was to understand farmers information needs and app characteristics by reviewing the literature and analyzing global agricultural mobile apps (study 1: chapter 3), the second and the third studies focused on evaluating the selected agricultural app developed for Indian farmers with usability experts in the United States (study 2: chapter 4), and evaluating the same app with rural farmers in India (study 3: chapter 5).

The first study identified the information needs of farmers extracted from agricultural and rural development literature to know the information needs of farmers globally (Herzberg, 2003; Pousttchi & Schurig, 2004; Mittal, Gandhi, & Tripathi, 2010; Elly & Epafra Silayo, 2013; Singh & Kumar, 2017). This study also selected and examined 11 agricultural apps available on the Google Play Store, the largest android app-related platform. I inspected these 11 apps for their general, usability, and functional characteristics with respect to the information needs and app characteristics identified from the literature.

An agricultural app titled *NaPanta* (NaPanta-Agriculture Crop Management App for Farmer - Apps on Google Play, n.d.) developed for Indian crop farmers was selected for the next two studies for its relevance and popularity. In the study with usability experts, the selected app was evaluated using two common usability inspection methods: cognitive walkthrough and heuristic evaluation to analyze the app for its usability and performance. In the study with farmers, the content was evaluated to analyze the app's functionality and utility. For this study, rural farmers from two Telugu speaking states, Andhra Pradesh (AP) and Telangana State (TS) of India were recruited via two agricultural farmer organizations and surveyed the selected app. The survey was conducted using a semi-structured questionnaire consisted of three phases: user characteristics; user demographics and current attitudes towards smartphone apps, app usage & Tasks; users explore the app and perform given tasks to inspect app's functionality, and final interview phase; to get insights from users on the overall survey experience including app's utility.

A mixed-methods study design was used to collect and analyze the data to investigate the app for its utility and functionality. This method helps to integrate both quantitative and qualitative data within a single investigation, enabling a more comprehensive and broad understanding of the data than separate qualitative or quantitative methods alone.

Dissertation Overview

This dissertation started by giving background and motivation to study Indian farmers and agricultural apps to meet their information needs followed by research objectives and questions. Relevant literature on mobile apps and ICT usage among rural farmers and mixed-methods approaches for usability studies were presented in the second chapter. In the next three chapters, three studies were discussed focusing on one study in each chapter. The complete dissertation overview can be viewed in Figure 1.

The three studies build on one another and each study in detail will be discussed in the corresponding chapter. The first study reviewed the literature to understand farmers and their information needs globally. Agricultural apps developed for crop farmers were selected and analyzed by the researcher for their content and usability. Findings and observations from this study were the foundation to develop questionnaires and scenarios for the studies with experts (study 2) and farmers (study 3). Insights and suggestions from usability experts in the United States also helped to frame questionnaire for study 3.

An integrated discussion of findings from all the studies and comparisons among them with respect to the research questions will be discussed in the sixth chapter followed by limitations and future research directions.

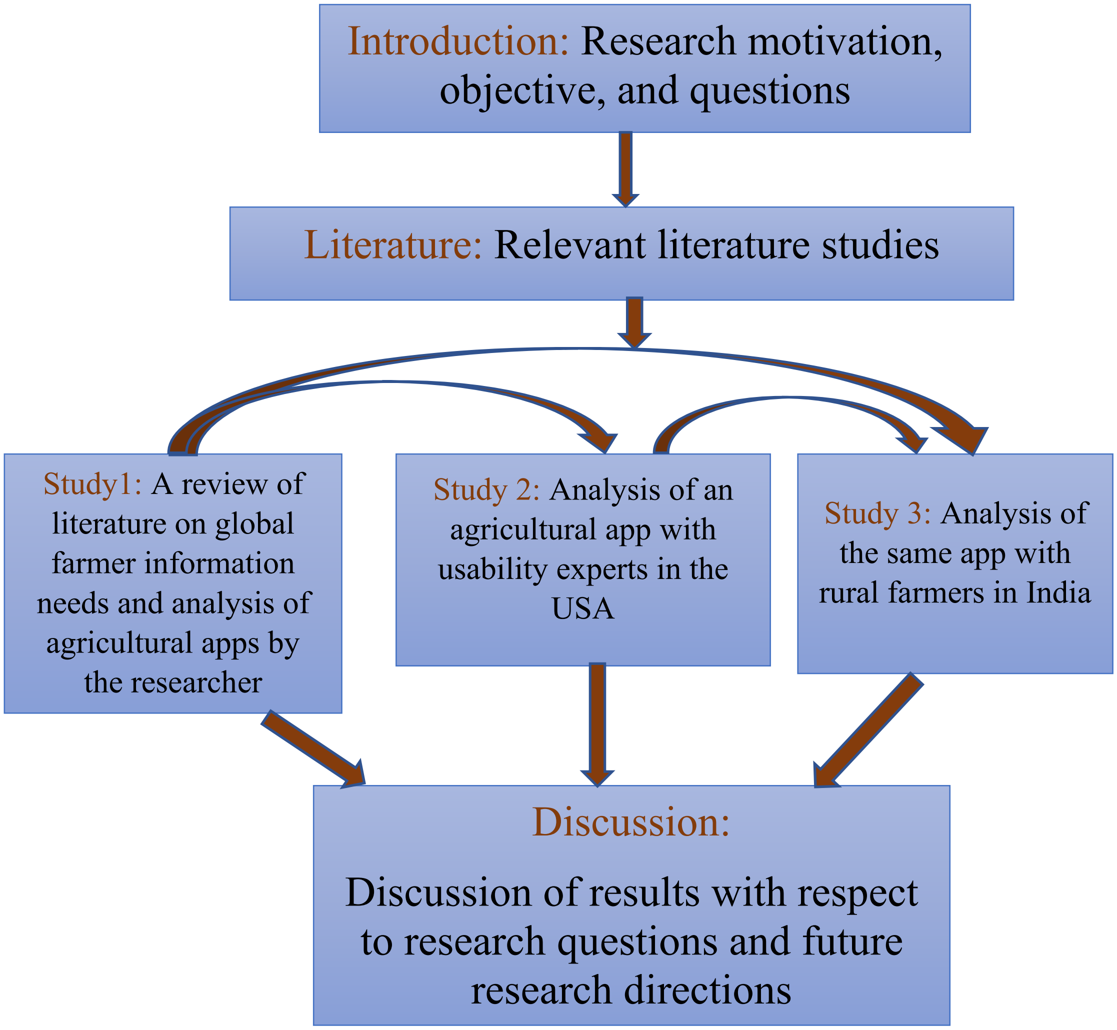


Figure 1. Dissertation outline and overview of chapters

This section discussed background of rural Indian farmers and their agricultural information needs, current sources of accessing that information and their limitations, and possible and efficient solutions using ICTs. Followed by presenting objective and research questions.

Additional details on information needs of farmers and current state of mobile technology and ICT in agriculture in India will be presented in the next section with support from the relevant literature.

CHAPTER 2: LITERATURE REVIEW

This section discusses the literature on mobile technology & ICT for Agriculture in India followed by the mixed-methods research design and its applicability in the mobile application usability analysis research.

Mobile Technology & ICT for Agriculture in India

The role of ICT is prominent in disseminating information more efficiently than traditional communication channels, such as newspapers, extension officers, etc., Accurate and timely information aids better decision-making, planning, field management, and market-related decisions. Many studies have found that mobile technology and ICT have significant positive impact on agricultural productivity including in developing countries such as India (Lio & Liu, 2006; Mittal, Gandhi, & Tripathi, 2010; Kiiza & Pederson, 2012; Nakasone, Torero, & Minten, 2014; Donovan, 2017; Banu, 2019; Parmar et al., 2019). Therefore, gains in mobile technology and ICT use among Indian farmers can improve their living and working conditions. Improving the life of these farmers can impact local, national, and potentially global agricultural production.

A decade ago, in 2009, Adhiguru, Birthal, and Kumar (2009) studied how and where farmers seek information on their farming needs at the national level with data from a national survey of 51,770 farm households. They noted that only 40 percent of households in their sample accessed information from one or another source with the popular information sources including mass media and fellow farmers. They proposed this percentage could be increased with the adoption of ICT and mobile-based services such as text messages, voice calls, and mobile applications. With the increase in the accessibility of information among farmers would increase agricultural production to meet the increasing food requirements of the global population.

In more recent years, studies have identified the uses of mobile technology in agriculture. Jain, Kumar, and Singla (2015) surveyed nearly 500 farmers in the Punjab state of India to understand the agriculture information services they use. Results indicated 99 percent of the participants use mobile phones with multimedia features efficiently, and 63 percent of them were familiar with internet browsing. However, only 38 percent of them used the internet on their phones to get agriculture-related information, citing preferences to receive information through text or voice messages/notifications.

Verma and Sinha (2016) surveyed over 300 farmers and examined the benefits of mobile-based agricultural extension services for farmers. They noted farmers' need to understand the potential usefulness and benefits of using technology-based services to adopt and use the technology. Wasan and Jain (2017) surveyed 150 villagers to identify the problems associated with using mobile phones and possible solutions to overcome them. One of the major problems they encountered was the language of the content shown on the phone. The possible solution is to have the content in the local language of the farmer which can be one of the important attributes of an agricultural mobile application to increase its adoption.

As a possible solution to the language localization problem, Patro, Singh, and Pati (2016) analyzed the ICT tool Kisan Mobile Advisory Services (KMAS). KMAS is a mobile-based information delivery system that allows farmers to receive information in their local language. This is a one-way communication medium in which government officials decide on the current information needs of farmers and send the information through KMAS to all farmers. While it has benefits of providing general information and emergency alerts during any natural disasters, it does not allow farmers to interact and to get information on specific information needs (Singh, Kaur, & Singh, 2015).

Most of the problems with one-way communication channels and traditional ICTs could be addressed by agricultural smartphone applications. Patel and Patel (2016) surveyed agricultural Android apps intended for Indian crop farmers. Many of the apps were found to only provide information; not to allow users to interact with one another. They also noted the majority of the apps were single functionality apps, providing information only on specific subjects, weather forecast information, for example. Their analysis was based solely on the apps' descriptions as provided by their developers. This is likely to produce erroneous insights because app developers often tend to overstate or understate their app's features (West et al., 2012).

Rana and Sontakki (2017) performed a comparative analysis of 25 different Mobile Based Agro Advisory Services (MAAS) in India based on the information provided by the service provider. Six of the MAAS were mobile applications and two of them were studied with users for their effectiveness and utility. One of the apps was studied with 32 farmers from Tamil Nadu and another with 33 farmers from Maharashtra. The questionnaire for both surveys was similar with most of the questions on the demographics of the participants. Only a few items were included in the survey regarding the utility of the app, including what they liked about the app and what they expected from the app. The majority of the participants from Tamil Nadu appreciated the interaction feature of the app and they noted they need more information on market prices. The app investigated in Maharashtra did not have interaction feature and the participants confirmed they like to have that feature.

The majority of the studies studied agricultural apps from app developer descriptions or studied farmers to know their information needs, but the study in this dissertation is the first of its kind to study Indian farmers for both their information needs and for analyzing the app with them, the real users. To conduct these studies, I followed a mixed-methods approach to collect and analyze data both quantitatively and qualitatively as it helps to obtain comprehensive understanding of the data. Mixed-methods study design for evaluating agricultural mobile application is the first of its kind, however the method was used in usability studies of apps in other domains especially healthcare apps. Relevant studies conducted using mixed-methods approach for evaluating mobile apps will be discussed in the next section.

Mixed Methods Approach for Usability Studies

In mixed-methods research, both quantitative and qualitative data are collected and analyzed (Creswell et al., 2003; Johnson & Onwuegbuzie, 2004). The process of general mixed methods research is shown in Figure 2. This approach is important and helps to collect more comprehensive data to understand farmers' and their needs better. Results from mixed-methods research help to broaden the understanding of research questions and the problems under study (Creswell et al., 2003; Hanson et al., 2005; Johnson & Onwuegbuzie, 2004; Onwuegbuzie & Leech, 2006; Johnson, Onwuegbuzie, & Turner, 2007).

Johnson & Onwuegbuzie (2004) identified nine mixed-method research designs based on the focus, priority, and sequence of qualitative and quantitative data collection for answering the research questions. The nine mixed-method categories are shown in Figure 3. These are only the nine common and traditional mixed-method study designs, and the researcher can develop more research specific and complex designs that effectively answer research questions in the study. A study can be considered mixed-methods research if the findings are mixed or integrated at some point in the research study in contrast to completely following either qualitative paradigm or quantitative paradigm (Johnson & Onwuegbuzie, 2004, p. 20).

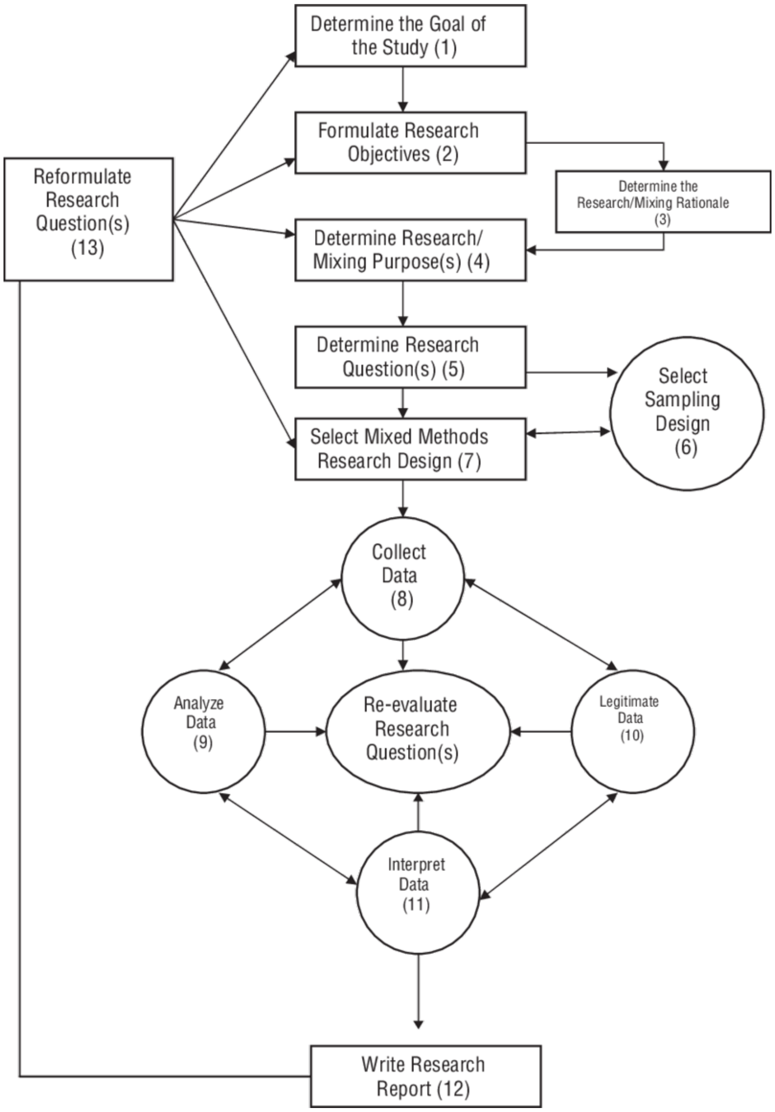
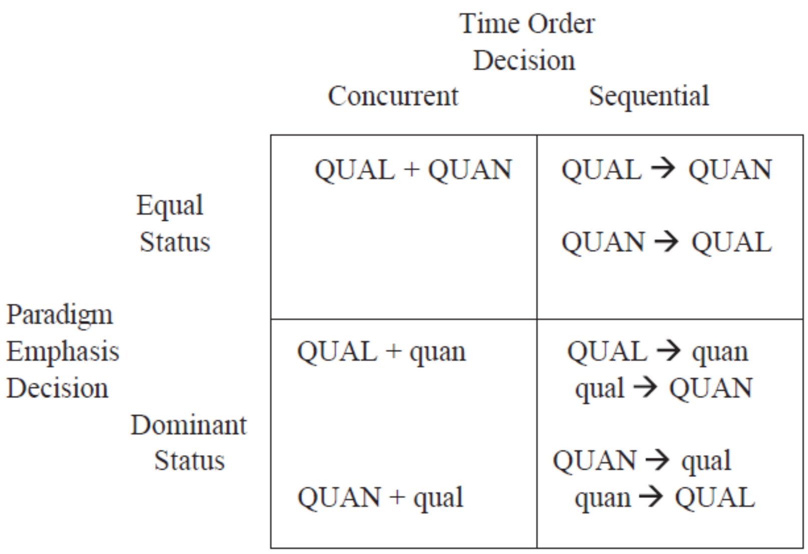


Figure 2. Mixed-methods research process (Onwuegbuzie & Leech, 2006)

Wisdom and Creswell (2013) explained a method can be considered integrative mixed-methods if the quantitative (closed-ended) and qualitative (open-ended) data is collected and analyzed using appropriate methods and integrated during collection, analysis or discussion phases. Nikolaou et al. (2019) followed an integrative mixed-methods study design to explore preferences and usage of lifestyle apps among young people in 6 different countries. They applied thematic analysis for the qualitative analysis and descriptive statistics for the quantitative analysis.



Note. "qual" stands for qualitative, "quan" stands for quantitative, "+" stands for concurrent, "→" stands for sequential, capital letters denote high priority or weight, and lower case letters denote lower priority or weight.

Figure 3. Mixed-methods research designs (Johnson & Onwuegbuzie, 2004)

The research approach followed in this study is an integrated mixed-methods approach where both the quantitative and qualitative data are collected within a single investigation, and the data were analyzed with qualitative (thematic analysis) and quantitative (descriptive and inferential statistics) methods. This method is also known as embedded mixed-methods design which involves the collection and analysis of one primary data (either qualitative or quantitative) with other data type collection and analysis occurs before, during, or after the primary methods (Creswell & Clark, 2017; Brady & O'Regan, 2009). The collection and analysis of the study primarily focused on the qualitative approach and obtained better understanding with the help of quantitative data and analysis.

Philosophical Assumptions

This study followed embedded mixed methods and the pragmatic paradigm is the most suitable worldview for this approach among the four major worldviews as discussed by Creswell and Clark (2017) based on different beliefs and assumptions namely postpositivist worldview, constructivist worldview, participatory worldview, and pragmatic worldview. The focus of pragmatic worldview is primarily on the research questions under study and the questions asked during the studies rather than the methods used. The epistemology – the relationship between the researcher and that being studied, of this worldview is practicality and it uses both formal and informal styles of writing. This worldview is also real-world practice-oriented and centered toward what works the best in understanding the questions and practice hence it reflects the philosophical assumptions of the mixed methods design employed in this research study.

CHAPTER 3: GLOBAL AGRICULTURAL APPS ANALYSIS

The objective of this study is to understand the characteristics of agricultural mobile applications suitable and usable for farmers and the information needs of farmers globally. To address this, most essential information needs of farmers were identified from agricultural and rural development literature. These information needs were used to examine the functionality of the selected apps. Eleven free mobile phone apps intended for global crop farmers on Google Play Store, the largest android app-related platform, were selected and analyzed for their general, usability, and functionality characteristics.

The methods section presents identifying app characteristics and global farmer information needs from the literature followed by keyword search method to select the apps for the analysis. Results and discussion sections will discuss the findings followed by conclusions.

Methods

This section contains two parts: 1) identifying general, usable, and functional characteristics of apps from the literature; and 2) selecting apps and examine them using the identified app characteristics. A content analysis with a combination of quantitative (frequency data) and qualitative (discourse) analyses were conducted on the selected apps.

Identifying app characteristics from the literature

General app characteristics

A mobile app's general characteristics influence consumers before installing the app since they can easily be reviewed on the app's listing on the app store, motivating users to install the app. Details such as the app title, current number of installations, user review count, user rating, number of permissions (requests to access user's data such as contact information, photos, or documents and to control the device such as request to vibrate the device or change display settings), size of the application (file size of the app in megabytes or MB), number of app versions (app developers deliver new versions to reduce bugs and to improve app's features based on users' feedback and requests), app release date, app age (number of days or months or years elapsed from the app's initial release till the data collection date), app description (length of the textual description of an app given by the developer), number of screenshots (visual descriptions of the app provided by the app's developer), app age-restriction levels (app developers self-rate their apps with corresponding age-restriction levels), app category (purpose of the app such as entertainment, games, education, health, or social), app developer data (information on occupancy of the developer and number of apps by the developers), in-app purchase (options to make transactions in the app or buying additional features), and in-app advertisements (displaying adds in the app during the app's usage) are considered as general app characteristics.

Several studies have identified the relationship between various general mobile app characteristics and user adoption of the app. The number of installations and user review count of an app determines the perceived app popularity, higher installs more popularity. Potential app users often read user ratings and read app reviews before installing apps. Perceived app popularity contributes to take decisions in downloading the app (Harris, et al., 2015; Shen, 2015; Gu, et al., 2017; Pagano & Maalej, 2013; Harris, et al., 2016).

The relative worth of user ratings, app reviews, and number of installs differ depending on the app type (hedonic or utilitarian apps) and the risk associated with the app. Hedonic apps (low perceived risk) are mainly for recreational purposes. Conversely, utilitarian apps (high perceived risk) are task-oriented and used to achieve specific goals such as banking, finance, health, and agricultural apps. The number of installs is a clearer indicator of quality when users are choosing a hedonic app, whereas users' ratings along with true experiences of users' reviews contribute significantly to users' evaluation in choosing a utilitarian app (Hazarika, et al., 2015; Shen, 2015).

Huang and Bashir analyzed 274 anxiety-related android apps to understand relationships between app permission and consumers' app adoption. They identified 27 common app permissions among the 138 types of permissions that an android app can request (Google Play Manifest, n. d.). A positive relationship between the number of app permissions and the number of installs was found. In addition, specific app permissions such as in-app purchases and sound settings were associated with increased user ratings while other permissions such as access to camera and location were associated with decreased ratings (Huang & Bashir, 2017).

Liu, Au, and Choi analyzed 1,597 android mobile apps to understand the implications of a hybrid free / premium pricing model, known as freemium (Hayes, 2008). Within a freemium strategy, consumers install apps and utilize their basic features without cost, but a premium is charged for additional advanced features. Users of free apps with an in-app purchase option tend to spend more on extra features when compared to similar users of paid apps with advanced features (Cutler, 2012). These investigators concluded higher review ratings among free apps contribute to higher revenue and in-app purchases of the paid version of the app.

Ghose and Han collected and reviewed 4,706 Apple apps and 2,624 Google apps for their general app data study. From this review, the researchers identified an extensive list of app characteristics and analyzed their influence on app adoption. For example, they found file size to be negatively associated with user adoption of an app (bigger apps are installed less often) whereas an app’s age and number of apps developed by the same developer were positively associated with app adoption. Ghose and Han suggested apps with large file sizes may frustrate users with longer installation times and higher data costs in order to contextualize these results. An app’s visual and text descriptions were also positively associated with increases in demand for an app. The textual description is the length of the description provided by the app developer and visual representations are the number of screenshots of in-app pages and videos of demos available for user before installing the app (Alexova & Hariharan, 2015; Ghose & Han, 2014).

Previous studies have investigated a subset of the aforementioned characteristics. Cheng, et al (2017) investigated an app's release date, file size, category, popularity, and user rating. Vieira and Lewis (2018) examined user rating, the app's price, the intended audience (e.g., adults, youth, children, general population), app developer (e.g., whether it is a university, medical institution, organization, foundation, corporation, or government entity), and purpose (e.g., for education, medical assessment, disease symptom management, to offer supportive resources, therapy). Different authors have used different terms to describe a specific characteristic. For example, some used the word “popularity” to represent the number of times the app has been installed. Based on this body of literature, this study defined an app's general characteristics as the number of installations, review count, user rating, file size, age (in months from initial release until February 2019), and number of screenshots.

Functionality characteristics

The terms ‘functionality’ and ‘usability’ are often erroneously used interchangeably to describe an app. Functionality entails evaluating an app based on the tasks it can perform. These tasks can vary by a given app’s purpose. Usability, on the other hand, generally answers the question, "Can I make the product do what I want it to do?", regardless of the developer's purpose for designing the app. Functionality, therefore, refers to "What does the product do?" to evaluate what tasks can users accomplish using the app (Goodwin, 1987; McNamara & Kirakowski, 2006).

Users generally select apps to help them perform tasks efficiently and effectively. Often, the functionality characteristics of a digital app help reduce physical labor on the part users. For example, a functionality test for an online banking app would seek answers to questions about sending and/or transferring money, scheduling money transfers, and making online payments (Herzberg, 2003; Pousttchi & Schurig, 2004). By comparison, the functionality of agricultural apps may be tested by answering questions related to providing the latest market prices for commodities, providing information to diagnose crop damages due to insects, and offering fertilizer recommendations, among others.

Like most stakeholders, farmers have a range of information needs, some of which have been extensively studied by research and extension specialists. For instance, Singh and Kumar (2017) surveyed 287 farmers of various ages, educational attainment, income level, and farming experience in India's Varanasi district. They found farmers in this part of the world clamored for information about modern cultivation systems, seeds and planting materials, diseases and pest management, fertilizer management, weather information, soil and water conservation practices, irrigation, government incentive schemes, and post-harvest techniques, as well as market and weather information. The majority of their respondents reported needing more information on soil and water conservation, seeds and planting materials, modern cultivation system, and weather information.

Elly and Epafra Silayo (2013) surveyed 120 male and female farmers of different education levels in the Iringa district of Tanzania and found almost all (99%) of their respondents said they grew crops; whereas only about 30% said they were involved in both livestock and crop farming. The Tanzanian farmers reported needing to know more about pests and diseases, new seed varieties, and the availability of training opportunities regarding new seed varieties, breeding, and general farming techniques. The farmer-respondents also required information on soil fertility and suitability, crop husbandry, and weather. The survey findings indicated aside from new crop varieties; farmers need to be trained on effective crop management.

Walisadeera, Wikramanayake, and Ginige (2013) identified the information needs of farmers in Sri Lanka by soliciting the observations of various sources; including subject matter experts from universities in Sri Lanka and Australia, agriculture officers and farmers, research articles and books, authoritative online source, the mass media (including newspapers, radio, and television), and meteorological data. Farmers in their study were in search of information about suitable crops to grow under specific agro-climatic conditions, fertilizers and fertilizer applications, crop diseases and their symptoms, pest management techniques, post-harvest management, market prices, and where to buy and sell products and services.

Elizabeth (2008) surveyed 300 women farmers of different ages and marital statuses who registered with the Agricultural Development Project of Adamawa State in the Mubi region of Nigeria in 2006. The majority of the respondents confirmed needing information on soil management, intercropping techniques, fertilizers, insecticides and their availability, pesticide application methods, and post-harvest processing of farm produce. Additionally, the women farmers desired information on how to increase farm income, the prices of the farm produce, future market prices, and the prices of products from other states.

Rodriguez, et al. (2015) reviewed 200 empirical documents between 2000 and 2012 published in reports, scholarly publications, and the popular press and analyzed changes in information needs of rural women from three continents including Africa, Asia, and Latin America. Agriculture is a primary activity for the majority (79%) of the economically active women in the developing world (Doss, 2014). From the reports, 14 major information needs of rural women were identified and agricultural production practices, health, education and training, gender issues, and general family well-being issues stand among the most desired information needs in all three developing countries. Other relevant information needs included information crop subsidies, financial management, and environment and natural resources management and conservation.

Duram and Larson (2001) distance surveyed 20 farmer-members of the Illinois Sustainable Agriculture Society, 50 farmers-members of the Illinois Organic Crop Improvement Association, and 42 researchers who received grant funding from the North Central Region of the United States Department of Agriculture’s Sustainable Agriculture Research and Education (USDA-SARE) program. Their respondents cited the need for more information about pest control, weed control, water quality management, and markets.

Mittal, Gandhi, and Tripathi (2010) summarized the information needs of farmers three groups including Know how; initial information requirements, context; weather based or region-based recommendations, market; all market related and post-harvest information. Information needs at every stage of the agricultural cycle are shown in Figure 4. These included soil management, seed varieties, cultivation techniques, fertilizer recommendations, disease and pest management, weed control, weather information, markets, post-harvest management, and where to buy and sell products and services. Although farmers are likely to seek information about specific topics as they go about their business, the present study used Mittal et al.'s functional characteristics to evaluate agricultural apps.

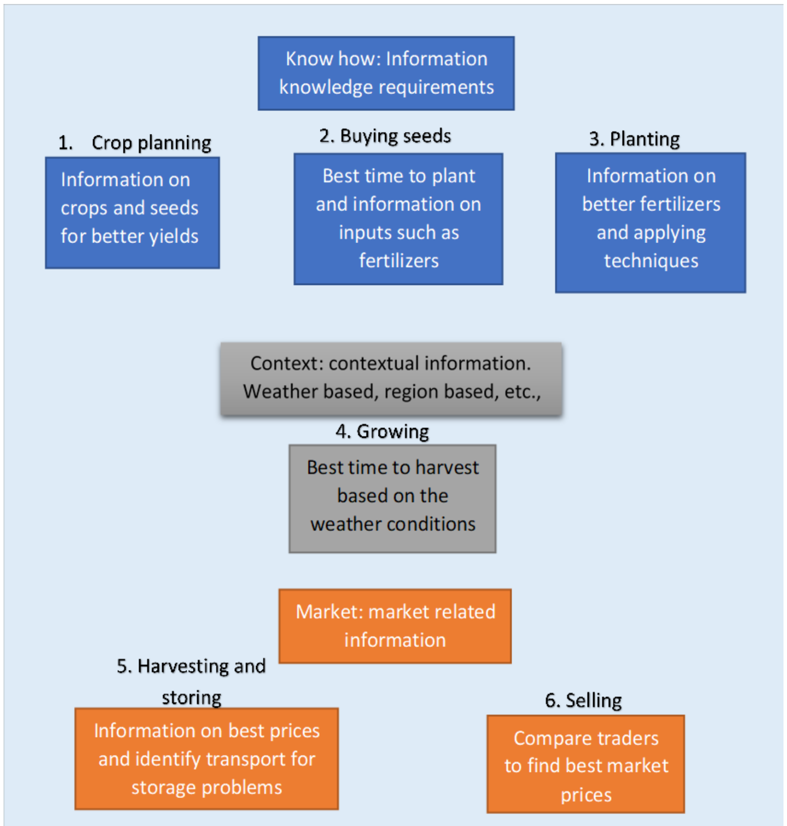


Figure 4. Information needs of farmers at each stage of the agricultural cycle adapted from Mittal et al. (2010).

Usability characteristics

Usability testing is the process of evaluating a product or a system with representative users while applying usability characteristics or principles. The list of usability characteristics varies from product to product, however; the five factors most widely used to test traditional desktop applications are efficiency, satisfaction, learnability, memorability, and errors (Nielsen, 1994). Harrison, Flood, and Duce (2013) added effectiveness and cognitive load to this list to evaluate the usability characteristics of mobile applications.

To evaluate usability, the current study adopts the Mobile App Rating Scale (MARS) developed by Stoyanov et al. (2015) which has been widely adopted by other researchers who performed usability testing of mobile applications (Bardus et al., 2016; Vieira & Lewis, 2018). MARS entails measuring an app's performance, ease of use, navigation (minimal movements due to smaller screen of the device, consistency in all pages, and coherent and self-evident visual signs), and gestural design (consistency and clear indications of in-app interactions such as clicks, hovers, and touches). Most of these features are extensions of one or more usability characteristics. For example, app performance measures the accuracy and speed of completing tasks, which is similar to efficiency. Learnability and memorability are the bases for ease of use, which essentially evaluates an app based on how easy it is to learn and to use. Navigation and gestural design evaluate the actions app users need to perform to use the app, such as consistency and control in swiping through different pages.

The app's usability characteristics considered for this study include the app's performance, ease of use, navigation, and gestural design.

Selecting apps and examining them using the identified app characteristics

Sample selection

To be included in this study, apps had to satisfy the following criteria: (1) specifically developed for crop farmers (the target audience), (2) listed in the Google Play Store / Android app store inventory through February 2019 (the data collection period), (3) available without cost to fulfill its stated purpose.

A keyword search strategy was used in identifying the apps to be analyzed for two reasons: 1) to mimic users' app search process, and 2) to follow the methods employed by other researchers who studied the content of apps (Ramo et al., 2015; Huang & Bashir, 2017). Five keywords were identified "agriculture," "farming," "cultivation," "agronomy," and "crop production" as the keywords to search for relevant apps. The Google Play Store returned 250 apps for each term. To identify the most relevant apps, several additional inclusion and exclusion criteria were applied. In the first round of review, apps that did not have at least one of the search terms in the title were culled out. Many of the resulting apps were game-related, which necessitated a second filter. In this step, apps with the word “farmer” but did not have the word “game” in their full description were retained (Figure 5). I developed a Python function to apply these filters automatically. The resulting 45 unique apps were classified into seven categories based on their focus, price, and language used. These categories are listed and described in Table 1.

Table 1. Categories of apps and their descriptions

App category (total apps)	**Description**
General agriculture Information (4)	Apps that provide only general information about agriculture, including terms, and farming basics not intended for farmers, but for students, teachers, and others who study agriculture
Agricultural information for crop farmers (25)	Apps intended for crop farmers. They provide broad information about crop varieties, seeds, diseases and pest management, among other information items.
Agricultural information for non-crop farmers (2)	Apps whose main audiences are farmers who do not grow crops (e.g., those who raise livestock and poultry)
Marketing apps (3)	Apps that deal primarily with the economic aspects of farming (e.g., how to market produce, commodity market prices, trades and futures, cash grain bids)
Calculators (3)	Apps that help calculate for yields, production inputs, and their costs (e.g., water requirement, yield rate)
Not in English (5)	Apps that were not in the English language
Paid apps/games (3)	Apps that need to be purchased, including game apps

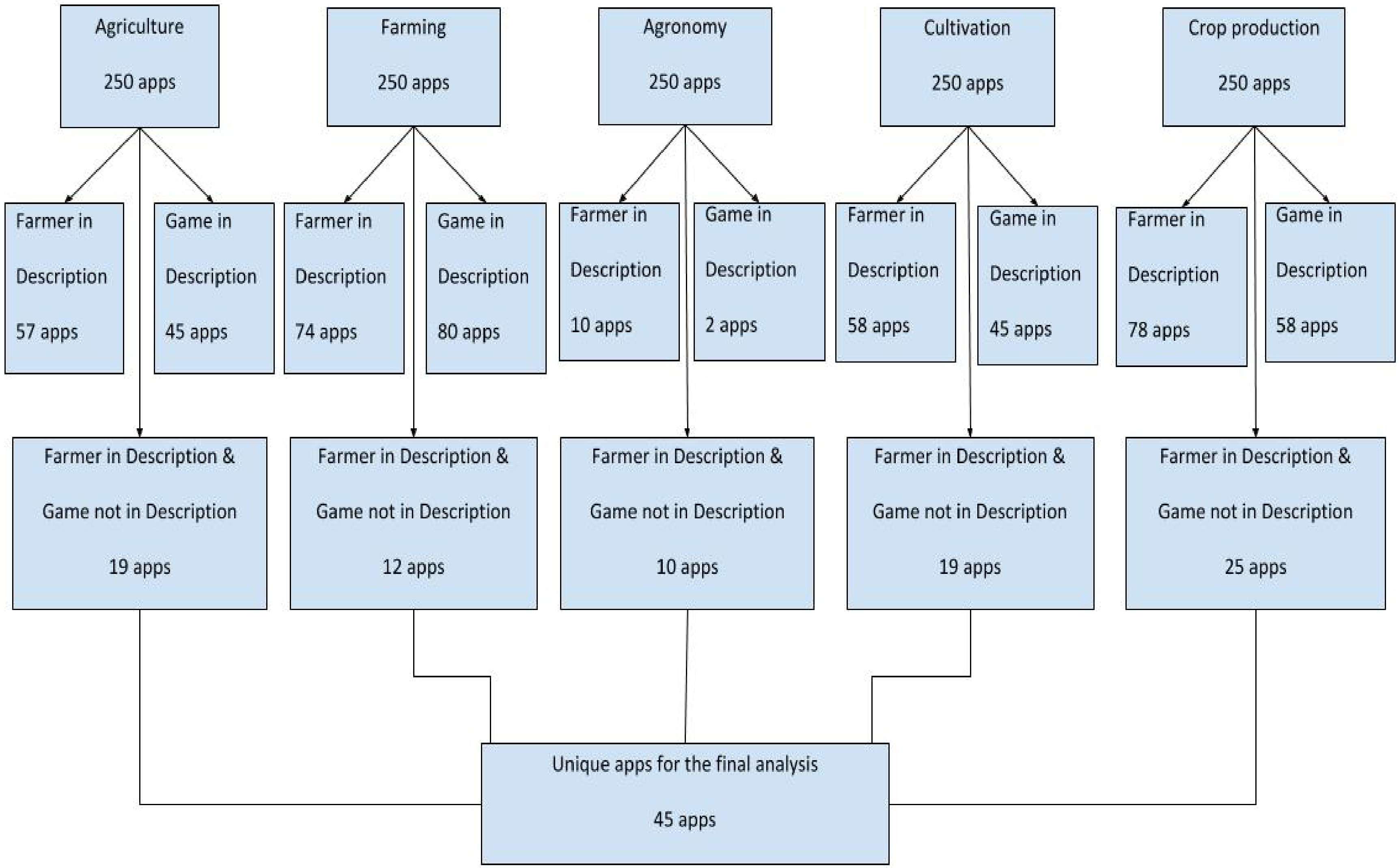


Figure 5. The process to identify relevant agricultural app

Only the 25 apps that fell under the category “Agricultural information for crop farmers” were selected for this study. Of these, 14 asked for stringent requirements (e.g., it asks for a local phone number to access content) or showed technical difficulties before, during, and after installation (e.g., installation failure). These apps were taken out of the sample, leaving 11 apps to be analyzed. I downloaded and installed the 11 focal apps to imitate users’ tasks and to be able to analyze each based on the actual (or in-app) content rather than relying solely on the description provided by the developer.

Measures

The unit of analysis for this study was each complete app. Individual apps were analyzed based on (1) general characteristics, (2) usability characteristics, or performance, and (3) functionality characteristics, or content. The operationalization of each of these domains is detailed in the following sections. Taken together, these criteria attempted to assess the overall quality of each application.

General characteristics. Six factors were measured to determine each app’s general characteristics: (1) user rating (how users rated the app on a scale of 0 to 5 where 0 is the lowest rating and 5 is the highest), (2) the size of the app in MB, (3) review count, or the number of users who wrote reviews about the app, (4) the number of times the app was installed, (5) app’s age in number of days since first launch, and (6) number of screenshots available on the app’s webpage or store listing.

Usability characteristics. Four attributes comprised each app’s usability characteristics: (1) app performance, (2) ease of use, (3) navigation, and (4) gestural design. App performance referred to the accuracy and speed of loading the content and other features. In this study, apps were rated as good, moderate, or poor. Ease of use designated the extent to which instructions, menus, and labels were easy to follow. It also denoted the degree to which information was easy to find (very easy; moderately easy; not easy). Navigation referred to the logical connections of screens (good; moderate; poor). Gestural design scores were based on the degree to which in-app interactions were clear and consistent (good; moderate; poor).

Functionality characteristics. Functionality traits were assessed by the presence or absence of information previous studies identified as the most vital. Based on the review of the existing literature, these ten information categories were: (1) soil properties and management, (2) seed and crop varieties, (3) production and cultivation techniques, (4) fertilizer and fertilizer applications, (5) pest and disease management, (6) weed control, (7) weather, (8) markets, (9) post-harvest management, and (10) where to buy and sell products and services.

Coding and data analysis

Two graduate student reviewers independently coded the apps following the protocols listed above. One of the reviewers is the main researcher and another student has expertise with software development and agricultural mobile apps, hence they both are considered qualified to code the apps.

The general app characteristics were directly taken from the app's web page, hence no variability between raters was found. I computed Fleiss' kappa and Krippendorff's alpha to determine inter-coder reliability for nominal variables (i.e., the functionality and usability characteristics) in RStudio following the formula and R-script in accordance with Zapf, Castell, Morawietz, and Karch (2016). After disagreements were resolved, the final inter-coder reliability for the coded variables are shown in Table 2. Fleiss' kappa and Krippendorff's alpha reliabilities gave the same values for all variables and were greater than 80%. I interpreted these findings as appropriate evidence of reliability within this data. It was also interesting to observe that the inter-coder reliability values are higher for variables with definitive meaning. For example, for market information it was straight forward to check if app provides market prices for crops or not where as for weather information, it involves some ambiguity such as whether to look for only current day weather information or weather predictions along with notifications on when it will rain etc., Hence, I found that variables with subjective meanings obtained lower reliabilities.

Frequency distributions were examined to generally describe the apps and determine their usability and functionality traits. Correlation coefficients among the general, usable, and functional characteristics were calculated using Pearson correlation function in R and the values are given in Table 3. I could not say statistical significance for these observations and findings because of the small sample size. Real users' comments from the play store were checked to validate these observations.

Table 2. Inter-coder reliabilities of nominal variables

Variable Name	**Inter-coder reliabilities**
Soil Management	0.909
Seed varieties	0.909
Cultivation Techniques	0.818
Fertilizer Information	0.909
Disease and pest management	0.909
Weed control	0.818
Weather information	0.818
Market information	1.000
Post-harvest management	0.818
Places to buy & sell	1.000
App Performance	0.909
Ease of use	0.818
Navigation	0.818
Gestural design	0.818

Table 3. Correlation coefficient matrix for nominal variables

	1	2	3	4	5	6	7	8	9	10	11
1. Rating	1										
2. Size	-0.65	1									
3. Reviews	0.14	0.23	1								
4. Installations	0.14	0.23	0.99	1							
5. Age	0.15	-0.33	0.21	0.21	1						
6. Screenshots	0.21	0.42	0.67	0.66	0.18	1					
7. Performance	-0.32	0.22	-0.24	-0.23	-0.13	-0.11	1				
8. Ease of Use	-0.48	0.78	0.35	0.35	-0.26	0.53	0.56	1			
9. Navigation	-0.5	0.81	0.35	0.33	-0.17	0.46	0.37	0.82	1		
10. Gestural Design	-0.44	0.64	0.34	0.33	-0.4	0.26	0.56	0.82	0.82	1	
11. Functionality	-0.44	0.34	0.51	0.5	-0.05	0.1	0.42	0.57	0.61	0.65	1

Limitations of the study

The sample size in the study may be a result of a keyword mismatch between the research team and those employed by developers to tag their apps. There were also instances where an app’s full descriptions were not consistent with its presented content. Additionally, the sample was exclusively composed of apps developed for farmers who grow crops. The exclusion of other types of farming (e.g., livestock or pastoral farming, aquaculture, and fishing) may also limit the generalizability of these results.

The study did not include subscription-based services and was limited to android-based applications. I searched only on the Android play store to find relevant apps using the keyword search strategy but did not use other ways such as searching for agricultural-related apps on other app-based websites. A combination of search results from both the app store and other websites might have revealed additional relevant apps.

The two graduate student coders in the study tested 11 agricultural apps usability and functionality characteristics *in vitro*, rather than in the field (*in vivo*). Testing with the intended users, such as farmers in their field, could reveal different insights and increase the validity of findings from this study.

Results and Discussion

General characteristics

As shown in Table 4, user ratings were higher (between four and five) for most (approximately 82%) of the apps, yet the review count and the number of installations were low. The mobile app file size is important, and an ideal and reasonable size depends on the category of an app. For example, hedonic apps like mobile games require larger memory capacities than information-oriented apps such as those designed for agricultural purposes. The majority of the apps (approximately 73%) in this sample fell below the average android app size of 11.5 MB (SweetPricing, 2017). Apps with greater size were found by coders in this study to have better usability characteristics, such as ease of use (r= 0.78), navigation (r= 0.81), and gestural design (r= 0.64), when compared to apps of smaller sizes. However, functionality ratings were not affected by app size. Review count and number of installations have a very strong positive correlation between them (r= 0.99). Visual elements, such as screenshots and videos on the app's description, increases user understandability and confidence to download the app and increases the demand (Ghose & Han, 2014). Number of installations tends to increase with number of screenshots the app provides (r= 0.66). The app with the highest number of screenshots in the sample was also the app with the highest number of installations, reviews, rating, and features.

Table 4. General app characteristics

General characteristic	Values	Count (number of apps)	% of total (round to two decimals)
User rating	0	1	9.09
	3	1	9.09
	4-5	9	81.8
Size (in MB)	1-5	4	36.36
	6-10	4	36.36
	11-15	3	27.27
Review count	0-10	5	45.45
	11-20	2	18.18
	21-30	1	9.09
	31-40	1	9.09
	100-1,000	1	9.09
	> 1,000	1	9.09
Number of installations	50	1	9.09
	100	2	18.18
	500	3	27.27
	1,000	1	9.09
	5,000	2	18.18
	10,000	2	18.18
	100,000	1	9.09
App age	1-10	5	45.45
	11-20	3	27.27
	21-30	2	18.18
	31-40	1	9.09
Number of screenshots	2	1	9.09
	3	6	54.55
	4	1	9.09
	6	1	9.09
	7	1	9.09
	8	1	9.09

Usability characteristics

As shown in Table 5, app performance was rated good for most of the apps (approximately 64%). Most apps except two were rated moderately in terms of their ease of use, navigation, and gestural design. The two apps which were rated as having poor navigation were the same apps found to have poor gestural design and usability. App performance, ease of use, and gestural design have a positive correlation among them (r= 0.56).

Usability characteristics must be addressed according to the representative users' requirements. For example, farmers might browse an app at different locations, such as indoors or in the field, and the app's display and other features must adapt accordingly. While farmers use the app in the fields, the in-app interactions (gestural design attributes) must be compatible and precise. Hence properly incorporating the usability needs of farmers into the application development plays a huge role in increasing the app's utility and efficiency.

Table 5. Usability characteristics

Usability characteristics	**Values**	**Count (number of apps)**	**% of total (round to two decimals)**
App performance	Good	7	63.64
	Moderate	3	27.27
	Poor	1	9.09
Ease of use	Very easy	4	36.36
	Moderately easy	5	45.45
	Not easy at all	2	18.18
Navigation	Good	4	36.36
	Moderate	5	45.45
	Poor	2	18.18
Gestural design	Good	4	36.36
	Moderate	5	45.45
	Poor	2	18.18

Functionality characteristics

Although the examined apps addressed less than half of the functionality needs as indicated in the literature, at least half displayed information about soil management, seed and crop varieties, production and cultivation techniques, fertilizers, pest and disease management, weed control, and weather information as shown in Table 6. Most apps did not contain information pertaining to markets, post-harvest management, and places to buy and sell produce, but those that did so were among the top-rated and received more user reviews. Functionality in the correlation matrix, Table 3, is the number of information needs provided by the app and it positively correlates with the review count (r= 0.5) and ease of use (r= 0.57).

In the sample of apps, some were dedicated to a specific crop while others provided information about different varieties of crops. Although single-crop apps were expected to provide extensive information on that crop, surprisingly there were not many differences in the information provided by these two types of apps. In fact, three of the four apps which provided the most extensive information on markets, post-harvest management, and places to buy and sell products are general crop apps with information on different varieties of crops.

The information needs of the farmers are interrelated, not mutually exclusive. For example, weather changes affect crop yields and market prices. Various cultivation techniques require specific fertilizers and differential techniques of weed control. With increasing yields and market fluctuations, farmers need to follow suitable and profitable post-harvest management techniques to sell their products optimally. Hence, whether focusing on a single crop or multiple crops, providing information on some aspects while omitting others is an ineffective and inefficient app design and implementation.

Table 6. Functionality characteristics of apps

Functionality characteristics	Count of apps displaying functionality	% of total (round to two decimals)
Soil management	6	54.55
Seeds and crop varieties	5	45.45
Production and cultivation techniques	6	54.55
Fertilizers and fertilizer application	5	45.45
Pest and disease management	6	54.55
Weed control	5	45.45
Weather	6	54.55
Markets	2	18.18
Post-harvest management	2	18.18
Where to buy and sell products and services	1	9.09

Users' comments

In addition to general, functional, and usability characteristics, I also examined users' comments. User reviews can act as online Word-Of-Mouth (WOM) to spread the word among the online community and to provide the developers with valuable and useful feedback (Tan & Vasa, 2011; Vasa et al., 2012; Frie et al., 2017).

An extract of relevant and useful users' comments is shown in Figure 6. To protect the privacy of the users, I replaced the name and original profile picture with a generic photo. All these comments were taken from the app's webpage on the Android Google Play store.


Users' comments on apps with lower number of reviews

[redacted]
★★★★☆ 26 January 2015
I liked it.... I guess I'm the 2nd person 2 download this awesome app

[redacted]
★★★★★ 7 May 2017
It's a wonderful app for improving agriculture technologies.

[redacted]
★★★★☆ 20 October 2018
Very productive

Users' comments on apps with higher number of reviews

[redacted]
★★★★★ 19 March 2019
Great app for agriculture purpose, i recommend u to use.

[redacted]
★★★☆☆ 23 September 2018
Its good but after update it take too much time for loading & i suggest plz Show the rice rate also

[redacted]
★★★★★ 13 April 2017
Sir everything is superb easily learn... If possible please attach 1 image for all symptoms n pests that will make more reliable ylto us

Figure 6. A snippet of users' comments on various apps

Conclusions

This study analyzed the usability and functionality of android mobile apps intended for and to use by crop farmers. A total of 11 apps selected from Google Play Store were examined. The findings indicate a majority of the apps had higher user rating values (between four and five), but lower user reviews (less than 100). The number of days since the app's release and number of screenshots were associated with more installations and higher user ratings. The app's performance was rated as good for most apps, while ease of use, navigation, and gestural design were rated as moderate. At least half of the apps displayed information about soil management, seed and crop varieties, production and cultivation techniques, fertilizers, pest and disease management, weed control, and weather information. However, most apps did not provide information related to market prices, post-harvest management techniques, and places to buy and sell produce.

Overall, apps' functionality characteristics were rated more poorly than general and usability characteristics. Reviewers' comments showed that most apps focused more on usability characteristics as compared to functionality characteristics.

The findings and observations from this study were the base for the additional study of an agricultural mobile app developed for Indian farmers. Evaluating the selected app with usability experts in the United States and rural farmers in India will be discussed in the next two corresponding chapters.

CHAPTER 4: APP ANALYSIS WITH USABILITY EXPERTS

The previous chapter explored different agricultural mobile apps developed for farmers globally to understand the information needs of farmers in general and what is the current state of agricultural apps in addressing those needs. This and next chapter will focus on a single app developed specially for Indian farmers. An agricultural app titled *NaPanta* (NaPanta-Agriculture Crop Management App for Farmer - Apps on Google Play, n.d.) was selected for the study for its relevance and popularity. A twofold method was used to understand the usability and functionality of the selected app. In the first phase, the app was subjected to expert review using cognitive walkthrough and heuristic evaluation method for usability and performance analyses which is discussed in this chapter. The second phase of the analysis was performed with rural Indian farmers (users) which is the focus of the next chapter.

This chapter starts with discussing usability inspection methods used to survey experts and selection of app, collecting data and analysis in the methods section. This will be followed by results and conclusions.

Methods

This section presents two common usability inspection techniques, Cognitive Walkthrough (Wharton, et al., 1994) and Heuristic Evaluation (Nielsen & Molich, 1990), to evaluate the usability of the selected agricultural mobile application, NaPanta, developed to provide necessary information to crop farmers in India. This will be followed by app selection, expert selection, and user selection processes, and data collection and analysis techniques.

App selection presents criteria to select an app to consider for the study based on the general mobile attributes and specific mobile application features that help to increase the adoption of the mobile app among farmers. The expert selection will give an overview of expert selection criteria and expert review process of the selected app. Research setting and data collection presents a detailed study design and procedure to collect mixed data from the expert survey. Data analysis outlines the mixed-method approach to perform both quantitative and qualitative data analysis techniques on the collected data.

Usability Inspection Methods

Usability inspection techniques are often used to test products and to find obvious and general issues before they are tested by potential users. Usability inspection methods need evaluators, usually specialists, to inspect usability-related aspects of a user interface. There are several usability inspection methods which give useful and important insights to gather supplementary data without needing users to conduct the tests. Some of these methods include Heuristic evaluation, Pluralistic walkthrough, Consistency inspections, Standard inspections, Cognitive walkthroughs, Formal usability inspections, and Feature inspections (Nielsen, 1994). Among these, Heuristic evaluation is an efficient and cost-effective usability inspection method and is the most common and most widely adopted (Scholtz, 2004; Jaspers, 2009). This study integrated the two common usability inspection methods: Cognitive Walkthrough and Heuristic evaluation to inspect the functionality and usability of the selected smartphone application.

Cognitive Walkthrough

Cognitive Walkthrough (CW) is one of the Usability Inspection methods where usability experts, participants, act as users of the app and they walk through the app by performing the given tasks, looking for potential problems. The Cognitive walkthrough method has evolved into various methods with different practical applications.

Some of the extensions of this method include Norman's Cognitive Walkthrough is based on the Norman model (Norman, 1986), this can be used by the design teams in different cities, even in different countries to identify interaction problems at a high level of abstraction. This method allows the team members in different locations to communicate without ambiguity.

Cognitive Walkthrough for the Web (Blackmon, Polson, Kitajima, & Lewis, 2002) is an extension of CW which tries to detect errors that occur when browsing and searching for information on a web site.

Groupware Walkthrough is a "substantive modification of cognitive walkthrough" that allows the "complexities of teamwork" to be considered (Pinelle & Gutwin, 2002, p. 455). This method is useful to evaluate systems that require group tasks and a group of evaluators will evaluate the system together.

Activity Walkthrough (Bertelsen, 2004) is based on the activity theory. It focuses to understand human activity, history, intentions, etc. This method can be used to evaluate products developed based on Activity-Centered Design (ACD) in which activities are the focus.

For this study, the Cognitive Walkthrough for the Web (CWW) method was followed to perform the CW phase of the study. This is the most relevant CW extensions to my study. CWW was used to detect issues in a mobile application when browsing and searching through it for the information instead of on a web site. Browsing and searching the mobile application for the information will be performed by experts for the tasks given by the researcher. The tasks for this purpose will be developed based on the information needs of farmers provided in Table 7. These information needs were taken from previous literature on agriculture and rural development that was discussed in the previous chapter under functionality characteristics (Table 6).

The cognitive walkthrough contains two phases:

1. **Preparatory phase**: In this phase, the researcher or test moderator explains participants about end-user's population of the app and tasks to be performed
2. **Evaluation phase**: Participants, acting as end-users, will perform the given tasks specific to the app's functionality. The app under this study is an information dissemination app that aims to provide necessary information to crop farmers. Hence, the tasks in this phase are information finding tasks. More details are described in the research setting and data collection section below.

Heuristic Evaluation

The heuristic evaluation (HE) method (Nielsen & Molich, 1990) is the widely used and most informal usability inspection method which involves having usability specialists and experts judge the usability of the user interface of the product/system by comparing with the established usability principles also known as heuristics. In this method, usability experts evaluate the interface to identify general usability issues based on the set of heuristics identified for that product, but not user specific issues.

There are many well-established heuristics proposed by usability scholars; the specific methods selected typically depends on the type of product being evaluated. Nielsen's ten heuristic principles are still widely used and the base for many modified heuristics (Agarwal & Venkatesh, 2002; Pliakoura, Beligiannis, & Kontogeorgos, 2018). A selected and suitable list of heuristics, combined from various proposed principles (Neilsen, 1994; Gerhardt Powals, 1996;

Weinschenk & Barker, 2000; Inostroza et al., 2016), for evaluating a mobile application is provided in Table 8.

Table 7. Information needs of farmers from the literature

Information need	Description	Relevant citations
Weather information	Information about best weather conditions and about current and future weather predictions	Singh and Kumar, 2017; Elly and Epafra Silayo, 2013; Mittal, Gandhi, and Tripathi, 2010.
Disease and pest management	Information about identifying pests and disease affected plants and solutions to protect them. Suggestions on protecting plant to prevent disease and pest attacks	Singh and Kumar, 2017; Elly and Epafra Silayo, 2013; Walisadeera, Wikramanayake, and Ginige, 2013; Mittal, Gandhi, and Tripathi, 2010; Elizabeth, 2008; Duram and Larson, 2001.
Weed control	Information about preventing or controlling the growth of weeds	Mittal, Gandhi, and Tripathi, 2010; Duram and Larson, 2001.
Soil management	What soil characteristics are necessary for healthy plant growth and how to protect soil and improve its performance	Singh and Kumar, 2017; Mittal, Gandhi, and Tripathi, 2010; Elizabeth, 2008.
Seed varieties	Information on the types and varieties of seeds and tips on selecting best seed for better produce	Elly and Epafra Silayo, 2013; Mittal, Gandhi, and Tripathi, 2010.
Cultivation techniques	Information about various cultivation techniques including modern production methods and resources on how to practice them	Elly and Epafra Silayo, 2013; Mittal, Gandhi, and Tripathi, 2010; Elizabeth, 2008.
Fertilizer information	Information about different fertilizers and suggest the best ones for plants growth	Singh and Kumar, 2017; Walisadeera, Wikramanayake, and Ginige, 2013; Mittal, Gandhi, and Tripathi, 2010; Elizabeth, 2008.
Market information	Information about current agricultural news including current market price, new technologies, etc.,	Singh and Kumar, 2017; Walisadeera, Wikramanayake, and Ginige, 2013; Mittal, Gandhi, and Tripathi, 2010; Elizabeth, 2008; Duram and Larson, 2001.
Post-harvest management	To protect produce for longer times. Information about storage, processing, packing, transportation, marketing, handling, etc.,	Singh and Kumar, 2017; Mittal, Gandhi, and Tripathi, 2010; Elizabeth, 2008.
Government schemes	Information on government schemes and policies especially during any natural disasters and/or possible crop loss situations	Singh and Kumar, 2017;
Agricultural news	Latest agricultural news information such as research and technology innovations in agriculture, etc.,	Walisadeera, Wikramanayake, and Ginige, 2013; Mittal, Gandhi, and Tripathi, 2010.
Places to buy & sell	Information about resources or places to buy seeds, fertilizers, other farming materials, and about places to sell their produce	Walisadeera, Wikramanayake, and Ginige, 2013; Mittal, Gandhi, and Tripathi, 2010.
Fellow farmers	Connecting with other farmers of similar interests in cultivation methods, crops, etc., and providing successful farmers' stories	Singh, Kaur, and Singh, 2015.
Interacting with the app	Information on how to interact with the app and any resources on learning and adopting to use the technology successfully	Rana and Sontakki, 2017; Patel and Patel, 2016.

Table 8. A list of selected heuristics

Heuristic	Description
Reduce uncertainty or increase visibility of system status	Display data clearly and give appropriate feedback to avoid uncertainty in decision making. For example, a clear indication of the progress of loading files.
Consistency and standards	Should follow standard conventions and the instructions through the product should be consistent. For example, a submit button should look the same across the system.
User control and freedom	The interface should allow the user to perform actions and navigations as they wish and give freedom to undo certain actions performed mistakenly. For example, having edit/delete options for a post
Simplicity and aesthetic integrity	Interfaces should be attractive, clear and should not contain unnecessary elements or information.
Compatibility	The interface should be compatible with potential users' skills and real work situations.
User support, recovery from error	To be free from errors is difficult. The interface should provide better and self-explanatory error messages and support to recover from errors.
Reduce cognitive load	Should reduce users' memory load by making objects more visible so users can understand by looking at them instead of remembering their actions.
Predictability	The current interface should be able to allow users to properly predict what will be the next step without unnecessary tensions or confusions.
Help and documentation	Ideally interface should be clear and allow the user to use them without having to look for documents, but, some users might need extra help to perform tasks successfully. It is always better to provide clear and easily searchable documentation or video demos to be able to help users when necessary.

App Selection

The mobile application innovation of ICT for crop farmers is still in development and early stages of adoption in India, especially among the rural farming community. Some innovations spread faster while some take many years. Rogers (2013) identified five general characteristics of innovations that impact the rate of adoption. They are relative advantage; the degree to which an innovation is perceived as better compared to the existing technology, compatibility; the degree to which an innovation is perceived as being consistent with the current values, and needs, complexity; the degree to which an innovation is perceived as difficult to understand and use by the potential adopters, trialability; the degree to which an innovation could be experimented on a limited basis, and observability; the degree to which the results of an innovation are visible to others.

Previous studies identified some specific attributes of mobile applications for farmers that influence the rate of adoption of mobile apps among the rural community. Among those, the important suggestions are having the required and relevant content in the native language, allowing users to interact with the application, delivering information via voice message in local language, and facilitating users to use the application in offline mode because of the infrastructure constraints such as low mobile network coverage and lack of wi-fi facilities (Duncombe, 2016; Jain et al., 2015; Wasan & Jain, 2017; Rana & Sontakki, 2017; Kaegi, 2015). The majority of the influencing factors are to do with localization of the content and voice interactions in addition to the text information considering lower literacy levels among rural farmers (Mittal & Mehar, 2016).

The best app identified from study 1 (Chapter 3) on agricultural apps analysis could not be considered for the latter studies (study 2 and study 3) because of the language considerations of the app. The app selected following the criteria mentioned below will be used for both study 2 and study 3. Study 2 will evaluate the app with the usability experts and study 3 will inspect the app with the real intended users.

The criteria to select the application for the study are: it must be available for free on the Android operating system, Android shares more than 90 percent in the Indian mobile operating system market (Mobile Operating System Market Share India, (n.d); Mobile OS share in India, 2012-2017, (n.d)), should be easily searchable on play store, intended for AP and TS crop farmers, content in native language, should facilitate offline use, allow users to interact with the app, high popularity, good reviews, and rating.

At first, a keyword search was performed, to imitate the user search process to make sure the app is easily searchable, on the Android's google play store using the keyword "Telugu agricultural apps" on 5/3/2019. Among the 250 resultant apps, the first 25 were considered to perform the analysis to select the final app to study. Nearly half of the apps were not for crop farmers but for other agricultural purposes such as dairy farming. For the rest of the apps, the developer's full description and screenshots on the app's webpage were used for the analysis. An app titled "NaPanta" was finalized for its unique features such as offline facility and voice-based interactions as mentioned on the website. The app is also very popular with 100,000+ installs, 4.4 ratings from 1,772 reviewers, and updates regularly.

Expert Selection

Cognitive Walkthrough and Heuristic Evaluation are used to evaluate the application by a group of selected experts. Experts with a relative experience of evaluating and using mobile applications, designing interfaces, and with relevant educational exposure were recruited for the study. The determining factor whether an individual is a usability expert in this subject area is that they self-identify as having some expertise in usability. This may include but not limited to having some experience with any of the following:

- Software design and development
- Familiarity with usability studies
- Experience in using agricultural mobile applications

All the recruitment material including survey announcements and questions were approved by the University of Illinois Institutional Review Board (IRB). Experts were recruited through email and verbal announcements (Appendix C) and snowball sampling (participants give recommendations of possibly interested participants).

Email announcements were sent to HCI/UX (HCI-Human Computer Interaction, UX-User experience) related groups in Champaign-Urbana including but not limited to the following:

- Siebel Center for Design at the University of Illinois
- Human-computer interaction group at the University of Illinois • Email announcements to site leaders at the research park to request them to send to their employees of interest
- UX Champaign-Urbana (CU) group – this group has hundreds of members with various backgrounds and expertise in UX related areas.

Verbal announcements were read at meetups of the above-mentioned groups, other similar meetups, and to the volunteers identified through Snowball sampling. A total of 18 individuals identified themselves as experts and participated in the study.

Research Setting and Data Collection

All in-person usability studies were conducted at the University of Illinois Urbana-Champaign campus. Urbana-Champaign being the university town and studies being conducted on campus, a majority of the participants are from the university community while others are from relevant industries in and around the area. I noticed some participants who had never conducted usability studies but are familiar with the concepts from the courses learned in their degree program. Hence, I classified participants into two groups: expert participants and intermediate participants. The expert participants are usability experts who would have done usability studies in real-time and intermediate participants have exposed to usability concepts and knowledge via classes and projects but did not have any practical experience of conducting the studies. With this classification criteria, I identified 9 participants as usability experts and 9 participants as intermediate experts out of 18 total expert participants.

A mixed-methods study design was used to investigate the agricultural mobile application's utility and functionality with the expert participants. This method enabled me to integrate both quantitative and qualitative data within a single investigation, permitting more comprehensive and synergistic utilization of the data than separate qualitative or quantitative data alone.

A two-phase survey was used to collect mixed data from expert studies. The survey started with the researcher briefly explaining the survey process and taking consent from participants to participate in the study. Study procedure beings by asking participants basic demographic questions such as age and profession or major then the first phase, cognitive walkthrough, of the study will begin.

In the cognitive walkthrough method, experts act as end-users to perform the tasks given by the researcher. Hence this phase starts with the researcher explaining the end-user's population of the app and tasks to be performed as given below:

- End-User Population: Rural Indian Farmers who usually have little or no experience in using smartphones or mobile applications.
- Tasks: The app under study, NaPanta, is an agricultural app whose main functionality is to disseminate required information to farmers. Hence the tasks will be to find information about general/identified information needs of the farmers given in Table 7.
- Guidance to perform the tasks: The app is already installed and activated with the local (Indian) mobile number. Hence participants would open the installed app directly and look for the information asked for in the given task.

The information needs were grouped into four stages of the agricultural life cycle including seed and cultivation varieties, disease and weed management, Market & Post-Harvest management, and Agriforum: an interactive chat forum. In the heuristic evaluation phase, the heuristic principles given in Table 8 are used to build the questions to test the app's interface for its usability and performance. The questionnaire used for this study can be found in Appendix E.

Participants were asked to speak out during the entire duration as the sessions were audio-recorded. As the researcher asks questions to perform the tasks to find information, the participants were speaking out their thoughts, ways of trying to find information, and comments on the app's interface. The researcher took notes while they were talking. Both the study notes and the audio recordings were used for the analysis.

Data Analysis

Researcher study notes and the audio recordings were used to develop the transcripts. Both quantitative and qualitative analysis were carried on the integrated data collected. Frist qualitative analysis was performed to identify themes, codes, and usability problems from the transcripts. Then descriptive statistics and inferential statistics such as t-test were performed on the average number of problems identified by two groups of participants: intermediate and experts to observe any differences between the two groups.

Qualitative Analysis

A hybrid approach of inductive and deductive coding and themes development was used. Some of the themes were taken from the previous study on apps analysis and some themes have emerged during the coding. The analysis started with multiple readings of the study notes (transcripts) to identify keywords and phrases. Relevant keywords and phrases were coded, and relevant codes were grouped into themes.

A 4-step data analysis process explained by Bengtsson (2016) was followed: decontextualization, recontextualization, categorization, and compilation as shown in Figure 7.

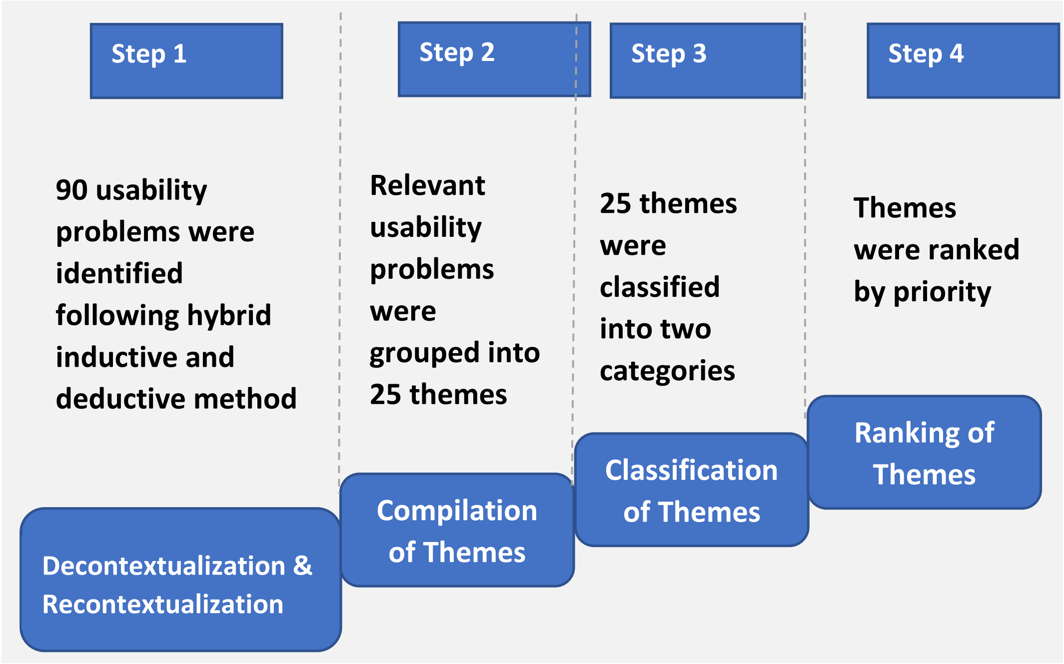


Figure 7. Thematic data analysis process

A total of 25 themes with a varying number of different usability problems under each theme were identified. The themes were further classified into two categories named general usability problems and app-specific usability problems. While the general usability problems category explains usability issues common for all apps in general, app-specific usability problems describe usability problems associated particularly with the app under study. The themes were ordered by considering the number of usability problems associated with the theme and the number of participants identified problems in that theme. Starting from the most prevalent theme, all main themes were described below with an explanation of usability problems identified under that theme along with some exemplar quotes. Quotes by expert participants are appended with [E] and quotes from intermediate participants are appended with [I] wherever quotes are used in this section.

General Usability Problems

Usability issues common to general smartphone applications are described in this section. Usability themes in this category emerged both from the previous study on usability characteristics (Table 5) and during the coding of the transcripts. Six themes were identified including Ease of use, Performance, Assistance, Consistency, Memorability, and Freedom. Major usability problems in each theme will be discussed below and all the usability problems are provided in Table 9.

Ease of use

Half of the participants said they found it difficult to use the app because of the lack of smooth flow as it needs many backs and forth clicks to find necessary information. They also reported that all the fields must be filled manually at multiple places in the app:

"For my regular crops on personal details settings, there is no button to add crop and the same crop has to be written manually for all seasons." [E]

"Losing interest after 5 clicks: too many clicks to get information." [I]

"It is not clear which one to click first? What is important? Where to start?" [I]

"Hunting challenge, not easy (not user-friendly): programmers create the interface." [E]

Performance

Performance of a mobile application is the perception of users on how well the application performs including how responsive the app is, time takes to start up, efficiency in using devices memory and power. Half of the participants reported that the app was loading very slowly with many redundant things scattered at various places. Some of them also said the app was complex and confusing:

"Slow even with the high-speed Wi-Fi here (maybe faster compare to data speed in India). How would it perform in India in rural places?" [I]

"If I don't find information in 5 seconds then I just google" [I]

Table 9. General Usability Problems Identified by Experts

Themes	Usability Problems (number of participants identified the problem)
Ease of use These were the identified issues which made the app difficult to use	Lack of smooth flow (7) Many clicks to reach destination (to complete task) (5) Redundant manual typing (1) No swipes on the page (2)
Performance Identified problems that reduce the performance of the app	Very slow (3) Duplicate things (1) App is so complex (2) Confusing: there is so much going on (4) Things are changing all over (2)
Assistance Missing features to get help when assistance is needed in using the app	No ask help button (2) No help documentation (6) No clear video tutorial on app's full functionality (2) No information to contact experts for help (1)
Consistency Lack of consistency throughout the app	Inconsistent navigation buttons (6) Inconsistent clickable & unclickable buttons (6) Inconsistent symbols for same feature (1)
Freedom Some actions cannot be altered	Users have no freedom over their posts (3) Default selection: Some fields are filled with defaults (6)
Memorability More on the user memory load	Users have to remember things (6)

Assistance

More than half of the participants (10/18, 55.6%) mentioned that some kind of help on app usage would be helpful. Most of them said that a video tutorial on the app's complete functionality with all the details would help understand and use the app efficiently. Some other ways of help reported by participants include help documentation, contact us page, and ask help button.

"How to ask general questions? What if my question doesn't fall under any category? Under ask question button, not allowing to post without any image and categories" [I]

"Additional help on app usage is not available on the main screen" [E]

Consistency

The app should follow standard conventions and the instructions throughout the product should be consistent. Eleven out of 18 participants (61.1%) reported inconsistent navigation buttons, especially with clickable and unclickable buttons. Unclickable buttons at some places look clickable and vice versa. Some of them also noticed changes in the icons: icon image changes for the same functionality.

"Something was clickable, and something wasn't, but both look similar, so it was very confusing" [E]

"Clickable and non-clickable are not consistent. For example, more info on dealer contact details looks clickable because of other clickables on the app, but it is not really!" [E]

"Hierarchy is inconsistent: some of them dropdowns, some of them cards, etc.," [I]

Freedom

Participants reported mixed opinions towards giving freedom to users in modifying their posts. Some of them (8/18, 44.5%) said interface should allow the user to perform actions and navigations as they wish and give freedom to undo certain actions performed mistakenly. While a couple of participants said users may misuse the capability of modifying their posts causing chaos in the discussions.

"Cannot attach images to the posts that I already posted later: Users should have control over their posts" [E]

"Not sure if users may misuse the freedom if they provide with complete freedom, maybe a time frame would be better" [I]

Memorability

The interface should reduce users' memory load by making objects more visible so users can understand by looking at them instead of remembering their actions. Six of the participants reported it was hard to remember things and the interface design puts more on the user memory load.

"I literally cannot remember which place I went to, but I found it eventually" [I]

"Do not remember how to get back to the home page, hard to remember the path since it was not smooth" [E]

App-Specific Usability Problems

The themes in this category were identified while reading and coding the transcripts as the themes describe the usability problems associated with functionalities provided by the app. Nineteen themes with a varying number of different usability problems under each theme were found in this category. Relevant and smaller themes were combined and described below along with findings and exemplar quotes. All the usability problems with themes under this category are given in Table 10.

Table 10. App-Specific Usability Problems identified by experts

Themes	Usability Problems (number of participants identified the problem)
Home screen Problems identified with the home page	Complex home with many things (4)
	Un organized boxes on home (8)
	Unnecessary things on the home page (1)
	Home looks slidable, but not really (1)
	No ask question on the home page (1)
Sidebar Issues with sidebar on home page	Very long sidebar (4)
	From sidebar pesticide information link takes to crops page (3)
	Redundant sidebar and home page (6)
Ads Problems reported with ads on home page	Distracting ads (4)
	Too much space for ads (1)
	Ads look like they are part of the app (3)
	The ads look more important and easier to click (3)
	Better placements of the adds (1)
Search Suggestions on search option feature	Text-based search: regular keyword search (9)
	Alphabetical search: popping up as we type in drop-down (7)
	Filter based search: search based on filters (4)
Labels Issues with label names for icons	Confusing labels: different information for that label name (5)
	Mismatch labels: label name changes after clicking (1)
	Unclear labels: unpredictable information for the given label (2)
Buttons Problems with missing and inconsistent buttons	Home button disappears on some pages (1)
	No home button on sidebar (1)
	App doesn't have a back button (4)
	Forward button is missing (1)
Visuals: Images Issues with mis representation of images for icons	A building for food processing looks like storage facility (5)
	Email symbol for commenting (3)
	Settings gear for personal information (1)
	crop expenditure tool icon doesn't say anything (1)
	Crop protection icon doesn't explain it also has seed varieties (4)
	Unexplained price trend graphs (1)
Visuals: Symbols Problems with weird symbols and suggestions on providing symbols for icons	Confusing symbol (?) at crop disease info next to cold storage dealer name (1)
	Unexplained symbols: cart and toxic levels (3)
	Should contain self-explanatory symbol for icons which will not information after clicking (5)
	functionality or usage of sell/buy crops is not clear (4)

Table 10. (cont.)

Themes	Usability Problems (number of participants identified the problem)
Visuals: Text Problems identified with fonts and themes	White text on black background might be hard to use outside (1) Too small text and labels (4) Color alone should not be the indication: asterisk (*) for mandatory fields instead of just the red color (1)
Visuals: Alerts	Too bright color for alerts and error messages (2) Annoying frequent alerts (7)
Visuals: Buttons	Hard to click on small size button (2) Buttons are too close to each other (1)
Visuals: Location Issues with location of icons	Some icons are towards the very bottom of the app (10) Important boxes at easily ignored spots (1)
Visuals: Status	No display of the status on where I am in the app (3)
Terminology Identified concerns with terminology of labels and text in the app	Too professional terminology (5) Unclear error message (2) Too long and unclear about us (1) Agri e-commerce: no clear description on what it is (2) Difference of crop protection and crop insurance is not clear (1) Difference between market and commodity is unclear (1)
Information: Incomplete Identified incomplete information features and concerns regarding them	Incomplete information on crop protection (7) Incomplete dealers' details: missing contact information (3) Cold storage capacity such as price, available space details are not provided (5) Incomplete my crop management feature (4) Incomplete price information: no details on if the price is per kilograms or grams or other units (1)
Information: A lot Issues with a lot of information	Too much information on the screen (8) Verify if all the information provided is really necessary (3)
Information: Scattered Same information on some topics is spread all over the app as complained by the participants	Information on seed dealers and seed varieties appeared at many different places (11) Equipment info is inside crop protection and cold storage (2) Cultivation types in different pages (5) Better to have categories like information for farmers and agricultural knowledge. Right now, it is mixed and confusing (1)

Table 10. (cont.)

Themes	Usability Problems (number of participants identified the problem)
Missing connections Problems with disconnected information due to missing connections	Buy pesticides and expenditure tool pages are not connected (1)
	Connections between relevant things are missing (6)
	Found information when looking for something else (9)
	Not automatically selecting based on previous actions (3)
	No link to get market prices in the sell crop page (1)
	No crop selection button on market price page (2)
	Missing fertilizer dealer connections in the fertilizer page (1)
	No link to pesticide dealer from diseases (2)
Agri forum Concerns reported on agri forum chat and interaction functionality in the app	First time when clicked on my posts it shows other posts (2)
	Not allowing to post without any image and categories (1)
	Not able to pin an accepted answer (1)

Home screen, Sidebar, and Ads

The home screen is an essential part of any mobile app. A majority of the participants (11/18) reported that the app's home screen is complex with many things scattered all over without having any structure. They further suggested placing boxes on the home screen following an agricultural life cycle to make it simple and clear. Similar views on the sidebar of the app. Seven of the participants (38.9%) reported that the sidebar is too long with many duplicates on both the home screen and sidebar. Some of them also mentioned that ads on the home screen take a lot of space and the ads look like part of the actual content. They often tried clicking on the ads which take them to unwanted pages.

"It is confusing as a lot going on the screen with flashing things. Having boxes in an agricultural life cycle in chronological order could be very helpful" [E]

"The difference between the sidebar and the home screen is not clear" [I]

"Ads with flashes in between the content are annoying" [I]

Search, Labels, and Buttons

Most of the participants (15/18) said that it is crucial to have search functionality in any app to make it usable and user-friendly and they reported that the app under study does not have any kind of search facility making it hard to find the information needed. Text-based search and keyword search are among the most suggested search options.

Names of the labels were misleading as reported by six of the participants (33.3%). For example, label name changes after clicking on the label and some label names are not self-explanatory. Forward and backward buttons play a vital role in smooth navigation of the app usage, however, app misses having forward and back buttons.

"Difficulty in finding actual information because app makes you click on many things to go to the actual information so search option would be very helpful" [I]

"No way that user could guess seed varieties that are hidden under crop protection, confusing labels" [E]

"No back button in the app, have to use the device's back button" [E]

Visuals: Images, Symbols, Text, Alerts, Buttons, Location, and Status

All the visual representational issues identified in the study are grouped into the theme Visuals. Most of the participants (16/18) identified some or other issues with the visuals.

Misrepresentation of the images, the image icon gives a different meaning than the information it contains, is one of the major issues.

"Seed varieties cannot be found because the images are not helping to identify that's the seed varieties" [E]

Some participants expressed that the app has unexplained symbols such as an online cart which many rural farmers may not know. Some accessibility issues with the text and buttons were identified: small fonts and buttons, black background and white text, less distance between buttons, and too much bright color for alerts.

"Bug symbol for crop protection—they have more info than just bug...so it is misleading" [E]

"Text on buttons is too small to notice and the buttons are too close to each other which makes it difficult to click on the desired one" [I]

More than half of them (10/18) complained that many important boxes were placed at easily ignored spots: towards the very bottom of the page makes it feel like those boxes are part of the device, but not the app.

"No display of the status on where I am in the app, not even a side map showing the navigation" [E]

"Some things such as ask question, nat/reg/org, are at the very bottom of the page, and looks as if they are part of the app, but not the page" [I]

Terminology and Information: incomplete, scattered, and too much

The app used some scientific terms which makes it difficult to understand the information provided by the app. Around half of the participants mentioned they could not understand some terms as they are too professional. They further expressed that it could be hard to understand for farmers as well.

"I was not sure what do they mean by commodity, it is too professional term I think" [E]

"Requires knowledge. Farmers may have to put NPK values in soil testing and what are those values?" [I]

A majority of the participants (16/18, 88.9%) reported having some issues with the information provided. The three sub-themes in this theme are the information is incomplete, information is scattered all over, and a lot of information.

"Information provided only about crop disease details, but not on protecting it. It is not clear if they are not providing this information on the same page or if there not providing at all" [I]

"Information is scattered: all information about a crop under one roof would be helpful" [I]

"All commercial info at one place instead of seed dealer info at sell/buy and find dealers" [E]

"It looks clutter due to so much information. Should have a trade-off between what info to provide vs what is actually needed" [E]

Missing connections

With the information scattered all over, there are also issues with missing connections among relevant features of the app, as reported by most of the participants (14/18, 77.7%).

"Buy pesticides and expenditure tool pages are not connected" [E]

"Found information at a different location than the desired one when looking for something else" [I]

Statistical Analysis

Descriptive statistics of themes and problems found along with inferential statistics were used to test differences between two groups of participants: expert and intermediate participants. Counts of themes, problems, and participants are given in Table 11 below.

Table 11. Number of themes and problems

Category	Count
Number of themes	17
Number of usability problems	90
Number of total participants	18
Number of expert participants (Group 1)	9
Number of intermediate participants (Group 2)	9

From the top 10 problems identified by expert problems as given in Table 12, it can be observed that the major problems were associated with app-specific usability problems such as scattered information, lack of search functionality, and disorganized interface design. These problems can be addressed with a more careful design of the information architecture in the app.

Table 12. Top 10 problems identified by 7 or more participants

Count	Usability Problem	Theme
11	Information on seed dealers and seed varieties appeared at many different places	Information: Scattered
10	Some icons are towards the very bottom of the app	Visuals: Location
9	Text-based search: regular keyword search	Search
9	Found information when looking for something else	Missing connections
8	Un organized boxes on the home	Home screen
8	Too much information on the screen	Information: A lot
7	Lack of smooth flow	Ease of use
7	Alphabetical search: popping up as we type in dropdown	Search
7	Annoying frequent alerts	Visuals: Alerts

Difference between two groups: expert and intermediate participants

The number of problems identified by each participant is shown in Figure 8. The first bar in the figure indicates that participant 'E2': second expert participant found 34 usability problems and the fourth bar indicates that participant 'I8': eighth intermediate participant found 22 usability problems. Similarly, the number of problems identified by all expert and intermediate participants is shown below.

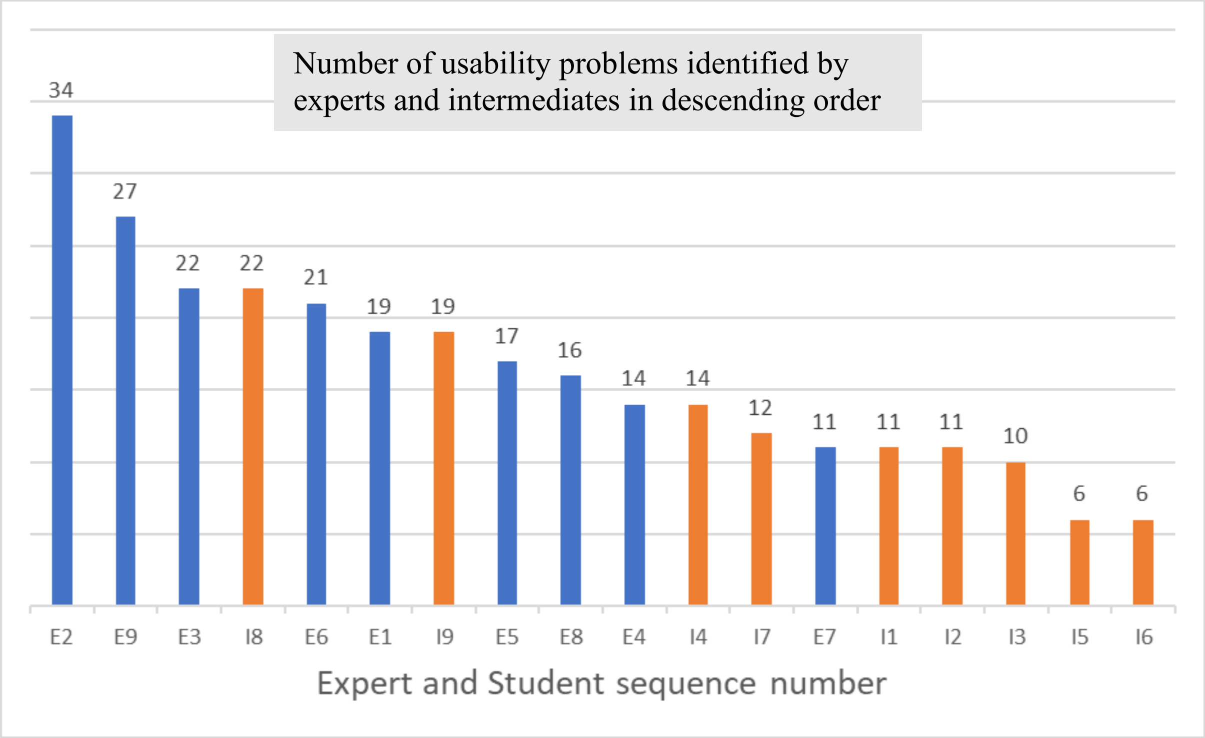


Figure 8. Number of problems identified by experts and intermediate participants

From the figure, it seems that there is a difference in the number of problems identified by intermediates and experts. To statistically examine this a t-test was performed on the average number of usability problems identified by two groups. An unpaired student t-test was conducted to find any difference between the number of problems identified by experts and users.

Experts (Group1): $\mu 1$: Mean of usability problems identified by expert participants

Intermediates (Group2): μ_2: Mean of usability problems identified by intermediate participants

Null hypothesis (H_0): $\mu_1 = \mu_2$; there is no difference between the average number of usability problems identified by experts and intermediates

Alternate hypothesis (H_A): $\mu_1 \neq \mu_2$; there is a difference between the averages

The number of problems identified by each expert and intermediate is given in Table 13 along with t-test calculations.

Table 13. Number of problems: experts and intermediates

Serial No	Experts	Intermediates
1	19	11
2	34	11
3	22	10
4	14	14
5	17	6
6	21	6
7	11	12
8	16	22
9	27	19

T test calculations

Group 1: mean (m1) = 20.11
standard deviation (s1) = 7.01

Group 2: mean (m2) = 12.33,
standard deviation (s2) = 5.36

degrees of freedom (df) = 16
P value = 0.017
The mean of Group 1 - Group 2 = 7.78
standard error of difference = 2.941
95% confidence interval of this difference: 1.54 to 14.01

The statistical test of means (t=2.8047; p=0.017) indicated a significant difference in the average number of problems reported by experts and intermediates. From the above P-value (0.017) the null hypothesis can be rejected at the 0.05 significance level. Hence, I can conclude with at least 95% confidence that there is a significant difference between the mean value of the number of usability problems identified by the expert and the intermediate participants. It was also observed that there is an interesting amount of expert and intermediate overlap. The best intermediate outperformed 6 experts. The best 2 intermediates outperformed 4 experts. However, no expert underperformed the worst 5 intermediates. These observations are also in accordance with the findings shown in part 3 of Table 15 below.

Number of problems identified by a single participant

It was interesting to notice that the majority of the problems were identified by a fewer number of participants; 31 problems were identified by a single participant. 14 problems were identified by 2 participants as shown in Figure 9. Some of the problems uniquely identified by a single participant can be found in Table 14.

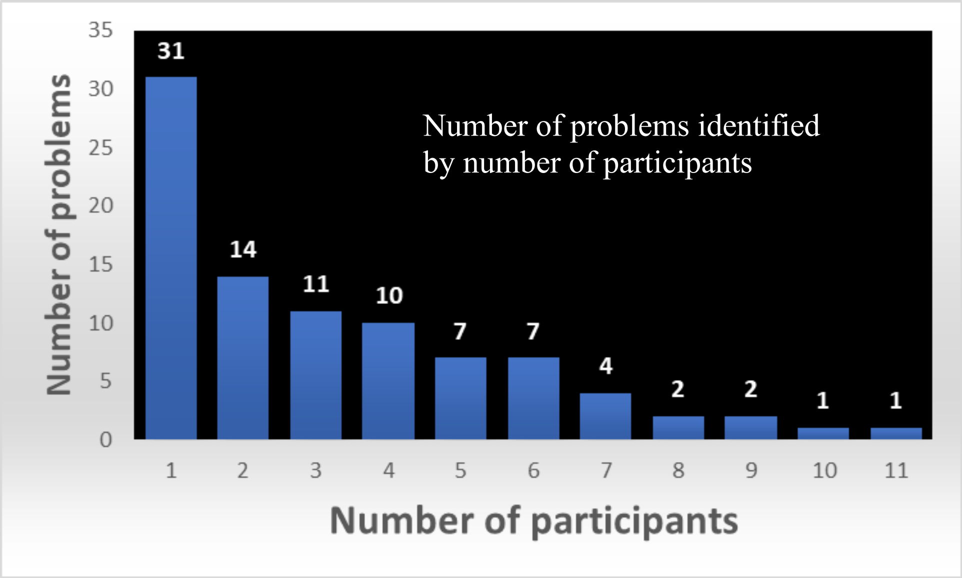


Figure 9. Number problems and number of participants

Table 14. A subset of important problems identified by a single participant

Usability problems
No information to contact experts for help
Inconsistent symbols for same feature
Too much space for ads
Mismatch labels: label name changes after clicking
Home button disappears on some pages
Color alone should not be the indication: asterisk (*) for mandatory fields instead of just the red color
Buttons are too close to each other
Important boxes at easily ignored spots
Incomplete price information: no details on if the price is per kilograms or grams or other units
Not able to pin an accepted answer

It was challenging to choose between combining multiple problems as one problem versus keeping the problem separate as impetuous grouping might hide the new problems identified by new participants in the sequence. For example, the problem “Some icons are towards the very bottom of the app” identified by 10 participants and another problem “Important boxes at easily ignored spots” which look similar but is different and gives different insight. The second problem was uniquely identified by a usability expert participant who is also an expert in web design and information architecture. The expert said:

“Find dealer functionality is great with a lot of necessary information, but the spot is widely missed spot according to the architectural design principles.”

Insights on the number of experts required for the usability study

“How many participants are really enough?” is a question of concern for many researchers and professionals in the field of usability engineering. Many pioneers in the field conducted studies with varying numbers of users on different products and reported two different views. Turner, Lewis, and Nielsen (2006) identified that five number of participants are enough to get 80% to 95% of the usability problems while other studies (Lindgaard & Chattratichart, 2007) believed that more than five participants are needed to identify most of the problems. Yet there is no consensus on the sample size as it depends on various factors including size and properties of the product, type of the product, method of the usability study, skills and personalities of participants (Alroobaea & Mayhew, 2014; Demir & Parraci, 2018).

The study with 18 participants (9 experts and 9 intermediates) identified a total of 90 usability problems in the app under study. As part of investigating how many participants would be enough to identify most of the problems, I used a random selection of 5 to 9 only experts, only intermediates, and a mix of experts and intermediates to get insights on what percentage of problems would be identified by how many numbers of participants.

In the first part of Table 15 on experts, the first row describes the maximum number of problems identified when 5 random participants from 9 expert participants for all combinations (9 choose 5 is 126) were selected. Similarly, the minimum and the average number of problems with a percentage of usability problems identified are given in the table.

Table 15. Combinations of experts and intermediates with the percentage of usability problems found

Number of participants	Max number of problems(percent)	Min (percent)	Avg (percent)
	Expert: all possible combinations (9 choose number of participants)		
5	67 (74.44)	42 (46.67)	57.92 (63.19)
6	69 (76.67)	52 (57.78)	63.38 (69.31)
7	71 (78.89)	58 (64.44)	66.16 (73.51)
8	73 (81.1)	66 (73.33)	70.6 (78.44)
9	74 (82.2)	74 (82.2)	74 (82.2)
	Intermediates: all possible combinations (9 choose number of participants)		
5	55 (61.11)	33 (36.67)	43.95 (48.84)
6	59 (65.56)	41 (45.56)	50.24 (55.82)
7	60 (66.67)	48 (53.33)	54.49 (60.54)
8	63 (70)	55 (61.11)	58.67 (65.12)
9	63 (70)	63 (70)	63 (70)
	Mixed experts and intermediates: all possible combinations (18 choose number of participants)		
5	70 (77.78)	29 (32.22)	52.24 (58.04)
6	74 (82.22)	34 (37.78)	57.55 (63.95)
7	78 (86.67)	38 (42.22)	62.11 (69.01)
8	81 (90.00)	43 (47.78)	66.01 (73.35)
9	83 (92.22)	48 (53.33)	69.53 (77.26)
10	85 (94.44)	56 (62.22)	72.60 (80.67)

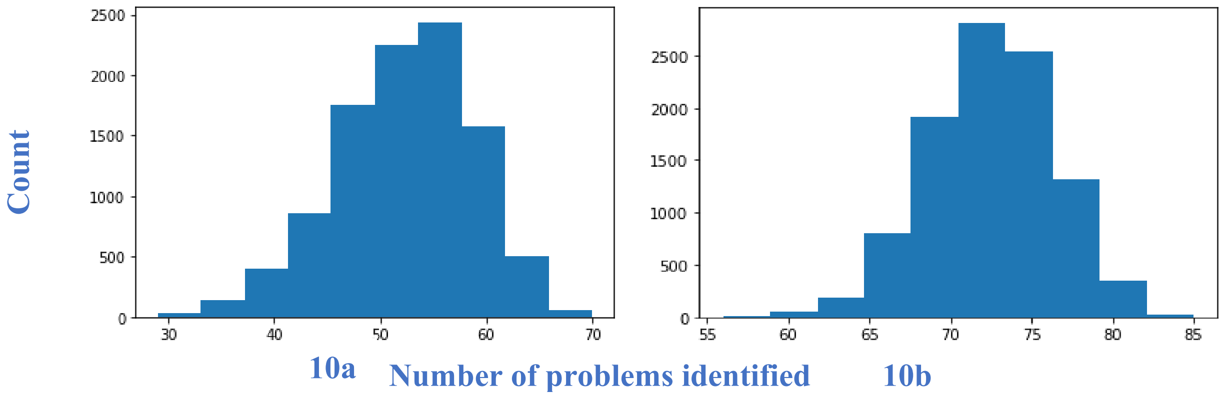


Figure 10a & 10b. Five and ten participant combinations from 18 participants

I wrote a Python function to select random numbers and to find the percentages of problems identified by the number of participants selected for that run. The same function was applied to 9 intermediate participants and obtained values displayed in the second part of the table below. For the third part, 5 to 10 participants were selected randomly irrespective of their experience with usability studies which considered all 18 participants. The random selections were repeated for all combinations of 18 choose 5 to 10 number of participants. The explanation for the first row of mixed experts and intermediates is: 5 participants were randomly selected from 18 participants and this random selection was repeated18 choose 5 times. The maximum number of problems identified from the 5 participants was 70/90 (77.78%) and the minimum was 29/90 (32.33%) and the average of all these values was 52.33 (58.14). Figures 10a & 10b show the graphs of the number of usability problems identified when 5 participants were selected, and 10 participants were selected from 18 participants respectively.

From Table 15, it can be noted that 8 experts could find around 80% of the total usability problems, and all 9 intermediate participants together found only 70% of the total problems. Some combinations of intermediates and experts identified more problems than from individual group as shown in the third part of Table 15. Six participants (combined experts and intermediates) were able to find around 80% of the problems whereas 8 participants from the expert group alone found 80% of the problems. This study required more than 5 participants to identify most of the usability problems which is different to the number suggested by Turner, Lewis, and Nielsen. This can conclude that there is no strict rule on the number of participants needed to identify most of the usability problems as it depends on the participant characteristics and the characteristics of the product under study.

Conclusions

This chapter explained selecting the app developed for Indian farmers to study with experts and users. Applied for IRB approval and recruited expert participants after the approval. A total of 18 participants participated in the survey including 9 experts (experience with conducting usability studies) and 9 intermediates (no experience with conducting usability studies but know them). Studies were conducted using the two most common usability inspection methods: cognitive walkthrough and heuristic evaluation to get mixed qualitative and quantitative data from the same study. Studies were audio-recorded, and notes were also taken.

Qualitative and quantitative data analysis were performed. Thematic analysis and descriptive and inferential statistics were calculated to understand the data better. First, transcripts were reviewed multiple times to identify codes, themes, and usability problems. A total of 90 usability problems were identified and grouped based on relevance to 25 themes. The themes were further classified into two categories: general usability problems and app-specific usability problems.

The major problems identified in this study indicate the app did not follow standard design principles such as consistency, ease of use, lack of smooth flow, a lot of information scattered all over with redundancy as the same information appears at different places, missing connections between feature which stopped participants to complete tasks, and a missing search functionality which made it even more difficult to use the app.

This study also contributes to usability research in terms of understanding the number of experts required to identify most of the usability problems. Out of 18 total participants, 9 were experts and 9 were intermediate participants. With an unpaired t-test, it was proved that there is a difference in the number of problems identified by experts and intermediates. A Python function was written to randomly select 5,6,7,8 participants from 9 experts to identify how much percentage of the problems are identified by respective number of experts and similarly for the intermediates. Results indicated that 8 experts were able to find around 80% of the total usability problems, and all 9 intermediates participants together found around 70% of the total problems. Interestingly it was found that some combinations of intermediates and experts identified more problems than from individual groups. Six participants (combined experts and intermediates) were able to find around 80% of the problems. With these findings and observations, I conclude that there is no strict rule on the number of participants needed to identify most of the usability problems. It depends on many factors including participant characteristics, moods at the time of participation, survey design, and app under study among others.

CHAPTER 5: USER STUDY WITH INDIAN FARMERS

Overview

Findings from the survey on expert participants in the previous chapter identified usability problems with the app. Evaluating the same app with the real intended users will be discussed in this chapter. Field studies were conducted with rural Indian farmers to understand their information needs from an agricultural mobile app and evaluated the app for its usability and functionality.

All the recruitment material including study scripts, flyers, announcements, and questionnaires were first written in English and then translated to the local language, Telugu. Due to low English literacy levels among Indian rural farmers, all study materials were in both Telugu and English. The local language is the researcher's mother tongue hence the researcher performed all translations from English to Telugu. Both the versions were approved by the Institutional Review Board (IRB) of the University of Illinois. After getting approval from IRB, participants were recruited, and studies were conducted.

Users were selected through local organizations, farmer meetups, and snowball sampling. A total of 53 farmers from various villages from two Telugu speaking states of India known as Andhra Pradesh (AP) and Telangana State (TS) took place in the research.

A semi-structured questionnaire was used to conduct the interviews. Questions were built based on the insights from the previous two studies (first study on apps analysis and the second study on usability evaluation of the app with experts). All the communications with farmers were in Telugu. Sessions were audio-recorded along with the researcher's study notes.

With the help of study notes and recordings, the researcher developed transcripts in English and use them as basic documents to identify codes and themes. A web-based data analysis software, Dedoose (Version 8.3.17, 2020), was used in conducting qualitative data analysis. All the demographic details were stored in Dedoose along with transcripts for each participant. Descriptive statistics and thematic analysis were conducted to get insights from the mixed data.

This chapter discusses the methods used to recruit users, mixed methods data collection from the studies, and the qualitative and quantitative analysis of the data collected.

Methods

The app under study, NaPanta, is an agricultural app whose main functionality is to disseminate required information to farmers and to allow them to interact with other fellow farmers. The previous study with experts in the United States focused mainly on the usability of the app and inspecting the app's interface. The current study with farmers in India focused mainly on the functionality of the app and evaluating it for the functions provided by the app.

This section presents user recruitment methods, data collection, and data analysis of the mixed data collected.

Research Setting and Participants

This study aims to understand the information needs of rural Indian farmers and how agricultural mobile applications can help in this regard. The main functionality of an agricultural app is to provide farmers with the information they need in an easily findable and understandable manner. NaPanta agricultural application's functionality (content) was analyzed with the rural farmers from two Telugu speaking states, Andhra Pradesh (AP) and Telangana State (TS) of

India. Farmers were recruited through two local farming organizations including Rythu Swarajya Vedika (RSV) and Rythunestham Foundation (RF). RSV and RF both are based in both AP and TS with RSV's major office is in TS while RF is in AP.

RSV was founded by an alumnus of the Indian Institute of Technology Madras, India, and the University of Maryland, USA (Kiran Kumar Vissa, n.d). RSV also collaborates with the Association for India's Development (AID), https://aidindia.org/, which is a secular charity organization based in the USA that supports and promotes quality education, better livelihood, sustainable agriculture, and the like in India. RSV works with farmers from different villages and districts in both the Telugu states (AP & TS) to know their needs and problems and RSV works for them with conducting awareness camps and sending proposals to governments for policies changes as necessary (Kisan Swaraj, n.d.; Naveen, 2017).

RF (Rythu Nestham Foundation, 2019) was started in 2005 as an agricultural magazine to disseminate and update farmers with agricultural news and information. RF magazines are very popular and widely spread among farmers with the publication of tens of thousands of copies every month. RF also offers services and training on new cultivation methods and other new agricultural technologies to update, motivate, and help farmers to make profitable agricultural outcomes.

Both RSV and RF helped in obtaining in-person farmer contacts. RF conducts frequent training programs where farmers from different places attend to learn about current affairs and advanced technologies in agriculture. With the help of RSV, I was able to attend those events and announce about the research study and the opportunity to participate in the survey. This allowed me to meet and inform several interested farmers who later on participated in the study. In addition to this, snowball sampling was also used to recruit more participants to have farmers with different identities including various age groups, education levels, gender, farming experience levels, among other factors. A total of 53 farmers with different identifies were participated in the study. Participant demographics were shown in Figure 11 below.

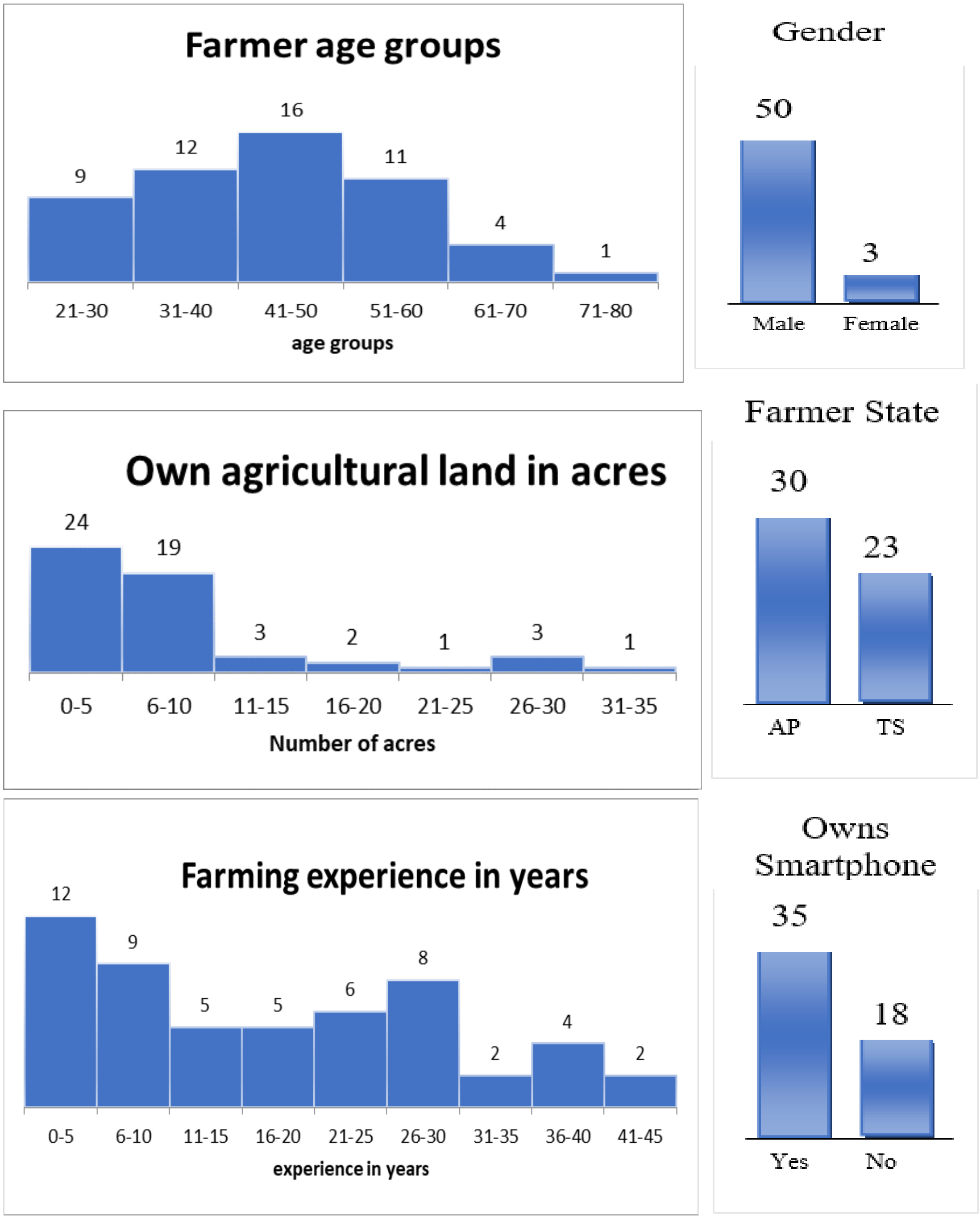


Figure 11. Demographics of farmer participants

Research Study Process

The study was designed following a mixed methods strategy to obtain integrated qualitative and quantitative data from a single study. The collected data was used to investigate the agricultural mobile application to assess its utility for agricultural purposes among rural Indian farmers.

The survey started with the researcher orally explaining the consent to participants in Telugu. The complete recruitment materials, announcements, and questionnaires can be found in Appendix I. After agreeing to the IRB consent, the study procedure started. The study contains three phases: User Characteristics, App Usage and Tasks, and Final Interview phase. All three phases of the study were audio recorded for future references. The researcher communicated with participants in the local language for the entire duration of the survey. The researcher asked all questions orally in Telugu and responses from the participants were written and stored by the researcher for the analysis purposes.

In the first phase, participant's demographic details about their current attitudes towards smartphones and their application usage, their experience with farming, current ways of obtaining information, and information on cultivation methods were collected. All the demographic details of the participants are shown in Figure 11.

In the second phase, participants were handed a smartphone and invited to explore the app and the researcher asked the participant to perform some tasks common to all participants plus some other tasks based on participant's interests from a pre-made list of tasks. Some tasks were also created on the spot according to the participant's behavior and interests. This is informed by Borlund's work on the simulated work task (Borlund, 2003). On the spot scenarios happened during the second phase of the study with the information obtained from the first phase on user demographics and observations from the second stage as well. An example scenario when I encountered a farmer was interested in natural farming is given in Figure 12.

Context: Discussion with a farmer who worked in the software after completing post-graduation. He quit his job to practice natural farming because of its health and environmental benefits.

The tasks were created based on the responses for the questions below.

Question: What do you expect/need from an agricultural mobile application?

Response: Farmer wants to market my own products directly with consumers.

I tried to create a task based on this and the farmer's response to the question "What crops do you grow?". Rice is one of the commonly cultivated crops in India and the farmer said he cultivates rice too, hence, I made tasks to try to sell farmer's rice using the app.

Follow up task: Please explore the app to see if the app allows you to sell your produce.

Response: Yes, I found it on the top "Sell/Buy Crops"

Follow up: Great! Now check if you can sell your produce, for example, rice.

Response: Yes, I think it is possible using the "Sell commodity". However, my rice variety is not listed in the select variety drop down after I selected rice as my crop to sell.

Important suggestion given by this farmer: It would be helpful if the app lets farmer enters new variety that is not in the list they provide.

Follow up: That's a great suggestion. Do you like to check for another seed variety to see how it works?

Response: Sure. I selected some variety which was available and then filled in all the details. Oh! Looks like I need to buy subscription to be able to publish this information to other farmers. I did not expect this to ask to pay money because nothing was mentioned in the description of the app.

Follow up: Right. Thank you for sharing your thoughts and suggestions.

We moved on with other tasks and scenarios.

Figure 12. An example on the spot scenario

In the third phase, a final interview using the semi-structured list of questions was conducted to understand the overall experience of using the app and other questions based on their performance from the first two phases. At the end of the survey, participants were thanked for their time and participation and provided with a gift (an aluminum water pot) which is useful for agricultural activities.

Data Collection and Analysis

A single semi-structured questionnaire was developed based on the information needs identified from the literature and previous study (Table 7). The integrated qualitative and quantitative data was collected through these questions.

The entire data collection happened from November 2019 through January 2020 including the intermediate data analysis. I followed a summary-aided approach for the analysis of the data collected as shown in Figure 13. This process allows performing data analysis while data collection continues. These brief analyses of the study notes allowed me to understand the data collected and to obtain insights into future data collection.

Miles et al. (2014) suggest the importance of data analysis while data collection progress, because it helps the fieldworker cycle back and forth between thinking about the existing data and generating strategies for collecting new, often better, data with the help of the interim reports produced from the early analysis of the data.

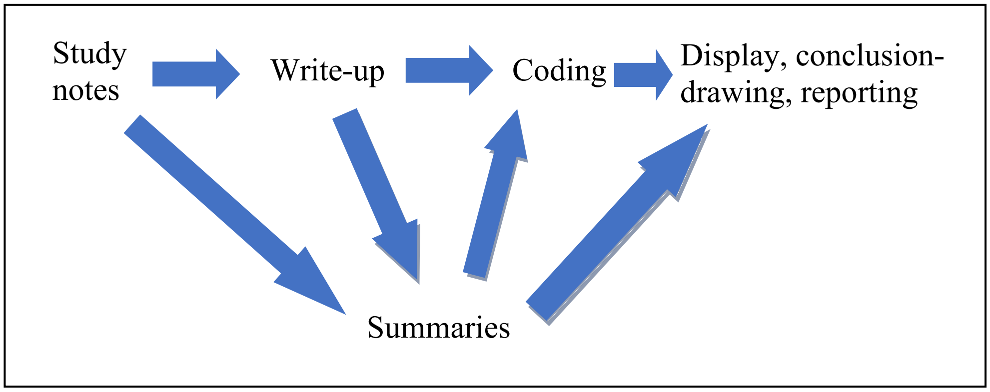


Figure 13. Summary-aided approach to analysis adapted from Miles et al. (2014)

Following the summary-aided approach, I conducted a brief analysis while collecting data. The first step in this approach was to translate the survey responses and field notes into English. Then summaries were made out of these notes. These intermediate analyses helped to frame better on the spot questions for farmers during the second phase of the study in exploring the app under study.

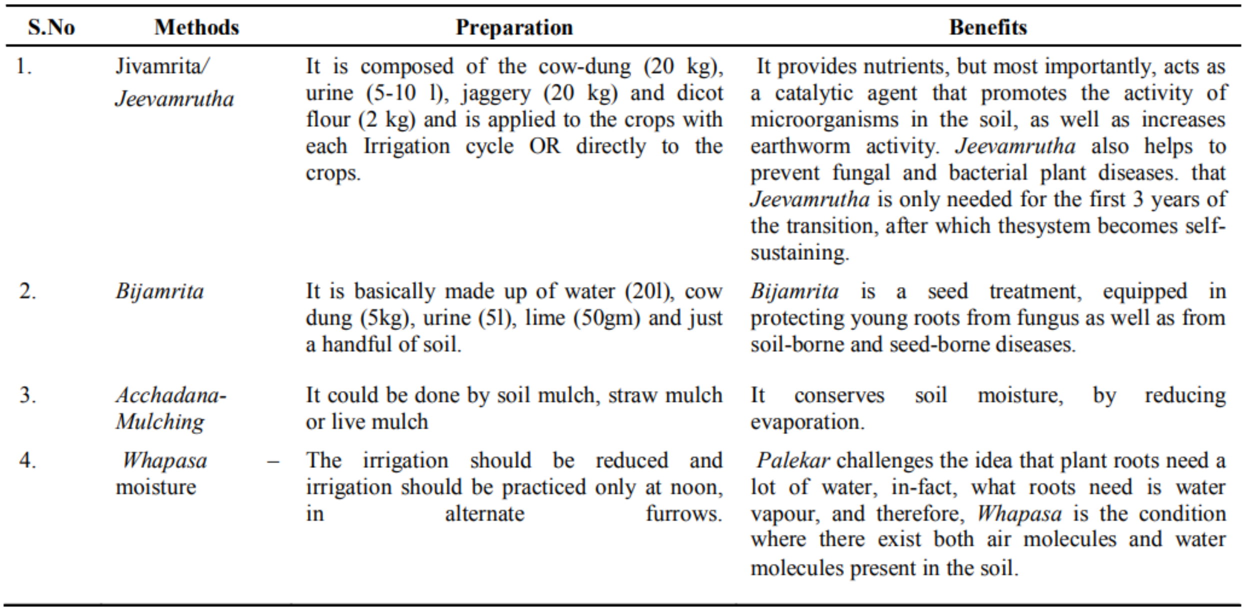
Benefits from analysis concurrent with data collection

From my observation and experience with following this approach, I got new perspectives and new directions in my research. For example, the initial study focus did not specify farmers' cultivation methods, and as the data collection happening, I learned that there are two main varieties of cultivation methods farmers currently practicing: chemical (conventional) and natural. Chemical farming is widely practiced, and natural farming is gaining popularity in recent times especially in southern parts of India. In chemical farming, chemical fertilizers and pesticides are used for the growth and protection of crops. Natural based fertilizers made of natural waste and manure are the basic inputs for natural farming.

In southern part of India, the popular natural farming technique is Zero Budget Natural Farming (ZBNF) as advocated by Subhash Palekar who conducted extensive research on various methods of natural farming and introduced ZBNF to the nation as it is the method of farming which minimizes the financial and resources required to cultivate the crops (Kumar, S., 2017). The government of India honored Subhash Palekar with India's fourth-highest civilian award Padma Shri in 2016 for his work in the agricultural sector (Kurian, N., 2016; Palekar, S., n.d.).

ZBNF was started as a peasant-led movement in the Karnataka state of India primarily as a rural movement with small and middle landholding farmers (Khadse et al., 2018). ZBNF is now spreading across India especially in the state of Andhra Pradesh (AP) where the state government took initiative to conduct awareness programs and to scale up the method in the state (Khadse, A. & Rosset, P. 2019; Zero Budget Natural Farming, n.d.).

Conventional farming has become expensive and caused damage to soil including decreased soil health, loss of soil organic material, ground and surface water pollution, increased pests and diseases, reduction in profits, increased pesticide and fertilizer prices, and unpredictable weather conditions (Asokan, R., Murugan, D., & Sathiyaraj, S., 2020; Naresh, R. et al., 2018; Bishnoi & Bhati, 2017; Devarinti, 2016). ZBNF is rapidly spreading among farmers for its low-cost inputs and health benefits. Agricultural scientists in India experimented and found that the local Indian cow's manure is the main ingredient needed for preparing natural fertilizers to practice ZBNF. Cow dung and urine alone help to increase soil health thereby increase in the yields. ZBNF uses 4 basic inputs made from cow manure and other natural material as shown in Figure 14 (Naresh, R. et al., 2018; Anand & Kumar, 2020; Bishnoi & Bhati, 2017).



S.No	Methods	Preparation	Benefits
1.	Jivamrita/ *Jeevamrutha*	It is composed of the cow-dung (20 kg), urine (5-10 l), jaggery (20 kg) and dicot flour (2 kg) and is applied to the crops with each Irrigation cycle OR directly to the crops.	It provides nutrients, but most importantly, acts as a catalytic agent that promotes the activity of microorganisms in the soil, as well as increases earthworm activity. *Jeevamrutha* also helps to prevent fungal and bacterial plant diseases. that *Jeevamrutha* is only needed for the first 3 years of the transition, after which thesystem becomes self-sustaining.
2.	*Bijamrita*	It is basically made up of water (20l), cow dung (5kg), urine (5l), lime (50gm) and just a handful of soil.	*Bijamrita* is a seed treatment, equipped in protecting young roots from fungus as well as from soil-borne and seed-borne diseases.
3.	*Acchadana-Mulching*	It could be done by soil mulch, straw mulch or live mulch	It conserves soil moisture, by reducing evaporation.
4.	*Whapasa* – moisture	The irrigation should be reduced and irrigation should be practiced only at noon, in alternate furrows.	*Palekar* challenges the idea that plant roots need a lot of water, in-fact, what roots need is water vapour, and therefore, *Whapasa* is the condition where there exist both air molecules and water molecules present in the soil.

Figure 14. Four basic inputs for ZBNF (Bishnoi & Bhati, 2017)

Conventional farming is practiced by the majority of the Indian farmers hence out of the first 30 participants only one participant practices natural farming. When I started seeing the redundant data from the field notes and summaries, I examined the participant characteristics then it was revealed that the insights from that one natural farmer were different from chemical farmers. At this point, it was understood that more natural farmers were needed to be interviewed to get new insights and new data from the natural farmer's point of view as well. The number of farmers from two states, AP and TS, and their farming method details are given in Table 16 below.

Table 16. Farmers region information

Method/ State	AP	TS	Total
Chemical	11	22	33
Natural	19	1	20
Total	30	23	53

Although the initial research study was not particular to any type of cultivating method, the concurrent analysis with data collection helped to identify new data and insights which makes the research findings complete and strong. Neither the research directions nor the survey questionnaire was affected, but these learnings were helpful to obtain more meaningful and comprehensive research findings. The same questionnaire and study design were used to conduct studies with all farmer participants due to the strength of the semi-structured questionnaire used for the study.

Trustworthiness of data and findings

The quality of data collected in qualitative research is essential to ensure the trustworthiness of the findings. I am, as the researcher, from the same region and culture of the participants which helps to be aware of the field study circumstances that helps to properly design the study procedure. During the interviews, I also noted down the observations which later helped to cross check with the interview transcripts when analyzing the data. Data from both expert and user studies of the same agricultural application helped in gaining comprehensive understanding of the app. I used a semi-structured questionnaire hence had the flexibility to add questions based on the conversations with the farmers and return back to the previously discussed questions when needed. This approach of iterative questioning helped to dwell into the concerns of the participants rather than trying to ask questions from a pre-made list of questions and tasks.

In addition to these strategies, I also provided detailed information on the research design, data gathering, and the analysis along with the boundaries of the study such as the number of participants and their demographic, data collection duration and methods, and the time period of the entire data collection. All these strategies and approaches I followed in this study along with the detailed information provided in this dissertation help to address the four main constructs in social sciences qualitative research such as credibility, transferability, dependability, and confirmability (Shenton, 2004; Guba, 1981) to gain a deeper understanding of the data and the research questions and to ensure the trustworthiness. These in turn help to ensure the quality and the trustworthiness of data collection and analysis processes.

Data Analysis

Mixed qualitative and quantitative data were collected in a single study with the semi-structured questionnaire. The questionnaire contains questions for each phase of the study: User Characteristics, App Usage and Tasks, and Final Interview phase. The analysis of the mixed data collected from three phases of user studies was performed using a web-based data analysis app, Dedoose for mixed methods research developed by researchers from the University of California, Los Angeles (Dedoose Version 8.3.17, 2020).

Thematic Analysis

All the 53 participants' demographics along with field notes and summaries were stored in Dedoose. The thematic data analysis process is similar to the process of expert study analysis as shown in Figure 4. The study notes were reviewed multiple times to identify codes and keywords. Then the codes were grouped by relevance and themes were formed. The themes were further classified into four categories including General usability problems, App specific usability problems, Information Needs, Suggestions on App Usage. The themes and categories emerged from both the previous analysis of expert reviews and the current study notes while coding them.

Creating codes and themes:

Two rounds of coding were performed following Saldaña's strategy as shown in Figure 15. An *In Vivo* coding method was applied for the first cycle of coding. This approach uses words or short phrases from the participant's own language. The field notes from these studies were translated to English by the researcher hence the phrases used in coding can be considered as a mixture of participant thoughts and researcher phrases. A list of codes from the previous study on expert studies was used to start with the coding process (deductive coding), and still, other new codes emerged during the coding of the data collected (inductive coding).

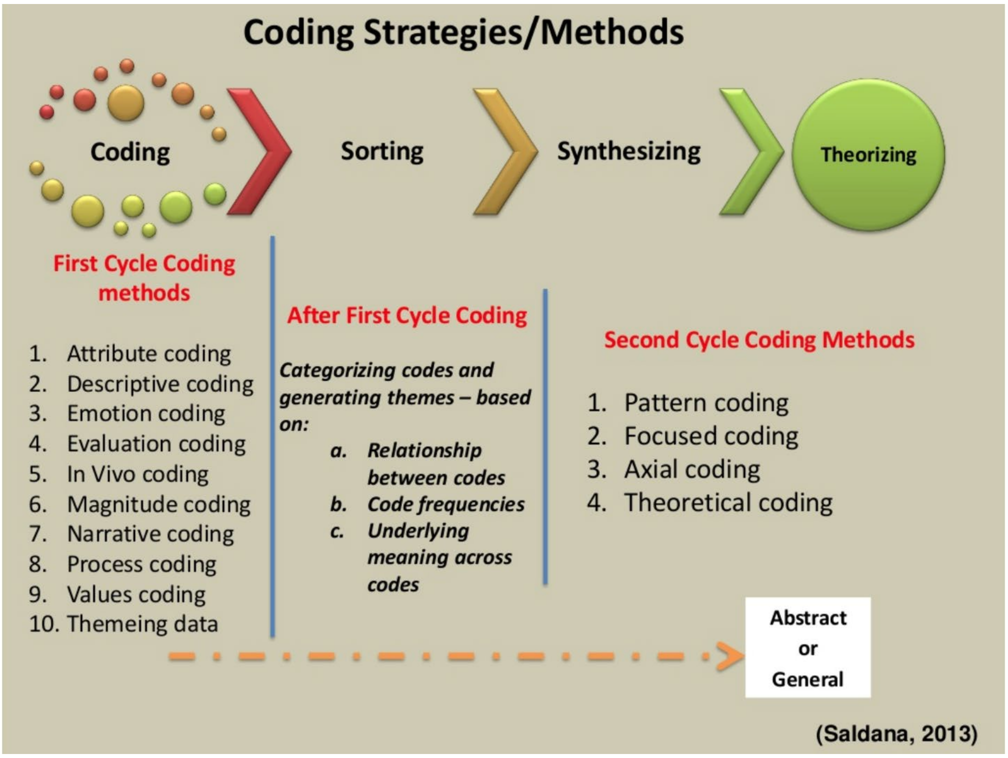


Figure 15. Coding process and methods (Adu, 2013).

After the first cycle of coding 161 codes were identified. These 161 codes were further sorted and grouped by relevance. After grouping and removing the duplicates, 108 codes were considered for the analysis. Frequencies of codes and relations among them were identifying during this phase.

In the second cycle of coding a pattern coding was used as it was the most suitable one. Pattern coding examines initial codes, identifies trends, patterns, and themes or categories. After the second cycle of coding, four main concepts (categories) with varying numbers of themes for each concept were identified. The concepts, themes, and codes emerged both from previous studies and current data collection as shown in Figure 16. The four categories are General usability issues, App-specific usability issues, Information needs, and App usage and development. The first two categories (General and App-specific usability issues) were taken from the expert study analysis, and third and fourth themes emerged from the user studies.

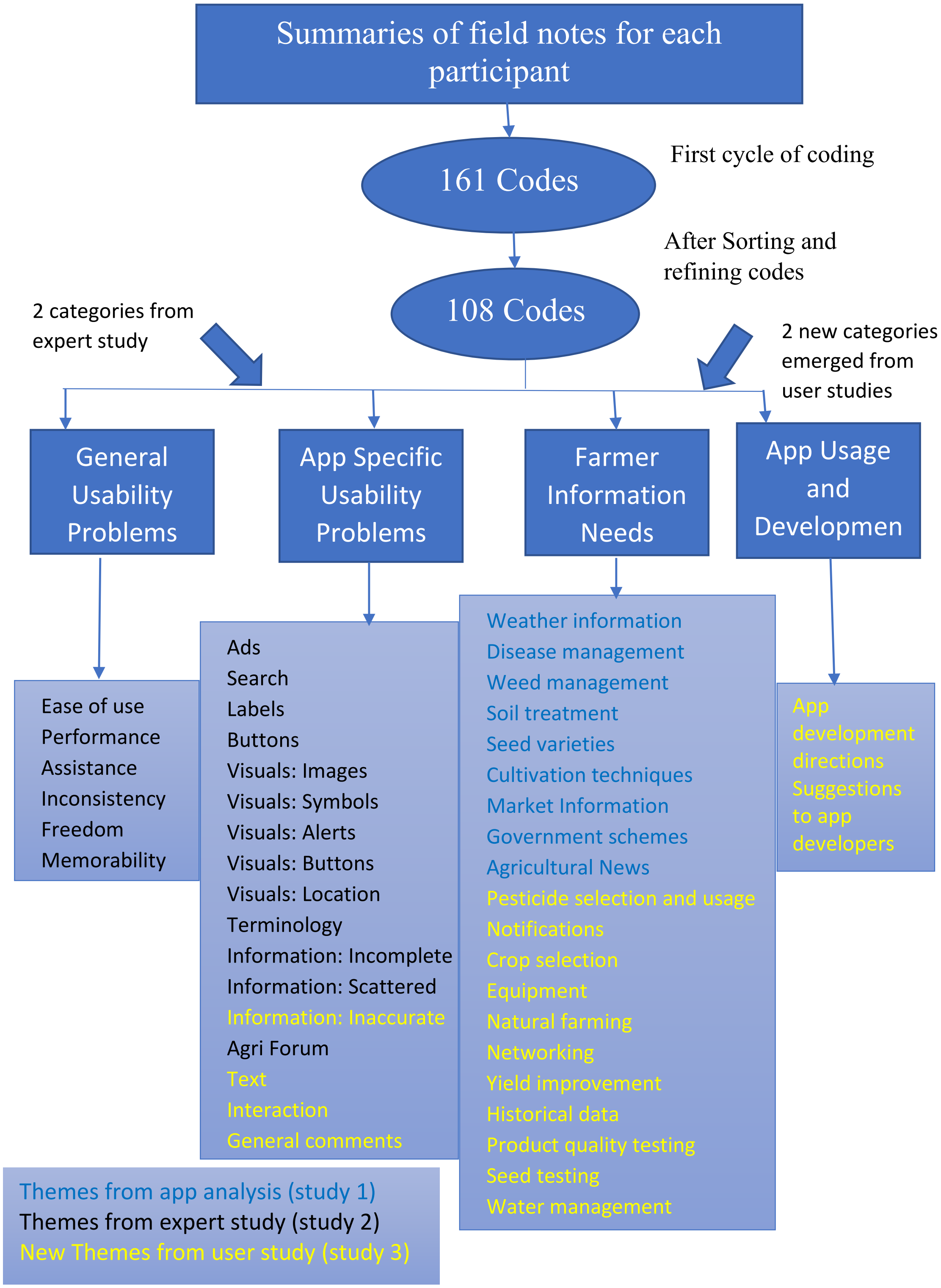


Figure 16. Coding process for user studies

General Usability Issues

All the themes in this category were taken from the expert study (Table 9) and no new themes were found during the analysis. Of the six themes, Ease of use, Performance, Assistance, Consistency, Freedom, and Memorability, lack of assistance in using the app was of the major concern in this category. Users (15/53, 28.3%) suggested incorporating video tutorials of all the functionalities of the app on how to use them. Some of them also suggested providing on-screen instructions to make it easy to use. All the usability problems identified in this category are provided in Table 17.

Lack of freedom for users to enter certain values in the fields to filter data is another concern (10/53, 18.9%) because of the default value selections. Farmers expressed their thoughts on the default selection as follows:

> *Sometimes things are selected by default which is confusing. To select a crop to know its market price, a crop called Ajwain is already selected. I was not sure of the crop Ajwain so I was confused as I could not understand that was default selection and I could select some other crop. So, I thought that the app does not have the crop I was looking for. The app should provide easy and clear instructions on using its functionalities through small videos.*

Table 17. General Usability Problems Identified by Farmers

Themes	Usability Problems (number of participants identified the issue)
Ease of use	Missing smooth follow: So many backs and forth inside the app (8) App looks confusing (3)
Performance	Very slow (4) No on-screen instructions (4)
Assistance	No clear video tutorial on app's full functionality (11)
Consistency	Click vs unclick inconsistency (8)
Freedom	Default selections of field values (10)
Memorability	Hard to remember things (1)

App-Specific Usability Issues

This concept was also taken from the expert study analysis. A total of 17 themes were identified, 13 from the previous study and 4 emerged during the analysis as shown in Figure 16. Though themes are the same there is some difference between problems identified by experts and users. For example, a problem “Agri forum: stop people from misusing” is under the theme Agri Forum, however, this problem was not identified by experts as it deals with the content of the Agri Forum; a chatbox facility for farmers to interact in the app. This might be because most farmer conversations are in the local language hence experts were not able to evaluate this. An extensive comparison of findings from experts and users will be discussed in the next chapter. The main themes and the problems associated with them will be described in this section along with exemplar quotes. All themes with issues identified can be found in Table 18.

Text: fonts and text in the app

Most of the users (42/53, 79.2%) reported issues with fonts and text in the app such as English fonts in between local language, usage of shortcuts without explaining the terms, and too small fonts for buttons and in general fonts are too small to read. Some of the farmers' comments on issues with fonts:

> *Some text is in English font, some is in complete English language, some are mixed. Each and every word should be in simple and clear local language. Alerts are in English even after selecting Telugu languages: it is confusing and intimidating.*
>
> *Font and images are very small so often missing to observe some details and labels. In addition to this the app does not allow to zoom the content or images makes it harder.*

Some farmers also found it hard to use the app in the dark; some studies took place late evenings in the real fields. This was an issue especially for senior farmers with vision problems as reported by 3 farmers (ages: 45, 49, and 60 years) during the late-night studies.

Information: Incomplete, Inaccurate, and Scattered

Incomplete information was another major issue discovered by most of the participants (40/53, 75.5%). Information was incomplete at various places in the app. For example, the details of the dealers who sell seeds or fertilizers do not contain contact numbers of the dealer, but only the name and address of the business location. Farmers said they would also be interested to see the information on what seed varieties does the dealer have if it is a seed dealer business. If this information cannot be provided, then contact details of the dealers would be helpful to communicate with the dealer to get all the required information to make the right decisions in finalizing the dealer shops when needed to purchase inputs. Some farmers said:

> *All labels are there but when clicked, they have incomplete information. At first sight, app looks simple and looks like it has a lot of information, however, when explores deep into it then it's difficult to use and have incomplete information. If complete information can be provided, then the app will be very useful. Incomplete information reduces reliability of the app.*

Around a quarter of participants (13/53, 24.5) reported finding inaccurate information especially with the information provided on natural farming methods. Some of them also mentioned that the app focused more on chemical farming and the information provided on natural farming is incomplete and inaccurate. A natural farmer, who has been practicing natural farming method from 5 years:

> *Apps give same information for everything especially in natural farming which is not accurate. Apps should connect with farmers to get their feedback and update the functionalities and information accordingly; they should not just leave the app like that after releasing to the users.*

Another issue with information is that it is scattered all over. Information in the app should be displayed following some order such as agricultural life cycle starting from soil preparation to marketing the produce or crop-wise information beginning from seeding the seeds to obtaining seeds (harvesting). Agricultural life cycle stages differ between chemical farming and natural farming methods hence providing users with an option to select their way of cultivation type and then display information based on the selection would be helpful to both chemical and natural farmers.

Search: searching for information in the app

As identified by the participants from the expert study, the app under study misses having any sort of search option. Many of the user participants (25/53, 47.2%) also found issues with a lack of search functionality. Voice-based search is the most suggested search type among user participants in rural India. They further expressed that having information speak out would be very helpful especially for users with literacy and accessibility issues. It was observed that these suggestions mostly came from farmers who already have a smartphone and they always use voice search in Google and in their device to find anything they want. They said they would also like to get results through voice as it would be close to their current ways of obtaining the information. Farmers with and without smartphones commented that voice-based services are a must in agricultural apps developed for rural farmers.

> *Voice search is faster and voice out information would be very helpful and easy to follow as I currently get information from phone calls and talking with other farmers so if voice based services are available then I do not have to learn something new to use the app, expressed 45-year-old farmer with a smartphone.*
>
> *I do not know to read and write Telugu, but I can speak and listen so if I can ask questions in Telugu and get responses for the information I need then the app would be useful even for users like me, by a 60-year-old farmer without a smartphone.*

Table 18. App-specific usability problems identified by farmers

Themes	Usability Problems (number of participants identified the problem)
Ads	Ads look like they are part of the app (2)
Agri Forum	Agri forum: stop people from misusing (1)
	Cannot reply to a comment (1)
Buttons	Home button disappears on some pages (2)
	App doesn't have a back button (4)
Information: inaccurate	Inaccurate market prices (5)
	Inaccurate seed dealer information (3)
	Information regarding natural farming is not accurate (5)
Information: Incomplete	Information is mostly for chemical farmers but not for natural farmers (4)
	Crops list is incomplete (6)
	Incomplete information on crop protection (8)
	Incomplete information on fertilizers (1)
	Incomplete information: contact details (7)
	Incomplete price information for crops and markets (12)
	Incomplete: Cold storage capacity information: price, total, used, available should be provided with these details (1)
	Participant's district is not in the list (1)
Information: scattered	Should display by agricultural life cycle (6)
	Crop-wise information from seed to seed in that order (2)
Labels	Mismatch labels: label name changes after clicking (3)
	Confusing labels: different information for that label name (2)
	Unclear labels: unpredictable information for the given label (4)
Search	Alphabetical search: popping up as we type in drop down (4)
	Voice search and voice out information (21)
Terminology	Confusing terminology (6)
	Difficult terminology: weather, fertilizer (5)
	Scientific terminology (11)
	Unexplained terms (1)

Table 18. (cont.)

Themes	Usability Problems (number of participants identified the problem)
Text	English fonts and texts (24) Should not use shortcuts in text (1) Hard to read in the field in dark (3) too small fonts (14)
Visuals: Alerts	annoying frequent in-app alerts (10)
Visuals: Buttons	Buttons are too close to each other (2) Hard to click on small size button (8)
Visuals: location	Some icons are towards the very bottom of the app (1)
Visuals: Images	A building for food processing looks like storage facility (1)
Visuals: Symbols	Unexplained symbols: cart and toxic levels (2)
Interactions	Zooming in/out is not possible (10)
General comments	Views on app changes after exploring (5)

Terminology

There are both scientific names and common names for all crops and other agricultural-related information. Many farmers (23/53, 43.4%) reported having difficulties in understanding the information as it has scientific terms. Farmers said that they would like to see all names of crops, fertilizers, and all other information in local and farmer-friendly terms and language. Comments from farmers on the terminology used in the app:

> *Information should be in simple and clear local language. Weather information is not clear especially the language of weather information.*
>
> *Fertilizer terms look like they are scientific terms so farmers can't understand. They must be in local terminology which farmers usually use.*
>
> *App has different terminology than what we use among us, so I tried to understand from symbols and images instead of the text.*

General comments on apps

Some of the farmers expressed that their views on the app altered after exploring it for a while. A 62-year-old farmer who worked in the United States until 2006 and returned to India for practicing natural farming said:

> *App looks complete and useful from outside but when dig deep into the app it is all incomplete.*

He further reported that he had a bad experience with apps he used in the past and stopped using them:

> *I used some agricultural apps before but none of them were useful I removed all of them and not using any app. I read new paper, agricultural magazines, and communicate with fellow farmers to get information these days.*

Information Needs

Farmers need information on different aspects of agricultural activities. The major farmer information needs were taken from the literature are shown in Table 7. Information needs identified by farmers who participated in the study were grouped into themes based on relevance. A total of 20 themes emerged from both the previous literature (Table 7) and the current user studies as shown in Figure 16. All themes with corresponding information needs can be found in Table 19. The main themes will be discussed below.

Disease Management and Pesticide Usage

Information on preventing diseases in crops is one of the major information needs by crop farmers in rural India. Most participants (33/53, 62.3) reported that they would like to follow prevention methods to protect crops from possible diseases. They believe that this would reduce pesticide costs and increase the quantity and quality of yields. Some farmers mentioned that they would be interested to know natural ways of dealing with diseases such as suitable inner crops for disease management instead of fertilizers.

> *Information on what type of inner crops should be grown to reduce pests and diseases. For example, we already know that marigold is an excellent trap crop which attracts many varieties of pests, so we plant them in between our main crop and in the borders of fields to deal with pests, as expressed by a 37-year-old natural farmer and his field is shown in Figure 17.*

Figure 17. A field with multiple crops including main crops and trap plants

> *Suggestions on protecting crops from diseases especially preventive techniques to stop spreading new diseases and pesticides to protect crops from them are very essential, commented by a 48-year-old chemical farmer.*

Farmers also mentioned that when they need to use pesticides then information on the availability of good quality pesticides, reviews on new fertilizers arrived in the market, soil-based fertilizer dosages; fertilizer quantity varies based on the soil type, efficient and healthy ways of spraying fertilizers.

> *We have formed groups and we experimented with various dosages of fertilizers on different soil types. We found that the dosage requirement varies based on the type of the soil. The same amount of fertilizer on one soil type might be more for another soil and we observed the high dosages of fertilizers killing the crops along with pests. We could only test with a few fertilizers hence suggestions from experts in this regard will be very useful, reported by a 40-year-old farmer who has been practicing natural farming for 5 years.*

Table 19. Information needs identified by farmers

Themes	**Information Needs (number of participants identified the problem)**
Agricultural News	Awareness on current issues and technologies in agriculture sector (2)
Crop selection	Suggestions to select crops based on the current demand, soil type, and weather conditions (6)
Cultivation techniques	Different and new farming methods such as natural farming, multi-crop methods, and suitable methods for given soil type and weather conditions (19)
Disease management	Preventive methods for diseases in crops (33) disease detection by uploading photo of the crop (1) Inner crops for disease management (3) Information on new diseases and suggestions on dealing with them (12)
Equipment	Agricultural equipment availability, price, dealer contact details (9)
Government schemes	Government policies and subsidy schemes, and government announces minimum support price information (9)

Table 19. (cont.)

Themes	Information Needs (number of participants identified the problem)
Historical data	Crops, seed, weather, and farmer statistics and historical data (8)
Market Information	Information on current and future market prices of different markets (18)
Natural farming	Information and awareness on natural farming methods (22) Natural fertilizers availability (12) Natural ways to prevent diseases (2) Inputs availability and locations for natural farming (5) Market info for naturally grown products (15) Natural products availability (2) Seed treatment in natural farming (2) Easy method for beginners of natural farming (4) Schedule in natural farming (6)
Networking	Connectivity with consumers (11) Connectivity with government officers (4) Connectivity with other farmers (9) Connectivity with researchers (8)
Notifications	Notifications and SMS alerts about changes in anything including market prices and weather predictions (4)
Pesticide selection and usage	Info on good quality pesticides, new fertilizers in the market, soil-based fertilizer dosage, efficient and healthy ways to spray fertilizers (6)
Product quality testing	Available methods for testing the quality of products, and markets which have this facility (1)
Seed testing	Techniques to identify quality seeds when buying seeds from seed dealers (2)
Seed varieties	Seed variety characteristics and uses (3) Available seed varieties and their sowing times (15) Desi (indigenous) seed varieties (6) Suitable seed variety for soil type and weather conditions (5) New seed varieties (7)
Soil treatment	Testing soil and treating it to improve fertility (12)
Water management	Water requirements and how frequent to water (4)
Weather information	Weather predictions and suitable weather for crops (13)
Weed management	Preventing and controlling weeds (1)
Yield improvement	suggestions on producing higher yields and improving profits (9)

Cultivation techniques and Natural Farming

Farmers said they would be interested to learn about various new and efficient cultivation techniques such as natural farming. Some of them further mentioned that they are keen to practice natural farming, but because of lack of awareness and information they are continuing conventional farming. Health benefits, fewer expenses, and sustainability are among the most motivational features of natural farming as explained an experienced senior farmer:

> *Information on inputs required for natural farming such as cow dung, and other resources is necessary it has become difficult to find them. This kind of farming used to be normal 40 to 50 years back when I started farming. All most all farmers at that time used to have cows, and many trees in the village with which we used to cultivate crops. Because of better yields and less labor work with chemical farming many of us started using chemical fertilizers instead of natural inputs. I am glad to see the trend of natural farming again and I am also trying to reduce chemicals and moving to natural farming, shared by a 75-year-old farmer who started farming when he was 30 years old and continuing.*

Major information needs to practice natural farming include natural fertilizers availability and locations; marketing ideas to sell naturally produced products directly to consumers; methods of produce quality check; simple and easy methods for beginners who would like to adopt natural farming; a schedule or steps of natural farming method for different crops; and naturally produced products availability information for consumers.

Historical Data and Crop Statistics

Crop production statistics such as yield rates for crops along with climatic conditions under which those crops were cultivated, soil types and fertilities, region information, variety of seeds, and methods of cultivation. They said that these statistics will help them to make better decisions on choosing crops and seed varieties based on current weather conditions and soil types which ultimately contributes to better yields and profits.

> *I maintain dairy - storing all the details on things I observe during farming, progress of crops, dealing with diseases, etc., I think if apps can let users store their daily things they can share them with others and refer back when needed at a later time. It would also be helpful to know ancient methods of farming and past crop statistics to make better decisions, as expressed by a 54-year-old farmer who served in the Indian army before started practicing natural farming in 2017.*

Networking

Some farmers said that they would like to connect with consumers directly to sell their produces while some others mentioned that they like to connect with agricultural researchers and officers to know about agricultural innovations and suggestions on ways to improve yields. Some of them further commented that having connections with researchers would also help researchers to learn from experiences of farming to make better insights into researcher findings:

> *Association between farmers and research institutes is essential to share research findings and farmer observations to make better insights and decisions which help to improve quantity and quality of yields.*

App Usage and Development

Suggestions provided by farmers to future app developers are grouped into two themes: App development directions and app characteristics to incorporate in the app development. Major suggestions from each theme will be described below and a complete list can be found in table 20.

Table 20. App usage and development directions by farmers

Themes	App Usage (number of participants identified the problem)
App development directions	Learning through sharing experiences (15)
	Special app for natural product marketing (15)
	Video lessons on natural farming from experts and researchers (12)
	Marketing farmers produce directly with consumers (10)
	Complete information in one app (10)
	Farmers share videos of practicing new methods (8)
	Network between farmers and agricultural labors (7)
	Awareness on benefits of consuming natural products (5)
	Awareness programs on apps usage (4)
	Farmers sharing videos of farming and photos of produce with consumers (4)
	Consumer share benefits of consuming natural products (2)
	Video lessons on natural farming in schools and help students grow their own food, awareness on these programs (2)
	Educating videos on natural farming health (2)
	A library style information of ancient cultivation methods (1)
	Personal information storing such digital dairy for agricultural activities (1)
Suggestions to app developers	Simple and clear local language (27)
	Accurate information (12)
	Up to date information (9)
	Timely information (8)
	Offline information (7)
	Short video tutorials on all functionalities (6)
	App developers should connect with farmers (4)
	External (maintenance team) assistance for farmers in using the app (4)

App Development Directions

Sharing farming experiences with the farming community is a great way of helping new farmers and learning from senior farmers. A farmer who started practicing natural farming from more than a year said that:

> *I attended training classes on natural farming, and they are very useful to start with, however, there were many times when I was stuck as I did not know what to do. I think this is due to the fact that there is always a gap between theory learned from classes and practicing it in the field. There are many things which I learned only from personal experience such as in natural farming prevention is the best and efficient way to deal with diseases since it would be hard to get rid of pesticides once they attack. This piece of suggestion I could not get from classes but from experience. If these sorts of valuable experiences can be shared with farmers in need then it would save their time and give me satisfaction. Currently, I get information and help from WhatsApp groups and senior farmers, but it is hard to refer back to the information in groups so a dedicated platform to share the experience with an easy way of searching information is necessary specially to practice new farming methods.*

Marketing is one of the major concerns in the agricultural sector. Many farmers reported that they do not get reasonable prices for their produces. This is an issue especially for natural farmers as they may get lesser yields to compare to chemical farmers, yet they sell their produce for the same price as produce from chemical farming because of lack of quality detection technology in the markets. This influenced many natural farmers to think about starting their own markets to sell their products directly to consumers at a reasonable price as per their understanding.

> *An app exclusively for natural product marketing will be very useful. The platform should let farmers and consumers connect directly to communicate regarding the availability and prices of products. It should also let farmers share photos and videos of their farming methods to develop reliability in consumers. It would also help if consumers can*

> *share benefits of consuming natural products after having purchased and used them, suggested by a 35-year-old natural farmer who completed a master's degree and worked in the industry for 6 years before coming to the agricultural field.*

He is also a famous figure in his village community as he conducts meetings and workshops to bring awareness on natural farming and its benefits. He also conducts programs in government schools in his village to teach students natural farming methods and helps students practice farming to grow their own food which school administration uses to make food for students; public schools in India provide food for kids. He mentioned that spreading and sharing news on these initiatives among the interested community through apps would be helpful.

Suggestions to app developers: App characteristics

Many farmers reported having issues with terminology and language used in the app. The simple and clear local language is the key characteristic of an agricultural app developed for rural farmers. The second most important feature is to provide accurate, up to date, and timely information as they affect the app's reliability among farmers. Making information offline is also an important concept as internet facilities in rural India are not that reliable.

> *Some pages were loading forever, for example agri chat forum, so making it offline to view old posts and information available offline would be helpful.*

Providing all the possible information through short videos is another key aspect to reach many diverse rural Indian farmer population.

> *Any information just in the text will be of no use. Everything should be in small videos. A person applying fertilizers, treating affected plants, etc. everything should be in videos then the farmer can easily follow.*

App developers should have a maintenance team to check the app's functionality and to connect with farmers to get their feedback to improve user experience.

> *Some people are using agri forum chat platform to promote their business so app developers should manage these and block those fake users.*

Table 21. Number of themes and problems from the user study

Category	Number of Themes	Number of Problems
General usability problems	6	8
App-specific usability issues	17	39
Information needs	20	38
App usage and directions	2	23
Total	45	108

Table 22. Top ten problems of rural Indian farmers about agricultural apps

Problem/ Suggestion	Count	Theme	Category
Preventive methods for diseases in crops	33	Disease management	Information needs
Simple and clear local language	27	Suggestions to app developers	App usage and development
English fonts and texts	24	Text	App specific usability issues
Information and awareness on natural farming methods	22	Natural farming	Information needs
Voice search and voice out information	21	Search	App specific usability Issues
Different and new farming methods such as natural farming, multi-crop methods, and suitable methods for given soil type and weather conditions	19	Cultivation techniques	Information needs
Information on current and future market prices of different markets	18	Market Information	Information needs
Available seed varieties and their sowing times	15	Seed varieties	Information needs
Special app for natural product marketing	15	App development directions	App usage and development
Learning through sharing experiences	15	App development directions	App usage and development

Descriptive Statistics

Frequencies of all codes were obtained from the qualitative software and the values are provided in the corresponding tables. The number of themes and problems for each category can be found in Table 21 above.

The top ten problems identified by rural farmers along with the corresponding theme and category details are given in Table 22. Problems identified by the majority of the participants come from information need category and suggestions on app characteristics and future app development directions.

Conclusions

In this chapter, I first described methods of recruiting users through different farmer organizations and snowball sampling. Then talked about a summary-aided data analysis approach which helped to get early insights from the data collected while data collection progresses. This, in turn, helped to recruit diverse participants with different identities such as farmers practicing the natural farming method. The natural farming method and its current movement among farmers were described. Participant demographics and transcripts were stored in qualitative software, Dedoose. Demographics were displayed and discussed. Thematic analysis was performed following two cycles of coding and identifying themes from both previous studies and current data analysis. Major themes and problems were discussed and described with frequencies and quotes from users.

Findings and observation from these studies with rural Indian farmers indicate that farmers do have a lot of information needs and many of them expressed that smartphone apps will be useful to meet their information needs if complete, accurate, and up to date information is provided. Interestingly not many farmers complained about using the app despite the app having a lot of issues identified from the expert studies; most of them said it was fine to explore the app by themselves even without any smartphone usage experience. It is in line with the top ten problems shown in Table 22 where none of them are from general app usability issues that deal with ease of use and performance.

Farmers also provided suggestions to future app developers on important app characteristics to make the app useful to rural farmers. Providing information in a simple and clear local language is one of the key factors in making the app usable. Some farmers also gave future app development directions such as creating a platform exclusively to market their own products directly to consumers, and a platform to share experiences and observations with fellow farmers and farming community so they will learn lessons from each other to contribute to each other’s profits and yields.

CHAPTER 6: DISCUSSION

This section presents results from all the three studies integrated with respect to the research questions studied in this dissertation. The section will complete by presenting dissertation conclusions along with future research directions.

Research Question One

What differences and/or similarities exist between expert and user views of the selected app?

In this study, I explored two different approaches of usability testing – Usability Studies and Field Studies. The two ways I studied in this dissertation are usability studies with experts and field studies with real users in the real fields. In usability studies, participants come to a lab or office, one-on-one with the researcher, and perform the tasks given by the researcher to evaluate the app. In field studies, the researcher meets and study participants in their natural environment, where the participants evaluate the app under study. The traditional usability studies that take place in a laboratory setting introduce ecological gaps because of their inability to capture the issues that may occur in the real environment and the context of real use.

Thomas and Kellogg (1989) explained that the lab testing does introduce ecological gaps, but it does not mean that lab testing is not useful. However, las testing must be designed by keeping in mind the issues of ecological validity, and possibilities of other kinds of assessment to address concerns that lab testing cannot cover.

The field studies conducted with real intended users in the real app usage environment – real fields or farmers' villages were naturally ecologically valid, hence, findings from these studies are expected to reduce the ecological gaps.

Usability studies are less expensive and more flexible whereas field studies are not only expensive but also involve many challenges such as training researchers in a cross-cultural context, time-consuming travel to unfamiliar places, and safety issues (Rohrer, 2014; Farrell, 2016). The less expensive usability studies are useful to evaluate the app's interface and navigation issues such as ease of use, performance, and effectiveness. The more difficult and expensive field studies are useful to get unbiased insights and findings from the real usage environment, to understand users and their needs (Kallio & Kaikkonen, 2005).

The purpose of this research question is to compare results from usability studies conducted with experts in the USA and the results from field studies conducted with rural farmers in India. For the usability studies, we used the two most common usability inspection methods: cognitive walkthrough and heuristic evaluation to evaluate the app's usability using a pre-made list of questions to use the app to perform some tasks and then to evaluate app's interface using the selected heuristics. For the field studies, I used a semi-structured questionnaire with the questions on participant demographics, exploring app usage with some tasks, and final interview phase to know participant's opinions on the app. For both the studies, sessions were audio recording and mixed qualitative and quantitative analysis was performed on the mixed data collected.

The findings from these studies show that there is a difference in the type of problems identified by experts and users. The problems identified from usability studies with experts are categorized into two categories - General usability problems and App-specific usability problems. Two additional categories were found from user studies – Information needs and App usage and development. The information needs category has various information needs reported by farmers at various stages of the agricultural life cycle. App usage and development category contain suggestions on characteristics to consider when developing agricultural apps for rural Indian farmers and insights on app development platform directions useful to farmers.

From these top-level findings, It can be inferred that less expensive usability studies are sufficient to identify problems associated with the app's interface and navigation issues (General and App-specific usability problems), and field studies are useful to understand users and their needs (Information needs and App usage and development). These findings are in line with the previous literature on field studies versus usability studies (Kallio & Kaikkonen, 2005; Razak et al., 2010). The actual problems identified by experts and users in these two categories will be discussed below.

General usability problems: Experts vs Users

There are six themes in this category – Ease of use, Performance, Assistance, Consistency, Freedom, Memorability. The number of problems identified by experts and users in each theme is given in Table 23. The problems identified by users in this category are all identified by experts as well. Hence, it can be inferred that inexpensive usability studies are sufficient to identify the general usability problems of an app.

Table 23. General usability problems in numbers by experts and users

Theme	Number of problems by experts	Number of problems by users
Ease of use	4	1
Performance	5	2
Assistance	4	2
Consistency	3	1
Freedom	2	1
Memorability	1	1

App-specific problems: Experts vs Users

Nineteen themes were developed in this category from the expert study and 17 themes were found from the user study; 13 of 17 are taken from the themes found in the expert study and

4 new themes emerged from the user studies. The new themes are associated with user-specific problems such as accuracy of the information, fonts and language of the text, and general comments on the app such as views on the app changes after exploring it for a while.

The number of problems identified by experts and users under each theme is shown in Figure 18 below. From the figure, it can be seen that experts found more problems than users when the number of problems is considered, however, from the analysis of qualitative data I found that the problems reported by experts and users are different for some of the themes and similar for some others. For example, for the theme “search” users suggested having voice-based search services that are different from expert suggestions to include text-based search.

On the other hand, experts were also able to find some user-specific issues such as “Unexplained symbols: cart and toxic levels” which are also identified by users. All expert participants who participated in the study are familiar with the cart symbol but they expressed concerns for farmers who may not be able to understand the online cart symbol if not explained clearly. With the power of hybrid usability inspection methods - cognitive walkthrough (task-specific) and heuristic evaluation (interface-specific), experts were able to find some of the user-specific problems as well.

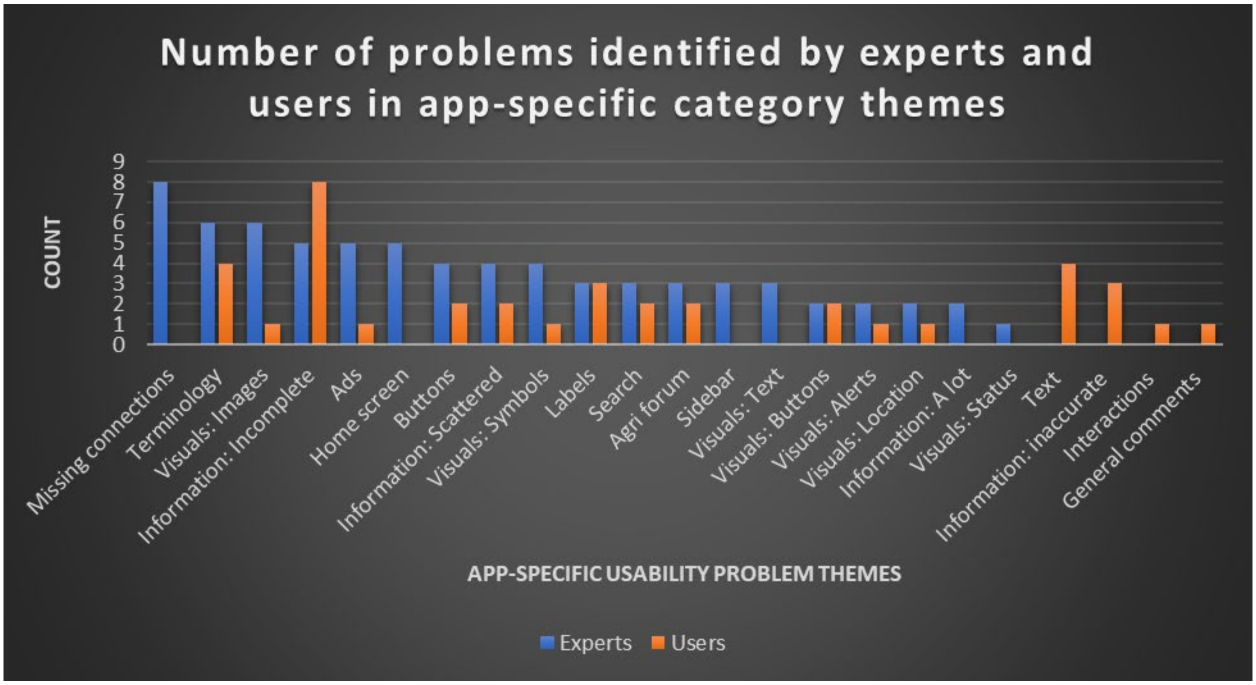


Figure 18. Number of problems identified by experts and users in the app-specific category

It was interesting to note that farmers seemed less worried about certain usability problems. Whereas findings from usability studies (CW and HE) found many minor usability problems. It could be due to many factors such as farmers were too polite to report the issues. When I asked about some usability issues raised by experts, farmers often mentioned that “it was not difficult to explore the app as long as the content is clear and the interface is simple”. It seemed they were too polite to complain about the issues or it may be true that they do not have problems with those issues. For example, expert participants identified around 8 usability issues with the home screen and the sidebar of the app, however, users reported none in these categories. Many users did not even open the sidebar, and when I asked them what do they think about the sidebar, they said: “it is fine, it has some buttons so I can click when I need”. This also resembled their hospitality and willingness to learn to get over the usability problems but not complain.

Another factor is the diversity in the expert and user participants. Expert studies were conducted in the United States where awareness on usability and user research is well-established with a lot of research studies. While in India, the area of HCI and UX is still in its development and not many developers are familiar with interface design and principles to follow to make the app user-friendly – so the users are put up with the bad usability in general for the apps. These inferences need further research to identify the effect of the diversity factor in identifying usability problems.

Most of the comments by farmers were about the content and the functionality than the interface and the usability. This is due to the fact that they are very familiar with the information given in the app and so, their main focus was on finding and evaluating the information rather than inspecting the interface.

Form these findings and observations, I conclude that there are both similarities and differences in the usability problems identified by experts and users. From the inexpensive usability studies, experts were able to find more interface-specific issues and from the hard field studies, users found a few interface-specific and more user-specific issues along with information on the needs of farmers and suggestions to future app developers.

Research Question Two

What are rural Indian farmers' major information needs and are there any differences in the information needs identified from the literature to the information needs of participated farmers?

The purpose of this question was to understand the information needs of farmers and to compare the identified needs to the information obtained from agricultural and rural development literature. The majority of the information needs reported by participated farmers fall under 8 themes – Disease management, Natural farming. Cultivation techniques, Market information, Seed varieties, Weather information, Soil treatment, and Networking (Figure 20). These are the problems identified by the majority of the participants. Information on “Preventive methods for diseases in crops” is the primary information all farmers need to grow their crops disease-free which reduces farming costs and in turn produce better yields. Some of the farmers further mentioned that they would like to know information on inner trap crops to protect main crops from pests and insects.

Information on natural farming such as availability of inputs required for natural farming (Figure 14) and market information especially about naturally grown products is the second most required information. This is a new theme identified from user studies because natural farming has been surging among the agricultural community especially in the southern states of India, because of its unparalleled benefits including low costs, better yields, healthy produce, and connections with ancient farming methods. Some farmers even mentioned that apps should let consumers to share their experiences with consuming naturally grown foods to inspire others and to spread awareness on natural farming and its benefits. Some of the natural farmers also mentioned that they are currently marketing their own produce as the proper product quality detection techniques are not available in the markets which make them sell their produce for the same price as chemically grown produces. Hence, they also requested suggestions to network with consumers to sell their produce at reasonable prices.

Information needs: Farmer studies vs literature

Out of these 8 major themes, 2 were found from user studies – natural farming and networking and both of them are interrelated as the majority of the information needs under the networking theme were reported by natural farmers. A total of 38 information needs were reported by farmers (Table 19). These needs are grouped into 20 themes of which 9 themes were taken from the previous literature on information needs (Table 7) and 11 new themes were found from the current study (Figure 16).

At the theme level, themes from the previous literature look similar to the themes from the current study, however, at the individual problem level, they are different. The themes from the literature contain definitions based on some generic problems under that theme. For example, the theme "Seed varieties" means "information on the types and varieties of seeds and tips on selecting best seed for better produce" from the literature (Table 7). Whereas Indian rural farmers participated in the study reported different information requirements for their agricultural activities:

- Available seed varieties and their sowing times
- New seed varieties
- Desi (indigenous) seed varieties
- Suitable seed variety for soil type and weather conditions
- Seed variety characteristics and us

Among these, "Desi seed varieties" is very particular to Indian farmers as farmers expressed interest to know about availability and cultivation methods suitable for desi seeds. An indigenous seed variety cultivated using natural farming is shown in Figure 19. This is in line with an article on a natural farmer (Vemuri, 2020). The article says it was difficult to find availability and locations of desi seed varieties:

> *The journey to discovering indigenous seeds and varieties has not been easy however in the process Baparao has inspired many farmers who are willing to living heavily urea, chemical and fertilizer dependent farming and move to organic farming with indigenous*

varieties like he has. He has become a beacon to many farmers and Agriculture Bsc students who come to him from across the twin Telugu speaking states to gain from his knowledge and wisdom.

Figure 19. Indigenous paddy seed variety (Vemuri, 2020)

Another interesting finding from this theme is “Seed variety characteristics and uses”. A farmer reported that every seed has different qualities and benefits, and it would be very useful to know the details such as what seed variety is suitable for pregnant women, seed variety for babies, etc., He further mentioned that his grandparents used to tell him such details.

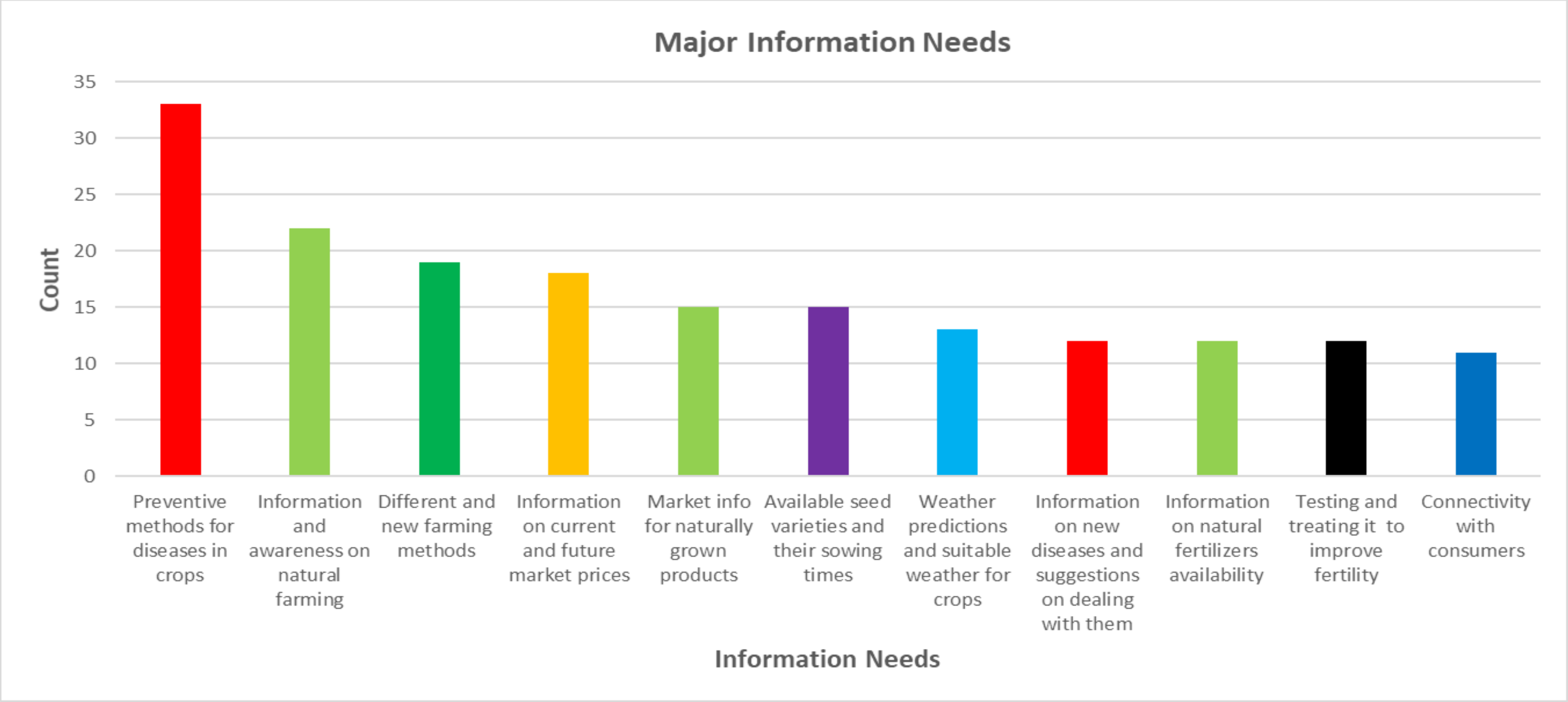


Figure 20. Major information needs of farmers

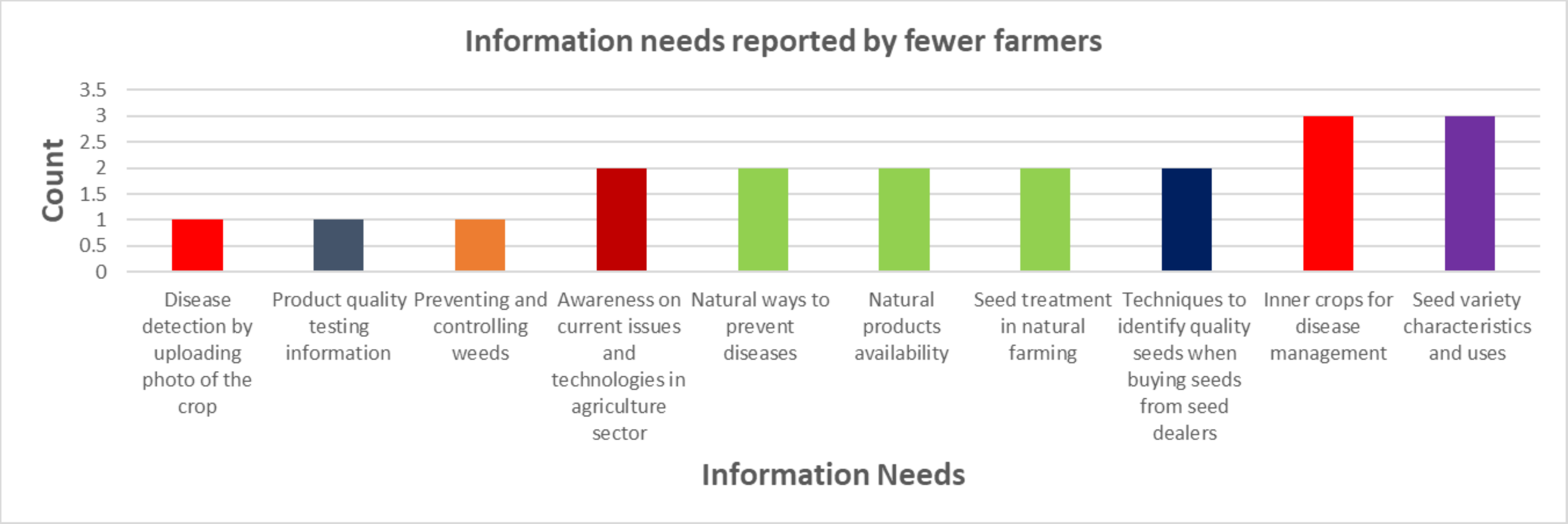


Figure 21. Information needs reported by fewer farmers

Color legend for both Figure 20 and Figure 21. Each color represents a different theme

🟥 Disease management	🟨 Market information	⬛ Soil treatment	⬜ Product quality testing
🟩 Natural farming	🟪 Seed varieties	🟦 Networking	🟥 Agricultural News
🟩 Cultivation techniques	🟦 Weather information	🟧 Weed management	🟦 Seed testing

There are also important information needs identified by fewer participants such as disease information by uploading a photo of the affected plant leaf, seeds, or flowers (Figure 21). The farmer who suggested this is a 21-year-old graduate farmer who uses a smartphone and used to use agricultural apps in the past but uninstalled them as the information given by them were not simple and clear.

The majority of the farmers reported that they rely completely on fertilizer shop owners and they often need to spend more because of trial and error with fertilizers given by the shop owners. Currently, farmers cut at affected plant's required parts – leaf or seed or flower and take them to the pesticide shops to get suitable fertilizer for that particular disease. The process they mentioned was:

They cut the plant's part and take that to the pesticide shop, then they buy pesticide suitable to deal with that pest as informed by the shop owner, after that if that particular pesticide does not work then they will again go to get more powerful pesticides. This requires farmers to spend on unnecessary inputs which in turn increases expenses without fruits. Many of the farmers in their current ways of dealing with diseases mentioned this process, but none of them expressed interest to get information on detecting diseases through mobile apps. However, many of them appreciated the idea of having disease detection technology within the app and to get suggestions on suitable and quality pesticides from agricultural experts and scientists.

From these findings and observations, I conclude that information on disease management, inexpensive and better cultivation methods such as natural farming, suggestions on marketing farmers' produce directly with consumers, networking with consumers and researchers, soil testing and improving fertility, seed varieties and sowing times, are among others. It was interesting to note that the majority of the themes identified by farmers are already found in the literature, however, the in-depth qualitative analysis revealed that the actual needs of information for Indian rural farmers are different from those found in the literature especially because of current ways of farming practices. The themes and their definitions identified from the literature may not give a complete understanding of actual farmers' needs hence the real field studies with farmers are required to get insights to develop useful agricultural apps in the future.

Research Question Three

What are the current attitudes and values of crop farmers in using smartphones and mobile applications?

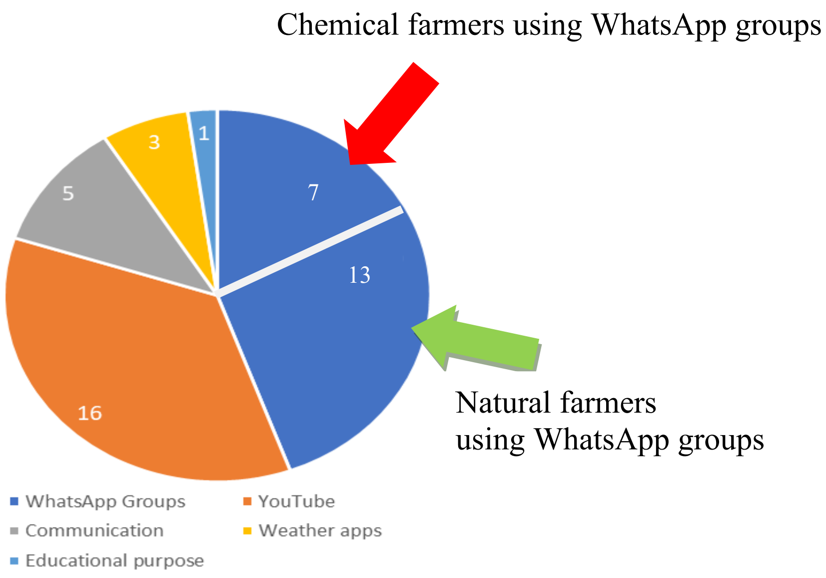
What are the major barriers in using smartphones and their applications?

What are the important attributes of a mobile application to make them more useful for the rural community?

The majority of the participated farmers (35/53, 66%) own a smartphone and are familiar with using it, however, not many of them are familiar with mobile apps. They mentioned though they have a smartphone they mainly use it for communication, entertainment, and WhatsApp as given in Figure 22. Surprisingly many of them also mentioned using YouTube both for entertainment and to watch agricultural-related videos. One of the farmers is also a student hence he said that he mainly uses the smartphone for his academic work. WhatsApp groups have become a popular way of sharing experiences and information on agricultural activities, especially among natural farmers.

A farmer who is a software professional turned natural farmer for 4 years said:

I mainly use WhatsApp groups for marketing my produce and I also market our village farmers' produce as I have more connections and network with consumers from different places in both Andhra and Telangana states. I give lectures on YouTube, so I am popular through it and many people contact me for naturally grown products. I was the first person to start naturally growing in our village, but after attending my workshops and learning of profits and success, many of our villagers got motivated and started growing *naturally. Mobile apps in this regard will be very useful to grow the network and to bring awareness of natural farming and its health benefits.*


Chemical farmers using WhatsApp groups

Natural farmers using WhatsApp groups

Figure 22. Smartphone usage among farmers with smartphones

It was also observed that the majority of the younger participants had smartphones and farmers practicing natural methods as many of them worked in some industry before turning to natural farmers (Table 24). This greater portion of natural farmers with smartphones allowed to find information needs and app development directions around natural farming which was not provided in any previous literature.

Table 24. Demographics of smartphone users

	Owns smartphone	**No smartphone**
Min age	21	28
Max age	62	75
Average age	40	53
Natural farmers	16	4
Chemical farmers	21	14

Smartphone usage: barriers and attributes

From the above observations and findings, it looks like the majority of the participants are familiar with smartphones and their apps. It was also interesting to observe how farmers in rural India attempt to use smartphones and apps even without any prior experience. The senior-most farmer in the study, aged 75 years old, who started using a regular cellphone from a few years was exploring the app by himself as shown in Figure 23.

Figure 23. A 75-year-old senior farmer using the app

> *He said exploring the app was not difficult even though it was the first time he was using a smartphone. However, using the app was difficult due to some problems such as smaller fonts, English text, scientific terms, unexplained symbols, unorganized structure, scattered information, are some of the barriers in using the app among others.*

The important attributes of an app to make it user-friendly for Indian rural farmers as mentioned by the participated farmers are:

All information including but not limited to on-screen instructions, main text in the app, icons, labels, news, crop names, pesticide terminology, and weather information must be in a simple and clear farmer-friendly language.

Apps should provide voice-based services such as voice search features and information spoken out as needed and requested by users. It should let users interact with the app, zoom in and out of images, text, and icons, and more interactive features as possible.

Apps should not create ambiguity in users such as some of the buttons lead to blank pages even after too many clicks. Apps should reduce the number of clicks needed to reach the destination (to find the required information) and should clearly state what will be displayed for each icon.

Providing timely, up-to-date, and accurate information is another key characteristic in sustaining the app’s usage. Making information offline would also be useful especially for rural farmers due to unreliable networks in some places.

Allowing farmers to share experiences through short videos was highly suggested especially by natural farmers. Networking with consumers to market their products and agricultural officers to get information directly from official persons will be very helpful.

Apps should also maintain a support team to assist users whenever needed and to manage the app for any unacceptable usage of the app such as identifying and dealing with fake users and fake posts.

These are among the important attributes suggested by farmers in making agricultural apps usable and user-friendly for rural farmers.

Conclusions

In this dissertation, I attempted to identify the information needs of Indian rural farmers and to inspect agricultural smartphone apps intended for crop farmers for usability (ease of use) and functionality (content, features, and information needs). To these ends, I conducted three studies: studying global agricultural apps (study 1), evaluating an agricultural app developed for Indian farmers with usability experts in the United States (study 2), and finally inspecting the same app with rural farmers in India (study 3).

The purpose of the first study was to understand the current mobile apps to identify the features that characterize good agricultural mobile applications and the information needs of farmers globally. The agricultural and rural development literature was reviewed to find the most essential information needs of farmers and eleven apps on the Google Play Store were evaluated against these findings. Results indicated the most prevalent usability characteristics were app performance, ease of use, navigation, and gestural design. The most frequently observed functionalities were soil management, seed and crop varieties, production and cultivation techniques, fertilizers, pest and disease management, weed control, and weather information.

An agricultural app titled “NaPanta” was selected to study with usability experts in the United States (study 2) and with rural farmers in India (study 3). The two most common usability inspection methods, cognitive walkthrough and heuristic evaluation, were used to test the app with experts (n=18) and a semi-structured questionnaire was used to conduct surveys with farmers (n=53). A mixed-methods approach was used to collect and analyze data using both qualitative (thematic analysis) and quantitative (descriptive and inferential statistics) methods. Results from study 2 included 90 usability problems within 25 themes and two overarching categories: (i) general usability problems and (ii) app-specific usability problems. Findings from study 3 indicated 108 concerns grouped within 45 themes among four categories with two new categories, (iii) information needs and (iv) app usage directions, in addition to the categories found from expert study.

The major usability problems identified by expert participants are lack of search functionality, lack of smooth flow in the app, disconnected similar features, lack of information architecture, and annoying frequent alerts among others. Lack of voice search and the presence of English fonts and text in the app are main obstacles for farmers in using the apps.

Farmers reported testing and treating the soil to improve fertility, available seed varieties and their sowing times, information and awareness on natural farming, and preventive methods for diseases in crops are among the major information needs. Providing accurate and up-to-date information in a simple and clear local language is the key app characteristic. Farmer further expressed interest in having an app exclusively for marketing their products directly with consumers. A platform to share experiences among farmers on different farming methods, their benefits, challenges, and learnings from practicing new methods and adopting new technology.

Many of the Indian rural farmers have phones and 35 of the 53 participants in this study had smartphones. With the emerging usage of smartphones and the information needs of farmers, developing agricultural mobile apps intended for farmers to provide timely and accurate information when they need the most plays a crucial role in farmers' agricultural activities. It is also essential to follow design principles recommended in this study and to provide the information needs identified by the farmers as usable and user-friendly are the key success factors for any product. However, there are many challenges in incorporating all the suggestions in improving an agricultural app's design and development due to its rich information and diverse users with varying information needs. This study helps to reduce the confusion among app developers on important and essential factors to consider when developing agricultural apps specially for Indian farmers. The simplicity of the interface and the accuracy of the information are the most prominent characteristics of an app as suggested by experts and farmers.

This study also contributed to usability research by giving insights on the number of experts required to conduct usability studies. It was found that this study required more than 5 experts to identify the majority (80%) of the usability problems. Eight experts were found to identify around 80% of the usability problems.

The comparison of less expensive usability studies with experts and more difficult and expensive field studies with users indicated that less expensive usability studies were determined sufficient to identify interface-specific problems, and greater field studies are needed to understand users and their problems better. This suggests that to reduce the ecological and user gaps, researchers need to consider field studies to identify the task-specific problems in the real context with the real users. While usability studies in the lab may reveal obvious usability problems that may or may not affect real users, field studies are required to understand end-users and their requirements to develop user-friendly apps.

Future research directions

There are several suggestions for future work emerged. First and foremost is to expand the user studies to other Indian states as the current study was conducted with only two Telugu speaking states of India, Andhra Pradesh and Telangana. This is also limited by the fact that the majority of the suggestions were about natural farming since it is surging in the twin states of the study location. Hence, future studies on farmers from various states could lead to better insights on farmers' needs in general. This study followed embedded mixed methods approach, it would also help to use other approaches such as explanatory method where researchers first perform quantitative data collection and analysis followed by qualitative methods to gain a better understanding. This approach might help to identify major problems by studying a greater number of farmers in the first phase then qualitative methods such as focus groups to investigate those problems in depth.

Further research to identify influencing factors such that cause differences in the usability problems identified with the usability inspection methods by the expert participants and with the field studies by the farmer participants can give interesting insights. Some interesting factors to consider in this research include demographics diversities of participants, general app usability practices/standards in the region where the app was developed such as existing and available research literature to the developers and the users, and developer attitudes towards the app development in the two different regions of the study locations.

It would also be interesting to conduct studies with experts and users from the same region such as experts in India and users in India on the usability and functionality of the agricultural app. This overcomes the drawback of domain knowledge and language barriers. For example, it might be relatively easier to find experts who know agriculture and the local language in India than in the United States. This comparison might help to understand the efficiencies of usability studies and field studies better.

The findings from study 3 – user studies, were mostly obtained using qualitative analysis which lacks identifying relations among various demographics such as any correlation between the age of farmers and the number of suggestions they provided and types of problems they identified. Statistical analysis such as inferential and correlation findings would be helpful to draw inferences, in turn, help app developers to develop apps usable and user-friendly to the general audience. Inclusion of discussion on strategies and issues about credibility and trustworthiness in social sciences qualitative research such as credibility, transferability, dependability, and confirmability (Shenton, 2004) would also help to gain deeper understanding of the data and the research questions.

This study was done only with a single agricultural smartphone app, however, there are several other agricultural apps available for crop farmers. A comparative analysis of various apps might reveal different insights. It is important to study any differences or similarities between studying a single app versus studying multiple apps. Apart from smartphone apps, farmers also use several social media platforms such as Facebook, WhatsApp, and YouTube to aid in obtaining information for their agricultural activities. Many farmers suggested having audio and video facilities in the app, which is the main content of YouTube, hence, examining other social media platforms would be a great research expansion as well.

Finally, it would be very interesting to develop an agricultural mobile app with the findings and insights obtained from these studies to see how practical the suggestions are. The research can further be extended by examining the app with users to find how useful those insights are and to get insights on any changes in the farmers' smartphone usage attitudes and needs.

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APPENDIX A: LEARNING EXPERIENCES FROM VISITING INDIAN VILLAGES

Coming from a small and remote village in India where agriculture is the main source of livelihood for the majority of the villagers including us, I thought I knew enough about the culture in Indian villages to be familiar with villages and agriculture in general until I actually visited many different villages during the studies. It was a shocking realization that each village I visited was so different and unique and it was an exciting experience to find out that there is so much to learn from the diverse cultural practices and differences in dialects between villages that are physically not so far apart. One common thing I observed among all of the villagers I met was they were very warm and welcoming, especially the female participants. This is possibly because they could easily get connected with me as I am also a female.

Figure 24. Female farmers on the field

Here I would like to mention an interesting observation that although the majority of the study participants were male, most of the time their female partners were also accompanying them – both at their homes and fields; as the studies were conducted either at participant’s homes or fields as per their convenience. Female farmers play a crucial role in agricultural activities, yet they are underrepresented. I was especially surprised to see them working in the fields but when I asked them if they would like to take part in the study they were hesitant and said they do not know much about technology or smartphone and that they follow what their husband/ father/ brother/ son suggests them to do. Female field workers with their kids along with myself in the field are shown in Figure 24 above.

Some farmers take more time to complete the study than others. The farmers who like to talk more mentioned that they have a lot of problems but nobody is there to listen to them. For example, a farmer said, it became hard to find field workers as they demand high wages but we as farmers cannot bear that. We request the government to look into possible ways of connecting laborers and farmers with an efficient wage management system where farmers pay reasonable amounts as per the wages determined by the government. Likewise, there were so many sad facts that farmers expressed while participating in the study.

With the delays in the studies, I happened to visit a very remote village where there was no electricity on that particular day – villagers mentioned that they have electricity in the village, but the power cut happens very frequently. It was late evening by the time I reached there and it seemed almost impossible to conduct studies with the power cut. However, with the help of a lot of people including my parents (mom & dad) - yes, they accompany me if any delays or late-night travels are expected considering the safety and security; and village boys who hold a mobile torch to show me and the participant to complete the studies without troubles. Figure 25 shows studies fields where studies happened late at night along with myself with the group of village boys and my parents.

Figure 25. Late-night studies in the field

When traveling from one village to another village, we often passed many fields with farming activities going on. Once we stopped at a farm where many agricultural activities were taking place. I started a conversation with the main farmer and introduced myself and the research study. However, they were not comfortable with participating in the study with a stranger even after I showed my school ID. When we were about to leave the place, a passing journalist noticed us as our attires were different compared to the field workers and stopped to find out what was going on. After he enquired about the study, he convinced the farmers about the importance of such studies and then they were very happy to participate in the study.

స్మార్ట్‌ఫోన్ ద్వారా వివరాల సేకరణ

గుండ్లసింగారం(నూతనకల్): గ్రామీణ భారతీయ రైతుల వ్యవసాయ మొబైల్ అనువర్తనాల(యాప్) వినియోగంపై ఇల్లినాయిస్, అర్బానా-ఛాపెయిన్ యూనివర్సిటీ విద్యార్థిని నారిశెట్టి శివరత్నకుమారి గురువారం పంటపొలాల్లో రైతులపై పరిశోధన చేపట్టారు. సాగులో వచ్చిన మార్పులు, స్మార్ట్‌ఫోన్ యాప్ ద్వారా తెలుసుకుంటున్న వివరాలను రైతు దంపతులు భూరెడ్డి మధుసూదన్‌రెడ్డి, ఉమాను వివరాలు అడిగి తెలుసుకున్నారు.

గుండ్లసింగారంలో వివరాలు అడిగి తెలుసుకుంటున్న విద్యార్థి పరిశోధకురాలు శివరత్నకుమారి

Figure 26. Study coverage in the newspaper

It seems villagers are confident when they get information from sources they trust. The first experience of randomly meeting farmers in the fields was exciting and a great lesson. Later on, after a few days, the journalist contacted me saying that he published an article about my research study in the newspaper “Eenadu”, which is the highest circulated newspaper in both the Telugu states, the coverage is shown in Figure 26. The details in the Figure are in the local language, Telugu. A brief translation of the news article is as follows:

> *A student researcher, Siva Ratna Kumari, from the University of Illinois at Urbana-Champaign conducted research in crop fields on Thursday in Gundlasingaram. She collected*

details from farmers on current cultivation methods and how information on these new technologies can be achieved through smartphone apps.

In total, there were so many lessons learned throughout the entire study duration from visiting and meeting many different villagers and farmers. The most important observations are that villagers, in general, are very friendly and welcoming especially female farmers. The sad fact is that though they work hard on the fields they are often underrepresented and they are not recognized as representative farmers not only by media, government, or researchers but also by themselves. It is necessary to include them in the research studies and to give an equal reputation.

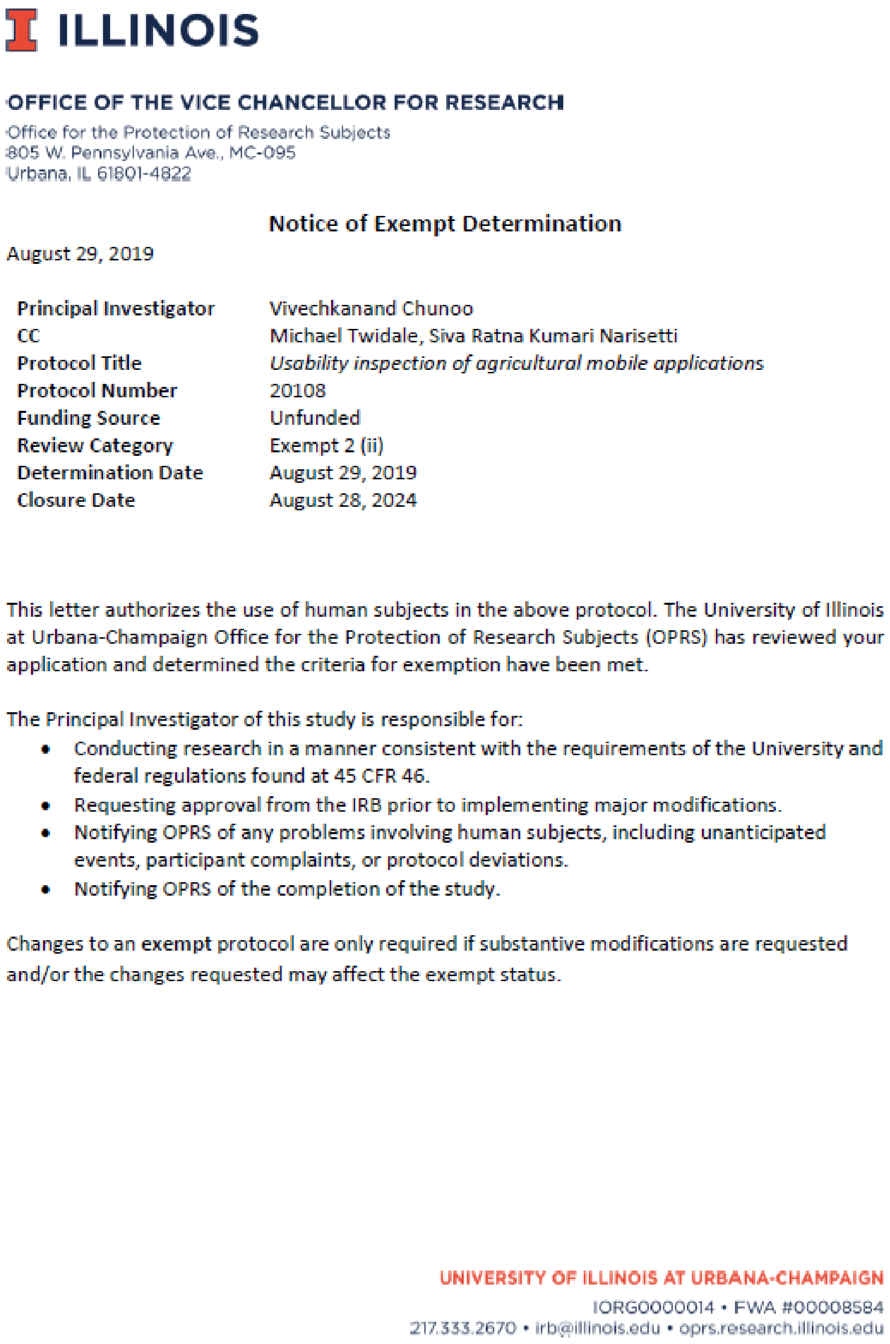
Some villages may still have electricity issues – if it is required to visit during late evenings or nights then it is advised to be accompanied by friends or family especially when visiting unfamiliar locations.

If a research study needs to select and study farmers randomly in the fields, it is possible, but with a little more work and fortune. From my observations, farmers, in general, are happy to talk to researchers, but they establish trust and comfort when they get information and assurance from familiar senior people, such as journalists or persons with some reputation.

I hope sharing these learnings will be helpful to future researchers to conduct research studies in India with rural farmers better!

APPENDIX B: IRB APPROVAL LETTER FOR EXPERT STUDY

IRB approval for expert study



ILLINOIS

OFFICE OF THE VICE CHANCELLOR FOR RESEARCH
Office for the Protection of Research Subjects
805 W. Pennsylvania Ave., MC-095
Urbana, IL 61801-4822

Notice of Exempt Determination

August 29, 2019

Principal Investigator	Vivechkanand Chunoo
CC	Michael Twidale, Siva Ratna Kumari Narisetti
Protocol Title	*Usability inspection of agricultural mobile applications*
Protocol Number	20108
Funding Source	Unfunded
Review Category	Exempt 2 (ii)
Determination Date	August 29, 2019
Closure Date	August 28, 2024

This letter authorizes the use of human subjects in the above protocol. The University of Illinois at Urbana-Champaign Office for the Protection of Research Subjects (OPRS) has reviewed your application and determined the criteria for exemption have been met.

The Principal Investigator of this study is responsible for:

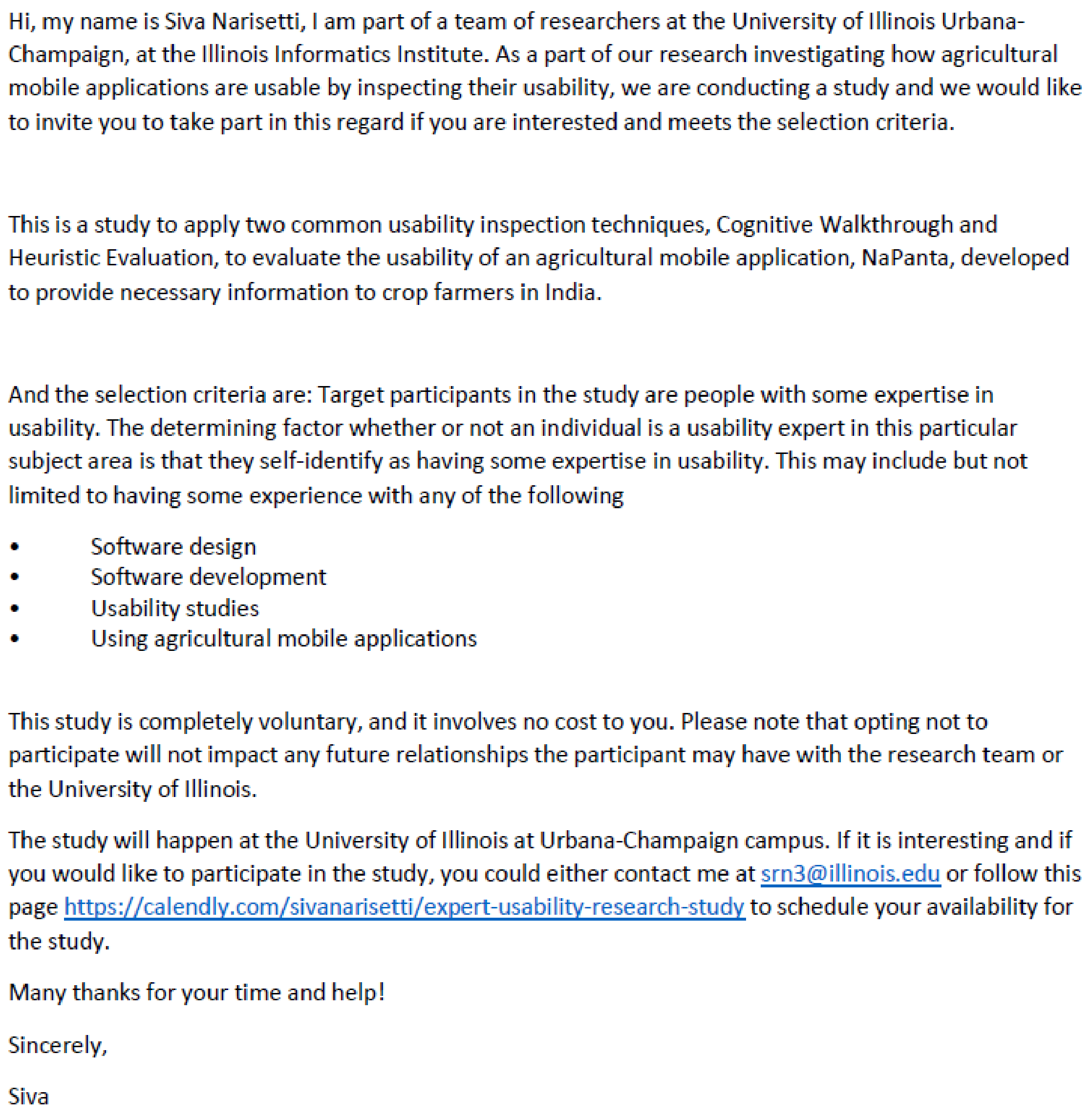
- Conducting research in a manner consistent with the requirements of the University and federal regulations found at 45 CFR 46.
- Requesting approval from the IRB prior to implementing major modifications.
- Notifying OPRS of any problems involving human subjects, including unanticipated events, participant complaints, or protocol deviations.
- Notifying OPRS of the completion of the study.

Changes to an **exempt** protocol are only required if substantive modifications are requested and/or the changes requested may affect the exempt status.

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
IORG0000014 • FWA #00008584
217.333.2670 • irb@illinois.edu • oprs.research.illinois.edu

APPENDIX C: RECRUITMENT MATERIALS FOR EXPERT STUDY

Expert study email announcement



Hi, my name is Siva Narisetti, I am part of a team of researchers at the University of Illinois Urbana-Champaign, at the Illinois Informatics Institute. As a part of our research investigating how agricultural mobile applications are usable by inspecting their usability, we are conducting a study and we would like to invite you to take part in this regard if you are interested and meets the selection criteria.

This is a study to apply two common usability inspection techniques, Cognitive Walkthrough and Heuristic Evaluation, to evaluate the usability of an agricultural mobile application, NaPanta, developed to provide necessary information to crop farmers in India.

And the selection criteria are: Target participants in the study are people with some expertise in usability. The determining factor whether or not an individual is a usability expert in this particular subject area is that they self-identify as having some expertise in usability. This may include but not limited to having some experience with any of the following

- Software design
- Software development
- Usability studies
- Using agricultural mobile applications

This study is completely voluntary, and it involves no cost to you. Please note that opting not to participate will not impact any future relationships the participant may have with the research team or the University of Illinois.

The study will happen at the University of Illinois at Urbana-Champaign campus. If it is interesting and if you would like to participate in the study, you could either contact me at srn3@illinois.edu or follow this page https://calendly.com/sivanarisetti/expert-usability-research-study to schedule your availability for the study.

Many thanks for your time and help!

Sincerely,

Siva

Expert study verbal announcement

Hi, my name is Siva Narisetti, I am part of a team of researchers at the University of Illinois Urbana-Champaign, at the Illinois Informatics Institute. As a part of our research investigating how agricultural mobile applications are usable by inspecting their usability, we are conducting a study and we would like to invite you to take part in this regard if you are interested and meets the selection criteria.

This is a study to apply two common usability inspection techniques, Cognitive Walkthrough and Heuristic Evaluation, to evaluate the usability of an agricultural mobile application, NaPanta, developed to provide necessary information to crop farmers in India.

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- Software design
- Software development
- Usability studies
- Using agricultural mobile applications

This study is completely voluntary, and it involves no cost to you. The study will happen at the University of Illinois at Urbana-Champaign campus. Please let me know if it is interesting and if you would like to participate in the study.

Please note that opting not to participate will not impact any future relationships the participant may have with the research team or the University of Illinois.

If yes: Thank you for accepting to participate. If you would like, we could set time up now or later at https://calendly.com/sivanarisetti/expert-usability-research-study or you could contact me at srn3@illinois.edu to schedule for the study. If you prefer, I could also contact you if you could provide your contact details (preferably email).

If no: Thank you for your time and for listening. Have a nice one!

APPENDIX D: CONSENT FORM FOR EXPERT STUDY

UNIVERSITY OF ILLINOIS, URBANA-CHAMPAIGN
CONSENT FORM FOR RESEARCH PARTICIPATION

Study Title: Usability inspection of agricultural mobile applications
Principal Investigator: Dr. Vivechkanand Chunoo
Student Researcher: Siva Ratna Kumari Narisetti

We are a team of researchers at the University of Illinois Urbana-Champaign, at the Illinois Informatics Institute. As a part of our research investigating how agricultural mobile applications are usable by inspecting their usability (easy of use and performance), we are conducting a study, and we invite you to take part in this regard. This form has important information about the reasons for doing this study, what we will ask you to do if you decide to be in this study, and the ways we would like to use the information collected, if you choose to be in the study.

Please note that opting not to participate will not impact any future relationships the participant may have with the research team or the University of Illinois.

Why are you doing this study?

Smartphones and their applications usage is emerging in India. Proper design and development of mobile applications can play vital role in many activities including agricultural sector such as providing farmers with the timely and accurate information. Since this innovation is still in its development stage there is a dearth in studies in understanding what design principles should be used to make the app perform better and easy to use. This study aims to inspect the app with usability experts who are familiar with app development and design to evaluate the app for its performance and ease of use. With this study we would like to provide future app developers with the design and developing principles to incorporate into their application to make it more usable and user friendly.
More information will be provided about this study at the end.

What will I do if I choose to be in this study?

A mobile device with the app preinstalled will be given to you to evaluate the usability of that app.
The study consists of three parts:

1. Heuristic evaluation – to test the app with the selected heuristic design principles
2. Cognitive walkthrough – participants will complete the given tasks
3. Post-Interview to about your experiences during the first two phases

Study time: Approximately 60 minutes

Study location: Champaign/Urbana

We would like to audio-record this survey to ensure that we accurately remember the information you provide. These recordings will only be used by the Research Team for this study's purposes only. Audio recording is an optional part of the study. Please let us know if you would like to opt in or opt out of the audio recording by checking the appropriate box below.

I OPT IN TO BEING RECORDED FOR RESEARCH PURPOSES [ ]
I OPT OUT OF BEING RECORDED FOR RESEARCH PURPOSES [ ]

What are the possible risks or discomforts?

To the best of our knowledge, this study will have no more risk of harm than you would experience in everyday life.

What are the possible benefits for me or others?

Understanding the current usability of the app will be useful to identify problems associated with that to potentially improve the app's performance and usability. Insights from this study could provide other researchers and future app developer to develop better and more usable apps which could improve user experience of using an agricultural mobile app.

Will my study-related information be kept confidential?

We will use all reasonable efforts to keep your personal information confidential, but we cannot guarantee absolute confidentiality. When this research is discussed or published, no one will know that you were in the study. But, when required by law or university policy, identifying information (including your signed consent form) may be seen or copied by: a) The Institutional Review Board that approves research studies; b) The Office for Protection of Research Subjects and other university departments that oversee human subjects research; c) University and state auditors responsible for oversight of research.

How will you protect the information you collect about me, and how will that information be shared?

Results of this study may be used in thesis, Journal articles, conference presentations, and research talks. Your study data will be handled as confidentially as possible. The audio recordings of the interview will be destroyed (deleted off local and UIUC Box) following transcription of the interview. The transcription will be kept in a secure UIUC Box location. The questionnaire data will be kept in a secure UIUC BOX/Qualtrics location. If results of this study are published or presented, individual names and other personally identifiable information will not be used. We may share the data we collect from you for use in future research studies or with other researchers – if we share the data that we collect about you, we will remove any information that could identify you before we share it. If we believe that there is the potential for harm to yourself or others, we will notify the appropriate people with this information.

Financial Information

Participation in this study will involve no cost to you and will not provide any compensation.

What are my rights as a research participant?

Participation in this study is voluntary. You do not have to answer any questions you do not want to answer. If at any time and for any reason, you would prefer not to participate in this study, please let any of the researchers know. We can take a break, stop, and continue at a later date, or stop altogether. You may withdraw from this study at any time, and you will not be penalized in any way for deciding to stop participation. If you decide to withdraw from this study, the researchers will ask you if the information already collected from you may be kept for the study's purposes.

Who can I contact if I have questions or concerns about this research study?

If you have questions, you are free to ask them now. If you have questions later, you may contact: Siva Narisetti at +1 573-808-7648 or email at srn3@illinois.edu

If you have any questions about your rights as a participant in this research, you can contact the following office at the University of Illinois: Office for the Protection of Research Subjects (OPRS) at 217-333-2670 or email at irb@illinois.edu

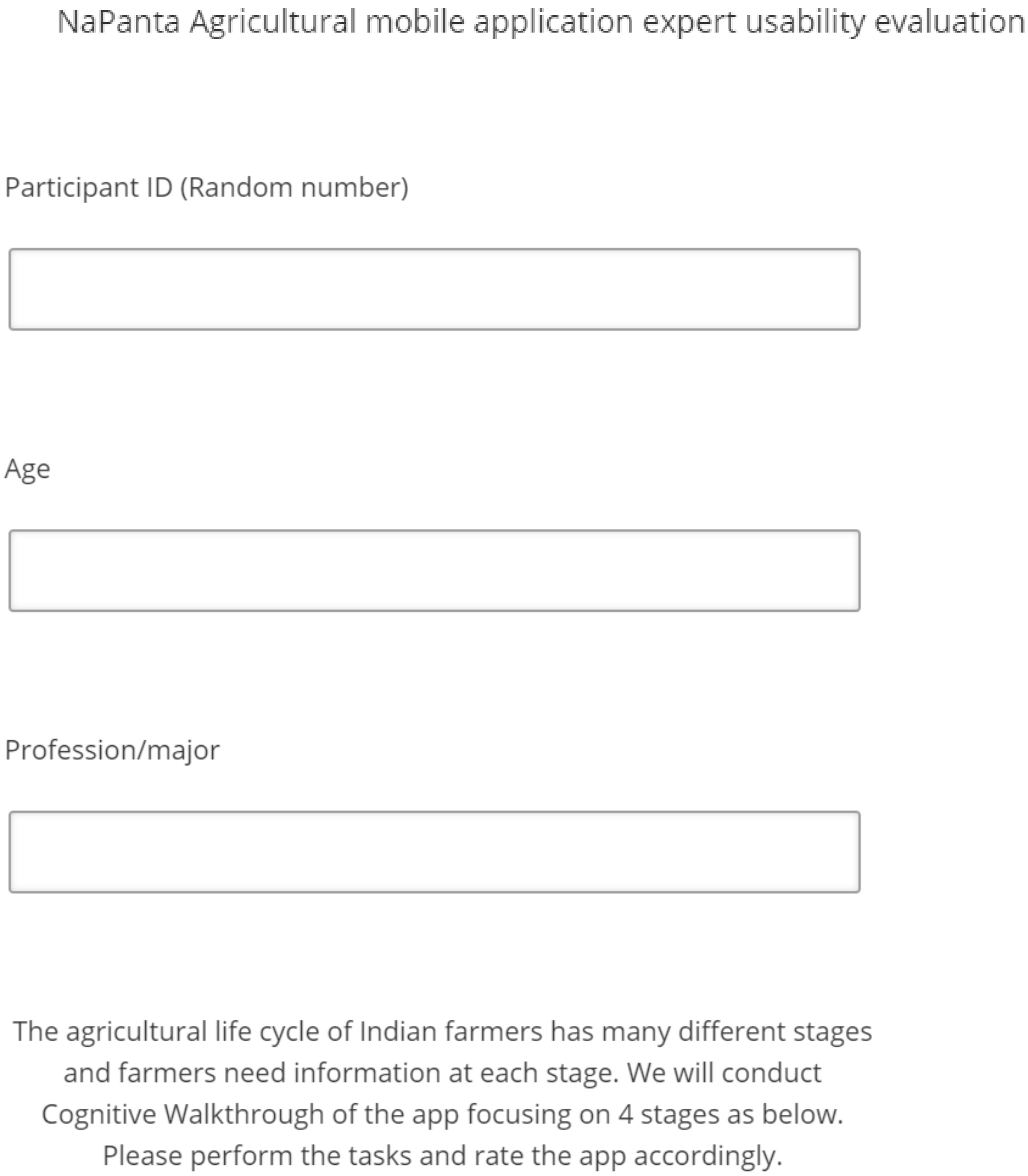
Consent

I have read this form and the research study has been explained to me. I have been given the opportunity to ask questions and my questions have been answered. If I have additional questions, I have been told whom to contact. I agree to participate in the research study described above and will receive a copy of this consent form.

____
Participant's Name (printed)

____ ______________
Participant's Signature Date

APPENDIX E: QUESTIONNAIRE FOR EXPERT STUDY



NaPanta Agricultural mobile application expert usability evaluation

Participant ID (Random number)

Age

Profession/major

The agricultural life cycle of Indian farmers has many different stages and farmers need information at each stage. We will conduct Cognitive Walkthrough of the app focusing on 4 stages as below. Please perform the tasks and rate the app accordingly.

Stage 1: (seed and cultivation varieties)
You are a farmer who has 2 acres of land and you would like to cultivate tomatoes so planning to buy seeds and looking for information on types of available seeds and advice on selecting seeds and cultivation techniques suitable for your land's soil

	Cannot find	Very difficult to find	difficult to find	It was not difficult/easy, but I was able to find	easy to find	Very easy to find
Could you find seed varieties for tomato crop?	○	○	○	○	○	○
Could you find information on seed dealers?	○	○	○	○	○	○
Could you find information on different cultivation types(organic, regular, etc.,) available for tomato crop?	○	○	○	○	○	○

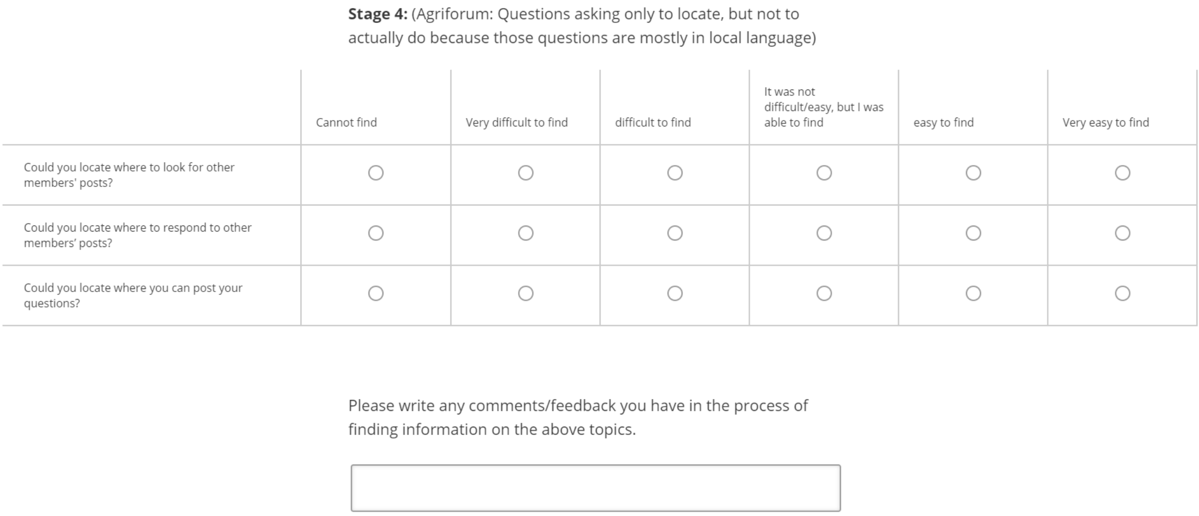
Stage 2: (Disease and weed management)
Now you have started growing tomatoes through regular farming and you observed your crops got "bacterial wilt disease", and your field is occupied by "Digera Arvensis".

	Cannot find	Very difficult to find	difficult to find	It was not difficult/easy, but I was able to find	easy to find	Very easy to find
Could you find information on bacterial wilt disease?	○	○	○	○	○	○
Could you find information on protecting your crop from bacterial wilt disease?	○	○	○	○	○	○
could you find information on Digera Arvensis weed?	○	○	○	○	○	○
Could you find information on protecting your crop from Digera Arvensis	○	○	○	○	○	○
Could you find information on where you can buy pesticides (pesticide dealer information)?	○	○	○	○	○	○

Stage 3: (Market & Post-Harvest management)
Your crops started giving produce and it's time to sell your tomatoes, so you are looking for information on places to sell your produce, what are the market predictions, and how/where to store your produce to sell when you like.

Example markets:
1) Tenali market in Guntur district in Andhra Pradesh, India
2) L B Nagar market in Hyderabad district in Telangana, India
3) Or you could try for any other market of your interest for any other crop

	Cannot find	Very difficult to find	difficult to find	It was not difficult/easy, but I was able to find	easy to find	Very easy to find
Could you find the market prices of tomatoes for a particular market of your interest?	○	○	○	○	○	○
Could you find information on storage facilities for your produce (cold storage dealer information)?	○	○	○	○	○	○



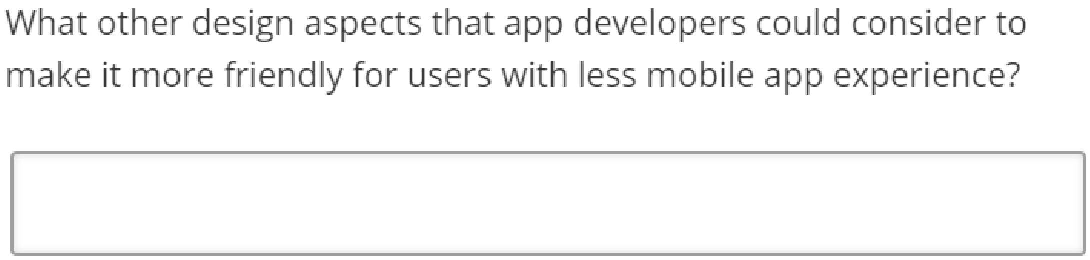
Stage 4: (Agriforum: Questions asking only to locate, but not to actually do because those questions are mostly in local language)

	Cannot find	Very difficult to find	difficult to find	It was not difficult/easy, but I was able to find	easy to find	Very easy to find
Could you locate where to look for other members' posts?	○	○	○	○	○	○
Could you locate where to respond to other members' posts?	○	○	○	○	○	○
Could you locate where you can post your questions?	○	○	○	○	○	○

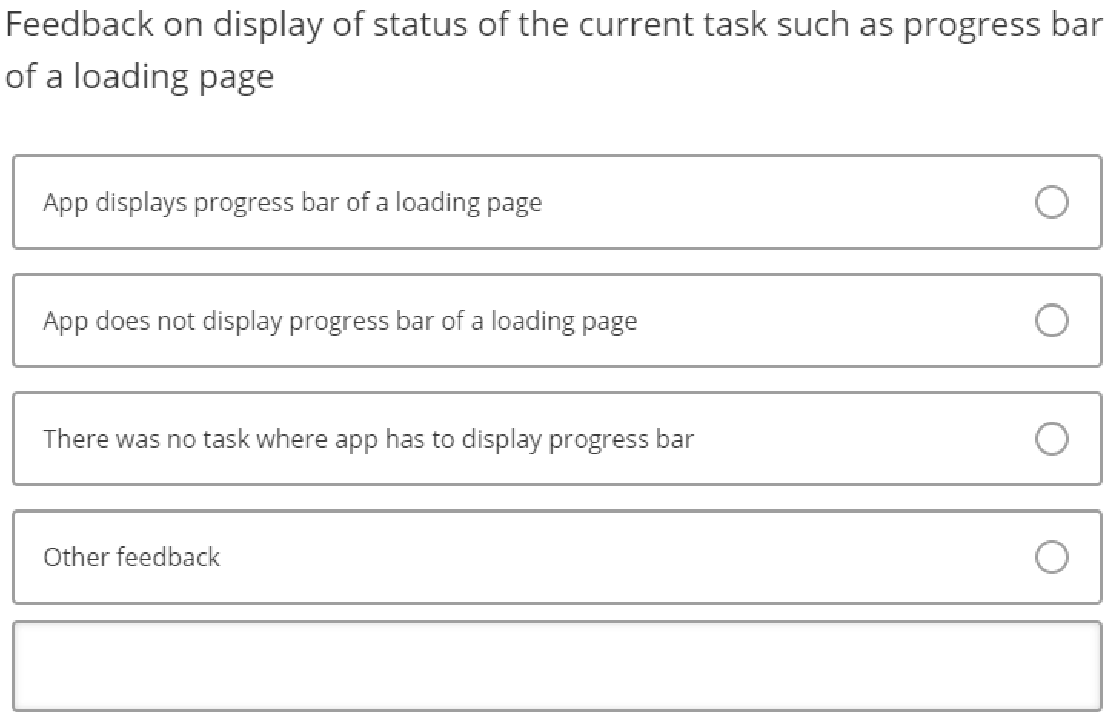
Please write any comments/feedback you have in the process of finding information on the above topics.

Degree of acceptance of the application's usability for this design principle - Heuristic Evaluation!

	1 - Strongly disagree	2 - Disagree	3 - Slightly disagree	4 - Neither disagree nor agree	5 - Slightly agree	6 - Agree	7 - Strongly agree	Other
The navigation signs throughout the app are consistent	○	○	○	○	○	○	○	○
The app looks simple	○	○	○	○	○	○	○	○
App is logical, letting users to predict what will happen next	○	○	○	○	○	○	○	○
Users have to remember the process, no instructions on the screen	○	○	○	○	○	○	○	○
The app looks very confusing	○	○	○	○	○	○	○	○
App provides clear and easily searchable help documentation for extra help	○	○	○	○	○	○	○	○
App's navigation signs are not consistent	○	○	○	○	○	○	○	○
App has clear instruction on the interface so users do not have to remember them	○	○	○	○	○	○	○	○
The app will be difficult to use for users with less mobile app experience	○	○	○	○	○	○	○	○
No way that users can guess what's going to come next	○	○	○	○	○	○	○	○
The app does not have any information for users who may need extra help	○	○	○	○	○	○	○	○
The app will be easy to use even for users with less mobile app experience	○	○	○	○	○	○	○	○

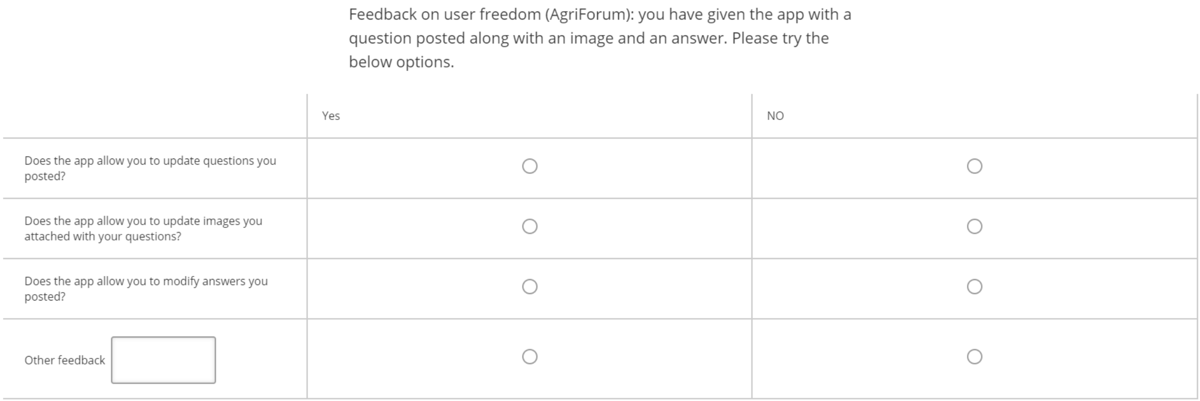


What other design aspects that app developers could consider to make it more friendly for users with less mobile app experience?



Feedback on display of status of the current task such as progress bar of a loading page

- App displays progress bar of a loading page ○
- App does not display progress bar of a loading page ○
- There was no task where app has to display progress bar ○
- Other feedback ○

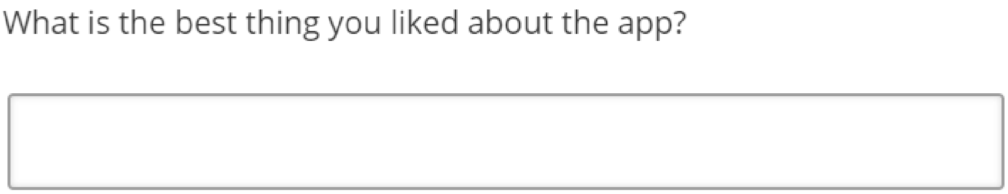


Feedback on user freedom (AgriForum): you have given the app with a question posted along with an image and an answer. Please try the below options.

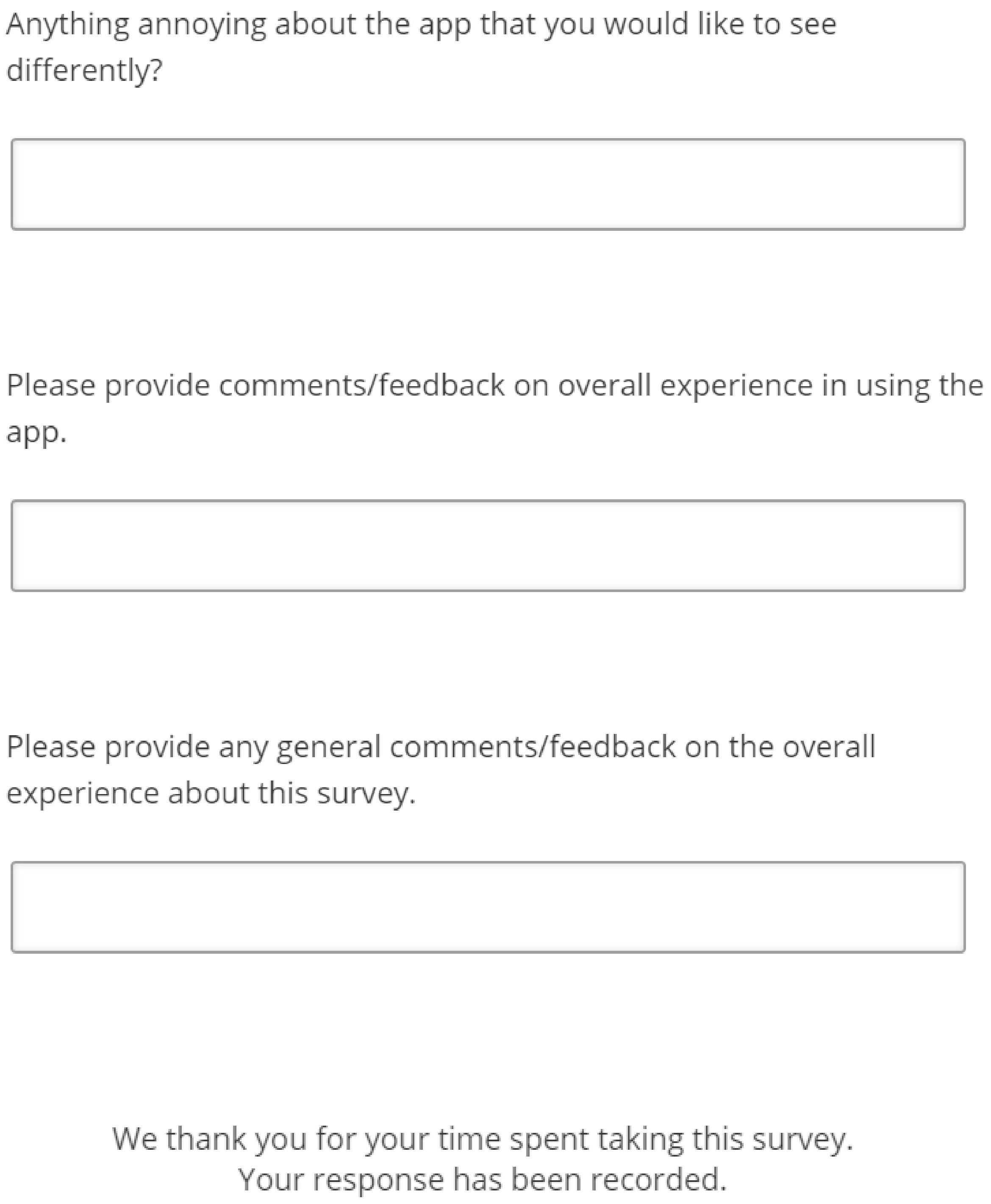
	Yes	NO
Does the app allow you to update questions you posted?	○	○
Does the app allow you to update images you attached with your questions?	○	○
Does the app allow you to modify answers you posted?	○	○
Other feedback ☐	○	○

Feedback on error messages

- I have not encountered any error messages ○
- The app has not provided any error messages even when error(s) occurred ○
- The app provided clear error messages ○
- The app provided error messages, but they are not very clear ○



What is the best thing you liked about the app?



Anything annoying about the app that you would like to see differently?

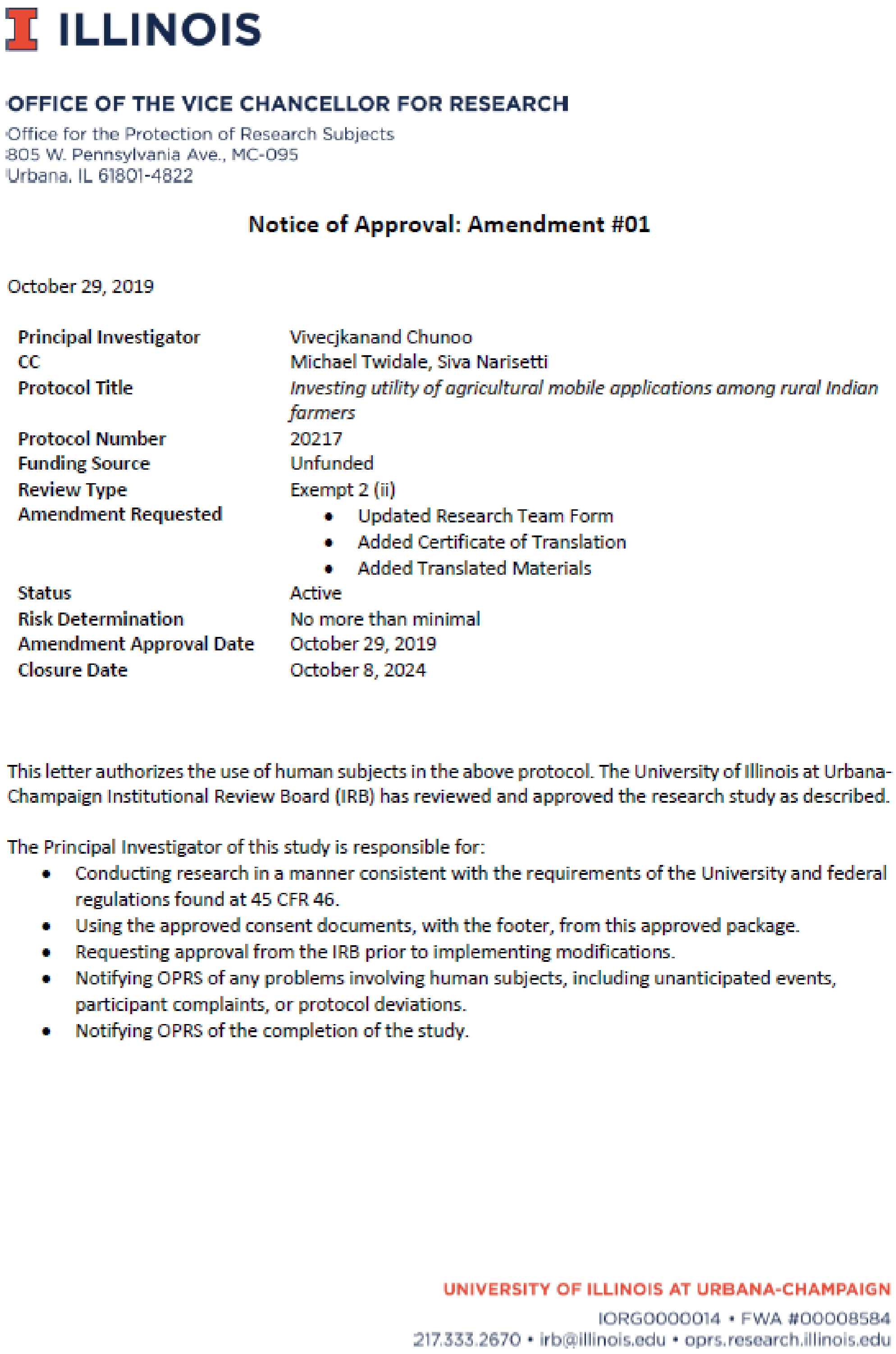
Please provide comments/feedback on overall experience in using the app.

Please provide any general comments/feedback on the overall experience about this survey.

We thank you for your time spent taking this survey.
Your response has been recorded.

APPENDIX F: IRB APPROVAL LETTER FOR USER STUDY

IRB approval letter for the user study



ILLINOIS

OFFICE OF THE VICE CHANCELLOR FOR RESEARCH
Office for the Protection of Research Subjects
805 W. Pennsylvania Ave., MC-095
Urbana, IL 61801-4822

Notice of Approval: Amendment #01

October 29, 2019

Principal Investigator	Vivecjkanand Chunoo
CC	Michael Twidale, Siva Narisetti
Protocol Title	*Investing utility of agricultural mobile applications among rural Indian farmers*
Protocol Number	20217
Funding Source	Unfunded
Review Type	Exempt 2 (ii)
Amendment Requested	• Updated Research Team Form • Added Certificate of Translation • Added Translated Materials
Status	Active
Risk Determination	No more than minimal
Amendment Approval Date	October 29, 2019
Closure Date	October 8, 2024

This letter authorizes the use of human subjects in the above protocol. The University of Illinois at Urbana-Champaign Institutional Review Board (IRB) has reviewed and approved the research study as described.

The Principal Investigator of this study is responsible for:

- Conducting research in a manner consistent with the requirements of the University and federal regulations found at 45 CFR 46.
- Using the approved consent documents, with the footer, from this approved package.
- Requesting approval from the IRB prior to implementing modifications.
- Notifying OPRS of any problems involving human subjects, including unanticipated events, participant complaints, or protocol deviations.
- Notifying OPRS of the completion of the study.

APPENDIX G: RECRUITMENT MATERIALS FOR USER STUDY IN ENGLISH AND TELUGU

Study recruitment flyer in English

FARMERS NEEDED FOR A RESEARCH STUDY

An opportunity to participate in a research study on mobile apps for farmers conducted by Siva Narisetti, a researcher from the University of Illinois, USA.

All are welcome irrespective of gender and age. Researcher will provide all the required equipment.

Study duration: 1 hour
Study location: farmer's village
Compensation: a farmer friendly gift

If interested, please contact
+91 9912364113 or srn3@illinois.edu

Siva Narisetti
Ph.D. Candidate
Illinois Informatics Institute
University of Illinois at Urbana-Champaign, USA.

ILLINOIS

Study recruitment flyer in Telugu

రైతుల అవసరాలపై జరిగే అధ్యయనంలో పాల్గొనండి!!

రైతుల కోసం మొబైల్ యాప్ లపై అమెరికాలోని ఇల్లినాయిస్ విశ్వవిద్యాలయానికి చెందిన పరిశోధకులు నారిశెట్టి శివ గారు నిర్వహిస్తున్న అధ్యయనంలో పాల్గొనే అవకాశం.

రైతులెవరైనా అధ్యయనంలో పాల్గొనవచ్చు. పరిశోధకులు అధ్యయనానికి అవసరమైన అన్ని పరికరాలను అందిస్తారు.

అధ్యయన వ్యవధి: 1 గంట
అధ్యయన ప్రదేశం: రైతు స్వగ్రామం
పరిహారం: ఒక చిరు బహుమతి

ఆసక్తి ఉంటే, దయచేసి +91 9912364113
లేదా srn3@illinois.edu ని సంప్రదించండి

నారిశెట్టి శివ
పీహెచ్డీ అభ్యర్థి
ఇల్లినాయిస్ ఇన్ఫర్మేటిక్స్ ఇన్స్టిట్యూట్
యూనివర్సిటీ ఆఫ్ ఇల్లినాయిస్, అర్బానా-ఛాంపెయిన్

ILLINOIS

Verbal announcement in English

Hi, my name is Siva Narisetti, I am part of a team of researchers at the University of Illinois Urbana-Champaign, at the Illinois Informatics Institute. We are conducting research investigating agricultural mobile applications developed for Indian farmers. We want to know more about what it is like for farmers to use such apps and what farmers want from those apps. I would like to invite you to take part in this study of an app if you are interested.

This study is completely voluntary, and it involves no cost to you. I will provide you with a gift that will be useful for general agricultural activities. The study duration is 1 hour, and location will be at your village. If you are interested, please contact me at +91 9912364113 or srn3@illinois.edu. Thank you!

Please note that opting not to participate will not impact any future relationships the participant may have with the research team or the University of Illinois.

Verbal announcement in Telugu

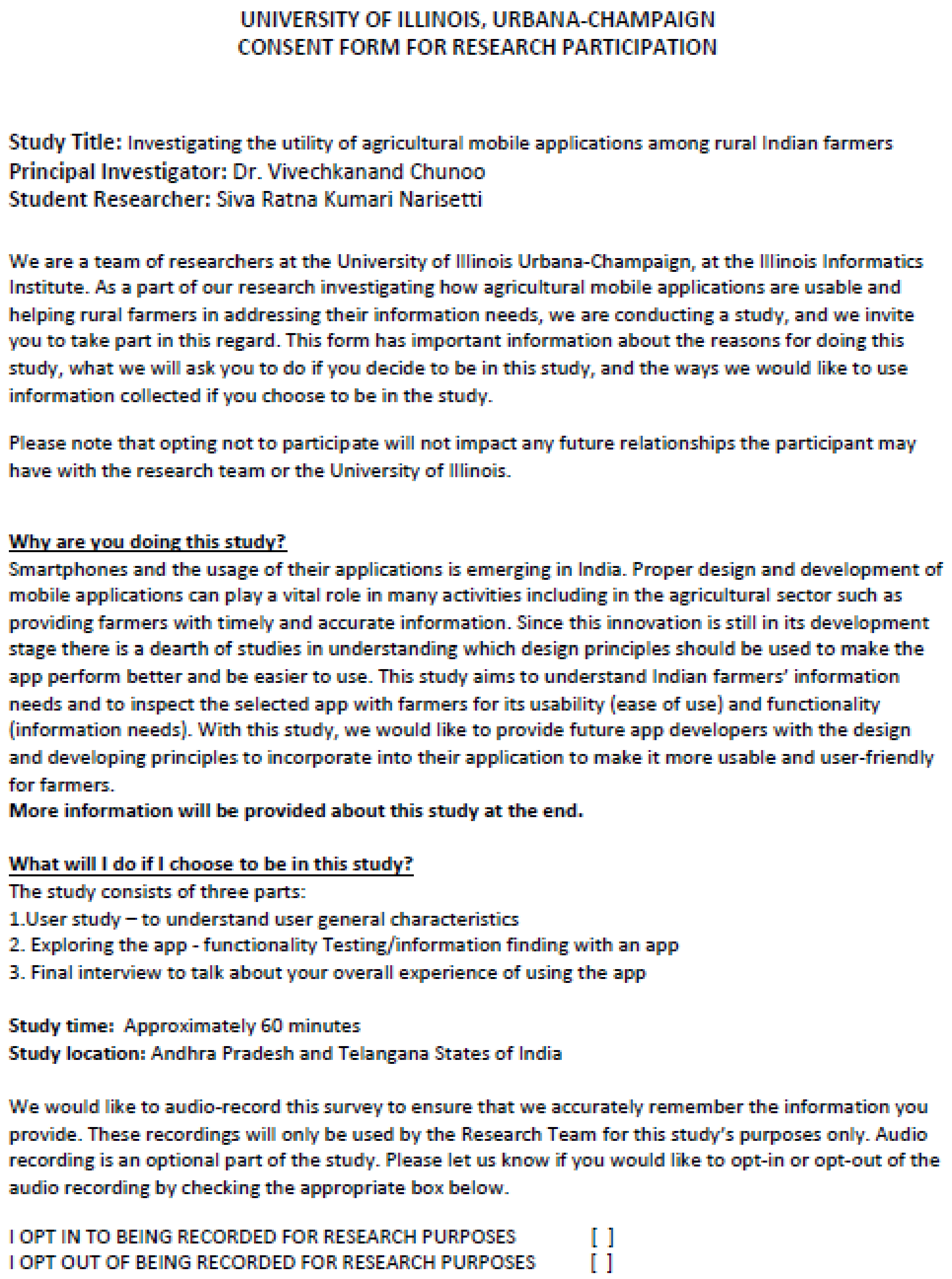
నమస్తే, నా పేరు శివ నారిశెట్టి, నేను ఇల్లినాయిస్ యూనివర్శిటీ అర్బానా-ఛాంపెయిన్ లో ఇల్లినాయిస్ ఇన్ఫర్మేటిక్స్ ఇన్స్టిట్యూట్ పరిశోధకుల బృందంలో ఒక పరిశోధకురాలిని. మా పరిశోధనలో భాగంగా, వ్యవసాయ మొబైల్ అనువర్తనాలు (యాప్స్) గ్రామీణ రైతులకు వారి సమాచార అవసరాలను తీర్చడంలో ఎలా సహాయపడడతాయో పరిశోధించడం కోసం నేను ఒక అధ్యయనం నిర్వహిస్తున్నాము మరియు ఈ విషయంలో పాల్గొనమని మిమ్మల్ని ఆహ్వానించాలనుకుంటున్నాను.

ఈ అధ్యయనం పూర్తిగా స్వచ్ఛందం మరియు ఇది మీకు ఎటువంటి ఖర్చును కలిగించదు. సాధారణ వ్యవసాయ కార్యకలాపాలకు ఉపయోగపడే ఒక బహుమతిని అధ్యయనం పూర్తి ఐన తరువాత మీకు ఇవ్వబడుతుంది. అధ్యయన వ్యవధి 1 గంట, మరియు స్థానం మీ స్వగ్రామంలో ఉంటుంది. మీకు ఆసక్తి ఉంటే, దయచేసి నన్ను +91 9912364113 లేదా srn3@illinois.edu లో సంప్రదించగలరు. ధన్యవాదాలు!

ఒకవేళ మీరు పాల్గొనకూడదని నిర్ణయించుకుంటే, పరిశోధనా బృందం లేదా ఇల్లినాయిస్ విశ్వవిద్యాలయంతో మీ భవిష్యత్ సంబంధాలను ప్రభావితం చేయదని దయచేసి గమనించండి.

APPENDIX H: CONSENT FORM FOR USER STUDY IN ENGLISH AND TELUGU

Consent form in English



UNIVERSITY OF ILLINOIS, URBANA-CHAMPAIGN
CONSENT FORM FOR RESEARCH PARTICIPATION

Study Title: Investigating the utility of agricultural mobile applications among rural Indian farmers
Principal Investigator: Dr. Vivechkanand Chunoo
Student Researcher: Siva Ratna Kumari Narisetti

We are a team of researchers at the University of Illinois Urbana-Champaign, at the Illinois Informatics Institute. As a part of our research investigating how agricultural mobile applications are usable and helping rural farmers in addressing their information needs, we are conducting a study, and we invite you to take part in this regard. This form has important information about the reasons for doing this study, what we will ask you to do if you decide to be in this study, and the ways we would like to use information collected if you choose to be in the study.

Please note that opting not to participate will not impact any future relationships the participant may have with the research team or the University of Illinois.

Why are you doing this study?

Smartphones and the usage of their applications is emerging in India. Proper design and development of mobile applications can play a vital role in many activities including in the agricultural sector such as providing farmers with timely and accurate information. Since this innovation is still in its development stage there is a dearth of studies in understanding which design principles should be used to make the app perform better and be easier to use. This study aims to understand Indian farmers' information needs and to inspect the selected app with farmers for its usability (ease of use) and functionality (information needs). With this study, we would like to provide future app developers with the design and developing principles to incorporate into their application to make it more usable and user-friendly for farmers.
More information will be provided about this study at the end.

What will I do if I choose to be in this study?

The study consists of three parts:
1.User study – to understand user general characteristics
2. Exploring the app - functionality Testing/information finding with an app
3. Final interview to talk about your overall experience of using the app

Study time: Approximately 60 minutes
Study location: Andhra Pradesh and Telangana States of India

We would like to audio-record this survey to ensure that we accurately remember the information you provide. These recordings will only be used by the Research Team for this study's purposes only. Audio recording is an optional part of the study. Please let us know if you would like to opt-in or opt-out of the audio recording by checking the appropriate box below.

I OPT IN TO BEING RECORDED FOR RESEARCH PURPOSES [ ]
I OPT OUT OF BEING RECORDED FOR RESEARCH PURPOSES [ ]

We may quote your remarks in presentations or articles resulting from this work. A pseudonym will be used to protect your identity unless you specifically request that you be identified by your legal name.

What are the possible risks or discomforts?

To the best of our knowledge, this study will have no more risk of harm than you would experience in everyday life.

What are the possible benefits for me or others?

Understanding rural farmers and their needs will provide other researchers and future app developers an opportunity to develop apps according to your current values and needs hence chances of improving your experience using an agricultural mobile app.

Will my study-related information be kept confidential?

We will use all reasonable efforts to keep your personal information confidential, but we cannot guarantee absolute confidentiality. When this research is discussed or published, no one will know that you were in the study. But, when required by law or university policy, identifying information may be seen or copied by: a) The Institutional Review Board that approves research studies; b) The Office for Protection of Research Subjects and other university departments that oversee human subjects research; c) University and state auditors responsible for oversight of research.

How will you protect the information you collect about me, and how will that information be shared?

The results of this study may be used in the dissertation, Journal articles, conference presentations, and research talks. Your study data will be handled as confidentially as possible. The audio recordings of the interview will be destroyed (deleted off local and UIUC Box) following transcription of the interview. The transcription will be kept in a secure UIUC Box location. The questionnaire data will be kept in a secure UIUC Box. If the results of this study are published or presented, individual names and other personally identifiable information will not be used. We may share the data we collect from you for use in future research studies or with other researchers – if we share the data that we collect about you, we will remove any information that could identify you before we share it. If we believe that there is the potential for harm to yourself or others, we will notify the appropriate people with this information.

Financial Information

Participation in this study will involve no cost to you. You will receive a gift (water pot) that could be used for your farming activities. The gift will be given to you at the end of the research study only after completing all three phases of the study.

I HAVE TAKEN THE GIFT [ ]
I HAVE NOT TAKEN THE GIFT [ ]

What are my rights as a research participant?

Participation in this study is voluntary. You do not have to answer any questions you do not want to answer. If at any time and for any reason, you would prefer not to participate in this study, please let the researcher know. We can take a break, stop, and continue at a later date, or stop altogether. You may withdraw from this study at any time, and you will not be penalized in any way for deciding to stop participation. If you decide to withdraw from this study, the researcher will ask you if the information already collected from you may be kept for the study's purposes.

Who can I contact if I have questions or concerns about this research study?

If you have questions, you are free to ask them now. If you have questions later, you may contact: Siva Narisetti at +1 573-808-7648 (USA) or +91 9912364113 (India) or email at srn3@illinois.edu

My father is fluent in the local language, please find his details below for the local contact details.
Radha Krishna Murthy Narisetti,
Door No: 2-27, Suddapalli (Post), Chebrole (Mandal), Guntur (District), Andhra Pradesh – 522213.
Phone No: +91 9912364113

If you have any questions about your rights as a participant in this research, you can contact the following office at the University of Illinois: Office for the Protection of Research Subjects (OPRS) at 217-333-2670 or email at irb@illinois.edu

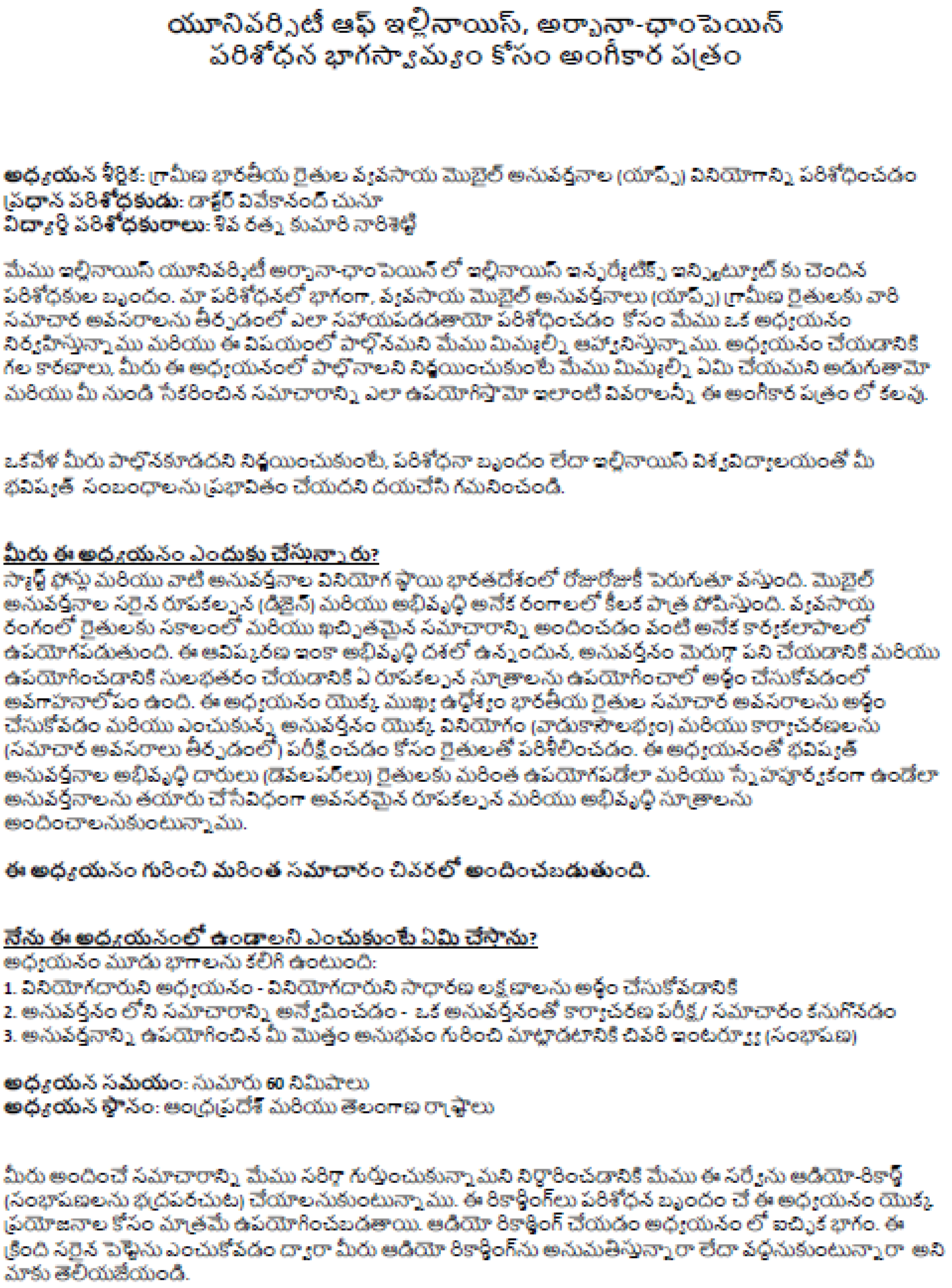
Consent

I have read this form and the research study has been explained to me. I have been given the opportunity to ask questions and my questions have been answered. If I have additional questions, I have been told whom to contact. I agree to participate in the research study described above and will receive a copy of this consent form.

____
Participant's Name (printed)

____ ____________
Participant's Signature Date

Consent form in Telugu



యూనివర్సిటీ ఆఫ్ ఇల్లినాయిస్, అర్బానా-ఛాంపెయిన్
పరిశోధన భాగస్వామ్యం కోసం అంగీకార పత్రం

అధ్యయన శీర్షిక: గ్రామీణ భారతీయ రైతుల వ్యవసాయ మొబైల్ అనువర్తనాల (యాప్స్) వినియోగాన్ని పరిశోధించడం
ప్రధాన పరిశోధకుడు: డాక్టర్ వివేకానంద్ చునూ
విద్యార్థి పరిశోధకురాలు: శివ రత్న కుమారి నారిశెట్టి

మేము ఇల్లినాయిస్ యూనివర్శిటీ అర్బానా-ఛాంపెయిన్ లో ఇల్లినాయిస్ ఇన్ఫర్మేటిక్స్ ఇన్స్టిట్యూట్ కు చెందిన పరిశోధకుల బృందం. మా పరిశోధనలో భాగంగా, వ్యవసాయ మొబైల్ అనువర్తనాలు (యాప్స్) గ్రామీణ రైతులకు వారి సమాచార అవసరాలను తీర్చడంలో ఎలా సహాయపడతాయో పరిశోధించడం కోసం మేము ఒక అధ్యయనం నిర్వహిస్తున్నాము మరియు ఈ విషయంలో పాల్గొనమని మేము మిమ్మల్ని ఆహ్వానిస్తున్నాము. అధ్యయనం చేయడానికి గల కారణాలు, మీరు ఈ అధ్యయనంలో పాల్గొనాలని నిర్ణయించుకుంటే మేము మిమ్మల్ని ఏమి చేయమని అడుగుతామో మరియు మీ నుండి సేకరించిన సమాచారాన్ని ఎలా ఉపయోగిస్తామో ఇలాంటి వివరాలన్నీ ఈ అంగీకార పత్రం లో కలవు.

ఒకవేళ మీరు పాల్గొనకూడదని నిర్ణయించుకుంటే, పరిశోధనా బృందం లేదా ఇల్లినాయిస్ విశ్వవిద్యాలయంతో మీ భవిష్యత్ సంబంధాలను ప్రభావితం చేయదని దయచేసి గమనించండి.

మీరు ఈ అధ్యయనం ఎందుకు చేస్తున్నారు?
స్మార్ట్ ఫోన్లు మరియు వాటి అనువర్తనాల వినియోగ స్థాయి భారతదేశంలో రోజురోజుకీ పెరుగుతూ వస్తుంది. మొబైల్ అనువర్తనాల సరైన రూపకల్పన (డిజైన్) మరియు అభివృద్ధి అనేక రంగాలలో కీలక పాత్ర పోషిస్తుంది. వ్యవసాయ రంగంలో రైతులకు సకాలంలో మరియు ఖచ్చితమైన సమాచారాన్ని అందించడం వంటి అనేక కార్యకలాపాలలో ఉపయోగపడుతుంది. ఈ ఆవిష్కరణ ఇంకా అభివృద్ధి దశలో ఉన్నందున, అనువర్తనం మెరుగ్గా పని చేయడానికి మరియు ఉపయోగించడానికి సులభతరం చేయడానికి ఏ రూపకల్పన సూత్రాలను ఉపయోగించాలో అర్థం చేసుకోవడంలో అవగాహనాలోపం ఉంది. ఈ అధ్యయనం యొక్క ముఖ్య ఉద్దేశ్యం భారతీయ రైతుల సమాచార అవసరాలను అర్థం చేసుకోవడం మరియు ఎంచుకున్న అనువర్తనం యొక్క వినియోగం (వాడుకసౌలభ్యం) మరియు కార్యాచరణలను (సమాచార అవసరాలు తీర్చడంలో) పరీక్షించడం కోసం రైతులతో పరిశీలించడం. ఈ అధ్యయనంతో భవిష్యత్ అనువర్తనాల అభివృద్ధి దారులు (డెవలపర్లు) రైతులకు మరింత ఉపయోగపడేలా మరియు స్నేహపూర్వకంగా ఉండేలా అనువర్తనాలను తయారు చేసేవిధంగా అవసరమైన రూపకల్పన మరియు అభివృద్ధి సూత్రాలను అందించాలనుకుంటున్నాము.

ఈ అధ్యయనం గురించి మరింత సమాచారం చివరలో అందించబడుతుంది.

నేను ఈ అధ్యయనంలో ఉండాలని ఎంచుకుంటే ఏమి చేస్తాను?
అధ్యయనం మూడు భాగాలను కలిగి ఉంటుంది:
1. వినియోగదారుని అధ్యయనం - వినియోగదారుని సాధారణ లక్షణాలను అర్థం చేసుకోవడానికి
2. అనువర్తనం లోని సమాచారాన్ని అన్వేషించడం - ఒక అనువర్తనంతో కార్యాచరణ పరీక్ష/ సమాచారం కనుగొనడం
3. అనువర్తనాన్ని ఉపయోగించిన మీ మొత్తం అనుభవం గురించి మాట్లాడటానికి చివరి ఇంటర్వ్యూ (సంభాషణ)

అధ్యయన సమయం: సుమారు 60 నిమిషాలు
అధ్యయన స్థానం: ఆంధ్రప్రదేశ్ మరియు తెలంగాణ రాష్ట్రాలు

మీరు అందించే సమాచారాన్ని మేము సరిగ్గా గుర్తుంచుకున్నామని నిర్ధారించడానికి మేము ఈ సర్వేను ఆడియో-రికార్డ్ (సంభాషణలను భద్రపరచుట) చేయాలనుకుంటున్నాము. ఈ రికార్డింగ్‌లు పరిశోధన బృందం చే ఈ అధ్యయనం యొక్క ప్రయోజనాల కోసం మాత్రమే ఉపయోగించబడతాయి. ఆడియో రికార్డింగ్ చేయడం అధ్యయనం లో ఐచ్ఛిక భాగం. ఈ క్రింది సరైన పెట్టెను ఎంచుకోవడం ద్వారా మీరు ఆడియో రికార్డింగ్‌ను అనుమతిస్తున్నారా లేదా వద్దనుకుంటున్నారా అని మాకు తెలియజేయండి.

పరిశోధనా ప్రయోజనాల కోసం రికార్డ్ చేయబడటానికి నేను అనుమతిస్తున్నాను [ ]
పరిశోధనా ప్రయోజనాల కోసం రికార్డ్ చేయబడటానికి నేను అనుమతివ్వను [ ]

ఈ అధ్యయనంలోని మీ వ్యాఖ్యలను మేము ప్రెజెంటేషన్లు (ప్రదర్శనలు) లేదా వ్యాసాలలో కోట్ చేయవచ్చు (ఉపయోగించవచ్చు). మీ గుర్తింపును రక్షించడానికి మారుపేరు ఉపయోగించబడుతుంది, మీరు మీ చట్టపరమైన పేరు ద్వారా గుర్తించబడాలని ప్రత్యేకంగా అభ్యర్థిస్తే తప్ప.

సాధ్యమయ్యే నష్టాలు లేదా అసౌకర్యాలు ఏమిటి?

మాకు తెలిసినంతవరకు, ఈ అధ్యయనం ద్వారా మీకు మీ రోజువారీ జీవితంలో ఎదుర్కొనే హానిని మించిన ప్రమాదం ఏమీ ఉండదు.

నాకు లేదా ఇతరులకు కలిగే ప్రయోజనాలు ఏమిటి?

గ్రామీణ రైతులను మరియు వారి అవసరాలను అర్థం చేసుకోవడం, మీ ప్రస్తుత విలువలు మరియు అవసరాలకు అనుగుణంగా అనువర్తనాలను అభివృద్ధి చేయడానికి పరిశోధకులకు మరియు భవిష్యత్ అనువర్తన డెవలపర్‌లకు అవకాశాన్ని అందిస్తుంది. అందువల్ల వ్యవసాయ మొబైల్ అనువర్తనాలను ఉపయోగించడంలో మీ అనుభవాన్ని మెరుగుపరిచే అవకాశాలు ఉన్నాయి.

నా అధ్యయనానికి సంబంధించిన సమాచారం గోప్యంగా ఉంచబడుతుందా?

మీ వ్యక్తిగత సమాచారాన్ని గోప్యంగా ఉంచడానికి మేము అన్ని విధాలుగా ప్రయత్నిస్తాము, కాని మేము పూర్తి గోప్యతకు హామీ ఇవ్వలేము. ఈ పరిశోధన చర్చించినప్పుడు లేదా ప్రచురించబడినప్పుడు, మీరు అధ్యయనంలో ఉన్నారని ఎవరికీ తెలియదు. కానీ, చట్టం లేదా విశ్వవిద్యాలయ విధానాలకి అవసరమైనప్పుడు ఈక్రింది విధానాల ద్వారా సమాచారాన్ని గుర్తించడం లేదా కాపీ చేయడం జరగవచ్చు: ఎ) పరిశోధనా అధ్యయనాలను ఆమోదించే సంస్థాగత సమీక్ష బోర్డు; బి) పరిశోధనా విషయాల రక్షణ కార్యాలయం మరియు మానవ విషయాల పరిశోధనను పర్యవేక్షించే ఇతర విశ్వవిద్యాలయ విభాగాలు; సి) పరిశోధన పర్యవేక్షణకు బాధ్యత వహించే విశ్వవిద్యాలయం మరియు రాష్ట్ర ఆడిటర్లు.

మీరు నా గురించి సేకరించిన సమాచారాన్ని ఎలా భద్రపరుస్తారు మరియు ఆ సమాచారం ఇతరులతో ఎలా చర్చించబడుతుంది (షేర్)?

ఈ అధ్యయనం యొక్క ఫలితాలను సిద్ధాంత వ్యాసం (డిసర్టేషన్), జర్నల్ కథనాలు (ఆర్టికల్స్), సమావేశ ప్రదర్శనలు (కాంఫరెన్సెస్) మరియు పరిశోధన చర్చలలో ఉపయోగించవచ్చు. మీ అధ్యయన సమాచారం సాధ్యమైనంత గోప్యంగా ఉంచబడుతుంది. ఇంటర్వ్యూ లని తర్జుమా (ట్రాన్స్క్రిప్షన్) చేసిన తరువాత ఇంటర్వ్యూ యొక్క ఆడియో రికార్డింగ్లు తీసివేయబడతాయి (స్థానిక మరియు యుబియుసి బాక్స్ నుండి తొలగించబడతాయి). ట్రాన్స్క్రిప్షన్ సురక్షితమైన యుబియుసి బాక్స్‌లో ఉంచబడుతుంది. అధ్యయన సమాచారం సురక్షితమైన యుబియుసి బాక్స్‌లో ఉంచబడుతుంది. ఈ అధ్యయనం యొక్క ఫలితాలు ప్రచురించబడితే లేదా ప్రదర్శించబడితే, వ్యక్తిగత పేర్లు మరియు వ్యక్తిగతంగా గుర్తించదగిన ఇతర సమాచారం ఉపయోగించబడవు. మేము మీ నుండి సేకరించిన సమాచారాన్ని భవిష్యత్ పరిశోధన అధ్యయనాలలో లేదా ఇతర పరిశోధకులతో పంచుకోవచ్చు - ఒకవేళ సమాచారాన్ని పంచుకుంటే, పంచుకునే ముందు మిమ్మల్ని గుర్తించగల సమాచారం ఏదైనా ఉంటే దానిని తీసివేస్తాము. మీకు లేదా ఇతరులకు హాని కలిగించే అవకాశం ఉందని మేము విశ్వసిస్తే, ఈ సమాచారాన్ని తగిన వ్యక్తులకు తెలియజేస్తాము.

ఆర్థిక సమాచారం

ఈ అధ్యయనంలో పాల్గొనడం వలన మీకు ఎటువంటి ఖర్చు ఉండదు. మీ వ్యవసాయ కార్యకలాపాలకు ఉపయోగపడే ఒక బహుమతి (నీటి కడవ) ను మీరు అందుకుంటారు.

నేను బహుమతిని తీసుకున్నాను [ ]
నేను బహుమతిని తీసుకోలేదు [ ]

పరిశోధనలో పాల్గొనేవానిగా నా హక్కులు ఏమిటి?

ఈ అధ్యయనంలో పాల్గొనడం స్వచ్ఛందం. మీరు సమాధానం ఇవ్వకూడదనుకునే ప్రశ్నలకు మీరు సమాధానం చెప్పాల్సిన అవసరం లేదు. ఎప్పుడైనా మరియు ఏ కారణం చేతనైనా, మీరు ఈ అధ్యయనంలో పాల్గొనకూడదని అనుకుంటే, దయచేసి పరిశోధకునికి తెలియజేయండి. మీరు విరామం తీసుకోవచ్చు, ఆపవచ్చు మరియు తరువాతి తేదీలో కొనసాగవచ్చు లేదా పూర్తిగా ఆపవచ్చు. మీరు ఎప్పుడైనా ఈ అధ్యయనం నుండి వైదొలగవచ్చు మరియు పాల్గొనడాన్ని ఆపివేయాలని నిర్ణయించుకున్నందుకు మీకు ఏ విధంగానైనా జరిమానా విధించబడదు. మీరు ఈ అధ్యయనం నుండి

వైదొలగాలని నిర్ణయించుకుంటే, మీ నుండి ఇప్పటికే సేకరించిన సమాచారం అధ్యయనం యొక్క ప్రయోజనాల కోసం ఉంచవచ్చా అని పరిశోధకులు మిమ్మల్ని అడుగుతారు.

ఈ పరిశోధన అధ్యయనం గురించి నాకు ప్రశ్నలు లేదా సమస్యలు ఉంటే నేను ఎవరిని సంప్రదించగలను?

మీకు ప్రశ్నలు ఉంటే, మీరు ఇప్పుడు వాటిని స్వేచ్ఛగా అడగవచ్చు. మీకు తరువాత ప్రశ్నలు ఉంటే, మీరు ఈ క్రింది వివరాల ద్వారా సంప్రదించవచ్చు: శివా నారిశెట్టి +1 573-808-7648 (అమెరికా) లేదా +91 9912364113 (భారతదేశం) లేదా sm3@illinois.edu కి ఇమెయిల్ చేయగలరు.

మా నాన్నగారు స్థానిక ప్రదేశం లోనే నివసిస్తారు మరియు స్థానిక భాషలో నిపుణులు. స్థానిక సంప్రదింపుల కోసం అతని వివరాలను క్రింద ఇవ్వబడినవి.
రాధా కృష్ణ మూర్తి నారిశెట్టి,
డోర్ నెం: 2-27, సుద్ధపల్లి (పోస్ట్), చేబ్రోలు (మండలం), గుంటూరు (జిల్లా), ఆంధ్రప్రదేశ్ - 522213.
ఫోన్ నెంబర్: +91 9912364113

ఈ పరిశోధనలో పాల్గొనేవారిగా మీ హక్కుల గురించి మీకు ఏవైనా ప్రశ్నలు ఉంటే, మీరు ఇల్లినాయిస్ విశ్వవిద్యాలయంలో ఈ క్రింది కార్యాలయాన్ని సంప్రదించవచ్చు: 217-333-2670 వద్ద ఆఫీస్ ఫర్ ది ప్రొటెక్షన్ ఆఫ్ రీసెర్చ్ సబ్జెక్ట్స్ (OPRS) లేదా irb@illinois.edu కి ఇమెయిల్ చేయగలరు.

సమ్మతి

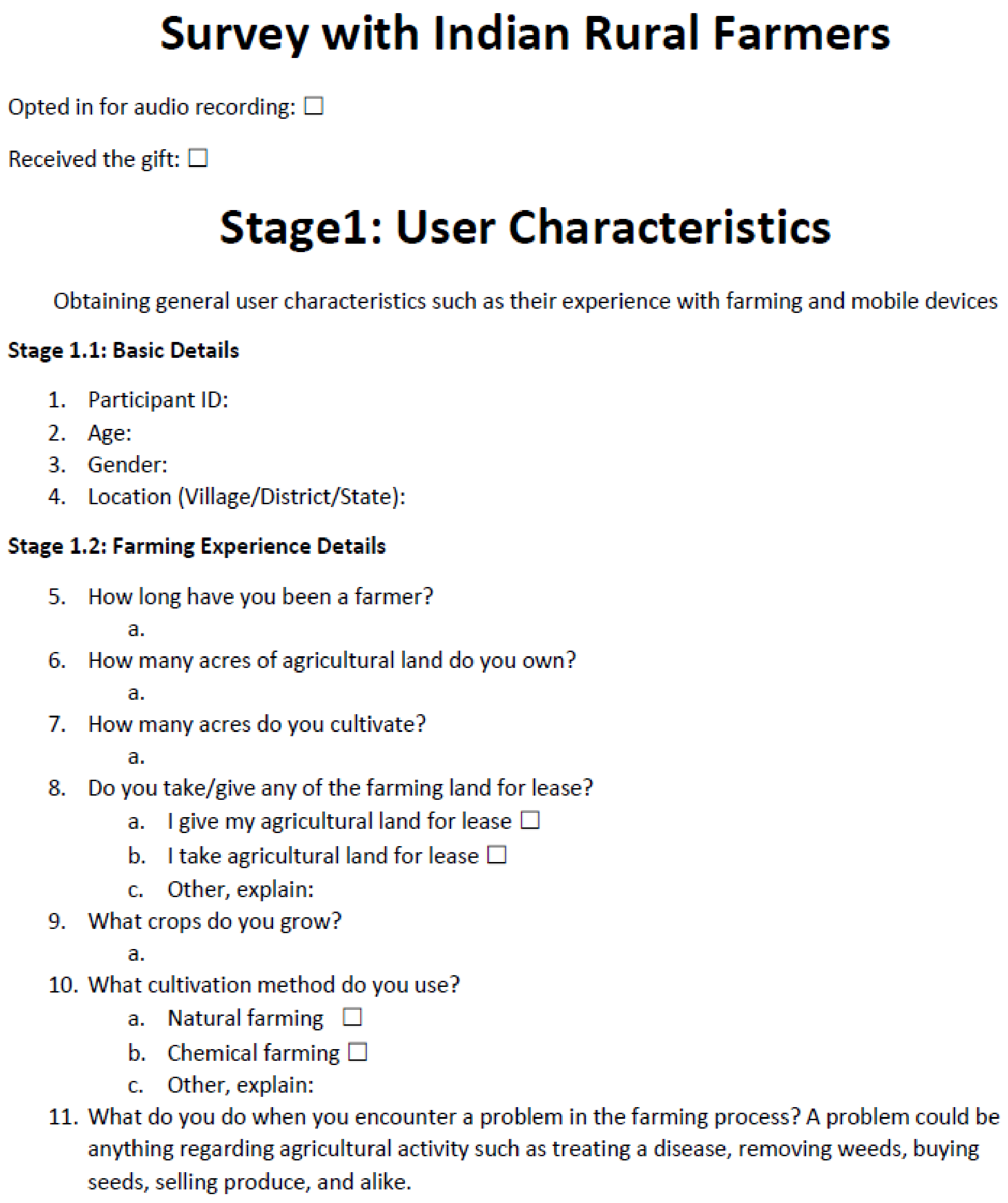
నేను ఈ పత్రం చదివాను మరియు పరిశోధన అధ్యయన విధానం నాకు వివరించబడింది. నాకు ప్రశ్నలు అడగడానికి అవకాశం ఇవ్వబడింది మరియు నా ప్రశ్నలకు సమాధానం ఇవ్వబడింది. నాకు అదనపు ప్రశ్నలు ఉంటే, ఎవరిని సంప్రదించాలో నాకు చెప్పబడింది. పైన వివరించిన పరిశోధన అధ్యయనంలో పాల్గొనడానికి నేను అంగీకరిస్తున్నాను మరియు ఈ సమ్మతి పత్రం యొక్క కాపీని అందుకుంటాను.

____
పాల్గొనేవారి పేరు (ముద్రించబడింది)

____________________________________ ____________
పాల్గొనేవారి సంతకం తేదీ

APPENDIX I: QUESTIONNAIRE FOR USER STUDY IN ENGLISH AND TELUGU

Questionnaire in English



Survey with Indian Rural Farmers

Opted in for audio recording: ☐

Received the gift: ☐

Stage1: User Characteristics

Obtaining general user characteristics such as their experience with farming and mobile devices

Stage 1.1: Basic Details

1. Participant ID:
2. Age:
3. Gender:
4. Location (Village/District/State):

Stage 1.2: Farming Experience Details

5. How long have you been a farmer?
    a.
6. How many acres of agricultural land do you own?
    a.
7. How many acres do you cultivate?
    a.
8. Do you take/give any of the farming land for lease?
    a. I give my agricultural land for lease ☐
    b. I take agricultural land for lease ☐
    c. Other, explain:
9. What crops do you grow?
    a.
10. What cultivation method do you use?
    a. Natural farming ☐
    b. Chemical farming ☐
    c. Other, explain:
11. What do you do when you encounter a problem in the farming process? A problem could be anything regarding agricultural activity such as treating a disease, removing weeds, buying seeds, selling produce, and alike.

Stage 1.3: Mobile Device Details

12. Do you use any mobile device?
    a.
13. If yes, is it a smartphone?
    a.
14. Does anyone else in your family uses smartphone?
    a.
15. What do you use mobile device for?
    a.
16. Do you use any applications (apps) on mobile device?
    a.
17. Do you use any agricultural related apps?
    a.
18. How did you hear about those apps?
    a.
19. Could you share your thoughts on smartphone apps for agricultural purposes?
    a.
20. What do you expect/need from an agricultural mobile application?
21. What are your current ways of obtaining agricultural related information?
    a. Agricultural extension officers ☐
    b. Fellow farmers ☐
    c. Visiting government offices ☐
    d. Television ☐
    e. Radio ☐
    f. News Paper ☐
    g. Agricultural Magazines ☐
    h. Mobile device (text and/or call) ☐
    i. WhatsApp groups ☐
    j. Smartphone Apps ☐
    k. Others, explain:

Stage2: App Usage & Tasks

Participant will explore the app and I (researcher) will ask participant to perform some common tasks and some other tasks based on participant's interests from a pre-made list of tasks. Some tasks might be created on the spot according to participant's behavior and interests.

Ask participant to speak out their thoughts throughout the entire study especially about the app while they perform the tasks.

1. Give the app to the participant
    a. What they think about the app at first sight?
2. Areas to explore (will be selected based on the needs and interests participant expressed so far)
    a. Personal details
    b. Crop Expenditure Tool
    c. Crop Protection (information on some will be provided only online)
        i. Seed Information
        ii. Disease, pest, and weed management
    d. Weather Information (online only)
    e. Crop Insurance (online only)
    f. Market Price (online only)
    g. Dealers Information
        i. Pesticide dealer
        ii. Storage facilities
    h. Soil testing information (information on some will be provided only online)
    i. Subsidy loan information (online only)
    j. Agro advisory (online only)
    k. News & events (online only)
    l. Agriforum (online only)
    m. Any other they would like to explore

a. Personal details: to update app with participant's details (sample questions)
    1. Information on crops that they grow
    2. Cultivation methods they use to grow crops
    3. Other information

b. Seed and cultivation varieties (sample questions)
    1. Could you find seed varieties for a particular crop of your interest (example: tomato crop)?
        a.
    2. Could you find information on seed dealers?
        a.
    3. Could you find information on treating soil?
        a.
    4. Could you find information on different cultivation types (organic, regular, etc.,) available for a particular crop of your interest (example: tomato crop)
        a.

c. **Disease and weed management (sample questions)**
   4. Could you find information on a particular disease (example: bacterial wilt disease)?
      a.
   5. Could you find information on protecting your crop from a particular disease (example: bacterial wilt disease)?
      a.
   6. Could you find information on a particular weed (example: Digera Arvensis weed)?
      a.
   7. Could you find information on protecting your crop from a particular weed (example: Digera Arvensis weed)?
      a.
   8. Could you find information on where you can buy pesticides?
      a.
   9. **Follow up questions:** what do you think about the names of the diseases and pesticides that are available in the app?
      a.

d. **Market & Post-Harvest management (sample questions)**
   10. Could you find the market prices of tomatoes for a particular market of your interest?
       a.
   11. Could you find information on storage facilities for your produce?
       a.

e. **Agriforum (sample questions)**
   12. Could you locate where to look for other members' posts?
       a.
   13. Could you locate where to respond to other members' posts?
       a.
   14. Could you locate where you can post your questions?
       a.
   15. Please try responding to other member's post
       a.
   16. Please try posting a question on the forum
       a.

On the spot task example scenario:

- For example, if while using the app the participant expresses particular interest in a topic X (such as Rent farming equipment), the researcher would develop a task that would require finding out more about what the app has available on X Or using a particular feature (that the researcher knows about but that the participant has yet not been asked to try) on the app that relates to X.
- The task could be: Could you try renting equipment using the app that you may need for your agricultural activities?

Stage3: Final Interview

Final semi-structured wrap-up interview

1. Any comments on the interaction with the app or anything in general about the app?
    a.
2. What do you think about the quality of the information given in the app?
    a.
3. What information would you like to be provided online vs offline?
    a.
4. What is the best thing you like in the app?
    a.
5. What is something annoying about the app?
    a.
6. What else would you like to see in the app?
    a.
7. What do you think about future of agricultural applications for Indian farmers?
    a.
8. Feedback about the overall experience of participating in the survey.
    a.
9. Any other questions as necessary based on participants performance so far
    a.

Questionnaire in Telugu

భారతీయ గ్రామీణ రైతులతో అధ్యయనం

ఆడియో రికార్డింగ్ చేయబడటానికి అనుమతించారు: ☐

బహుమతి అందుకున్నారు: ☐

దశ 1: వినియోగదారుని లక్షణాలు

వ్యవసాయం మరియు మొబైల్ పరికరాలతో వారి అనుభవం వంటి వినియోగదారుల సాధారణ లక్షణాలను పొందడం

దశ 1.1: ప్రాథమిక వివరాలు

1. పాల్గొనేవారి గుర్తింపు సంఖ్య (ఐడి):
2. వయస్సు:
3. లింగము:
4. (గ్రామం / జిల్లా / రాష్ట్రం):

దశ 1.2: వ్యవసాయ అనుభవ వివరాలు

5. మీరు ఎంతకాలం రైతుగా ఉన్నారు?
    a.
6. మీకు ఎన్ని ఎకరాల వ్యవసాయ భూమి ఉంది?
    a.
7. మీరు ఎన్ని ఎకరాలు సాగు చేస్తారు?
    a.
8. మీరు వ్యవసాయ భూమిని కౌలుకి తీసుకుంటారా?
    a. నా వ్యవసాయ భూమిని కౌలుకి ఇస్తాను ☐
    b. నేను వ్యవసాయ భూమిని కౌలుకి తీసుకుంటాను ☐
    c. ఇతరత్ర, వివరించండి:
9. మీరు ఏ పంటలను పండిస్తారు?
    a.
10. మీరు ఏ సాగు పద్ధతిని ఉపయోగిస్తున్నారు?
    a. సహజ వ్యవసాయం ☐
    b. రసాయన వ్యవసాయం ☐
    c. ఇతరత్ర, వివరించండి:
11. వ్యవసాయ ప్రక్రియలో మీకు సమస్య ఎదురైనప్పుడు మీరు ఏమి చేస్తారు? అది వ్యవసాయ కార్యకలాపాలకు సంబంధించి ఏదైనా సమస్య కావచ్చు వ్యాధికి చికిత్స చేయడం: కలుపు మొక్కలను తొలగించడం, విత్తనాలను కొనడం, ఉత్పత్తులను అమ్మడం మరియు ఇలానే వ్యవసాయ కార్యకలాపాలకు సంబంధించి ఏదైనా సమస్య కావచ్చు.

దశ 1.3: మొబైల్ పరికర వివరాలు

12. మీరు ఏదైనా మొబైల్ పరికరాన్ని ఉపయోగిస్తున్నారా?
    a.
13. అవును అయితే, అది స్మార్ట్‌ఫోనా?
    a.
14. మీ కుటుంబంలో మరెవరైనా స్మార్ట్‌ఫోన్ ఉపయోగిస్తారా?
    a.
15. మీరు మొబైల్ పరికరాన్ని దేని కోసం ఉపయోగిస్తున్నారు?
    a.
16. మీరు మొబైల్ పరికరంలో ఏదైనా అనువర్తనాలు (యాప్స్) ఉపయోగిస్తున్నారా?
    a.
17. మీరు ఏమైనా వ్యవసాయ సంబంధిత అనువర్తనాలను ఉపయోగిస్తున్నారా?
    a.
18. మీకు ఆ అనువర్తనాల గురించి ఎలా తెలిసింది?
    a.
19. వ్యవసాయ ప్రయోజనాల కోసం స్మార్ట్‌ఫోన్ అనువర్తనాలపై మీ ఆలోచనలను పంచుకోగలరా?
    a.
20. వ్యవసాయ మొబైల్ అప్లికేషన్ నుండి మీరు ఏమి ఆశిస్తారు / అవసరం?
    a.
21. వ్యవసాయ సంబంధిత సమాచారాన్ని పొందటానికి మీ ప్రస్తుత మార్గాలు ఏమిటి?
    a. వ్యవసాయ విస్తరణ అధికారులు ☐
    b. తోటి రైతులు ☐
    c. ప్రభుత్వ కార్యాలయాలను సందర్శించడం ☐
    d. టెలివిజన్ ☐
    e. రేడియో ☐
    f. వార్తా పత్రిక ☐
    g. వ్యవసాయ పత్రికలు ☐
    h. మొబైల్ పరికరం (సమాచారం మరియు / లేదా కాల్) ☐
    i. వాట్సాప్ గ్రూపులు ☐
    j. స్మార్ట్‌ఫోన్ అనువర్తనాలు ☐
    k. ఇతరములు, వివరించండి:

దశ 2: అనువర్తన వినియోగం & విధులు

పాల్గొనేవారు అనువర్తనాన్ని అన్వేషిస్తారు మరియు ముందే తయారుచేసిన పనుల జాబితా నుండి పాల్గొనేవారి ఆసక్తుల ఆధారంగా కొన్ని సాధారణ పనులను మరియు కొన్ని ఇతర పనులను చేయమని నేను (పరిశోధకురాలు) అడుగుతాను. పాల్గొనేవారి ప్రవర్తన మరియు ఆసక్తుల ప్రకారం కొన్ని పనులు అక్కడికక్కడే సృష్టించబడతాయి.

పాల్గొనేవారు మొత్తం అధ్యయనం అంతటా ప్రత్యేకించి అనువర్తనం గురించి పనులను చేసేటప్పుడు వారి ఆలోచనలను పైకి మాట్లాడమని అడగవలెను.

1. పాల్గొనేవారికి అనువర్తనాన్ని ఇవ్వవలెను
    - a. మొదటి సారి చూసినప్పుడు వారు అనువర్తనం గురించి ఏమనుకుంటున్నారు?

2. అన్వేషించాల్సిన ప్రాంతాలు (పాల్గొనేవారు ఇప్పటివరకు వ్యక్తం చేసిన అవసరాలు మరియు ఆసక్తుల ఆధారంగా ఎంపిక చేయబడతాయి)
    - a. వ్యక్తిగత వివరాలు
    - b. పంట జమ ఖర్చులు
    - c. పంట రక్షణ (కొన్నింటికి సంబంధించిన సమాచారం ఆన్‌లైన్‌లో మాత్రమే, ఇంటర్నెట్ ఉంటేనే, అందించబడుతుంది)
        - i. విత్తన సమాచారం
        - ii. వ్యాధి, తెగులు మరియు కలుపు నిర్వహణ
    - d. వాతావరణ సమాచారం (ఆన్‌లైన్‌లో మాత్రమే)
    - e. పంట భీమా (ఆన్‌లైన్‌లో మాత్రమే)
    - f. మార్కెట్ ధర (ఆన్‌లైన్‌లో మాత్రమే)
    - g. డీలర్ల సమాచారం
        - i. పురుగుమందుల వ్యాపారి
        - ii. నిల్వ సౌకర్యాలు, శీతల గిడ్డంగి
    - h. నేల (మట్టి) పరీక్ష సమాచారం (కొన్నింటికి సంబంధించిన సమాచారం ఆన్‌లైన్‌లో మాత్రమే అందించబడుతుంది)
    - i. సబ్సిడీ రుణ సమాచారం (ఆన్‌లైన్‌లో మాత్రమే)
    - j. వ్యవసాయ సలహా (ఆన్‌లైన్‌లో మాత్రమే)
    - k. వార్తలు & సంఘటనలు (ఆన్‌లైన్‌లో మాత్రమే)
    - l. వ్యవసాయ చర్చావేదిక (ఆన్‌లైన్‌లో మాత్రమే)
    - m. మరేదైనా వారు అన్వేషించాలనుకుంటే

a. వ్యక్తిగత వివరాలు: పాల్గొనేవారి వివరాలతో అనువర్తనాన్ని పొందుపరచడానికి (మాదిరి ప్రశ్నలు)
   1. వారు పండించే పంటలపై సమాచారం
   2. పంటలను పండించడానికి వారు ఉపయోగించే సాగు పద్ధతులు
   3. ఇతర సమాచారం

b. **విత్తనం మరియు సాగు రకాలు (మాదిరి ప్రశ్నలు)**
   1. మీకు ఆసక్తి ఉన్న ఒక పంటకు విత్తన రకాలను కనుగొనగలరా (ఉదాహరణ: టమోటా పంట)?
       - a.
   2. విత్తన డీలర్లపై సమాచారాన్ని కనుగొనగలరా?
       - a.
   3. మట్టి చికిత్సకు సంబంధించిన సమాచారాన్ని కనుగొనగలరా?
       - a.

4. మీకు ఆసక్తి ఉన్న ఒక పంటకు అందుబాటులో ఉన్న వివిధ సాగు రకాల (సేంద్రీయ, రెగ్యులర్, మొదలైనవి) సమాచారాన్ని మీరు కనుగొనగలరా (ఉదాహరణ: టమోటా పంట)?
    a.

c. వ్యాధి (తెగులు) మరియు కలుపు నిర్వహణ (మాదిరి ప్రశ్నలు)

4. మీరు ఒక నిర్దిష్ట వ్యాధి పై సమాచారాన్ని కనుగొనగలరా (ఉదాహరణ: బాక్టీరియల్ ఎండు తెగులు)?
    a.
5. మీ పంటను ఒక నిర్దిష్ట వ్యాధి నుండి రక్షించే సమాచారాన్ని మీరు కనుగొనగలరా (ఉదాహరణ: బాక్టీరియల్ ఎండు తెగులు)?
    a.
6. మీరు ఒక నిర్దిష్ట కలుపు (ఉదాహరణ: డిజిరా అర్వెన్సిస్ కలుపు) పై సమాచారాన్ని కనుగొనగలరా?
    a.
7. మీ పంటను ఒక నిర్దిష్ట కలుపు నుండి రక్షించే సమాచారాన్ని మీరు కనుగొనగలరా (ఉదాహరణ: డిజిరా అర్వెన్సిస్ కలుపు)?
    a.
8. పురుగుమందులను ఎక్కడ కొనుగోలు చేయవచ్చునే సమాచారాన్ని కనుగొనగలరా?
    a.
9. తరువాతి ప్రశ్నలు: అనువర్తనంలో లభించే వ్యాధులు మరియు పురుగుమందుల పేర్ల గురించి మీరు ఏమనుకుంటున్నారు?
    a.

d. మార్కెట్ & పంట పండించిన తరువాతి నిర్వహణ (మాదిరి ప్రశ్నలు)

10. మీకు ఆసక్తి ఉన్న ఒక మార్కెట్ యొక్క టమోటాల ధరలను కనుగొనగలరా?
    a.
11. మీ ఉత్పత్తులను నిల్వ చేయడం కోసం నిల్వ సౌకర్యాలపై సమాచారాన్ని కనుగొనగలరా?
    a.

e. వ్యవసాయ చర్చావేదిక (మాదిరి ప్రశ్నలు)

12. ఇతర సభ్యుల పోస్టుల కోసం ఎక్కడ చూడాలో గుర్తించగలరా?
    a.
13. ఇతర సభ్యుల పోస్ట్‌లకు ఎక్కడ స్పందించాలో గుర్తించగలరా?
    a.
14. మీ ప్రశ్నలను ఎక్కడ పోస్ట్ చేయవచ్చో గుర్తించగలరా?
    a.
15. దయచేసి ఇతర సభ్యుల పోస్ట్‌కు ప్రతిస్పందించడానికి ప్రయత్నించండి
    a.
16. దయచేసి ఫోరమ్‌లో ప్రశ్నను పోస్ట్ చేయడానికి ప్రయత్నించండి
    a.

అక్కడికక్కడే సృష్టించబడే పనులకు ఒక ఉదాహరణ

a. ఉదాహరణకు, అనువర్తనాన్ని ఉపయోగిస్తున్నప్పుడు పాల్గొనేవారు ఏదైనా ఒక అంశం (అద్దె వ్యవసాయ పరికరాలు వంటి అంశం) పై ఆసక్తిని వ్యక్తం చేస్తే, పరిశోధకురాలు ఆ అంశానికి సంబంధించిన పనిని కల్పిస్తారు. ఆ పనిని చేయడం ద్వారా లేక చేసేందుకు ప్రయత్నించడం ద్వారా పాల్గొనేవారు వారికి ఆసక్తిగల అంశం పై తెలియని సమాచారాన్ని తెలుసుకొనగలరు.

b. మాదిరి పని: అనువర్తనాన్ని ఉపయోగించి, మీ వ్యవసాయ కార్యకలాపాలకు అవసరమైన పరికరాలను అద్దెకు తీసుకోవడానికి ప్రయత్నించగలరా?

దశ 3: తుది ఇంటర్వ్యూ

చివరి దశ ఇంటర్వ్యూ

1. అనువర్తనం వాడకం పై మరియు అనువర్తనం గురించి ఏవైనా సాధారణ వ్యాఖ్యలు ఉన్నాయా?
    a.
2. అనువర్తనంలో ఇచ్చిన సమాచారం యొక్క నాణ్యత గురించి మీరు ఏమనుకుంటున్నారు?
    a.
3. ఎలాంటి సమాచారం ఆన్‌లైన్ లో మరియు ఎలాంటి సమాచారం ఆఫ్‌లైన్‌లో అందిస్తే ఉపయోగం అనుకుంటున్నారు?
    a.
4. అనువర్తనంలో మీకు బాగా నచ్చిన విషయం ఏమిటి?
    a.
5. అనువర్తనంలో మీకు బాగా నచ్చని విషయం ఏమిటి?
    a.
6. మీరు అనువర్తనంలో ఇంకా ఏమి చూడాలనుకుంటున్నారు?
    a.
7. భారతీయ రైతుల వ్యవసాయ అనువర్తనాల భవిష్యత్తు గురించి మీరు ఏమనుకుంటున్నారు?
    a.
8. సర్వేలో పాల్గొన్న మొత్తం అనుభవం గురించి అభిప్రాయం.
    a.
9. పాల్గొనేవారి పనితీరు ఆధారంగా ఏమైన ఇతర ప్రశ్నలు.
    a.