DESIGN REQUIREMENTS FOR AN ONLINE DATA EXCHANGE PLATFORM TO BRIDGE THE GAP BETWEEN FARMERS AND RESEARCHERS IN INDIA

by

© Ashmean Kaur Sran

A Dissertation submitted

to the School of Graduate Studies in partial fulfillment of the

requirements for the degree of

Master of Science in Management

Faculty of Business Administration

Memorial University of Newfoundland and Labrador

December 2021

St. John's Newfoundland and Labrador

Abstract

The rising awareness of information transparency and the increasing trend of citizen participation in the agriculture sector has created new opportunities for information sharing. There are numerous information resources available for farmers from private, government sources and industry stakeholders. There are also various farm surveys by which farmers contribute towards the agricultural sector. However, no such platform connects farmers and researchers in which data exchange happens simultaneously between them. This gap in information exchange contributes to slow growth in the advancement of the agricultural sector. Research results do not reach the end-users in time to adopt agricultural improvement practices. Often researchers do not get the opportunity to engage and encourage farmers to be citizen scientists to contribute to the research.

In this thesis, we develop design requirements for an online web-based prototype data exchange platform to bridge the gap between researchers and farmers. The platform can serve as a way to build farmers' trust in researchers and encourage them to contribute more towards agricultural research to develop the sector. We believe that the findings of this study will prove helpful to interface designers and researchers to inform and guide future work in this critical area.

Keywords: website design, agriculture, information system, data exchange

Acknowledgements

I would like to take this opportunity to acknowledge the individuals who assisted me in this journey. Foremost, I would like to express my sincere gratitude to my supervisor, Dr. Jeffrey Parsons, for the continuous support during the entire Master of Science program. The immense knowledge, motivation, and guidance have helped me with my studies, research, and writing of my thesis during the uncertain COVID-19 pandemic. I could not have imagined gathering the strength to complete my degree without his continuous support. He is the best advisor one can ever wish for.

My sincere thanks go to all those with whom I have had the pleasure to work during this research project. I wish to thank my loving and supportive parents for providing me with unfailing support and continuous encouragement throughout my years of study and through the process of researching and writing this thesis. My family and friends have always been there whenever I needed guidance and additional support or care. This accomplishment would not have been possible without them.

Table of Contents

List of Tables

List of Figures

Chapter 1. Introduction

1.1. Background

Agricultural growth and farm data exchange vary from country to country. Many developed countries like the USA and UK have adopted modern farming practices, precision, or digital agriculture, focusing on adopting technologies like GPS, GIS, satellite, and drone imagery. In contrast, some countries still struggle to provide adequate modern farming machinery to farmers (Ministry of Agriculture, 2001). Agricultural technology advancement is based on new biological, mechanical and chemical techniques that can be used at the farm level (Birthal et al., 2015; Ministry of Agriculture, 2001; van de Gevel et al., 2020). Technology adoption is affected by farmers' demographics such as age, location, income and knowledge, including training, education, information and advice (Almekinders et al., 2019; Birthal et al., 2015; Rao, 2007; van de Gevel et al., 2020; Vosough et al., 2015). Internet connectivity has also become a significant factor of consideration for farming techniques that are highly modernized, including smart farming and precision farming.

The World Wide Web is a primary information source in various sectors, including agriculture. Extension officers provide advisory services to the farmers as agricultural stakeholders to improve productivity, profitability and the quality of their livelihoods (Njelekela & Sanga, 2015). Farmers, extension officers and researchers have been extensively utilizing online websites to fulfil their agricultural information needs, including access to government programs and policies on agriculture (Misaki et al., 2019). The increasing use of citizen science in various social sciences fields, especially in developing countries, has promoted the implementation of e-services in the agricultural sector. Central and state governments have developed official websites as one of the sources to deliver information about agriculture to the public and farmers, informing about government subsidies, promoting the usage of the online platform for seeking information, and assuring information of adequate regional extension services. For farmers, finding accurate and up-to-date information based on their information needs can be a difficult task, especially for those who are not skilled in navigating knowledge management websites (Lalmas et al., 2007). Searching through the literature of government websites with numerous portable document format (PDF) links may be difficult, resulting in wandering through multiple web-based databases and search engines that are not helpful for the farmer. These sites do not target knowledge acquisition and do not focus on ease of information collected from the farmers as that is not the focal area of the websites (Bhattacharya et al., 2012). Additionally, the information displayed on these sites may not be user-friendly, mainly because of the complexity and numerous clicks to find the desired information.

The Internet offers a wide variety of information formats, including videos, news updates, live streaming, and pictorial information and images, which can be pivotal for better understanding a concept that might be outside of the user's personal experience and communicating the information to others knowledge. Moreover, there is a vast potential to use online data collection platforms like customized surveys which are faster, cheaper, quick to analyze, easy to style and use by researchers, and have high flexibility. No website, to our knowledge, combines data dissemination sources for farmers like literature search engines and eLearning with data collection functionalities that can be used to exchange data between researchers and farmers to improve knowledge and understanding of the agricultural community. Thus, we created a prototype online web-based platform for facilitating the agricultural information exchange with the main focus on the information needs of the farmers. We have proposed a design system that can be used for both agricultural data collection and data dissemination and increase engagement between farmers and researchers.

Through the online platform, farmers will be able to provide data required by the scientists without going to the laboratories, and the researchers will no longer require hiring and training field data officers for individually going to separate farms for data collection. Citizen science in agriculture can accelerate and improve agricultural efficiency by improving farm practices and making farmers well informed of the latest technology. The farmers can themselves examine crops based on criteria set by the researchers like quality, vigour, and yield. Under traditional research data collection, scientists or field officers are required to go to the farmlands and collect relevant data for the research project. Farmers with remote farmlands are often neglected because of a lack of accessibility, affecting the generalizability of the research (Eitzinger et al., 2019). With our platform, researchers can investigate agricultural data from different regions across the world, collect and share data with the farmers by readily engaging them with the help of this user-friendly online website.

1.2. Motivation from Indian Farming

India enjoys a unique combination of climate and geography, making it the 10th largest arable land in the world (Singh et al., 2020). It comes as no surprise that India has 20 agri-climatic regions, and all of the world's 15 significant climates exist in India (Singh et al., 2017). Agriculture is a primary source of income generation for 58% of the Indian population (India Brand Equity Foundation, 2020). However, it only contributes 14% to the national GDP (Singh et al., 2020) compared to the service sector, which contributes a substantial 59% to GDP with only 23% of the workforce (Lakshmanan, 2019). Furthermore, as India is the second-most populous country globally with 1.371 billion people (United Nations, 2019), providing food security is an ever-growing concern. The Indian government is trying its best to adapt farming technologies and practices according to the growing population by increasing food grain production with the help of agricultural scientists (Veeranjaneyulu, 2014). Thus, the agriculture sectors output has become a crucial part of India's national development plan for global competition with other economies. It poses a unique challenge for Indian agriculture in terms of future growth, and it requires urgent attention and out-of-the-box solutions approach to properly channel the workforce in utilizing the potential of the Indian agricultural sector. There is no surprise that India is thriving as one of the top food-producing countries in the world, but it is also very clear that the agricultural techniques need upgrading by integrating with disruptive technologies. Farmers need awareness and access to latest agricultural research and technologies, but they lack such information. As a result, farming success rates are lower than what is possible given the available technology and research, costing potential agricultural sector growth decline and potential farmers' income.

The agriculture sector is undergoing a technological transformation to combat food security challenges under climate change scenarios (Almekinders et al., 2019). With the vast workforce employed in agriculture, India has the capacity to increase agrarian production with the use of advanced research and technology. Applying innovative methods and recent technologies like the Internet of Things (IoT), automation, CONCE, and geospatial technologies can support in revolutionizing the agrarian sector (Ballantyne, 2009; Eitzinger et al., 2019). There is a strong need to bridge the gap between farmers and researchers to increase agricultural efficiency and promote the sector's growth.

The role of information technology is changing in our everyday lives, and our dependence on it increases. Technology has made it possible for farmers to document their production records and share them with agricultural experts whenever needed. The question is: How easy and how accessible are the technological upgrades and adaptations for the farmers? The agricultural sector employs many people with low literacy levels and little knowledge about farming practices. Some farmers end up investing in expensive agricultural machinery that might be unfit according to their agricultural land, overuse of fertilizers that badly affect soil fertility, and other exploitation and wastage of resources, which all occur because of lack of proper information (Murria, 2018). Farmers are deeply dependent on traditional agricultural practices and have little or less awareness of technological advancements. The main reasons are lack of literacy, fear of technology, the narrow spread of technology in rural areas, and resistance to shifting from traditional to tech-savvy methods (Baumüller, 2018; Marimuthu et al., 2017).

Information and communication technology (ICT) can act as a source to provide support to the farmers by disseminating helpful information related to agricultural improvements, variable prices of inputs, latest farm technologies, market updates, agricultural know-how, among others. Fulfilling farmers' informational needs can help them in optimum utilization of the agricultural resources and generate maximum profits with increased crop productivity (Armstrong et al., 2012). Despite a large number of well-educated, well-trained and well-organized agricultural researchers, around 60% of farmers in the country still remain deprived and not served by any extension agency or functionary (Rao, 2007). ICT can help bridge the gap between agricultural scientists and farmers, leading to improved agricultural research, education and expansion (Singh et al., 2015).

1.3. Motivating Farmers as Citizen Scientists

Farmers' involvement in participatory research can take different forms: providing useful information to scientists, collecting data themselves, or helping design the research questions. However, farmers may be reluctant to participate in research projects because of potential mistrust between farmers and scientists. This mistrust partly originates from the fear that research results may be used to put burdening regulations in place against farming activities, including changes in market policies and government regulations

(Minet et al., 2017). The intrinsic motivation of contributing to science or tackling intellectual challenges is sufficient for many volunteered contributors to join crowdsourcing initiatives in science (Reed et al., 2013). Some contributors might be interested in developing national or global agricultural data infrastructure by providing valuable inputs for farmers.

Farmers can act as an essential part of agricultural research by acting as citizen scientists and helping researchers to get the data they need. Citizen science has emerged as one of the latest participatory research methods enabled by new digital technologies across a wide range of disciplines. There is no universally agreed definition of citizen science, and several researchers stress that plurality of understandings in different fields are critical to creation and innovation in citizen science (Eitzel et al., 2017; Schäfer & Kieslinger, 2016). Rick Bonney is credited as the first one to publicly use the term citizen science to describe the large-scale public participation in data collection initiatives (Bonney et al., 2014). He described citizen science as an alternative form of public outreach to empower the public with scientific literacy and harness large number of people for data collection. Thus, citizen science allows researchers to include the public in authentic scientific activities for collecting research data and experimentation (Bonney et al., 2014; Eitzel et al., 2017).

Citizen science is a narrow subset of crowdsourcing, a form of open public participation in the scientific process where the participants may or may not receive a monetary contribution for their service (Schenk & Guittard, 2011). Crowdsourcing offers the opportunity to gather more data at a lower cost through enhanced spatial and temporal coverage (Fuccillo et al., 2015; McCormick, 2012). Through crowdsourcing, citizens voluntarily help in data collection, for example, biodiversity measurements (Fuccillo et al., 2015), crop experimentation (Van Etten, de Sousa, et al., 2019), bird monitoring (Kelling et al., 2015) and monitoring air quality (Ottinger, 2009). Citizen science in agriculture is a newly introduced but growing practice (Minet et al., 2017; Ryan et al., 2018). Citizen science has proved to be efficient in collecting observations from farmers (Minet et al., 2017). For example, van Etten et al. (2019) performed large-scale on-farm experimentation focused on crop variety evaluation through citizen science.

Through engagement of the online web platform, small farmers will get access to direct advising from researchers for the farming practices; it will allow them to make better and more sustainable decisions about the types of crops they plant and how to manage crops efficiently once they are sown. It might also lead to better yields, higher quality products and increased wealth for the farming communities around the world (Janssen et al., 2017). More transparent involvement of farmers in the research will enable the researchers to develop better quality crop seeds, make recommendations for improving farming techniques and get real-time feedback from a broader scope of farmers. Generally, small farmers do not get a chance to be part of the latest agricultural research, but a direct virtual connection will help bridge the gap between farmers and researchers. Citizen science not only supports efficient and effective data generation for scientific research but it also supports participant and community learning, accompanied by wider social accountability of scientific research (Bonney et al., 2014; Cooper et al., 2015). The farmers gain new skills or knowledge (C. Evans et al., 2005), learn to manage their day-to-day data (Janssen et al., 2017), improve scientific literacy (Jordan et al., 2011), and deeper community involvement (Bell et al., 2008). Citizen science also plays an important role in broadening the perspectives of participants by engaging them in decision-making (Shirk et al., 2012) and addressing concerns of their community by active engagement (Ottinger, 2009). It also creates pathways of development for farmers by using the latest technology in the agricultural sector (Hansen et al., 2014).

1.4. Research Goals and Objectives

There is a need to facilitate knowledge generation and exchange in the agricultural sector for its development and digitalization. This thesis proposes a unique platform for farmers and researchers that can be used for sharing information between the two parties. It aims to be a one-stop-shop with all farming solutions for the farmers, and it will provide researchers with direct on-farm data without involving third parties for data collection. It aims to solve the researchers' data collection problems and provide knowledge to the farmers about the agricultural sector's technological advancements and expert guidance from agricultural scientists to increase crop productivity.

Data analysis and citizen science can help us advance agriculture and contribute to a prosperous future of farming. Citizen science can not only help in collecting essential data related to crops but also in increasing the engagement of the end-user (farmers) in agricultural research. Data collection becomes cost-effective, and the expanding scale of the research becomes more feasible for investigators when using citizen science. With the help of citizen science, researchers can get sample data across a broad geographic area and get data from regions that earlier seemed inaccessible. Scientists can build strong relationships with farmers and aid farmers in applying research output to address on-farm challenges. The platform will act as a mediator between the researchers and the farmers for data collection and providing suggestions on efficient crop varieties to increase farming productivity and contribute to the general awareness of farmers about the latest research in the agricultural sector. Through the research project, we aim to explore the application of online websites to aid farmers and researchers and make necessary recommendations for future improvements in the platform.

In response to the coronavirus pandemic times, it has been challenging to conduct in-person or face-to-face interviews for data collection and arrange extension services and information sessions to educate the community in regions, nationally and globally. The online data collection approach comes in handy to reach broader sections of the population without direct human contact. The data collection can be done efficiently in a small timeframe using the online methods, and it also gives the added advantage to engage participants for future studies. eLearning and knowledge of extension services play a significant role in disaster preparedness, prevention, response and recovery training by community engagement and sharing relevant information (Koundinya et al., 2020).

Introducing technology in the agriculture sector can empower farmers, build a strong community, increase their efficiency, and improve competitive dynamics

(Ballantyne, 2009; Nelson et al., 2019). It has been observed that farmers fail to exploit their true potential towards farming activities due to a lack of resources and knowledge (Eitzinger et al., 2019). Data dissemination can improve agricultural researchs digital visibility and transparency and establish trust in online research studies. Farmers perceive "fellow farmers" as the preferred source of information over the government and private companies because of less bias (Marimuthu et al., 2017). With this in mind, we combined expert guidance of agricultural experts with the trust of fellow farmers through the website to build farmers' trust in the researchers and empower them to make the right farming decisions and raise farming standards. This explains the motive behind the concept of a web-based information-seeking platform for both farmers and researchers. Based on this research, the future potential of the platform is evaluated, and suggestions are made for its improvement and usage by farmers and researchers.

In a nutshell, this thesis focuses on answering the research question: *What are the design requirements for developing an online data exchange platform to bridge the gap between farmers and researchers in India based on a design science approach?* The design requirements of the online platform focus on making the platform easy to use, readily accessible, and functional with quality content as per user requirements.

The expected contributions of this research are:

1. Developing design requirements for an online data exchange platform based on the concepts of crowdsourcing and citizen science, as this offers the opportunity to gather large-scale data at a lower cost through enhanced spatial and temporal coverage.
2. Facilitating knowledge generation and exchange in the Indian agricultural sector for its development and digitalization if the prototype platform gets widely used and adopted in India.
3. Providing farmers with the opportunity to access direct advice from researchers for farming practices. Agricultural scientists can directly seek farmers' support in their research, including developing better quality crop seeds, improving farming techniques and getting real-time feedback from a broader scope of farmers to enhance their research quality. Thus, the prototype aims to support participant and community learning, accompanied by wider social accountability of scientific research in the agricultural field.

1.5. Thesis Organization

Chapter 2 presents a literature review of the existing resources in the agriculture sector that uses information and communication technology (ICT) to share information from agricultural experts to the farmers. It also sheds light on the evolution of data collection practices in the agriculture sector, discusses the existing data collection system to obtain statistics, and reviews currently available approaches to improve the practice. Chapter 3 discussed the design and development process of the web-based system in detail.

Chapter 4 presents the detailed research methodology used in the study. Chapter 5 provides the rationale for using the online platform to improve data collection and data dissemination practices and provides a means by which farmers can communicate with the experts and farming community. Limitations of the proposed model are also mentioned. The thesis concludes by summarizing the research contribution and its implication to practice and suggests several areas for future research.

Chapter 2. Literature Review

In this section, we have divided the literature review into three broad subsections: background, traditional data exchange, crowdsourcing and citizen science. We start by providing a background related to the research topic. We then covered traditional data collection and dissemination methods followed in the agriculture sector. Literature around traditional methods includes traditional data collection practices in the agriculture sector, the evolution of farm survey practices, online practices of data collection, areas of improvement in the online data collection, how information is disseminated in the agricultural sector and how it can be improved. In the end, we provided a literature background for the concept of crowdsourcing and citizen science and how these concepts are adopted in the agricultural sector.

2.1. Background

Data exchange through our platform includes the process of data collection and data dissemination, so we discuss the context and applicability of both these processes from the perspective of the Indian agriculture sector. For data collection purposes, agricultural researchers commonly use conventional survey administration modes, including mail, in-person interviews, telephone, and web-based surveys (Fleming & Bowden, 2009). In India, mail and in-person interviews are the widely used form of data collection (Rhoades & Aue, 2010; Vogel, 1986). The application of web-based surveys in the agricultural sector still needs exploration. With our study, we also examine areas where agricultural researchers can use web-based data collection. After successful evaluations and new scientific discoveries in the field of agriculture, it is equally essential for agricultural researchers to share the research findings with the agricultural institutes and farmers to increase their awareness. Recommendations from researchers for innovation and change in areas including proper equipment and technology, seed selection, market trends and guidance in production can increase farmers overall engagement in research (Nelson et al., 2019). Farmers' active interaction with the research community as citizen scientists can further improve research quality and innovation processes (Ballantyne, 2009). Results from the study will provide a necessary factual basis for consideration of the usage of a web-based platform for online data collection and dissemination methods in the agricultural sector.

Farmers collect and evaluate a large amount of data in each growing season related to types of crops harvested, plantation of seeds, inputs usage like labour and machinery, among others. The data collected is used by farmers to optimize the crop production cycles and increase agricultural efficiency (Bhange & Hingoliwala, 2015). The traditional farming crops are no longer compatible with climate changes. Agricultural scientists are inspecting to understand how farm data from farmers might help develop seeds and introduce farm techniques for adapting to climate change by modernization of agricultural practices. According to the Intergovernmental Panel on Climate Change (Rosen, 2019), climate change is projected to reduce agricultural production by two percent every decade until 2050. So, there is an immediate need to alter farming practices and improve crop varieties based on regional variations to be able to maintain and increase the food supply. This can only happen with an increased connection between farmers and researchers so that they work together to improve the farming resources based on regional variations.

Research conducted by Van Etten et al. (2019) showed the potential of using citizen science to generate insights on crop varieties adaptation and helping farmers with appropriate recommendations of resources. In that case study, however, the farmers were not provided access to an on-the-go platform or any website where they could have provided information to the scientists in real-time. We have created an online website that both agricultural researchers and farmers can use to fulfill their individual and collective goals of sharing and collecting information for the improvement of the agricultural sector.

2.2. Traditional Data Exchange Practices

2.2.1. Traditional Agricultural Data Collection

Agricultural economists have been using mail surveys, observational procedures, and experimental procedures for primary data collection. Among these methods, the mail surveys approach has been used for decades (Pennings et al., 2002). Producing high-quality data with mail surveys is impeded due to the low response rate and lack of representativeness (Dillman et al., 2014; Tourangeau, 2004). In survey methods, respondents are assumed to be able to answer the survey questions through in-person or telephone interviews and/or mail questionnaires. Observational procedures are when researchers make observations about the behaviour of interest and objects either manually or by using mechanical devices (Vogel, 1986). Under experimental procedures, researchers introduce selected stimuli into a controlled environment and then manipulate them to note the changes (Wu & Little, 2011). Enumerative surveys and interviews have become fundamental research tools for all social sciences to conduct primary research, guide policies, and improve practical operations in public and private sectors (Ponto, 2015). Farm surveys concerned with farm management are different from the surveys concerned with farm soil or other physical attributes, as the former is mainly concerned with farmers. Nevertheless, these farm surveys have the same function and role in agricultural economics as any other social survey bears to its social science or group of disciplines and to its related policy areas (Pennings et al., 2002).

Different organizations collect and store various kinds of agricultural data based on their goals. According to Danes et al. (2014), the government collects and manages agricultural data for administrative procedures, monitoring purposes and information management. The data includes national agricultural statistics, weather data, subsidies and taxes, data to monitor environmental performance and climate change. The data is collected and stored in a uniform format on a regularly scheduled basis for as long as data remains relevant for the government's agricultural policies (Janssen et al., 2017). According to Veeranjaneyulu (2014), researchers collect data for their projects through farm and household surveys, soil sampling, observational and experimental procedures, and laboratory measurements to meet specific project needs. The data collection is often incidental based on an irregular schedule and non-uniform in format. These data files are often non-usable by the public and farmers because of the privacy and confidentiality of research (Janssen et al., 2017). The data files require appropriate licensing schemes to allow open access to the information. Famers and private organizations, including industries, collect data for their own operations. They do not share their data due to competitive or privacy concerns. The availability of data in farming households and communities of developing countries is low compared to the developed countries (Ballantyne, 2009). All these combined data sources have led to access to the agricultural data available for research and usage.

2.2.2. Evolution of Farm Survey Practices in India

The first farm survey on cereals was carried out in 1943-44 in Punjab, UP and Orissa states of India using an extensive random sampling method. Agricultural statisticians were appointed as field officers to conduct the surveying as the majority of the farmers could not read or write, and there was poor communication between the villages in rural areas (Sukhatame, 1950). Stratified multi-stage random sampling was adopted to improve the farm survey practices. The country's provinces were divided into districts by the Revenue Inspectors, and a few districts together constituted the strata. A specific number of villages were randomly selected from each stratum for farm data collection purposes. Provincial field staff used to get training before appointment to conduct experiments. The efficiency of surveys increased by implementing the improved sampling method. However, the involvement of supervisory staff and field officers had added expenses of training and touring for survey purposes. Sukhatame (1950) concluded that results of farm surveys get better precision based on the stratification method compared to random sampling, and thus, it would remove sampling error and increase the generalizability of the research. He also mentioned that the choice of survey units has to be made for both administrative convenience and statistical efficiency. Since then, agricultural researchers prefer to use stratification sampling method to conduct farm surveys.

According to the Central Statistical Organization's report (2007), The National Commission on Agriculture was appointed in 1970 to make several important recommendations for improving the data collection system in India. All states have a decentralized system to collect and compile agricultural statistics, particularly crop statistics. Some major agencies responsible for agricultural data collection or methodological studies on agricultural statistics are the State Agricultural Statistics Authorities (SASAs), National Sample Survey Organisation (NSSO), the Indian Agricultural Statistics Research Institute (IASRI), and the State Directorate of Economics and Statistics (State DESs) (Central Statistical Organization, 2007). Enumeration surveys, experimental and observational procedures are the primary data collection methods used on a quinquennial basis to collect essential agricultural statistics, including yield estimates, agricultural wages, market intelligence, weather conditions, irrigation statistics, and other parameters.

Based on crop area and production statistics reports from the Government of India's Ministry of Statistics and Programme Implementation, most farm surveys were initiated in the 1940s in Punjab and adopted around the 1960s to collect data (Central Statistical Organization, 2007). Most of the data collected are concerning crops and farmlands with significantly less focus on the farmers. Various factors concerning farmers, including their farm activities, health, education and awareness for agriculture, can be studied to improve the agricultural efficiency of the farmers and provide recommendations for increasing their profits.

2.2.3. Online Data Collection

Online web-based surveys are frequently used in different areas of research for data collection aimed at general populations. Web survey data collection remains an attractive mode of data collection for two main reasons. First, web surveys are more efficient regarding cost and speed compared to conventional modes of data collection (Fleming & Bowden, 2009). Second, web-based surveys provide the ability to deliver complex survey instruments while minimizing social desirability biases (Burkill et al., 2016; Kreuter et al., 2008). An additional benefit of online surveys is the increase in large-scale population-based experiments with minimal effort (Mutz, 2011).

While examining online data collection practices, one should note that the internet is evolving, and survey researchers adapt to these changes. In recent years, mobile internet devices (particularly smartphones and tablets) have contributed significantly to the overall increase in internet coverage, presenting both challenges and opportunities for researchers. Specifically, some studies, including Couper (2017), Link et al. (2014), and Couper et al. (2017), have found that smartphone users have lower response rates, higher breakoff rates, and longer completion times than PC users when completing web surveys. Mobile optimization reduces some of these adverse effects, but it does not eliminate them. Mobile optimization is a process of adjusting website content between desktop and mobile devices to ensure optimized content flow for user satisfaction (Link et al., 2014). On the positive side, with a few exceptions, the data quality obtained from smartphone respondents are comparable in terms of accuracy, completeness, reliability, timeliness and relevance, to those obtained from respondents using PCs or tablets (Couper et al., 2017) and (Link et al., 2014).

A diverse range of online research methods is currently employed in the academic and social sciences, including qualitative, observational, and experimental methods, among which web-based surveys dominate them all (Buchanan & Hvizdak, 2009; Krantz & Williams, 2010; Reips, 2012). However, web surveys are not without challenges, including reduced experimenter control (Stieger et al., 2007), relatively high levels of item non-response rates (Heerwegh & Loosveldt, 2008; Peytchev, 2012) and dropout (Peytchev, 2009), and some unethical considerations which require addressing (Buchanan & Williams, 2010; Roberts & Allen, 2015). Despite these challenges, web-based online methods of surveying are popular over traditional methods due to their advantages, including cheap, flexible, and rapid access to diverse, ample, geographically disparate and challenging to access samples (Best & Krueger, 2004; Evans & Mathur, 2005; Gosling et al., 2004; Hewson & Laurent, 2008; Skitka & Sargis, 2006; Tuten, 2010). With the increase in technological adoption in rural areas, more people can engage with web-based platforms for bi-directional data and knowledge transfer between researchers and farmers.

With the COVID-19 pandemic, it has become challenging for researchers to perform data collection using conventional means, so looking for technological alternatives and improving practices have become very important (Menon & Muraleedharan, 2020). The added advantages of automated electronic data collection, entry and analysis have made online data collection usage one of the popular methods for researchers (Dillman, 2007; Tourangeau, 2004; Weible & Wallace, 1998). The low cost involved in conducting online surveys helps in facilitating large sample sizes and thus increases the potential subgroup analysis and decreased sampling variance (Witte et al., 2000). Web-based surveys are fast to administer, reduce human error, and provide consistent results if well-designed (Loomis & Paterson, 2018).

2.2.4. Areas of Improvement with Online Data Collection

The paper-based farm surveys often take much time to reach out to the farmers and are prone to data entry errors by the person responsible for data collection (Tuten, 2010). Important variables like machinery, labour, and farmers' well-being are often ignored while making recommendations based on the traditional farm surveys. According to the report of the National Crime Records Bureau, 10,281 farmers and farm labourers committed suicide in 2019 (Staff, 2020), which is 7.4% of India's total suicide victims. This also accounts for 28 suicides every day in India's farming community. The root causes of the suicides among farmers are bankruptcy and debt to farming-related issues and crop failures.

Since the agricultural surveys are conducted on a quinquennial basis, it is hard to derive solutions to the problems which are accumulated over time. Many farmers pour money into improving their irrigation facilities and investing in pesticides and machinery without being aware of the actual manner by which they can improve their crop productivity. With paper-based surveys, data is predominantly collected in field notebooks by the field officers, which is then manually entered into computer-based database software packages for analysis and reposition. Areas of weaknesses among the paper-based field surveys include time delays in analysis and providing feedback, non-availability of data upon demand, data loss in transfers of field notebooks, lack of means for data management, storage, deletion and lack of data availability for referencing purposes (Evans & Mathur, 2005). Using online modes of farm surveys may save a substantial amount of time and fast-track the data delivery to agrarian researchers, providing more refined solutions to the farmers based on their problems. Building a better connection between the researchers and farmers can improve crop productivity, leading to an increase in agricultural products in the economy (Hansen et al., 2014).

The primary purpose of the online platform for data exchange is to endeavour to understand and likely improve farming performances that cannot be attributed solely to farm size and other physical attributes. Data collection about various parameters of farmers such as attitudes to borrowing, propensity to innovate, levels of knowledge, willingness to take risks, and investing for further increases in farm production can help grow the agricultural sector. Such information is essential at all levels of policy formation and implementation to show an accurate picture of the farmers' needs.

Despite the fairly broad approach of the traditional farm surveys, it is evident that they do not play a significant role in the Indian agricultural economic policies. Even agricultural research for improving farm practices is conducted on a microscopic scale (Sumberg et al., 2003). In most of the farm survey practices, there has been little innovation since the methodology was adopted from the 1950s, given that the particular aims, sampling, and analysis have followed a well-defined pattern (Central Statistical Organization, 2007). Experimenting with the online practices of stratification sampling based on factors like farm size, education, soil type, crop rotation and so on may bring fruitful results instead of adhering to traditional sampling methods. More can be done to compare farming and farmers' well-being to look for ways to develop the agriculture sector. Farming employs more than 50% of the Indian population but still, there are only limited studies to make the farming experience more enriching for the people involved (Narechania, 2015). There is a scope for following up surveys with individual farm budgets to work on the state's extension services for farming and to provide support to the farmers in the areas where they need the most help. The research to scale and quantify levels of knowledge of the farmers can be fruitful by engaging a wider range of parameters in the farm surveys.

According to Šūmane et al. (2018), a well-rounded programme of research in the field of agriculture can be outlined as follows: (i) Prevailing farming systems and measurement of current changes in farming; (ii) Detailed analyses of farm management problems by size, type, location and other factors; (iii) Economic effects of institutional and technological changes on agricultural production; and (iv) Exploration of research methodologies. We incorporated these parameters while preparing our online farm survey to understand its usefulness for data collection. The online surveys can provide timely data to perform fundamental analyses of the efficiency of farm resources, which can serve as a basis for improving the governments agricultural policies . Surveys can also be conducted to understand the credit needs of farmers and the availability of credit in rural areas. To determine the satisfaction curves of the farmers towards the acceptability of a given programme or policies introduced by the government, online surveys can prove indispensable. It can also serve as a platform to measure the functioning and support of government resources and agricultural research towards the farmers. Thus, it will provide a fair and just view of farmers by involving them directly towards conducting research and policymaking.

2.2.5. Dissemination of Information

Development, dissemination, and adoption of technologies play a vital role in achieving sustainable agriculture and considerable advancement in the agricultural sector. Technology and research adoption at the farm level is affected by numerous factors, including education, training, awareness, advice, and information, which form the basis of a farmer's knowledge (Ministry of Agriculture, 2001). In general, the farmers have a conservative attitude and need more time, trust, and information to be persuaded to adopt the latest new technologies in their daily farm activities (Sumberg et al., 2003). It is thus essential to disseminate accurate and reliable data along with technical guidance to the farmers based on their local conditions. Farmers can minimize the risk of implementing new technologies with detailed information and technical assistance from agricultural experts (Nelson et al., 2019). In addition, there is likely high consumer trust knowing that farmers have received adequate technical guidance (Janssen et al., 2017). Agricultural organizations and extension services play a significant role in the knowledge dissemination process to maximize individual farmers benefits. The key questions to address knowledge dissemination are:

− What information is to be provided to the farmers?

− How should the information be provided to the farmers?

− How may we help individual farmers comprehend the information in the best possible manner?

− How may we deliver reasonable, practical, and economically feasible solutions for agricultural practices?

The crucial role of information dissemination for the development of the agricultural sector has been underscored in the previous literature. It can be observed that there are plenty of sources for providing agricultural information to the farmers, and there has been much research to improve farming activities. However, the different sources of agricultural information derived from research studies are not readily accessible to the farmers. Depending on the geographical region, economic condition, and factors unique to the farmers, it is unknown which sources of information are preferred and used by the farmers. Similarly, in terms of data collection, it becomes difficult to involve farmers from hard-to-reach areas, which might affect the generalizability of the research (Janssen et al., 2017). To overcome these issues, we designed a platform for gathering and sharing helpful information transparently, which can fulfill the requirements of both farmers and researchers and aim to improve communication between the stakeholders.

2.3. Crowdsourcing and Citizen Science

2.3.1. Crowdsourcing and its Applications

Crowdsourcing is the practice of using information and communication technologies (ICT) to harness the skills and interests of a crowd of people who act as a key to solving problems and drive innovation at every phase of the project (Eitzel et al., 2017). Thus, crowdsourcing realizes specific tasks, such as data collection, by a network of people (contributors) who are not doing so for their usual professional activities, which is also termed as citizen sensing (Boulos et al., 2011). There are numerous task-based crowdsourcing scientific projects, including, classification of landmass based on earth imagery available online through Google Earth and Geo-Wiki (See et al., 2015). Google Image Labeler is also one such example of crowdsourcing tasks where the platform is built as a sort of a game, and users are asked to label pictures for improving images search results (Geiger et al., 2011).

Crowdsourcing can also be used beyond micro-tasks for long-term continuous data collection and a deeper understanding of the environment, which is called observational crowdsourcing (Lukyanenko & Parsons, 2018). This form of crowdsourcing can be used to harness the information gathering abilities and expertise of humans in the environment in which they operate. One can find dozens of mobile applications which support monitoring of environmental observations, for example, BirdLog (bird monitoring), Secchi (study on phytoplankton), Marine Debris Tracker (log of coastline and waterways trash); a list can be found here: http://brunalab.org/apps/. Wearable technologies and sensors in the health sector enable real-time data collection and monitoring for huge masses of people (Kostkova, 2015). HealthMap (https://outbreaksnearme.org/us/en-US/) is mobile crowdsourcing apps that use geolocation for leveraging the power of the internet and mobile phones to provide a unique level of citizen engagement and participation in their local communities.

Knowledge-based crowdsourcing is also a powerful tool to engage people in generating information through knowledge-sharing portals and Q&A forums. In the field of computer programming, https://stackoverflow.com/ is one of the primary sources of information that have made the existing official software documentation obsolete (Treude et al., 2011). Wikipedia (https://www.wikipedia.org/) is also an example of knowledge-based crowdsourcing, which is a collaborative content management system. It allows organizing user-generated content creating online encyclopedias (Kucherbaev et al., 2016). Quora (https://www.quora.com/) and Yahoo Answers (which was officially shut down on May 4, 2021) are some of the well-known online community-driven Q&A forums, which are generic in nature (Zhao et al., 2015).

2.3.2. Agricultural Applications of Crowdsourcing

The citizen scientists contributing towards crowdsourcing may or may not receive a monetary contribution for their service (Schenk & Guittard, 2011). The internet boom has strongly supported crowdsourcing and citizen science initiatives over the last decade.

In agricultural research, crowdsourcing is related to participatory research and development projects (Van Etten et al., 2019).

2.3.2.1. Crowdsourcing of tasks

Crowdsourcing helps in getting simpler or complex tasks done by citizen scientists. Pawar et al. (2015) point out that crowdsourcing helps in receiving better quality results contributed from a large number of people who can offer their best ideas, experience, and solutions. Posadas et al. (2021) demonstrated that a mobile crowdsourcing application could collect high-quality ground data used in prescription maps for precision agriculture. PlantVillage Image (Hughes & Salathe, 2016) is a plant disease image identification dedicated to helping farmers identify pests and diseases that affect their crops. By late 2015, more than 50,000 crop disease images of 16 crops were available through the platform. Skilled technicians provided most images who took high-quality pictures of the infected leaves following a thorough protocol. In a similar manner, Rahman et al. (2015) used a combination of computer-automated imagery and two levels of crowdsourcing for weed identification. First, non-expert people attempt to perform weed identification if not already done by the computer. Second, experienced agricultural experts validate the identification and contribute to non-classified images. Pictures are initially taken by farmers who then benefit from weed identification along with weed control and management.

2.3.2.2. ***Crowdsourcing of local visual observations***

Crowdsourcing also helps gather visual observations with the help of local people, allowing the collection of large amounts of data without engaging field officers. Such application of crowdsourcing is prevalent in the field of biodiversity and environmental monitoring. According to Kelling et al. (2015), people who engage in bird monitoring record visual observations and communicate them with short notes and pictures uploaded on a web platform. One can find several crowdsourcing initiatives in environmental sciences, but there are only a few examples of widely-used initiatives in agriculture. Van Etten et al. (2019) proposed and implemented pilot studies in India, Africa and Central America for crop breeding and improvement based on a crowdsourcing system that recorded local visual observations. Farmers were asked to provide details about their observations to extension officers and researchers, with or without monetary compensation. The farmers received crop seeds for participating in the research, which was at a very small scale.

2.3.2.3. ***Crowdsourcing through sensory systems***

Another initiative is crowdsourcing of data from disseminated sensor measurements using permanent or portable measuring devices. The agricultural sector has been using GPS-driven machinery, low-cost environmental sensors, and mobile devices equipped with sensors to gather a larger amount of data, indicating the use of big data in agriculture (Wolfert et al., 2017). PocketLAI is a mobile application developed by Francone et al. (2014) which enables measuring leaf area index of a crop using accelerometer and camera of an ordinary mobile phone. Leaf area index is the total surface area of one side of leaf tissue per unit ground surface area, which is a commonly used variable in the crop and remote sensing to assess biomass of a crop and monitor its vegetation growth (Francone et al., 2014). However, farmers are not aware of this variable per se as it is a scientific term used by researchers in the agricultural field. Marx et al. (2016) contributed another participatory experiment where mobile phone GPS and cameras were used to measure the height of maize crops. The experiment concluded that measuring the maize crop with a simple ruler is a more robust method than the process of taking images by phone camera.

A few applications are developed with the use of crowdsourcing, which caters more to the farmers' needs. For example, Wageningen University and Research in the Netherlands developed the Akkerweb platform (https://akkerweb.eu/en-gb/), which allows centralized crop field information combined with satellite and soil data for providing integrated cropping plans to the farmers. The information is then shared with consultants to optimize crop production at the field scale. However, the data gathered for the project is only single-use as they do not use it for further research or operational applications.

2.3.2.4. ***Crowdsourcing of knowledge***

Crowdsourcing is used as a powerful tool to gather information and knowledge through user-generated content web platforms, Q&A forums, knowledge portals, and discussion web platforms. The knowledge-sharing portals act as a platform where the contributors generate information through questions and answers, moderated by the administrator or other contributors. Readers make themselves aware and build their knowledge by participating in the crowdsourcing process through contributing answers for survey questions (active use) or gathering information through content posted on the forum (passive use). Bruce (2016) implemented the crowdsourcing knowledge initiative in the agricultural field by developing a platform, Cropotech, to provide information about weeds, pests and crop diseases to the farmers in the UK while establishing a two-way relationship between researchers, who designed the platform, and the farmers. Several agricultural Q&A forums operate in local languages and are based on regional contexts (Hansen et al., 2014; Hughes & Salathe, 2016). These forums help researchers to get the know-how, disseminate new technologies and practices, and validate awareness and knowledge in the community. Major topics covered in similar knowledge-based portals in agriculture include advice on the use of agricultural machinery, trade and market trends, pest and crop disease identification, agricultural regulations by the government, informal discussions, and trends in agricultural technology. Some farmers also run online blogs on agriculture to share their know-how and work with the general public and other farmers. These knowledge portals help disseminate new agricultural practices and technologies on a global level, for example, Big Data in agriculture and organic farming.

2.3.3. Citizen Science and its Applications

Citizen science is a form of modern participatory research, and it is a narrower subset of crowdsourcing. It aims to engage the general public for collaboration in scientific research, producing new scientific knowledge and increasing public understanding of science and democratizing the research process at the same time (Cooper et al., 2015). The citizen science projects are often in partnership with or under the direction of professional scientists and research institutes, which help society to find solutions for modern problems. Participatory research through citizen science using digital crowdsourcing approaches has the potential to engage a large number of volunteers to be citizen scientists and generate large datasets for more wide-ranging analysis. For example, the public can participate in data transcribing projects using Sensr for converting physical data into digital data (Kim et al., 2013). Researchers are also exploring ways to use existing systems as alternative platforms for facilitating citizen science. Twitter is one such platform that supports distribution participation from people on an everyday basis (Demirbas et al., 2010). It is a good platform for publishing time-critical incidents such as disaster reports or activities related to rescuing and less for reporting observational data. Galaxy Zoo is another web-based interface project which involves interpreting more than 100 million galaxy images by general people (Raddick et al., 2010).

Ushahidi (https://www.ushahidi.com/) is a platform that uses custom web forms, PHP and MySQL for building a collaborative reporting environment that aggregates and shares information provided by citizens (Kim et al., 2013). It was created after elections in Kenya for reporting violence during elections (Williams, 2013). It is a web and SMS-based open-source platform that combines GIS information with time, allowing a person to filter by place and time, making it ideal during disasters (Boulos et al., 2011). The platform has been used for violence, elections, disasters, reporting of corruption and cholera after an earthquake in Haiti and in Uganda, Kenya, Nigeria, Libya, and Egypt (Freifeld et al., 2010; Williams, 2013).

Individuals participate in different kinds of projects to learn, contribute to science, and the community, enact change and increase their general awareness. With proper training and matching individuals with appropriate tasks according to the expertise, the volunteers of all age groups can provide valuable contributions, broaden the scope of citizen science projects, and help in gaining efficiency in the research without compromising on data quality (Ellwood et al., 2017).

2.3.4. Involvement of Farmers as Citizen Scientists

Farmers are the critical source of information for improvement in agricultural policies and research. However, a large percentage of farmers do not respond to the traditional surveys mainly because of the period in which field officers approach for data collection, lack of compensation, and perceived length of questionnaire (Pennings et al., 2002). Our online platform's data collection portal will provide less time-consuming surveys and more freedom to the farmers for completing the survey. The data dissemination portal will provide solutions to farmers' concerns about the latest farm techniques, government policies, interaction with the farming community, and others. It could also serve as a go-to source of data collection for the researchers. Social media and online platforms enable increased access to information by the farmers even during their workday and provide a digital blended learning tool to adopt technology, share information and improve the agricultural sector (Casey et al., 2016).

The most crucial factor for the involvement of the farmers is to motivate and engage them. Agricultural management, improvement of farming machinery, access to the latest information of technological changes and government policies are some of the ways to increase farmers' awareness and include them in data collection processes. Agricultural management for effective adaptation and improvement depends on both farmer willingness and capacity to pursue such actions (Sran, 2019). The disparity between creating meaningful and critical information for farmers and its actual dissemination or use by the stakeholders in farming practices presents an information usability gap. This topic has similar applicability as the climate information usability gap, which shows the gap between what scientists understand as helpful information for the creation of climate knowledge and what users in the agricultural community recognize as usable in their decision-making process (Lemos et al., 2012; Prokopy et al., 2017). The gap in the application of agricultural research to decision-making points towards: (i) challenges of how decision-makers perceive the credibility and legitimacy of knowledge; (ii) examining how new information fits with existing techniques and knowledge; (iii) how and what challenges arise when the scale of knowledge of farming information creation and use are mismatched; (iv) decision-makers concern for political impacts; and

(v) psychological well-being of stakeholders (Birthal et al., 2015; Marimuthu et al., 2017; Meera et al., 2004; Minet et al., 2017; Rhoades & Aue, 2010).

Integrated and participatory approaches have been advocated as an effective manner to overcome the usability gap, deliver complex and challenging science-based information and support agricultural communities in adapting to agricultural modernization (Minet et al., 2017; van de Gevel et al., 2020; Van Etten, de Sousa, et al., 2019). A recent literature has criticized academic knowledge for failing to serve the community and stakeholders outside academia and advocating for greater emphasis on creating more useful scientific research (Clark et al., 2016). This requires a shift in delivery models of science communication from one-way "data seeking" to a better two-way, collaborative and participatory relationship where both researchers and stakeholders are reasonably engaged (Eitzinger et al., 2019). Approaches to bridging the gap have reflected the importance of networks in supporting farmers learning for improved management (Casey et al., 2016; Schneider et al., 2009).

Farmers of sub-Saharan Africa and South Asia emphasize the personal relationship and reputation of individuals rather than professional titles when evaluating new information (Hujala et al., 2009; Wood et al., 2014). Farmers also like to know how the research results can be applied on their own farms to benefit from the researchers' work (Van Etten, de Sousa, et al., 2019; Wood et al., 2014). Our research works on this same line and emphasizes on involving stakeholders in the process of knowledge production. The intent is to bring farmers and researchers together to improve agricultural research and draw benefits that can be used in actual farm activities.

Farmer organizations and networks also play a vital role in guiding and supporting the farming community (Nelson et al., 2019). Farmer networks and extension services are also identified as a pivotal platform to share knowledge and play a critical role in driving innovation to the agricultural knowledge systems. Farmer networks can thus play an essential part in motivating farmers to adopt an online platform for data collection, data dissemination and serve as citizen scientists and become a valuable asset to promote the development of the agricultural sector (Ryan et al., 2018; Van Etten, Beza, et al., 2019). Farmer groups offer to share practical knowledge, which they accumulate from their own experience (Berardi, 2002; Kroma, 2006), but they need access from outside expert information to drive innovation (Dolinska & d'Aquino, 2016). Connecting the farmers directly with the researchers facilitates trust and interactive processes crucial for collective action, shared decision making, idea testing, and information processing into a planned course of action (Kroma, 2006; Rao, 2007). Peer networks within communities create a social multiplier effect that significantly impacts management decisions (Hogset & Barrett, 2010).

Local farmers' knowledge and involvement in agricultural research have proven to make a considerable contribution towards agricultural sustainability and resilience (Šūmane et al., 2018). With our website design of incorporating online surveys, we attempt to reach a broader range of geographically scattered farmers and voice their opinions and farming practices to reflect upon the research in the agricultural domain. Our approach recognizes farmers as experts and crucial partners for research and bringing innovative solutions to bring a positive change in agricultural practices. The approach to putting farmers' interests first places farmers' opinions as essential in designing interventions required to successfully meet new and evolving challenges and highlights a flexible evolving knowledge system that influences necessary innovations (Scoones & Thompson, 1994). Our study identifies an online data exchange platform as an ideal place for data collection for agricultural research and data dissemination for increasing farmers' awareness for innovation and growth. Documenting strategies and farming practices emerging from agricultural research and delivering it back to the farming community is a way to provide essential information for growth in the agricultural sector by reflecting the needs and ideas of the farmers (Scoones & Thompson, 1994; Van Etten, Beza, et al., 2019).

From the literature review, it can be ascertained that there is a vast potential of using crowdsourcing and citizen science practices in agriculture. Many researchers and organizations worldwide are trying to explore the best practices to benefit the agriculture sector. Another observation is that very little research has been done on implementing crowdsourcing practices in Indian agriculture, which supports our motivation to work on our study. In the next chapter, we propose design system requirements for our online web-based platform.

Chapter 3. Website Design Requirements

3.1. Introduction

Creating a platform for delivering and collecting information electronically for the agricultural sector requires active farmers' engagement, information processing, evaluation, and compliance to standards set by the agriculture department (Sun & Zhang, 2010). To effectively facilitate the presentation of agricultural information for the farmers, it is essential to design a system based on the user's needs and to incorporate interaction design and usability principles. Previous works based on user-centered design have also mentioned that usability positively influences the user satisfaction and continuance usage intention of web-based platforms (Martínez Pérez & Turetsky, 2015).

Incorporating usability principles and interaction design in system development is mostly conveyed via its interface design. A good interface facilitates the users in performing their intended tasks effectively and efficiently without much distraction. Some of the widely used interface system design methodologies are User Centered Design (UCD) and Activity Centered Design (ACD). UCD works based on the interests and needs of the users focusing on making the system usable and understandable (Abras et al., 2004), whereas ACD focuses on the activities that users should be able to perform by using the design system (Norman, 2005). ACD is applied when we have heterogeneous user groups and the goals of the users vary, but the user activities are more common (Norman, 2005). In this study, we have combined UCD and ACD to accommodate data collection requirements by the researchers' and farmers' requirements thoroughly to ensure the delivery of information in the easiest and most acceptable manner. Thus, the involvement of researchers and farmers throughout the system development process was essential (Puspitasari, 2016). The ACD design process includes specifying the organizational requirements, the context of use, designing and evaluating the solution against the organizations requirements , and the UCD design process, including the same steps but focusing on the user's requirements (Maguire, 2001).

The governments central and regional agricultural department websites are responsible for providing information about agricultural resources to farmers and offering extension services. However, the websites are mostly built representing the department's perspective and internal consensus without involving the actual stakeholders' feedback on platform improvement. This subjectivity leads to the unfulfillment of essential requirements and nullifies online web-based platforms goal s to support the users. Often, users get overwhelmed by tons of information on a single page and end up being unable to find the information for which they are looking. Considering the problems in existing platforms, our research aims to create a prototype platform based on recommendations and feedback from users to improve information exchange and user experience.

3.2. Methodology

We chose the design science research methodology (DSRM) process (Peffers et al., 2007) because it is the best fit for this study. It is used to improve the system design and its output as an IT artifact. Peffers et al. (2007) proposed and developed a

DSRM methodology for the production of design science research consisting of six activities, explained in Table 1.

Table 1: Design Science Research Methodology (DSRM) Peffers et al. (2007)

Research Step	**Description**	**Entry Point**
1. Identify problem & motivate	Define the specific research problem and justify the value of a solution	Problem-centred Initiation
2. Define objectives of a solution	Infer objectives of the solution from the problem definition and knowledge of what is possible and feasible	Objective-centred Initiation
3. Design & development	Create the artifact	Design & Development-Centered Initiation
4. Demonstration	Demonstrate the use of artifact to solve one or more instances of the problem	Client/Context Initiated
5. Evaluation	Observe and measure how well the artifact supports a solution to the problem	
6. Communication	Communicate the problem, its importance, artifact, its utility and novelty, the rigour of its design, and its effectiveness to researchers and other relevant audiences	

DSRM is a problem-solving paradigm that is applied for the design, development, and creation of an application system. Out of the four research entry points, the applicable entry point depends on the intended purpose of the project. For our study, we start with Design and Development-Centered Initiation. The process can proceed with iterations, for example, after evaluation in step 5, going back to step 2 for seeking a solution (Peffers et al., 2007; Venable et al., 2017).

Problem identification and defining objectives are covered in Chapter 1 of this study. For the research, the following steps of design science research methodology are performed, including design and development, demonstration, evaluation and communication. The research process for this study based on Design and Development-Centered Initiation is shown in Figure 1.

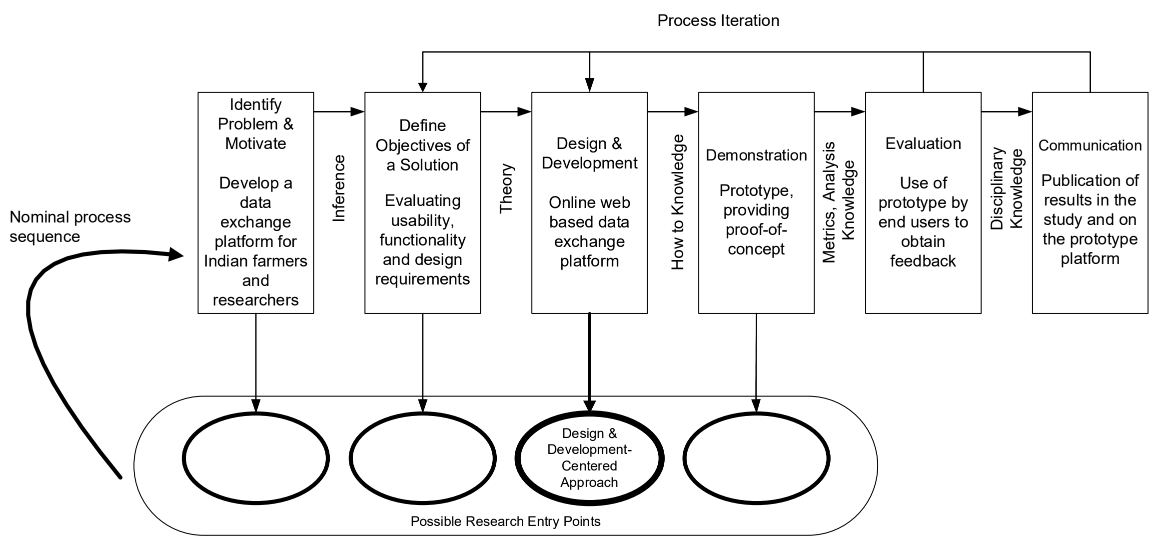


Figure 1: DSRM Process for data exchange platform based on Peffers et al. (2007)

3.3. Design and Development

In the first phase, we specified the context of use by identifying the users and assigning the use context. We interviewed and had discussions with four farmers and four researchers to gather requirements from the perspective of both provider and user. The participants were selected by coordinating with the Dean of Punjab Agricultural University. The university provided details of four researchers and four farmers who have been actively involved in research aligning with our thesis. The participants gave informed consent and were asked to evaluate and share their experiences about regional and national government agricultural websites as part of the initial phase for designing the prototype-1. The participants also provided feedback on the survey questions before we used it for the sample population. For assigning the context of use, we evaluated the existing websites based on heuristic evaluation and general feedback from farmers' and experts' perspectives.

The second phase focused on developing ACD and UCD design systems based on feedback received as part of phase one, researchers' and users' requirements, identification and analysis of user tasks from the government agricultural website. The output of phase two was user tasks analysis and designing a base model for prototype-1. Phase three comprised developing the solution to transform user requirements into a prototype platform of the user interface. The design and development of interaction design are revised as prototype-2 based on further recommendations made by the participants after using the prototype website for helping in data collection and using it to acquire agricultural information. Final revisions based on farmers' feedback were made to recommend the interface design proposal. The final version of the prototype can be accessed at https://www.askfarmers.info/. The research model for the website interface is shown in Figure 2, which is derived based on UCD, ACD and the design science research process (Abras et al., 2004; Norman, 2005; Peffers et al., 2007).

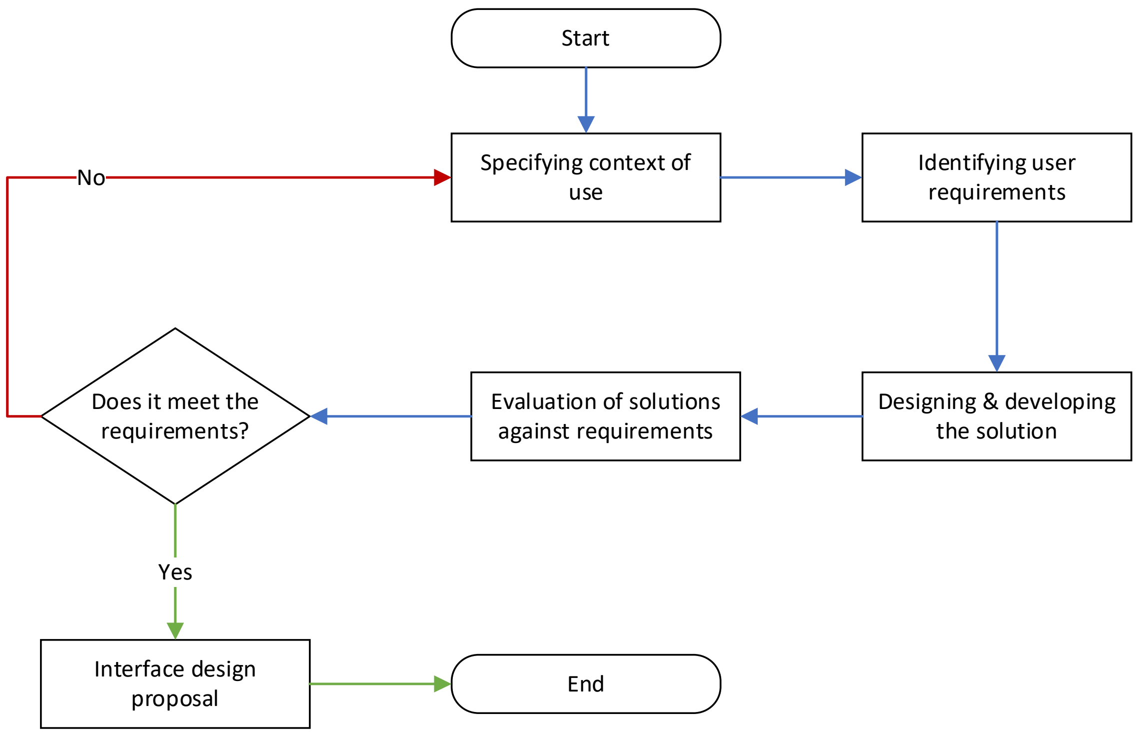


Figure 2: Research design based on steps proposed by Abras et al. (2004); Norman (2005); Peffers et al. (2007)

3.3.1. User Identification and Context of Use

Based on initial contact with four farmers and four researchers to study the existing websites and literature review, four user classes were identified as described in Table 2. Although we have defined four user classes for the purpose of generalizability of this study, we have focused our study majorly on farmers as they are the primary expected users and beneficiaries of the platform. Data collection and user participation are centred on farmers for in-depth and detailed analysis of the specific user class experience with the prototype platform.

Table 2: User Identification

User Class	Usage Purpose
Farmers	1. Input agricultural data in farm surveys. 2. Retrieve agricultural information from researchers. 3. Access government's updates and policies related to agriculture. 4. Connect with the farming community.
Researchers	1. Create farm surveys for data collection. 2. Retrieve agricultural information from farmers. 3. Publish research to create awareness among farmers. 4. Support farmers' decision making through community assistance.
Government	1. Monitor the information provided on the platform. 2. Administer sharing of correct information with all stakeholders.
Society	1. Access general agricultural trends. 2. Download agronomic data.

3.3.2. Assigning Context of Use

Initial feedback from the participants of phase one for the existing websites was used to assign the context of use. The constructs measured for the website design assessment includes relevance, reliability, scope, and perceived usefulness. We used a five-point Likert-type scale ranging from extremely unlikely (1) to extremely likely (5) to measure the questions for each heuristic indicator. The feedback from the participants resulted in narrowing down heuristic indicators for the website designing to the following: aesthetic and minimalist design; visibility of system status; consistency and standards; match between system and the real world; flexibility and efficiency in usage, use control and freedom; and help and documentation (Gómez et al., 2014). The heuristic indicators included questions about website content usefulness, reliability of resources, relevance of information for the users, and scope of information provided on the website. The participants also provided their input about navigational design and website aesthetics.

As part of the initial testing phase, four farmers and four researchers contributed to the design requirements and development of the website platform. The farmers reported a high preference for minimalist design and user support services. One respondent expressed support for minimalist design, "too much information on one web page increases confusion." Another farmer stated, "overcrowded information makes it difficult to find what we are looking for." The farmers suggested including figures, video tutorials and recommendations of other farmers on the website to help understand new concepts. Farmers showed great interest in using feedback forms to communicate their needs to the researchers and the government. The researchers supported adding information from government sources and including details of services offered to farmers. One of the researchers mentioned, "inclusion of government verified information resources on the website can increase credibility and trustworthiness."

Another researcher stated, "having a discussion forum to facilitate direct communication between researchers and farmers can induce more involvement of farmers in research and provide a better understanding of farmers' needs to the researchers."

3.3.3. Identifying User Requirements

Table 3 shows user requirement analysis based on feedback received from the participants in phase one. F1, F2, F3, and F4 refer to the four farmers and R1, R2, R3, and R4 refer to the four researchers who contributed to the initial testing phase.

Table 3: Proposed design requirements based on participants feedback in phase one

Proposed Requirement	**Participant**
Concise and straightforward user interface design	F1, F3, F4, R2, R3
Direct communication between farming community and researchers	F2, F3, R1, R2, R4
Inclusion of documentation from government agricultural website	F2, R1, R3
Sharing services offered by extension services and the government	F1, F4, R2, R4
User feedback service	F1, F2, F3, R1

3.3.4. Task Analysis

As part of phase three, we performed task analysis for the user classes. The tasks were identified with the help of our participants. We reviewed our user profiles and came up with questions, including:

- What are the users looking for when they come to visit our website?
- What do they hope to achieve by coming to our website?

- What information are they looking for?
- How do they currently perform these tasks without our website?

By creating the task analysis, we were able to conform our website design with the user's view of the task. We created scenarios as a technique to focus our website design on the real-world tasks. We were able to identify what the audience is trying to achieve when they come to our website and were able to determine the desired content and website design aesthetics that was essential to fit to the users' needs.

The task analyses integrate user identification from a service providers perspective and the requirements from the user's perspective. Table 4 shows the results of task analysis for each user class. The task analysis table highlights the tasks that a user must take in order to achieve their goals. It helps in refining the prototype expectations based on users' goals realized through discussions with the users and through an understanding of how users interact with agricultural information websites.

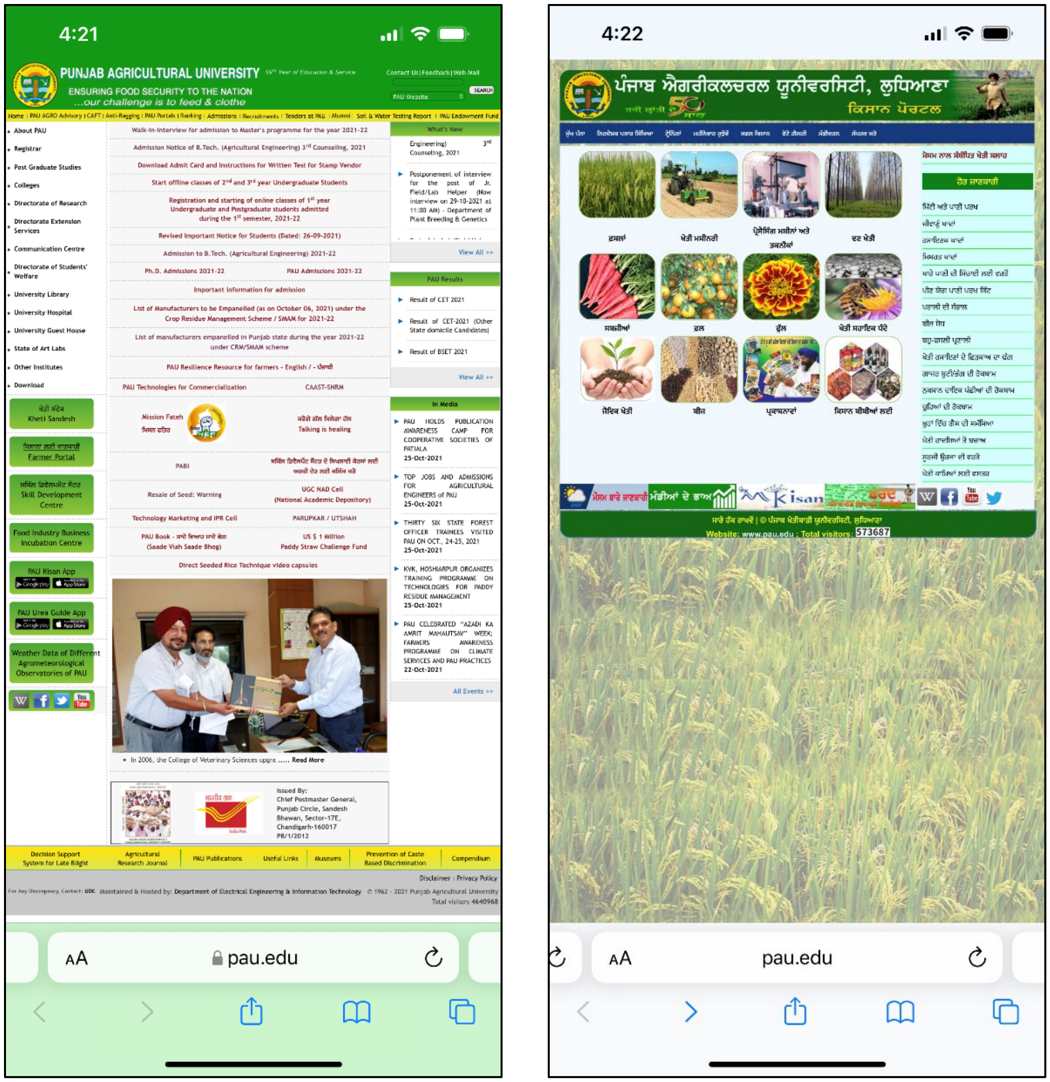
Table 4: User Tasks

User Class	Task
Farmers	1.1. Access the online web-based platform
	1.2. Provide agricultural data through farm surveys on the website
	1.3. Seek agricultural information
	1.4. Connect with farming community and researchers
	1.5. Submit feedback related to the website and the available information
	1.6. Download data and documentation
Researchers	2.1. Access the online web-based platform
	2.2. Seek data accumulated through farm surveys
	2.3. Upload research results on the website
	2.4. Connect with the farming community to address their concerns
	2.5. Download data and documentation
Government	3.1. Access the online web-based platform
	3.2. Monitor the activities by accessing the content posted on the website related to agriculture
	3.3. Understand the farmers requirements and share accurate information accordingly
	3.4. Download data and documentation
Society	4.1. Access the online web-based platform
	4.2. Submit feedback related to the website and the available information
	4.3. Download data and documentation

3.4. Designing and Developing the Solution

As part of phase three, we designed and developed the website interface. The first step for designing the platform was to create a content design. The content design defines the content, layout, structure, and outline of the website content consistently. The interface should be intuitive and easy to use, eliminate dependency on third-party platforms by providing contextual and accurate information through trusted sources, provide a wide range of and in-depth agricultural information according to the users' needs, facilitate smooth and straightforward data collection process, and support interaction among farmers and the agricultural experts. The content design focused on the content of the prototype website, aesthetics and navigational design.

Existing website platforms for information sharing with users have a complex interface with clustered information on each webpage, making it difficult for the user to achieve their goals after visiting the platform. Some Indian government agricultural websites (for example, https://www.pau.edu/ (Figure 3), http://mkisan.gov.in/ (Figure 4), https://farmer.gov.in/ (Figure 5)) are not mobile-friendly, and farmers tend to access agricultural information through their mobile phones on the go instead of using other desktop devices. Due to this reason, we have given importance to the navigation and aesthetics design along with the content and usability of the website platform (Figure 6). All the screenshots shown below are taken on an iPhone. Our platform serves as a medium for crowdsourcing knowledge to assist Indian farmers in getting information about technological developments, farming practices, market trends, weather, and government policies and for helping researchers gather information on how to improve agricultural sector research. Since the platform is majorly used by the farmers, the design is kept simple for ease of use and adoption.



(a) *(b)*

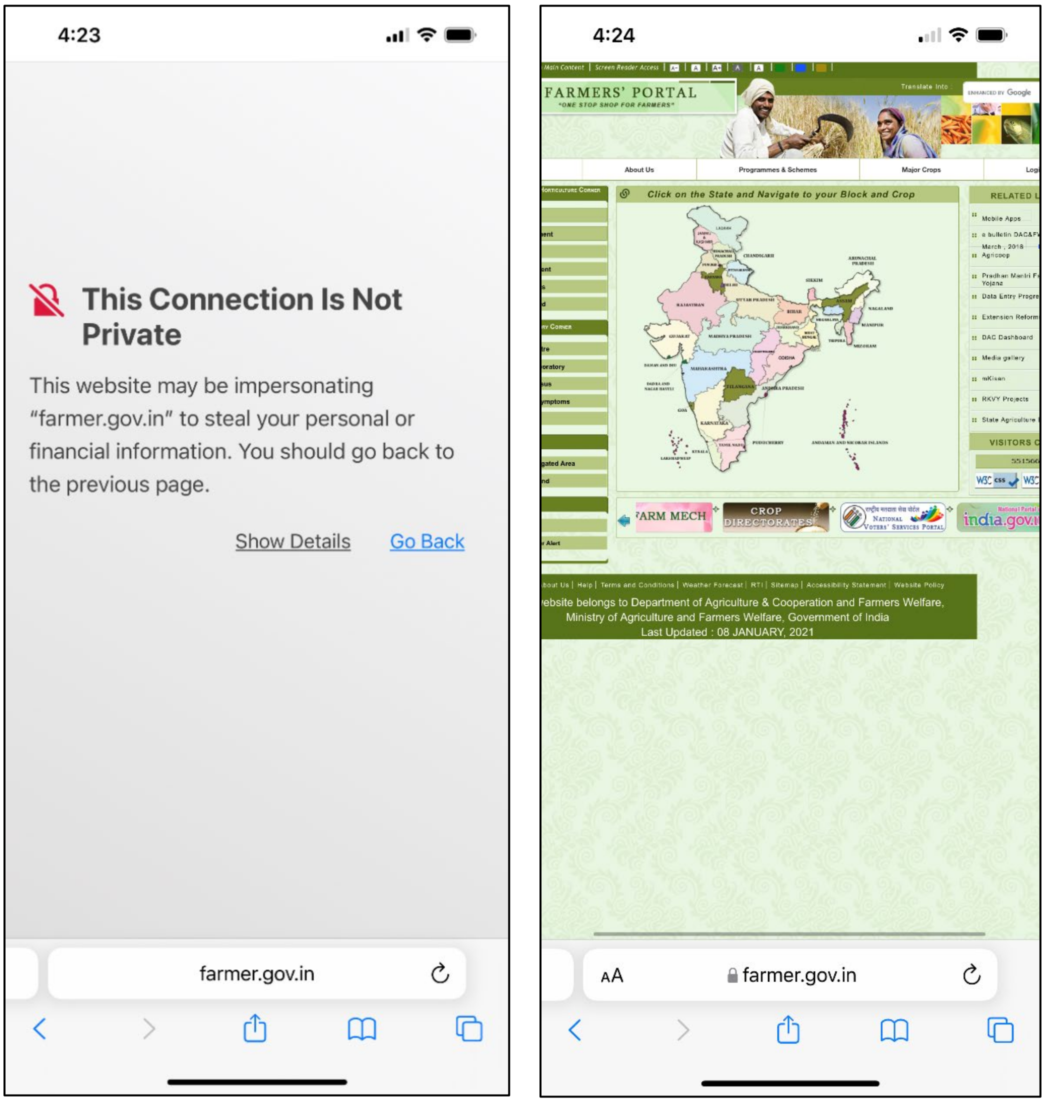
Figure 3: (a) Mobile website screenshots of Punjab Agricultural University homepage and (b) their farmer portal

We can see the homepage of the Punjab Agricultural University website in Figure 3(a) and the homepage of the Kisan (Farmer) Portal in Figure 3(b). In both the screenshots, one can observe that the web pages are not mobile-friendly as the font size is too small to be easily read on the phone, and both web pages are filled with hyperlinks to

PDFs and other web pages. The information looks very cluttered for a new user and makes it challenging to find the information for which a person came to the website in the first place. The participating farmers stated this problem about existing platforms, and based on their suggestions, we designed and built our platform.

Figure 4: Mobile website screenshots of mkisan.gov.in

Figure 4 shows screenshots of http://mkisan.gov.in/ website on a mobile phone. One can see that this website is not mobile-friendly as the web page content is not completely visible in a mobile screen frame. A user has to swipe the content horizontally to see the entire page content, and there is no indication to guide a user about it. The font size is small, and the web page has a yellow marquee ribbon (scrolling text) on the top, which is not even loading correctly and, as a result, is flickering on the website.



(a) *(b)*

Figure 5: Mobile website screenshots of farmer.gov.in (a) error message because web portal is not secured (b) homepage of farmers' portal

Figure 5 shows screenshots of the https://farmer.gov.in/ website on a mobile phone. In Figure 5 (a), when we tried to access the website on the phone, we got an error message that the website connection was not secured and might result in the stealing of personal information. We continued to visit the website irrespective of the security threat to determine the mobile user-friendliness of the platform. Figure 5(b) shows that website is not mobile-friendly as the web page content is not completely visible in a mobile screen frame (same case as with http://mkisan.gov.in/). A user has to swipe the content horizontally to see the entire page content, and there is no such indication to guide a user about it.

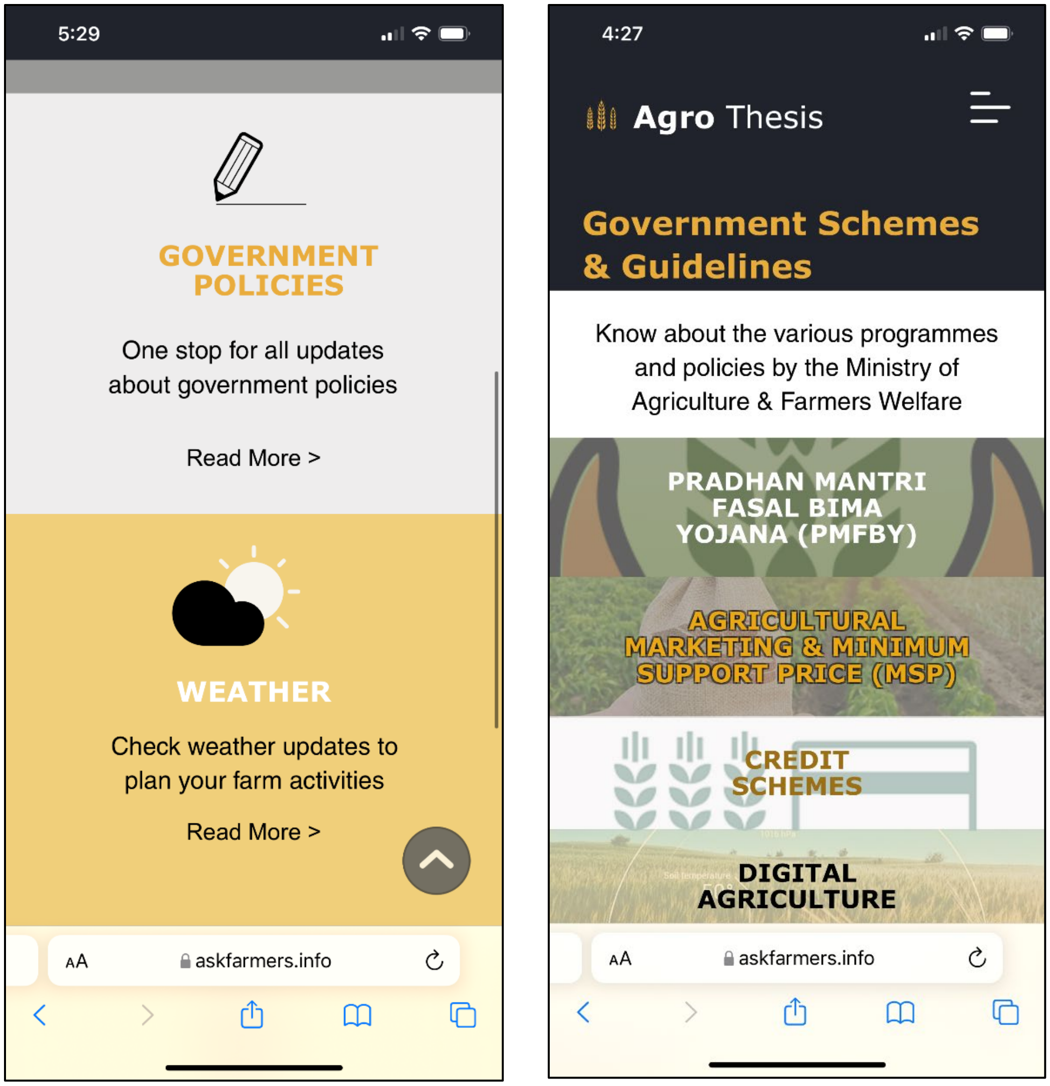


Figure 6: Screenshots of the prototype web-based platform

Figure 6 shows that the prototype web-based platform is mobile user friendly, has a readable font size, navigational arrows and indications, and provides information to the user in a less-cluttered manner.

3.4.1. Information Content

Content design of a website is based on setting clear goals for each webpage of the website and making sure that the user aims to complete the task for which they accessed the website platform. Content design is a convenient manner to increase a website's usability and encourage visitors to visit the platform more frequently (Hu & Kuang, 2014). Information Content of a website platform refers to information that is of high quality, assessed by the user to be complete, sufficient, and effective for achieving their goals to visit the website (Cyr, 2013). Based on the user task analysis, we accessed quality content for the users from the reliable agricultural government website resources.

The content on our platform is arranged in such a manner that the user does not feel overwhelmed with the information, and at the same time, is able to fulfil their information goals after landing on our platform. We can see in Figures 3 to 6 how content is made available to the users on existing websites and how content is posted on our prototype platform. Figures 3 to 5 shows that existing websites have a lot of hyperlinks and buttons without any categories, which can make it challenging for a first-time user who lands on the page to find some information. To troubleshoot this problem, we categorized information on our prototype platform based on farmers' feedback that we received through the farmer survey. The prototype website provides the users with the opportunity to participate in data collection surveys for agricultural research, use services of a knowledge portal, including information about the latest farming technology, research updates, government policies about agriculture, weather according to the user's location, and involve in a discussion forum with farmers and researchers for farming advice and sharing experiences.

3.4.2. Aesthetics Design

The success or failure of a design is dependent on whether it can satisfy the users' needs in a friendly or efficient manner (Hu & Kuang, 2014). Web designing is much more than putting all information elements, functions, or buttons together (Fowler & Stanwick, 2004). Integrating public aesthetic psychology with the websites goals directly affects the web interaction and site recognition by the user community (Hu & Kuang, 2014). According to Puspitasari et al. (2018), aesthetics in interaction design refers to coordination between function and layout to unify aesthetic feeling between intrinsic purpose and external form. When users interact with a website platform as per their expectations, they feel a sense of order, and their impulsiveness and anxiety for information fade away (Gómez et al., 2014).

Figure 7 shows the website prototype's "Data Collection" page view. Theme colours, layout and font schemes are part of the aesthetics design. The selected theme colors for the proposed website platform are white (hex code: #C7C7C7), brown (hex code: # E8A805), grey (hex code: # 5D6A83), and green (hex code: # 61BA89). The theme colours were selected based on themes of existing agricultural websites and to accommodate the colour-blind users in the community (Fowler & Stanwick, 2004). Also, green is the most common colour to represent agriculture, plants and nature, followed by earth tones like brown, yellow and beige (*Agriculture Logo Ideas: Make Your Own*

Agriculture Logo - Looka, n.d.). Images, videos and icons used for the website design are inspired by the agriculture sector and existing information sharing government websites.

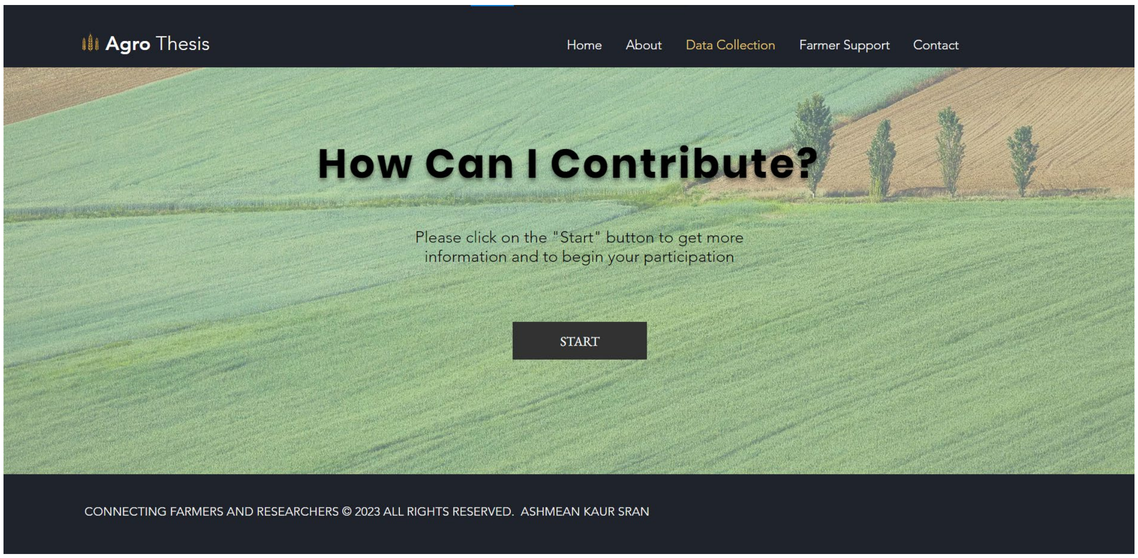


Figure 7: Data collection webpage view

In the first website prototype redesign, user requirements included specific needs for less complex and easy-to-read material. Thus, the pages are not clustered with overwhelming information to make it easier for the users to understand the goal of each page. Around 10% of the world population is dyslexic, according to the International Dyslexia Association, so we also selected the font schemes (Helvetica, Verdana, and Arial) with the highest readability to facilitate reading for people with dyslexia (Rello & Baeza-Yates, 2013).

3.4.3. Navigational Design

The basic website layout for the homepage and all content pages is the same: a header on the top, a navigation menu towards the top right side, content in the central body portion, and a footer on the bottom. The top menu consisted of Home, About, Data Collection, Farmer Support (Data Dissemination) and Contact. “Farmer support” offers different areas of information to the farmers, so the category has a drop-down sub-menu with classes under the same navigation bar. To make the websites primary purpos e clear, we placed the main goals as headings in the navigation menu to enable more significant exposure. The main menu that shows the highest user interaction level is on the top of the page in a desktop view and on the right-hand side in a mobile view. Since the website is a prototype and meant for research purposes only, it is mentioned clearly in the “About” section of the website. There are “Data Collection” and “Farmer Support” headings in the navigation menu to provide ease of access to the user for navigating through the website according to their area of interest. The website’s navigation layout facilitates the user to have faster and more accessible content surfing. Figure 8 shows the layout of the web navigational home page in desktop view, and Figure 9 shows the navigational layout in mobile view.

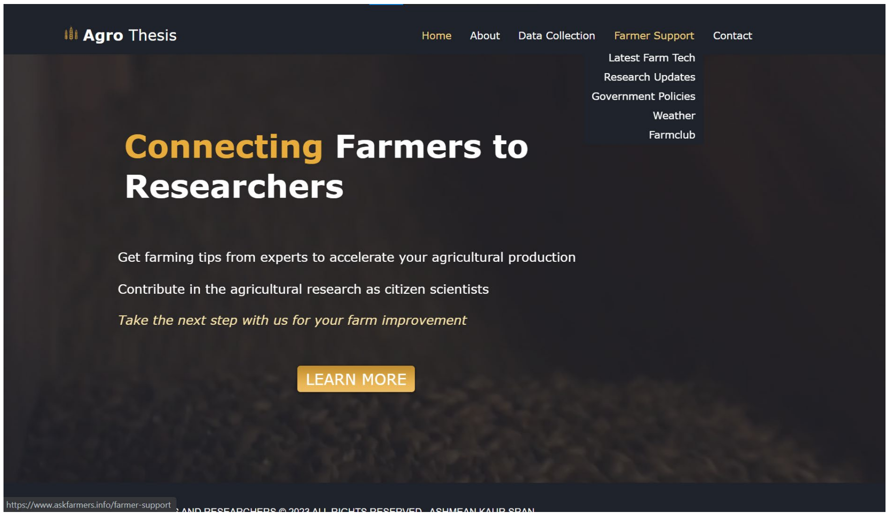


Figure 8: Navigation design of homepage in desktop view

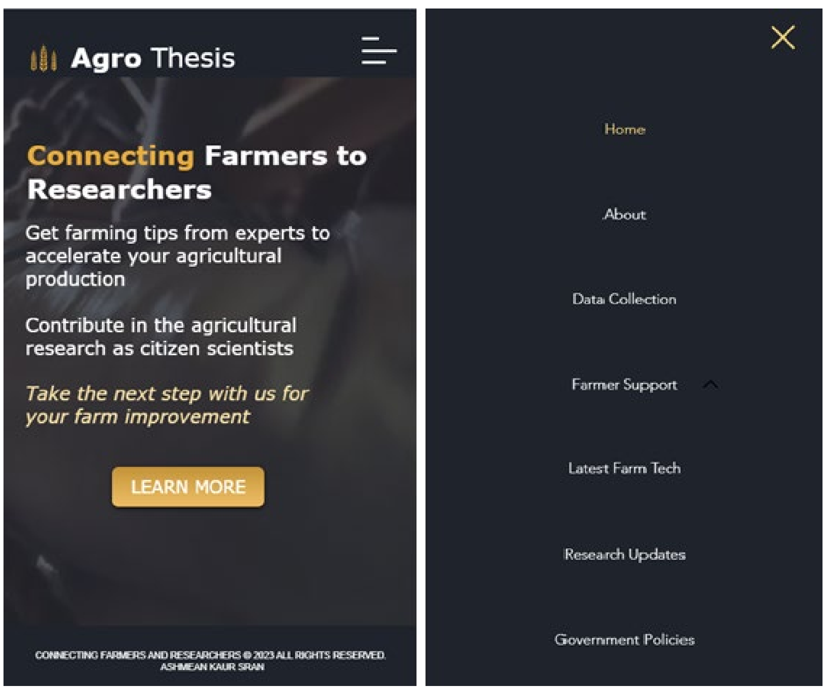


Figure 9: Navigation design of homepage in mobile view

In order to help users navigate and feel the confidence to continue using the website, we added a feature to highlight the cursor or touch to tell the users about their current position on the webpage. As they move the cursor around the website, the clickable links and buttons change colour so that the user can know where they are and where they can go on the website. The fonts and designs for the website remain consistent to make it visually pleasing and ease website interaction for users.

3.4.4. Designing the Platform

Based on internal testing of the existing websites with four researchers and four farmers, we worked on improving the design requirements of the platform. We created a design template based on user requirements and task analysis. Possible user interaction scenarios for each web page were discussed, and possibilities to add a broad range of information for the farmers were explored. The last step was building the website prototype-1 based on the initial recommendations.

After building prototype-1, external testing was performed using the website prototype. The website URL was selected as https://www.askfarmers.info/ to keep it simple and easy to remember by the farmers. The selection of participants is explained in detail in the next chapter, Research Methodology. The platform was made available to all the participants, and they were asked to use it and provide feedback about the overall interface and suggest further improvements. Based on the evaluation of participants' feedback, the final prototype was built. The feedback received from the participants is described in detail in the Results & Discussions section.

Figures 10, 11 and 12 show the updates made based on participants' recommendations. Figure 10 shows the "Farmer Support" webpage, which provides agricultural information to farmers on various interest areas, broadly categorized into five sections: latest farm tech, research updates, government policies, weather, and farm club. The categories are described in the Results & Discussion section. All these categories were added based on participants input in the website feedback survey.

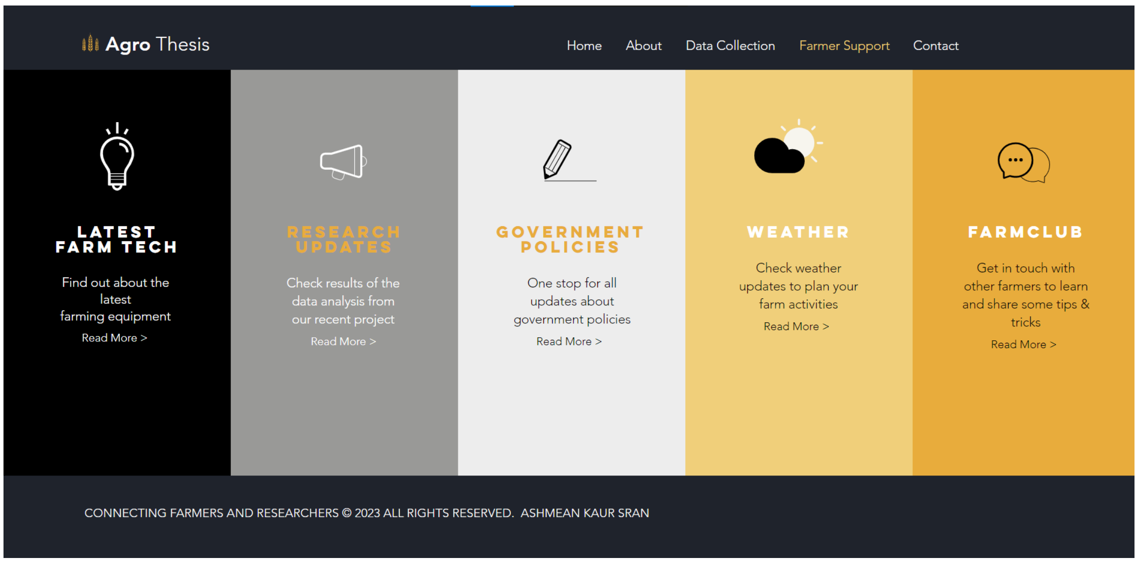


Figure 10: Screenshot of "Farmer Support" webpage

In Figure 11, a screenshot of the "latest farm tech" webpage is presented, which includes information about the latest technological advancements in the agricultural sector, which the farmers can use to improve their agricultural practices. Figure 12 shows the "government policies" webpage, which mentions different government policies, schemes and guidelines for the farming community. Designing all these web pages are inspired by the existing government websites for familiarity and easy adaptability. The website interface has multi-level page visual consistency, logical organization, and functional salience, giving the users confidence to quickly grasp logical functions of the web platform throughout the website and confidence to use the site features (Hu & Kuang, 2014).

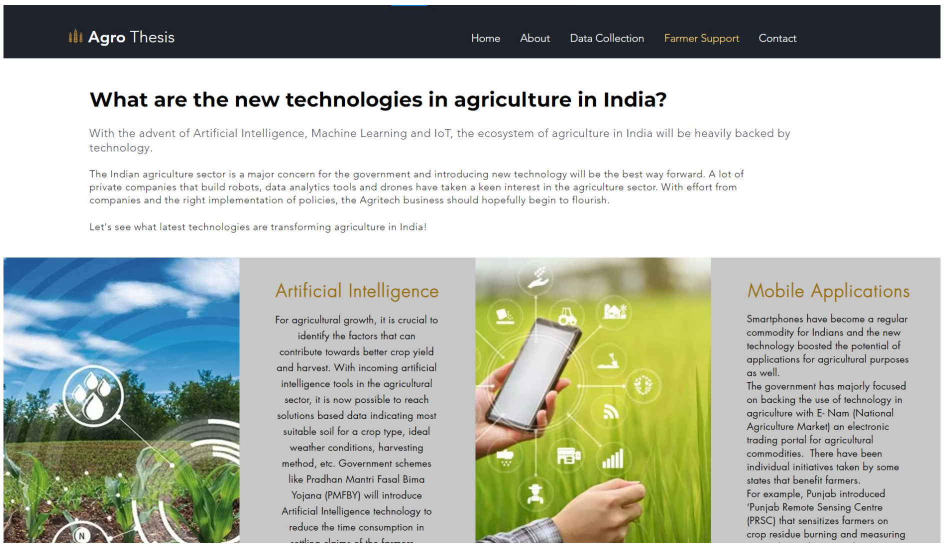


Figure 11: Screenshot of "latest farm tech" webpage

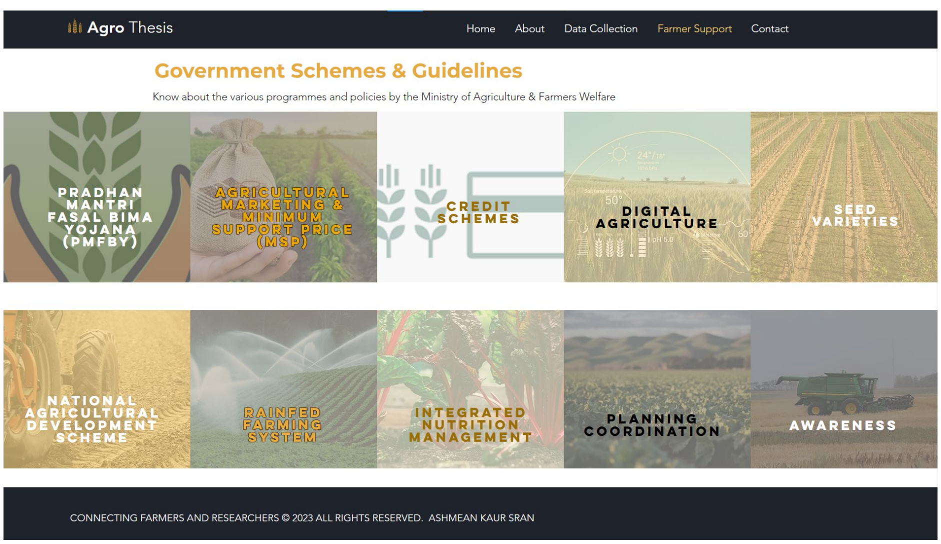


Figure 12: Screenshot of "government policies" webpage

Chapter 4. Data Collection Methodology

4.1. Introduction

In this chapter, the approach used to test the data collection aspect of the website platform is described in detail. Along with that, the survey tool used for testing the prototype-1 version of the website platform is also explained. Both surveys are essential to achieve the goal of testing various aspects of the prototype website interface. It helped us to investigate the scope of using an online platform for agricultural data collection and dissemination and bridging the gap between farmers and researchers. A survey was conducted across Punjab state to gather quantitative information from the farmers across the region about their experience of using the prototype online platform. Results from the survey were analyzed and interpreted to support the research objectives.

4.2. Study Area

This study was designed to gather information from the farmers across the northern region of Punjab state in India, using a random sampling approach. We collaborated with local farmer networks, unions and agricultural researchers to solicit survey responses from farmers through invitations sent via WhatsApp and email listservs of the farmer networks.

Kleffman Group's study (2018) indicates that the share of farmers connected to the internet is increasing rapidly, and nearly all farmers will be connected in the near future.

In 2016, the number of farmers with internet access rose from 13% to 17% towards the end of the year. By far, the most common way to surf the internet is through mobile phones; only a tiny proportion of them surf the internet through PCs or laptops. Another report from Kleffman Group (2018) highlighted that over 70% of people in the Punjab region had internet access on their phones in 2018. According to a survey in 2016, 25% of Indian farmers obtained agricultural information through the internet, and this figure rose to 41% in 2017. Mobile internet users in India have risen drastically in the last 4-5 years, and Punjab is one of the states with the highest mobile users in urban and rural areas (Nielsen Holdings, 2019).

Punjab is a state with 1.09 million farming households, and it has a literacy rate of 76.7%, one of the highest in India (Rao, 2007). Punjab is also considered the food grain basket of India and is one of Indias top producers of wheat (Grover et al., 2017; Singh et al., 2017). Considering all the facts mentioned above, Punjab is the ideal state for data collection as part of our study. It shows a willingness of the farmers to incorporate the internet in their daily lives and farming activities in increasing day-by-day. These trends indicate our platforms prospects for engaging farmers to collect and disseminate agricultural data and connect farmers and researchers.

4.3. Choosing Participants

One hundred fifty-two respondents completed the farm survey, representing the north region of Punjab from six districts of the state. After accepting responses from the desired sample size, we performed data coding, reviewing and cleaning for further analysis. We used SPSS 27 (Statistical Package for Social Sciences) for descriptive and quantitative analysis of the collected data and evaluated it towards the research objectives. The omission or case-wise deletion process for data handling was used to remove the missing data (Couper, 2017). We removed 20 responses due to incomplete survey responses for mandatory questions. After data cleaning and removing the bad data, 132 responses were used for data analysis. Of the 152 farmers who participated in the “Farm Survey,” 125 farmers responded to the “Website Feedback” survey.

4.4. Random Sampling and Sample Size Calculation

We used Stratified Random Sampling for our study since this method of sampling is widely used for farming surveys, and it increases precision and reduces variability, providing accurate estimates over the entire population (Birthal et al., 2015; Central Statistical Organization, 2007; Coe, 1996).

The same sample is used for both the farm data collection survey and the usability testing survey. Increasing the effectiveness of the usability studies is an important goal for Human Computer Interaction (HCI) researchers. Nielsen (2012) mentioned that most usability testing methods never discover all the usability problems, even if a large sample is used. He further said that it is more productive to balance time with finding problems and fixing them. Schmettow (2012) asserts that sample size is primarily based on the context of a study for usability testing. To find more major, minor and cosmetic problems relating to design, navigation and the key goals and functions for which the system is built, it is ideal for 16±4 users for testing purposes (Alroobaea & Mayhew, 2014). Considering sample size requirements for a farm survey and usability testing, we set a sample of 100 farmers for both surveys to test the use of the online platform. Farmers were invited from the Punjab, India, through local farmer networks, unions and agricultural researchers to participate in the surveys and provide feedback about their overall experience using the surveys and the website platform.

4.5. Demonstration of Online Farm Survey and Website Feedback Survey

The study used non-experimental descriptive and correlational survey research designs. Combining different research designs is suggested to capture the best findings with each method and allow triangulation of the research findings, thus raising the validity of the results (Creswell & Creswell, 2018). An online web platform was developed to link the researchers and farmers to seek valuable information for both parties. It included a general introduction of the research model to the visitors to make them aware of the project and its benefits.

The researchers can use the data collection feature of the platform for updating new surveys on the website and collecting information from the farmers for their research work. The farmers can use the same platform to help researchers in data collection by acting as citizen scientists. Farmers can provide real-time feedback on agricultural research conducted by scientists and farm surveys for improving agricultural practices and supporting research work.

The farm survey and website feedback survey were prepared based on six prior surveys on similar themes (Appiah, 2018; Rhoades & Aue, 2010; Singh et al., 2017; van de Gevel et al., 2020; van Etten et al., 2019; White, 2019). Four farmers and four researchers trialled the survey, and then it was revised based on their feedback before finalizing the survey. For testing the applicability of the data collection feature, we asked the sample users to fill the farm survey based on their experiences and observations. The farm survey was designed using Qualtrics and then linked with the online web platform. The survey begins with an informed consent form, which was mandatory for all the participants to agree before moving to the survey questions. The farm survey collected responses from the farmers about their farmlands, experience with mail surveys and online platforms, and information about wheat production. After completing the "Farm Survey," the participants were transferred to the "Farmer Support" webpage of the main website. The participants were allowed to surf the prototype 1 version of the website interface, go through all the webpages, interface with the navigational and aesthetics design, go through the information provided to support farmers' concerns on various agricultural topics. In the end, the farmers were requested to complete a "Website Feedback" survey by going to the "Contact" webpage and by clicking on the "GO" button. The Website Feedback survey consisted of several questions that can be categorized under four sections: website content, navigation, performance and general questions (see Appendix 2). None of the pages were overwhelmed with information to keep it simple and easier to grasp knowledge from materials available on the website.

Based on the feedback received from the farmers, the website version was revised to prototype-2, and future research suggestions were made to improve the online interface design proposal. The platform clearly stated that it is built for a research project and indicated that it was a university study about designing a platform for exploring the potential of online practices to bridge the gap between farmers and researchers. The farm survey was prepared so that the expected completion time remains under 20 minutes as it is the recommended time length for web surveys considering the attention span of an adult (Revilla & Ochoa, 2017). The website feedback had an expected completion time of 5 minutes. On successful completion of the survey, farmers receive information to support farming activities and how to improve productivity from the researchers. The consent for the survey clearly stated that the information collected from the respondents would remain strictly confidential, and the respondents could call the project researchers if they had any questions or concerns about the research (see Appendix 1). The contact details for the researcher were also included in the consent form. The online surveys were made available in English and Punjabi to make them accessible for a larger population of farmers.

4.6. Data Collection Procedure

In the online farm survey, we collected demographics and farm and crop-related information from the farmers and summarized the demographic variables to understand the participants better. The online farm survey helped us understand its usage for farm data collection. The variables covered in the farm survey include farmers' age, gender, education level, farming experience, gross annual income, preference of survey language, experience with in-person field surveys and preferred sources to seek support in farming activities. The second portion of the survey evaluates the farmers' experience with existing information sources and their feedback about our prototype website.

Survey responses were solicited online through farmer networks via email listservs and WhatsApp. The prospective participants were sent a maximum of three reminders to enhance the survey response rates and, at the same time, avoid spamming or pressuring the respondents (Blumenberg et al., 2019; Menon & Muraleedharan, 2020). The survey was created using online Qualtrics survey software in English and Punjabi (regional language) to optimize the questionnaire's readability, usability and response rate. Using the online survey software, we provided the participants with an option to switch between two languages anytime during the survey according to their convenience. The participants could see all the questions in both languages for clarity and better understanding. The online survey platform provided google translation to translate surveys into different languages, but we used an independent translator to translate the survey content and information in the two languages. The purpose was to ensure that the original meaning of the content remained the same.

The farm survey instrument was divided into eight sections with a combined total of 75 questions, including a majority of closed-ended questions, multiple-choice and Likert-type questions with six short open-ended questions with a maximum of 100 characters. The questions were framed to understand (i) farmers' experience with usage of networks, information and technology in terms of agriculture; (ii) overview of landholdings and farming equipment; (iii) wheat crop management practices; (iv) coping mechanism and associated strategies; (v) demographic information; and (vi) feedback about the online platform. Only a portion of the comprehensive survey results is reported in this study, consisting of the results related to the research goal. The farm survey responses were collected for the purpose of analyzing if online farm surveys are an effective way for data collection from farmers.

The primary goal of the thesis is to understand the farmers' experience with online survey methodologies and resources provided by agricultural institutes and the government, along with getting their feedback on how to improve the approaches. We also asked for farmers' feedback after using the website for improvement of the website platform. Questions were asked about website navigation, content, performance, and general feedback. The questions were framed to allow researchers to assess and compare trends in the usage of online platforms for data collection and dissemination. We also intend to improve the website platform based on the farmers' feedback to increase their tendency to continue using the platform for future research and information-seeking purposes.

Chapter 5. Results and Discussions

5.1. Introduction

Chapter five presents and discusses the results as part of the Demonstration and Evaluation step of the DSRM process. The chapter evaluates the “online farm survey” and later discusses the “website feedback survey.” In the online farm survey, we collected demographics, farm and crop-related information from the farmers and summarized the demographic variables to understand the participants better. The online farm survey also helped us in understanding its usage for farm data collection. The variables covered in the first section of the discussion include farmers’ age, gender, education level, farming experience, gross annual income, preference of survey language, experience with in-person field surveys and preferred sources to seek support in farming activities. The second section evaluates the farmers’ experience with existing information sources and their feedback about our prototype website.

Data was collected from a sample of hundred thirty-two respondents. SPSS 27 is used for descriptive and quantitative analysis. We began the analysis with descriptive statistics such as frequency tables, bar graphs, pie charts and other measures of central tendencies to summarize and evaluate the data for knowing the participants involved.

5.2. Descriptive Statistics of Farm Survey

5.2.1. Location

With the advent of the COVID-19 pandemic and diminishing opportunities to collect face-to-face data, internet-based online data collection tools offer a rapid and robust alternative. We were able to collect data responses from different villages across six districts of the Punjab region, India, even during the severe pandemic situation. The different villages from where data has been gathered have been marked on the map, as seen in Figure 13. It can be observed that we were able to collect data from both rural and urban areas. Notably, we even received responses from farmers living close to the national boundaries and these areas are often considered hard to reach. Thus, the use of online data collection and dissemination platforms can help reach wide geographical coverage.

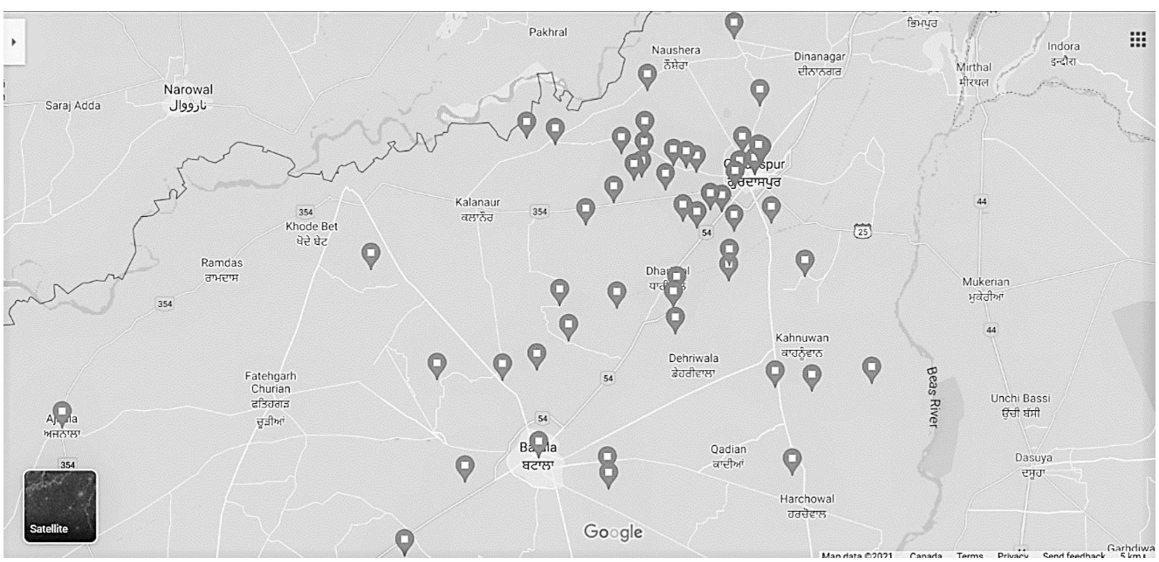


Figure 13: Geographic scope of survey respondents in northern Punjab, India

5.2.2. Demographic Variables

With the farm survey, we gathered data about the farmers' demographic variables, including age, gender, level of education and income. Table 5 shows a breakdown of age, gender and education level of the participants. As per the survey results, most respondents belonged to the range of 20 to 40 years (44.03%). It suggests that Punjab has a population of young farmers who are more tech-savvy and are more likely to respond to online surveys. The age group classification in the survey is done based on paper-based field surveys used by the government and agricultural institutes for data collection (Singh et al., 2017; Van Etten, de Sousa, et al., 2019; White, 2019).

The farming industry is perceived to be male-dominated, and it was interesting to find out similar outcome with the sample data—the majority of the respondents identified as Male (80.3%) (Table 5). Studies link higher education levels to agricultural efficiency, productivity, and the likelihood of using information sources to increase awareness (Njelekela & Sanga, 2015; Vosough et al., 2015). The majority of the survey respondents (51.88%) indicated that they have at least achieved a university-level education. Of the sample, 40.6% has finished secondary education, and only 7.52% have a formal education of less than high school. The educational background of respondents is in alignment with the high literacy rate of Punjab (76.7%) (Rao, 2007). The statistics here are suggestive of a well-educated population engaged in agriculture.

Table 5: Demographics of the farmers who participated in the study (n=132)

Age Group		**Gender**		**Education level**	
Category	**Response %**	**Category**	**Response %**	**Category**	**Response %**
Under 20	9.7	Male	80.3	Under Class 10	7.52
20-40	44.03	Female	17.4	Class 10-12	40.6
40-60	37.31	Prefer not to say	0.8	Bachelor program	36.09
Above 60	8.96	Other	1.5	Master program	9.77
				Above master program	6.02

The participants were given the option to switch between the languages at any point of time in the survey and most of them preferred to answer the survey in the regional language, Punjabi (PA-IN: 55.3%). We also used the farm survey to know about the gross annual income of the farmers and to find information about any subsidiary employment they have along with farming. The numbers presented in the survey are according to the Indian numbering system because the gross annual income of the farmers is in Indian currency. It is seen that people have more gross annual income when they have a supplementary source of income. The majority of the respondents belong to the lower-income category, and only 4% of the respondents fall under the high-income category. Thus, the results reflect that the participants are marginal small to middle-class farmers. The majority of participants who have earned more than Rs. 50,00,000 are dependent on government sector jobs, and the people who spend full-time in agricultural activities cannot make more than Rs. 50,00,000 annually (Figure 14).

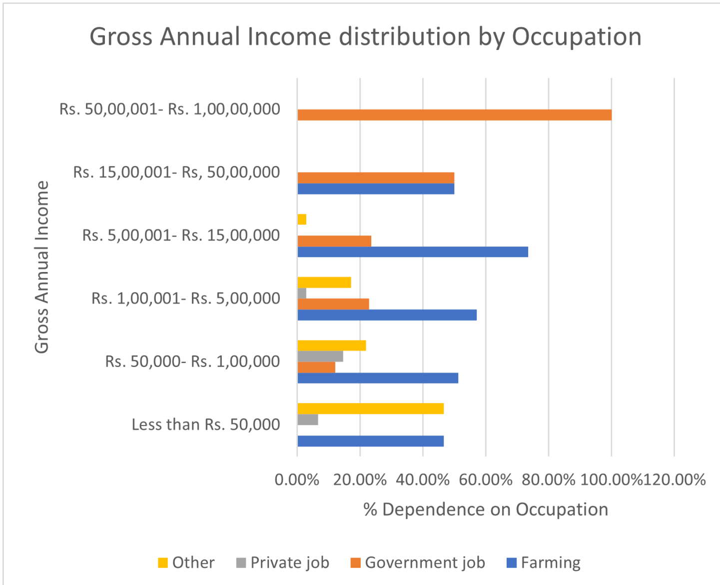


Figure 14: Distribution of Gross Annual Income by Occupation of the Respondents

5.2.3. Farmers and Landholdings

As per the collected data, most of the farmers (87.6%) have their own land. Less than 5% have taken or given their land on lease. The data suggests that most farmers are well involved in the day-to-day administration and decision-making for their farmlands, making them ideal for our study. Table 6 shows that the farmers who responded to the survey had small to medium landholdings, and their houses and irrigation sources were close to their farmlands. It also shows the most and least common farming equipment. It reflects that the farmers are less likely to use the old and traditional farming methods and adopt modern equipment for their farm activities. The experience of farmers in the agricultural sector varies in the sample. Farmers with less than five years of experience are in the minority (28.57%), whereas those exceeding five years of experience are more than double in number with 71.43%.

Table 6: Details of farm landholdings and farming equipment (n=126)

Total farmland area (acres)	M= 8.75, SD= 8.38
Cultivable farmland area (acres)	M= 8.13, SD= 7.15
Distance of fields from house (kms)	M= 2.17, SD= 3.60
Distance of fields from irrigation source (kms)	M= 6.24, SD= 8.68
Top three popular farm equipment	Electric Motor (77.06%), Tractor with accessories (58.72%), Modern plough (51.38%)
Most common source of irrigation	Submersible pump/ Tubewell (74.34%)

5.3. Results of Website Feedback Survey

The “Website Feedback” survey aimed to understand farmers’ perspectives about the overall experience with the website platform. We also asked them questions to understand better their expectations to make further improvements and recommendations for the future. Website feedback was focused on asking users about their experience while interacting with the platform, the type of information they wish to see in the website content, and their likelihood of returning to the website. The website feedback survey was separately designed and made accessible to the study participants through the website’s “Contact” webpage.

Based on the content and understanding of the websites usefulness, 82% of farmers mentioned that they would recommend the website to other farmers, friends, or family to seek agricultural information, whereas only 11% were detractors. Out of all the respondents, 84.43% were highly impressed by the usefulness of the content, and 86.5% of them liked the navigational and aesthetic design of the platform. Questions concerning website performance gathered satisfactory results, with more than 85% of participants finding it easy to use, faster loading of links and webpages, and well-organized content. Some participants also mentioned that less information clustering on our website compared to some existing government websites made it easier to comprehend the information. Overall, approximately 10% or fewer people showed disagreement or provided critique to enhance the platform further.

The responses to open-ended feedback questions in the survey elicited both long and short answers from farmers. For instance, when asked about the recommendations for improving the website and further feedback, some farmers offered short answers such as "well done" or "great work." While others would list their ideas such as, "Kindly add a comparison of per hectare expenditure with an average income of the farmer so that he can know the net profit," or "आप सबको ऑर्गेनिक सब्जियां उगाने के लिए प्रेरित करें," which translates to "please inspire everyone to grow organic vegetables and crops." Some farmers gave more detailed feedback like, "Must provide information on latest farm innovation and techniques. The marketing aspect is of utmost importance in Punjab, so Minimum Support Price (MSP) data shall also be considered. Weather conditions too shall be a part of data collection." Some farmers suggested adding new features to the website platform, including farmers success stories and a productivity calculator for farm management. Overall, farmers provided valuable feedback for improvement in the website content, including the latest farming technologies, weather information, community networking to connect with fellow farmers information about pesticides, and average revenue of specific crops based on regions. We have incorporated some of these suggestions to add new reading materials to the website as part of the final version (prototype-2). Some of these suggestions are discussed in the future recommendation section as well.

5.3.1. Sharing Agricultural Research and Farm-related Information with Farmers

Farmer feedback was collected for our online data collection and data dissemination platform to suggest future improvements. Figure 15 shows that based on farmers' experience, the most preferred source of information for innovation and adopting new farming techniques was "fellow farmers' advice (18.82%)" followed by "websites & internet videos (17%)," "social media (12.92%)," and "agricultural university support (9.83%)." With our online platform, we bring all preferred information sources to one place for providing ease of access to the farmers. Akridge et al. (2000) concluded that using internet-based resources increases the probability of a farmer perceiving online information sources usefulnes s. The platform can provide information about highly preferred topics by farmers, including the latest farming technology, research on seed improvements to increase crop productivity, weather, and government subsidies. It can be seen from the results that farmers had an overall positive experience with in-person and internet-based support from experts in agricultural institutes. Thus, the farmers studied appeared to be more receptive to information provided through expert researchers and have provided very positive feedback for our online web-based platform.

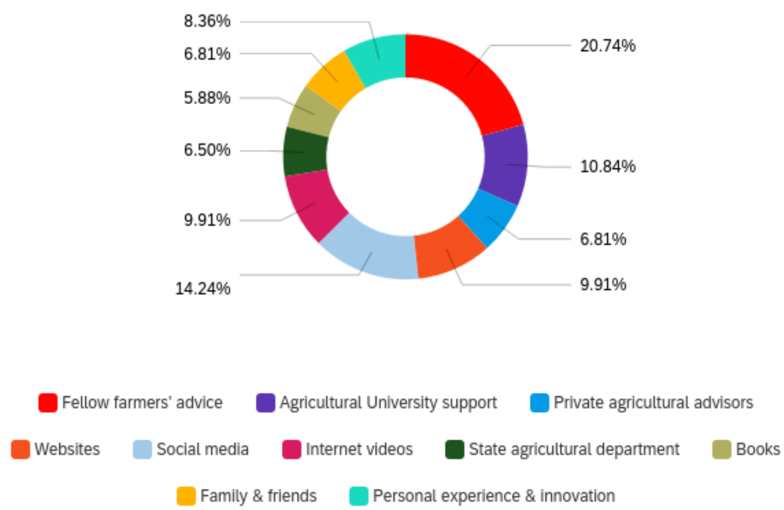


Figure 15: Preferred sources to seek agricultural information

5.3.2. Provide Ease of Access and Increase Participants' Engagement

As per the survey results, 74.02% responded that field officers never came to them for data collection, which is a somewhat surprising finding. With the help of the online survey method, we managed to gather data from geographically distant farmers living in small villages far away from main cities. Also, the farmers were given the option to choose between the regional language (Punjabi) or English for added ease of access. The majority of the respondents used the regional language to complete the survey. The online survey also provided added freedom to the respondents to complete the survey according to their own pace, which increased engagement and led to quick and complete responses.

As per one of the survey questions, farmers prefer to use websites (55.36%) over mobile applications (44.64%), and our platform is already aligning with their preferences, such that both options were available. Farmers have preferred regional (46%) and national (45%) websites over international (9%) websites to seek information, and the majority of the farmers stated that they have reached out to agricultural institutes for seeking agricultural support with regards to “guidance in production” (28.22%) and “to know about new technology for production” (23.31%). We asked the farmers, “what incentives would most likely encourage you to participate in future data collection surveys for research purposes?” It appeared from the results of the study (Figure 16) that the top three dominant reasons were – access to proper equipment and technology (25.21%), access to latest seed variety for improving crop production (23.14%) and technical assistance (16.12%). There is a likelihood that if we incorporate farmers preferred type of information on our web platform, it will increase their engagement and motivate them to participate in data collection.

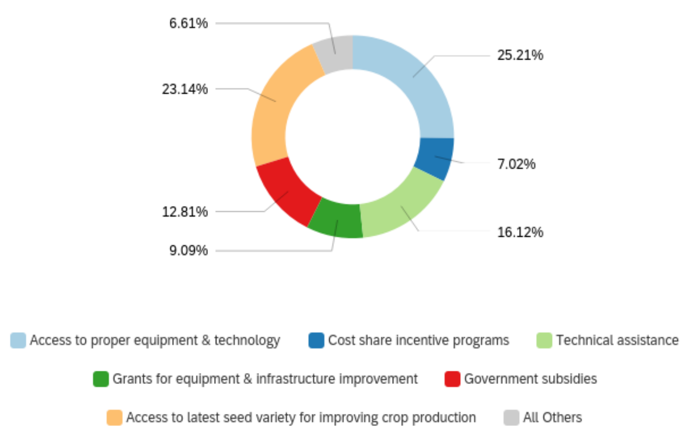


Figure 16: What incentives would most likely encourage you to participate in future data collection surveys for research purposes?

5.4. Discussion Based on Farm Survey Results

Data collection from farmers for agricultural research is integral for the sectors growth, and data dissemination is equally essential to increase farmers' awareness and knowledge for increased agricultural production and productivity. The study sought to find ways to provide ease of access to farmers and increase their engagement in agricultural research. According to Njelekela and Sanga (2015), a farmer's choice to use various information sources is influenced by their individual traits such as farm size, farming experience, age, education level, and income. In this study, we have also collected a similar set of variables to evaluate the probability of an individual farmer using the online platform for helping in data collection and seeking agricultural information. We have found that most of the respondents belonged to the age group of 20-40 years, which suggests that young farmers involved in agricultural practices are more tech-savvy than the elderly farmers and are open to supporting technological advancements. The survey results also showed that the study participants were either semi-literate or literate, and they had used in-person or online government resources to improve their agricultural practices. We provided dual language options to the participants for completing the survey, and as a result, more than 55% of farmers preferred their regional language (Punjabi) over English. Choice of language increased convenience for the farmers. The results show that farmers are more comfortable communicating through regional languages, and this preference can be incorporated in further improvement of the information portal of the online website platform.

The farming sector needs immediate attention by the government for its improvement as more than 60% of the economy's population are dependent on it for their livelihood, yet people cannot earn enough income from farming to sustain their livelihood. That is why many farmers look for alternative sources of income and cannot focus their attention on increasing agricultural production and efficiency. Our results show that farmers seek information about innovative and adaptive farm techniques through their farmer networks and agricultural university support. To support the preference of farmers to stick with their farmers' network as a trusted source to seek information, we have suggested incorporating the "Farmclub" feature on the website. Farmers can go to the "Farmer Support" web page to seek different information sources and can find the "Farmclub" button on the page. "Farmclub" will act as a virtual meeting and conversational platform which can connect farmers with other farmers. It will also incorporate a feature to connect farmers with agricultural researchers for expert opinion. They can ask questions about their farming concerns and find support from their community. This feature will build the farmers' trust towards the platform and increase their visits to the platform. It is also evident from the survey that farmers are keen to seek information about the latest technological advancements, farming techniques and modern machinery to increase their crop production and agricultural efficiency.

5.4.1. Traditional vs. Online Farm Surveys

Traditional in-person field surveys are generally time and cost-intensive and involve many efforts for data collection from respondents who are geographically scattered (Fleming & Bowden, 2009; Tuten, 2010). Our online farm survey proved that the online mode takes less time to deliver surveys, is cost-effective, and can cover wider geographical regions for gathering data efficiently. As per the survey data, the average time taken by the respondents was 10 minutes and 19 seconds, which is well below the recommended estimated time of 15-20 minutes for survey completion (Revilla & Ochoa, 2017). The participants took a maximum of 32 minutes and 46 seconds and a minimum of one minute to complete the survey. Concerning field officers engagement with the farmers for field surveys, we found that field officers never visited 74.02% of the respondents for farm data collection. The field officers visited farmers who lived in big villages or areas closer to cities. Thus, it can be interpreted that small villages and places that are far from main cities may be neglected in the paper-based field surveys.

5.4.2. Feedback of Farmers and Researchers

Understanding the benefits of using online web platforms for conducting data collection has been a topic of interest among business and social science researchers (Burkill et al., 2016; Couper, 2017; Tourangeau, 2004). The respondents reported a high preference for the online survey as opposed to the paper-based field surveys. One respondent mentioned in the survey feedback form, “It is easy to submit online surveys.” Another respondent compared online surveys with paper-based by saying, “It takes less time to take the survey and do it at our own convenience than paper surveys with field officers.” The efficiency of the data collection process also increases as we are no longer required to keep track of survey papers and go from one person to another for data collection. A researcher from the Punjab Agricultural university spoke in favour of our web platform. He highlighted that the real-time survey delivery is better than the slower collection and manual data entry for paper-based survey forms. Online web-based surveys provide the added advantage of time and cost-effectiveness that fuel the demand to increase the use of online surveys. Investment of time and cost on field officers training is also not required with the online surveys as the survey responses can be recorded online without the assistance of a large number of field officers. Online surveys can also be ideal for data collection during pandemics when face-to-face data collection is not possible. Online data collection surveys can be used as a productive way to reach farmers over a wide geographic area for data collection and perform more inclusive research for better generalization.

5.4.3. Identification of Topics for Data Collection

We collected general demographics of farmers, including age, gender, education level, farm size, ownership status and annual income. Data about farmers' coping mechanisms, farmland details, irrigation sources, details about wheat crop production, and accessibility to information sources were also collected using short answer text fields for scalar data and multiple-choice questions to collect nominal and ordinal data. We used the wheat crop for data collection because Punjab is one of the main producers of wheat crops, and the majority of the farmers are involved in wheat production (Singh et al., 2017). Additionally, at the time of data collection, farmers finished their wheat production and had all the information on hand which we required for testing our data collection platform. In the survey, farmers were asked to report their experience using currently available agricultural information sources. Often, government policies and regulations concerning the agriculture sector change, having a significant impact on farmers, and there is friction in the adoption of these policies by the farmers. The tensions around policies can reduce by receiving feedback from farmers before sanctioning such changes. Farmers' feedback confirms that most of the time, they are unaware of the latest government policies and agricultural research. The majority of the farmers get informed about these latest trends through word of mouth from fellow farmers, friends and family, the internet, and social media.

We also collected data related to wheat crop production by the farmers and asked them about the reasons to prefer some seeds over others for wheat cultivation. The farmers were given an option to choose from 26 varieties of the wheat that they use for production, and 20% of the farmers selected the "PBW 752" seed variety, which is the most common seed variety. Farmers selected the reasons of preferring seed varieties, and the most common reason was to induce an "increase in yield (37.02%)," followed by "improved quality of the product (29.83%)" and the least preferred reason was "end product nutrient level (3.31%)". The researchers can use the respondents data to analyze the farmers' needs and make suggestions for increasing crop production and provide information as they desire. We also collected farmers' feedback for current online and offline information sources and asked for feedback about our platform through the online platform. We can receive real-time feedback from the farmers, keep the platform updated with all the latest research findings, and increase farmers' awareness. Agricultural researchers can receive farmers feedback about different small or big projects and increase their engagement in the research. The government officials can also use the platform to ask farmers' opinions on the government's policies and increase their involvement in decisions central to them. Thus, there are many potential areas for which information can be collected using the online web-based platform.

Chapter 6. Future Work and Conclusion

6.1. Summary

This thesis focused on answering the research question: *What are the design requirements for developing an online data exchange platform to bridge the gap between farmers and researchers in India based on a design science approach?* We created a prototype web-based platform and discussed its design requirements with the focus on making the platform easy to use, readily accessible, and functional with quality content as per the suggestions of the participants of the study.

The expected contributions of this research were:

1. Developing design requirements for an online data exchange platform based on the concepts of crowdsourcing and citizen science, as this offers the opportunity to gather large-scale data at a lower cost through enhanced spatial and temporal coverage.
2. Facilitating knowledge generation and exchange in the Indian agricultural sector for its development and digitalization if the prototype platform gets widely used and adopted in India.
3. Providing farmers with the opportunity to access direct advice from researchers for farming practices.

Through our platform, we have created a one-stop prototype solution for both data collection and data dissemination for the benefit of Indian agriculture. The design requirements of the platform are provided in the thesis for supporting future work in the field. The platform can be used by researchers for conducting farm surveys to gather large-scale data at a lower cost directly from the farmers. We linked the website with Qualtrics survey software for our project, but the researchers can link the website platform to any other 3rd party survey software including SurveyMonkey, Hotjar, Survicate, Iterate, and others. We used our website platform to provide agricultural information related to the latest farming techniques, government policies, weather and research updates in the field to all the users in one place. We kept the design of the platform simple, easy to use, readily accessible from mobile phones and laptops for added convenience, and we took all the information from the official government websites. Simultaneously, our platform seeks to provide the opportunity to the users to connect with the agricultural community through the discussion forum for sharing their knowledge and expertise with other members. Farmers can also seek advice from agricultural experts for improving their farming practices and increasing efficiency. Thus, our prototype aims to support participant and community learning, accompanied by wider social accountability of scientific research in the agricultural field.

Table 7 summarizes showing how this research followed the DSRM process.

Table 7: Design Science Research Methodology (DSRM) summary table Peffers et al. (2007)

Research Step	**Description**	**Explanation in the study**
1. Identify problem & motivate	Define the specific research problem and justify the value of a solution.	Clearly stated the research problem and motivation in Chapter 1.
2. Define objectives of a solution	Infer objectives of the solution from the problem definition and knowledge of what is possible and feasible.	Expected objectives were defined in Chapter 1.
3. Design & development	Create the artifact.	The design and development of the website platform is explained in Chapter 3 and 4.
4. Demonstration	Demonstrate the use of artifact to solve one or more instances of the problem.	Screenshots of the website platform are available in Chapter 3, methodology to solve data collection and data dissemination problem is stated in Chapter 4, results from the survey gathered through the use of website platform are presented in Chapter 5.
5. Evaluation	Observe and measure how well the artifact supports a solution to the problem.	Discussions about the proposed solution are presented in Chapter 5. Final observations and proposed changes for improvement in the solution platform are stated in Chapter 6.
6. Communication	Communicate the problem, its importance, artifact, its utility and novelty, the rigour of its design, and its effectiveness to researchers and other relevant audiences.	Details of the study are published through this master's thesis.

6.2. Assumptions and Limitations

The website content needs to be verified for any errors or mistakes before posting it on the platform for the users to seek knowledge. The involvement of agricultural experts to ensure accurate information presentation on the website is ideal. We took content from the existing regional and government websites by assuming that the information is verified since it is a government source. The websites used for seeking content are https://agricoop.nic.in/en, https://www.pau.edu/fportalnew/, and https://www.pau.edu/index.php?_act=manageSandesh&DO=allSandesh.

The sample farmers in the study were selected randomly from Punjab, India, and the relative homogeneity of the sample may limit the generalizability of the findings related to information requirements. Our sample might also be affected by "selection by the respondent" bias, where respondents interested in the subject of the questionnaire may respond relatively more than others who are not as interested in the research topic. In this case, non-respondents differ from respondents and potentially result in biased survey results. Our sampling method has drawbacks, but we believe it allowed us to aptly explore the usability of the data exchange platform and farmers' expectations about the kind of information they look for on an online website for improving their agricultural efficiency. Future research needs to investigate further how different demographic groups respond to the online data exchange platform and what kind of information they tend to seek from the platform.

We provided respondents with the option of dual languages for attempting the survey questions, and the translation of research questionnaires may threaten research validity. We ensured that the translation remained consistent with the original meaning of the questionnaire content and reduced the possibility of validity threats to an acceptable minimum. In addition, since the study used a prototype website with several disabled functions and limited information, the results might vary when using a fully functional website. Despite limitations, our platform, which provides data collection and data dissemination methods altogether at one place, can be more efficient for the users than surfing through separate platforms for these tasks. Our platform empowers individuals to generate and manage their data as citizen scientists and share their knowledge in the farming community.

6.3. Implications and Future Recommendations

While most of the results correspond positively to the study, further iterations of the design prototype are necessary to complete the website and fulfill all the user requirements. Updating the website with new content is an ongoing process, and to make it fully functional, updates need to happen on a regular basis to share the latest trends and information with the users. Further evaluations should be conducted by involving an even larger group of farmer participants and some researchers. Future researchers can also examine how farmers' attitudes towards the websites usefulness get affected by changes in the design layout of the website or changes in their satisfaction level based on different information media like text, images, audio, and video under varying levels of information involvement. Further research can be done by using the online farm survey for data collection and drawing conclusions for improvement in the agriculture sector.

Using the internet for data collection and data dissemination is not a new concept but putting both things together on one platform brings distinctiveness. Data dissemination through internet sources is quite common in the agriculture sector, but online data collection from farmers and using them as citizen scientists to engage them in research still needs much exploration. The platform can be further enhanced to work on its “Farmclub” feature for engaging and encouraging experienced farmers to share their experience with less experienced farmers and grow together as a community.

Designing the website platform was highly worthwhile, but planning, development and improvement of the website prototype during the pandemic situation was more challenging than expected. Website building needs many iterations and continuous feedback at every stage from the users for increasing its success rate. Another study can be conducted after accommodating our suggested revisions in the website platform to make it more accessible and friendly to users responses towards the updates. The problems that we anticipated while making the study design model and during implementations can be used as guidelines in future research.

6.4. Conclusion

We designed a Farmer Researcher Information Exchange Management System (FRIEMS) to bridge the information and data gap between the farmers and researchers.

We have proposed design requirements of an online web-based platform that fulfils the researchers data collection requiremen ts and provides agricultural information to cater to farmers' needs. Farmers served as citizen scientists by directly providing information to the researchers through the online farm survey, and they helped check the usability of the online surveys in the agriculture sector. Farmers received valuable information through the website platform about their questions or concerns through government verified sources and agricultural institutes. We focused on the design requirements for the website design to make it adaptable and easier to use by the farming community.

The study proposed the application of User-Centered Design (UCD) and Activity Centered Design (ACD) to create a data exchange platform for bridging the gap between farmers and researchers. The UCD ensures overall website development incorporating all the users needs, and the ACD ensures incorporating the needs of the organizations that collect agricultural data. This is essential for the website design because it essentially caters to both farmers and the researchers needs and has broad audiences in general. The improved website (prototype-2) exhibits improvements in the content and overall design based on the prototype-1 design evaluation. Overall, the website platform received an overwhelmingly positive response from the participants for the design interface. The participants suggested the inclusion of the latest updates of the agriculture sector, farming techniques and government subsidies which were later on added to the platform. The website is a prototype and still in the development phase; thus, updating content does not happen frequently. These feedbacks and improvements confirm that the user-focused development of the website can capture the users r equirements more comprehensively. Thus, it increases the likelihood of system success.

For design improvement and to cover a broader range of audiences, we used multiple languages in the website surveys and created the website design to be suitable for colour-blind and dyslexic people. Recognizing and accommodating the different accessibility needs of the users helped to increase the outreach of the platform. The platform also facilitated data exchange between farmers and researchers during the COVID-19 global pandemic. The users did not need to leave their premises or invite others for either data collection or for seeking agricultural information.

The results of this study support five main contributions: (i) detailed identification and analysis of the targeted users, (ii) inclusion of specific user requirements based on feedback, (iii) application of UCD to improve the user experience, (iv) application of ACD to incorporate content required by the research organizations, (v) exploring the usability of online farm survey for data collection. The designing and development of the website platform are exhibited in Chapter 3, and the final version prototype-2 can be accessed at the weblink: https://www.askfarmers.info/. We came to know that majority of the farmers were happy about the website layout and content. Getting feedback with open-ended questions helped us get their suggestions for increasing the usability of the platform. We hope that the experiences we described are likely to become fundamental for continued research for future researchers in agriculture and the social sciences field to make a similar platform or improve the one we created.

References

Abras, C., Maloney-Krichmar, D., & Preece, J. (2004). User-centered Design. *Bainbridge, W. Encyclopedia of Human-Computer Interaction. Thousand Oaks: Sage Publications*, *37*(4), 445–456. https://doi.org/10.3233/WOR-2010-1109

Agriculture Logo Ideas: Make Your Own Agriculture Logo - Looka. (n.d.). Retrieved July 23, 2021, from https://looka.com/logo-ideas/agriculture-logo-design/

Akridge, J., Gloy, B., & Whipker, L. (2000). Sources of information for commercial farms: Usefulness of media and personal sources. *International Food and Agribusiness Management Review*, *03*. https://doi.org/10.1016/S1096-7508(01)00046-5

Almekinders, C. J. M., Beumer, K., Hauser, M., Misiko, M., Gatto, M., Nkurumwa, A. O., & Erenstein, O. (2019). Understanding the relations between farmers' seed demand and research methods: The challenge to do better. *Outlook on Agriculture*, *48*(1), 16–21. https://doi.org/10.1177/0030727019827028

Alroobaea, R., & Mayhew, P. J. (2014). How many participants are really enough for usability studies? *Proceedings of 2014 Science and Information Conference, SAI 2014*, *August*, 48–56. https://doi.org/10.1109/SAI.2014.6918171

Appiah, C. (2018). *Analysis of sources of Market information for farmers in Saskatchewan*. *March*, 90.

Armstrong, L. J., Gandhi, N., & Lanjekar, K. (2012). Use of Information and Communication Technology (ICT) tools by rural farmers in Ratnagiri District of

Maharastra, India. *Proceedings - International Conference on Communication Systems and Network Technologies, CSNT 2012*, 950–955. https://doi.org/10.1109/CSNT.2012.202

Ballantyne, P. (2009). Accessing, sharing and communicating agricultural information for development: Emerging trends and issues. *Information Development*, *25*(4), 260–271. https://doi.org/10.1177/0266666909351634

Baumüller, H. (2018). The Little We Know: An Exploratory Literature Review on the Utility of Mobile Phone-Enabled Services for Smallholder Farmers. *Journal of International Development*, *30*(1), 134–154. https://doi.org/https://doi.org/10.1002/jid.3314

Bell, S., Marzano, M., Cent, J., Kobierska, H., Podjed, D., Vandzinskaite, D., Reinert, H., Armaitiene, A., Grodzińska-Jurczak, M., & Muršič, R. (2008). What counts? Volunteers and their organisations in the recording and monitoring of biodiversity. *Biodiversity and Conservation*, *17*(14), 3443–3454. https://doi.org/10.1007/s10531-008-9357-9

Berardi, G. M. (2002). Changing the way America Farms: Knowledge and Community in the Sustainable Agriculture Movement. *Ethics, Place & Environment*, *5*. https://doi.org/10.5860/choice.37-5093

Best, S., & Krueger, B. (2004). *Internet Data Collection*. https://doi.org/10.4135/9781412984553

Bhange, M., & Hingoliwala, H. A. (2015). Smart Farming: Pomegranate Disease Detection Using Image Processing. *Procedia Computer Science*, *58*, 280–288.

https://doi.org/10.1016/j.procs.2015.08.022

Bhattacharya, D., Gulla, U., & Gupta, M. P. (2012). E-service quality model for Indian government portals: citizens' perspective. *Journal of Enterprise Information Management*, *25*(3), 246–271. https://doi.org/10.1108/17410391211224408

Birthal, P. S., Kumar, S., Negi, D. S., & Roy, D. (2015). The impacts of information on returns from farming: Evidence from a nationally representative farm survey in India. *Agricultural Economics (United Kingdom)*, *46*(4), 549–561. https://doi.org/10.1111/agec.12181

Blumenberg, C., Menezes, A. M. B., Gonçalves, H., Assunção, M. C. F., Wehrmeister, F. C., Barros, F. C., & Barros, A. J. D. (2019). The role of questionnaire length and reminders frequency on response rates to a web-based epidemiologic study: a randomised trial. *International Journal of Social Research Methodology*, *22*(6), 625–635.

Bonney, R., Shirk, J. L., Phillips, T. B., Wiggins, A., Ballard, H. L., Miller-Rushing, A. J., & Parrish, J. K. (2014). Next steps for citizen science. *Science*, *343*(6178), 1436–1437. https://doi.org/10.1126/science.1251554

Boulos, M. N. K., Resch, B., Crowley, D. N., Breslin, J. G., Sohn, G., Burtner, R., Pike, W. A., Jezierski, E., & Chuang, K.-Y. S. (2011). Crowdsourcing, citizen sensing and sensor web technologies for public and environmental health surveillance and crisis management: trends, OGC standards and application examples. *International Journal of Health Geographics*, *10*(1), 67. https://doi.org/10.1186/1476-072X-10-67

Bruce, T. J. A. (2016). The CROPROTECT project and wider opportunities to improve farm productivity through web-based knowledge exchange. *Food and Energy Security*, *5*(2), 89–96. https://doi.org/10.1002/fes3.80

Buchanan, & Hvizdak, E. E. (2009). Online Survey Tools: Ethical and Methodological Concerns of Human Research Ethics Committees. *Journal of Empirical Research on Human Research Ethics*, *4*(2), 37–48. https://doi.org/10.1525/jer.2009.4.2.37

Buchanan, T., & Williams, J. E. (2010). Ethical issues in psychological research on the Internet. In *Advanced methods for conducting online behavioral research.* (pp. 255–271). American Psychological Association. https://doi.org/10.1037/12076-016

Burkill, S., Copas, A., Couper, M. P., Clifton, S., Prah, P., Datta, J., Conrad, F., Wellings, K., Johnson, A. M., & Erens, B. (2016). Using the web to collect data on sensitive behaviours: A study looking at mode effects on the British national survey of sexual attitudes and lifestyles. *PLoS ONE*, *11*(2), e0147983. https://doi.org/10.1371/journal.pone.0147983

Casey, M. J., Meikle, A., Kerr, G. A., & Stevens, D. R. (2016). Social media - a disruptive opportunity for science and extension in agriculture? *NZGA: Research and Practice Series*, *16*, 53–60. https://doi.org/10.33584/rps.16.2016.3248

Central Statistical Organization, I. A. S. R. (2007). *Manual on Area and Crop Production Statistics*.

Clark, W. C., Van Kerkhoff, L., Lebel, L., & Gallopin, G. C. (2016). Crafting usable knowledge for sustainable development. In *Proceedings of the National Academy of Sciences of the United States of America* (Vol. 113, Issue 17, pp. 4570–4578). PNAS. https://doi.org/10.1073/pnas.1601266113

Coe, R. (1996). Sampling Size Determination in Farmer Surveys. *ICRAF Research Support Unit Technical Note No 4, Kenya: ICRAF World Agroforestry Centre Nairobi.*, 11.

Cooper, C., Bailey, R., & Leech, D. (2015). *The role of citizen science in studies of avian reproduction* (pp. 208–220). https://doi.org/10.1093/acprof:oso/9780198718666.003.0017

Couper, Antoun, C., & Mavletova, A. M. (2017). *Mobile Web Surveys: A Total Survey Error Perspective* (P. P. In Biemer, E. D. De Leeuw, S. Eckman, B. Edwards, F. Kreuter, L. E. Lyberg, C. Tucker, & B. T. West (Eds.)). New York: Wiley.

Couper, M. P. (2017). New developments in survey data collection. *Annual Review of Sociology*, *43*, 121–145. https://doi.org/10.1146/annurev-soc-060116-053613

Creswell, J. W., & Creswell, J. D. (2018). *Research design: qualitative, quantitative, and mixed methods approaches* (Fifth). SAGE.

Cyr, D. (2013). Website design, trust and culture: An eight country investigation. *Electronic Commerce Research and Applications*, *12*(6), 373–385. https://doi.org/10.1016/j.elerap.2013.03.007

Danes, M. H. G. I., Jellema, A., Janssen, S. J. C., & Janssen, H. (2014). *Mobiles for agricultural development : exploring trends, challenges and policy options for the Dutch government (Alterra-rapport; No. 2501). Alterra, Wageningen-UR. https://edepot.wur.nl/297683*.

Demirbas, M., Bayir, M. A., Akcora, C. G., Yilmaz, Y. S., & Ferhatosmanoglu, H. (2010). Crowd-sourced sensing and collaboration using twitter. *2010 IEEE International*

Symposium on "A World of Wireless, Mobile and Multimedia Networks", WoWMoM 2010 - Digital Proceedings. https://doi.org/10.1109/WOWMOM.2010.5534910

Dillman, D. A., Smyth, J. D., & Christian, L. M. (2014). *Internet, phone, mail, and mixed-mode surveys : The tailored design method.* (pp. 301–350). Wiley.

Dillman, D. A. (2007). *Mail and internet surveys : The tailored design method* (2nd ed., 2). John Wiley & Sons, Inc.

Dolinska, A., & d'Aquino, P. (2016). Farmers as agents in innovation systems. Empowering farmers for innovation through communities of practice. *Agricultural Systems*, *142*, 122–130. https://doi.org/https://doi.org/10.1016/j.agsy.2015.11.009

Eitzel, M. V, Cappadonna, J. L., Santos-Lang, C., Duerr, R. E., Virapongse, A., West, S. E., Kyba, C. C. M., Bowser, A., Cooper, C. B., Sforzi, A., Metcalfe, A. N., Harris, E. S., Thiel, M., Haklay, M., Ponciano, L., Roche, J., Ceccaroni, L., Shilling, F. M., Dörler, D., … Jiang, Q. (2017). Citizen Science Terminology Matters: Exploring Key Terms. *Citizen Science: Theory and Practice*, *2*(1), 1. https://doi.org/10.5334/cstp.96

Eitzinger, A., Cock, J., Atzmanstorfer, K., Binder, C. R., Läderach, P., Bonilla-Findji, O., Bartling, M., Mwongera, C., Zurita, L., & Jarvis, A. (2019). GeoFarmer: A monitoring and feedback system for agricultural development projects. *Computers and Electronics in Agriculture*, *158*(February), 109–121. https://doi.org/10.1016/j.compag.2019.01.049

Ellwood, E. R., Crimmins, T. M., & Miller-Rushing, A. J. (2017). Citizen science and conservation: Recommendations for a rapidly moving field. *Biological*

Conservation, *208*, 1–4. https://doi.org/10.1016/j.biocon.2016.10.014

Evans, C., Abrams, E., Reitsma, R., Roux, K., Salmonsen, L., & Marra, P. P. (2005). The Neighborhood Nestwatch Program: Participant Outcomes of a Citizen-Science Ecological Research Project. *Conservation Biology*, *19*(3), 589–594. https://doi.org/https://doi.org/10.1111/j.1523-1739.2005.00s01.x

Evans, J. R., & Mathur, A. (2005a). Read- The value of online surveys. *Internet Research*, *15*(2), 195–219. https://doi.org/10.1108/10662240510590360

Evans, J. R., & Mathur, A. (2005b). The Value of Online Surveys. *Internet Research*, *15*, 195–219. https://doi.org/10.1108/10662240510590360

Fleming, C. M., & Bowden, M. (2009). Web-based surveys as an alternative to traditional mail methods. *Journal of Environmental Management*, *90*(1), 284–292. https://doi.org/10.1016/j.jenvman.2007.09.011

Fowler, S., & Stanwick, V. (2004). The Browser Framework. In *Web Application Design Handbook*. https://doi.org/10.1016/b978-155860752-1/50002-5

Francone, C., Pagani, V., Foi, M., Cappelli, G., & Confalonieri, R. (2014). Comparison of leaf area index estimates by ceptometer and PocketLAI smart app in canopies with different structures. *Field Crops Research*, *155*, 38–41. https://doi.org/10.1016/j.fcr.2013.09.024

Freifeld, C. C., Chunara, R., Mekaru, S. R., Chan, E. H., Kass-Hout, T., Ayala Iacucci, A., & Brownstein, J. S. (2010). Participatory epidemiology: use of mobile phones for community-based health reporting. *PLoS Medicine*, *7*(12), e1000376–e1000376. https://doi.org/10.1371/journal.pmed.1000376

Fuccillo, K. K., Crimmins, T. M., de Rivera, C. E., & Elder, T. S. (2015). Assessing accuracy in citizen science-based plant phenology monitoring. *International Journal of Biometeorology*, *59*(7), 917–926. https://doi.org/10.1007/s00484-014-0892-7

Geiger, D., Seedorf, S., Schulze, T., Nickerson, R., & Schader, M. (2011). Managing the crowd: Towards a taxonomy of crowdsourcing processes. *17th Americas Conference on Information Systems 2011, AMCIS 2011*, *5*, 3796–3806.

Gómez, R. Y., Caballero, D. C., & Sevillano, J. L. (2014). Heuristic Evaluation on Mobile Interfaces: A New Checklist. *Scientific World Journal*, *2014*(September). https://doi.org/10.1155/2014/434326

Gosling, S. D., Vazire, S., Srivastava, S., & John, O. P. (2004). Should We Trust Web-Based Studies? A Comparative Analysis of Six Preconceptions About Internet Questionnaires. *American Psychologist*, *59*(2), 93–104. https://doi.org/10.1037/0003-066X.59.2.93

Grover, D. K., Singh, J. M., Kaur, A., & Kumar, S. (2017). *State Agricultural Profile-Punjab*. *AERC STUDY No. 44*, 1–74.

Hansen, J. P., Jespersen, M. L., Brunori, G., Jensen, A. L., Holst, K., Mathiesen, C., Halberg, N., & Rasmussen, A. (2014). ICT and social media as drivers of multi-actor innovation in agriculture. *World Conference on Computers in Agriculture and Natural Resources, University of Costa Rica, San Jose Costa Rica*, 1–8. http://journals.sfu.ca/cigrp/index.php/Proc/article/view/162

Heerwegh, D., & Loosveldt, G. (2008). Face-to-face versus web surveying in a high-internet-coverage population: Differences in response quality. *Public Opinion*

Quarterly, *72*(5), 836–846. https://doi.org/10.1093/poq/nfn045

Hewson, C., & Laurent, D. (2008). Research design and tools for Internet research. In N. Fielding, R. Lee, & G. Blank (Eds.), *The Handbook of Online Research Methods* (pp. 58–78). Sage. http://www.sagepub.com/booksProdDesc.nav?prodId=Book229285

Hogset, H., & Barrett, C. B. (2010). Social Learning, Social Influence, and Projection Bias: A Caution on Inferences Based on Proxy Reporting of Peer Behavior. *Economic Development and Cultural Change*, *58*(3), 563–589. https://doi.org/10.1086/650424

Hu, M., & Kuang, Y. (2014). Human-machine interface: Design principles of pagination navigation in web applications. *Proceedings of the 9th International Conference on Computer Science and Education, ICCCSE 2014*, *Iccse*, 1140–1143. https://doi.org/10.1109/ICCSE.2014.6926640

Hughes, D. P., & Salathe, M. (2016). *An open access repository of images on plant health to enable the development of mobile disease diagnostics*.

Hujala, T., Tikkanen, J., Hänninen, H., & Virkkula, O. (2009). Family forest owners' perception of decision support. *Scandinavian Journal of Forest Research*, *24*(5), 448–460. https://doi.org/10.1080/02827580903140679

India Brand Equity Foundation. (2020). *Agriculture and Allied Industries*. www.ibef.org

Janssen, S. J. C., Porter, C. H., Moore, A. D., Athanasiadis, I. N., Foster, I., Jones, J. W., & Antle, J. M. (2017). Towards a new generation of agricultural system data, models and knowledge products: Information and communication technology. *Agricultural*

Systems, *155*, 200–212. https://doi.org/10.1016/j.agsy.2016.09.017

Jordan, R. C., Gray, S. A., Howe, D. V, Brooks, W. R., & Ehrenfeld, J. G. (2011). Knowledge Gain and Behavioral Change in Citizen-Science Programs. *Conservation Biology*, *25*(6), 1148–1154. https://doi.org/https://doi.org/10.1111/j.1523-1739.2011.01745.x

Kelling, S., Fink, D., La Sorte, F. A., Johnston, A., Bruns, N. E., & Hochachka, W. M. (2015). Taking a 'Big Data' approach to data quality in a citizen science project. *Ambio*, *44*(4), 601–611. https://doi.org/10.1007/s13280-015-0710-4

Kim, S., Mankoff, J., & Paulos, E. (2013). Sensr: Evaluating a Flexible Framework for Authoring Mobile Data-Collection Tools for Citizen Science. *Proceedings of the 2013 Conference on Computer Supported Cooperative Work*, 1453–1462. https://doi.org/10.1145/2441776.2441940

Kleffmann, G. (2018). Internet behaviour of corn farmers living in India. In *Kleffmann Group*. http://news.agropages.com/News/NewsDetail---28905.htm

Kostkova, P. (2015). Grand challenges in digital health. *Frontiers in Public Health*, *3*, 134. https://doi.org/10.3389/fpubh.2015.00134

Koundinya, V., Chiarella, C., Kocher, S., & Kearns, F. (2020). Disasters Happen: Identifying Disaster Management Needs of Cooperative Extension System Personnel. *Journal of Extension*, *58*(5), 1–13.

Krantz, J. H., & Williams, J. E. (2010). Using graphics, photographs, and dynamic media. In *Advanced methods for conducting online behavioral research.* (pp. 45–61). American Psychological Association. https://doi.org/10.1037/12076-004

Kreuter, F., Presser, S., & Tourangeau, R. (2008). Social desirability bias in CATI, IVR, and web surveys: The effects of mode and question sensitivity. *Public Opinion Quarterly*, *72*(5), 847–865. https://doi.org/10.1093/poq/nfn063

Kroma, M. M. (2006). Organic Farmer Networks: Facilitating Learning and Innovation for Sustainable Agriculture. *Journal of Sustainable Agriculture*, *28*(4), 5–28. https://doi.org/10.1300/J064v28n04_03

Kucherbaev, P., Daniel, F., Tranquillini, S., & Marchese, M. (2016). Crowdsourcing Processes: A Survey of Approaches and Opportunities. *IEEE Internet Computing*, *20*(2), 50–56. https://doi.org/10.1109/MIC.2015.96

Lakshmanan, R. (2019). *Service Sector in India – Statistics and Overview | Invest India*. https://www.investindia.gov.in/team-india-blogs/service-sector-india-paradigm-shift

Lalmas, M., Bhat, R., Frank, M., Frohlich, D., & Jones, M. (2007). Bridging the digital divide: Understanding information access practices in an indian village community. *Proceedings of the 30th Annual International ACM SIGIR Conference on Research and Development in Information Retrieval, SIGIR'07*, *May 2014*, 741–742. https://doi.org/10.1145/1277741.1277886

Lemos, M. C., Kirchhoff, C. J., & Ramprasad, V. (2012). Narrowing the climate information usability gap. *Nature Climate Change*, *2*(11), 789–794. https://doi.org/10.1038/nclimate1614

Link, M. W., Murphy, J., Schober, M. F., Buskirk, T. D., Hunter Childs, J., & Langer Tesfaye, C. (2014). Mobile Technologies for Conducting, Augmenting and Potentially Replacing Surveys: Report of the AAPOR Task Force on Emerging

Technologies in Public Opinion Research. In *AAPOR (American Association for Public Opinion Research)* (Vol. 78, Issue 4). https://doi.org/10.1093/poq/nfu054

Loomis, D. K., & Paterson, S. (2018). A comparison of data collection methods: Mail versus online surveys. *Journal of Leisure Research*, *49*(2), 133–149. https://doi.org/10.1080/00222216.2018.1494418

Lukyanenko, R., & Parsons, J. (2018). Beyond micro-tasks: Research opportunities in observational crowdsourcing. *Journal of Database Management*, *29*(1), 1–22. https://doi.org/10.4018/JDM.2018010101

Maguire, M. (2001). Methods to support human-centred design. *International Journal of Human Computer Studies*, *55*(4), 587–634. https://doi.org/10.1006/ijhc.2001.0503

Marimuthu, R., Alamelu, M., Suresh, A., & Kanagaraj, S. (2017). Design and development of a persuasive technology method to encourage smart farming. *2017 IEEE Region 10 Humanitarian Technology Conference (R10-HTC)*, 21–23. https://doi.org/10.1109/R10-HTC.2017.8288930

Martínez Pérez, G., & Turetsky, R. (2015). FGMReview: Design of a Knowledge Management Tool on Female Genital Mutilation. *Journal of Transcultural Nursing*, *26*(5), 521–528. https://doi.org/10.1177/1043659614534447

Marx, S., Hämmerle, M., Klonner, C., & Höfle, B. (2016). 3D Participatory Sensing with Low-Cost Mobile Devices for Crop Height Assessment--A Comparison with Terrestrial Laser Scanning Data. *PloS One*, *11*(4), e0152839. https://doi.org/10.1371/journal.pone.0152839

McCormick, S. (2012). After the Cap: Risk Assessment, Citizen Science and Disaster

Recovery. *Ecology and Society*, *17*(4). https://doi.org/10.5751/ES-05263-170431

Meera, S. N., Jhamtani, A., & Rao, D. U. M. (2004). Information and Communication Technology in Agricultural Development: A Comparative Analysis of Three Projects from India. *Agricultural Research & Extension Network (AgREN)*, *135*. http://dlc.dlib.indiana.edu/dlc/bitstream/handle/10535/4915/agrenpaper_135.pdf?sequence=1&isAllowed=y

Menon, V., & Muraleedharan, A. (2020). Internet-based surveys: Relevance, methodological considerations and troubleshooting strategies. *General Psychiatry*, *33*(5), 1–3. https://doi.org/10.1136/gpsych-2020-100264

Minet, J., Curnel, Y., Gobin, A., Goffart, J. P., Mélard, F., Tychon, B., Wellens, J., & Defourny, P. (2017). Crowdsourcing for agricultural applications: A review of uses and opportunities for a farmsourcing approach. *Computers and Electronics in Agriculture*, *142*(November), 126–138. https://doi.org/10.1016/j.compag.2017.08.026

Ministry of Agriculture, N. (2001). Adoption of Technologies for Sustainable Farming Systems. *Wageningen Workshop Proceedings*, 149.

Misaki, E., Apiola, M., & Gaiani, S. (2019). Developing a communication application system for Chamwino small-scale farmers in Tanzania: A participatory design research. *2019 42nd International Convention on Information and Communication Technology, Electronics and Microelectronics, MIPRO 2019 - Proceedings*, 1368–1373. https://doi.org/10.23919/MIPRO.2019.8756898

Murria, P. (2018). Indian Agrarian Economy or Suicide Economy: Is There Any Way

Out? *Productivity*, *59*(1), 10–20. https://doi.org/10.32381/prod.2018.59.01.2

Mutz, D. C. (2011). *Population-based survey experiments*. Princeton University Press.

Narechania, A. (2015). KisanVikas-Android Based ICT Solution in Indian Agriculture to Assist Farmers. *Proceedings of the 7th International Conference on Information and Communication Technologies in Agriculture, Food and Environment (HAICTA) 2015, Kavala, Greece*, 17–20.

Nelson, R., Coe, R., & Haussmann, B. I. G. (2019). Farmer Research Networks as a Strategy for Matching Diverse Options and Contexts in Smallholder Agriculture. *Experimental Agriculture*, *55*(S1), 125–144. https://doi.org/10.1017/S0014479716000454

Nielsen Holdings. (2019). India Internet 2019. In *Internet and Mobile Association of India*. https://cms.iamai.in/Content/ResearchPapers/2286f4d7-424f-4bde-be88-6415fe5021d5.pdf

Nielsen, J. (2012). *How Many Test Users in a Usability Study?* Nielsen Norman Group. https://www.nngroup.com/articles/how-many-test-users/

Njelekela, C., & Sanga, C. (2015). Contribution of Information and Communication Technology in Improving Access to Market Information among Smallholder Farmers : The case study of Kilosa District. *The International Journal of Management Science and Information Technology*, *17*(September), 56–72.

Norman, D. A. (2005). Human-centered design considered harmful. *Interactions*, *12*(4), 14–19. https://doi.org/10.1145/1070960.1070976

Ottinger, G. (2009). Buckets of Resistance: Standards and the Effectiveness of Citizen

Science. *Science, Technology, & Human Values*, *35*(2), 244–270. https://doi.org/10.1177/0162243909337121

Pawar, C. V., Patni, S. S., Wale, S. K., Chemate, H. B., & Dasgupta, P. A. (2015). Exploring Agriculture Sector Using Crowdsourcing Predictors. *International Journal for Research in Applied Science & Engineering Technology (IJRASET)*, *3*(4), 711–714.

Peffers, K., Tuunanen, T., Rothenberger, M. A., & Chatterjee, S. (2007). A Design Science Research Methodology for Information systems Research. *Journal of Management Information Systems*, *24*(3), 45–77. https://doi.org/https://doi.org/10.2753/MIS0742-1222240302

Pennings, J. M. E., Irwin, S. H., & Good, D. L. (2002). Surveying Farmers: A Case Study. *Review of Agricultural Economics*, *24*(1), 266–277. https://doi.org/10.1111/1467-9353.00096

Peytchev, A. (2009). Survey Breakoff. *Public Opinion Quarterly*, *73*(1), 74–97. https://doi.org/10.1093/poq/nfp014

Peytchev, A. (2012). Consequences of Survey Nonresponse. *The ANNALS of the American Academy of Political and Social Science*, *645*(1), 88–111. https://doi.org/10.1177/0002716212461748

Ponto, J. (2015). Understanding and Evaluating Survey Research. In *Journal of the advanced practitioner in oncology* (Vol. 6, Issue 2, pp. 168–171).

Posadas, B. B., Hanumappa, M., Niewolny, K., & Gilbert, J. E. (2021). Design and Evaluation of a Crowdsourcing Precision Agriculture Mobile Application for

Lambsquarters, Mission LQ. In *Agronomy* (Vol. 11, Issue 10). https://doi.org/10.3390/agronomy11101951

Prokopy, L. S., Carlton, J. S., Haigh, T., Lemos, M. C., Mase, A. S., & Widhalm, M. (2017). Useful to Usable: Developing usable climate science for agriculture. *Climate Risk Management*, *15*, 1–7. https://doi.org/10.1016/j.crm.2016.10.004

Puspitasari, I. (2016). Stakeholder's expected value of Enterprise Architecture: An Enterprise Architecture solution based on stakeholder perspective. *2016 IEEE 14th International Conference on Software Engineering Research, Management and Applications (SERA)*, 243–248. https://doi.org/10.1109/SERA.2016.7516152

Raddick, M. J., Bracey, G. L., Gay, P. L., Lintott, C. J., Murray, P. G., Schawinski, K., Szalay, A. S., & vandenBerg, J. (2010). Galaxy Zoo: Exploring the Motivations of Citizen Science Volunteers. *Astronomy Education Review*, *9*, 10103.

Rahman, M., Blackwell, B., Banerjee, N., & Saraswat, D. (2015). Smartphone-based hierarchical crowdsourcing for weed identification'. *Computers and Electronics in Agriculture*, *113*, 14–23.

Rao, N. H. (2007). A framework for implementing information and communication technologies in agricultural development in India. *Technological Forecasting and Social Change*, *74*(4), 491–518. https://doi.org/10.1016/j.techfore.2006.02.002

Reed, J. T., Raddick, M. J., Lardner, A., & Carney, K. (2013). An Exploratory Factor Analysis of Motivations for Participating in Zooniverse, a Collection of Virtual Citizen Science Projects. *2013 46th Hawaii International Conference on System Sciences*, 610–619.

Reips, U.-D. (2012). Using the Internet to collect data. In *APA handbook of research methods in psychology, Vol 2: Research designs: Quantitative, qualitative, neuropsychological, and biological.* (pp. 291–310). American Psychological Association. https://doi.org/10.1037/13620-017

Rello, L., & Baeza-Yates, R. (2013). Good fonts for dyslexia. In *Proceedings of the 15th International ACM SIGACCESS Conference on Computers and Accessibility, ASSETS 2013*. https://doi.org/10.1145/2513383.2513447

Revilla, M., & Ochoa, C. (2017). Ideal and maximum length for a web survey. *International Journal of Market Research*, *59*(5), 557–565. http://10.0.9.197/IJMR-2017-039

Rhoades, E., & Aue, K. (2010). Social Agriculture: Adoption of Social Media by Agricultural Editors and Broadcasters. *Southern Association of Agricultural Scientists Conference, February, Orlando, FL*.

Roberts, L. D., & Allen, P. J. (2015). Exploring ethical issues associated with using online surveys in educational research. *Educational Research and Evaluation*, *21*(2), 95–108. https://doi.org/10.1080/13803611.2015.1024421

Rosen, C. (2019). *Citizen science helps farmers adapt to climate change - SciDev.Net*. SciDev.Net. https://www.scidev.net/global/agriculture/news/citizen-science-helps-farmers-adapt-to-climate-change.html?__cf_chl_jschl_tk__=96a2c11b7d430d9b3a3258ac83dff23bd6683d10-1588613660-0-AWZpUegHVqK7GBMkvS9wCmk2HydUQVq061nzPX5EAcY8ayEUjMf69nqSS

9JHeHeDYbuWcqT6a4X

Ryan, S. F., Adamson, N. L., Aktipis, A., Andersen, L. K., Austin, R., Barnes, L., Beasley, M. R., Bedell, K. D., Briggs, S., Chapman, B., Cooper, C. B., Corn, J. O., Creamer, N. G., Delborne, J. A., Domenico, P., Driscoll, E., Goodwin, J., Hjarding, A., Hulbert, J. M., … Dunn, R. R. (2018). The role of citizen science in addressing grand challenges in food and agriculture research. *Proceedings of the Royal Society B: Biological Sciences*, *285*(1891), 20181977. https://doi.org/10.1098/rspb.2018.1977

Schäfer, T., & Kieslinger, B. (2016). Supporting emerging forms of citizen science: A plea for diversity, creativity and social innovation. *Journal of Science Communication*, *15*(2), 1–12. https://doi.org/10.22323/2.15020402

Schenk, E., & Guittard, C. (2011). Towards a characterization of crowdsourcing practices. *Journal of Innovation Economics & Management*, *1*(7), 93–107.

Schmettow, M. (2012). Sample size in usability studies. *Communications of the ACM*, *55*(4), 64–70. https://doi.org/10.1145/2133806.2133824

Schneider, F., Fry, P., Ledermann, T., & Rist, S. (2009). Social Learning Processes in Swiss Soil Protection—The 'From Farmer - To Farmer' Project. *Human Ecology*, *37*(4), 475–489. https://doi.org/10.1007/s10745-009-9262-1

Scoones, I., & Thompson, J. (1994). *Beyond Farmer First: rural people's knowledge, agricultural research and extension practice. 1*. https://doi.org/10.3362/9781780442372

See, L., Fritz, S., Perger, C., Schill, C., McCallum, I., Schepaschenko, D., Duerauer, M., Sturn, T., Karner, M., Kraxner, F., & Obersteiner, M. (2015). Harnessing the Power of Volunteers, the Internet and Google Earth to Collect and Validate Global Spatial Information using Geo-Wiki. *Technological Forecasting and Social Change*, *98*, 324–335.

Shirk, J. L., Ballard, H. L., Wilderman, C. C., Phillips, T., Wiggins, A., Jordan, R., McCallie, E., Minarchek, M., Lewenstein, B. V, Krasny, M. E., & Bonney, R. (2012). Public Participation in Scientific Research: a Framework for Deliberate Design. *Ecology and Society*, *17*(2:29). https://doi.org/10.5751/ES-04705-170229

Singh, Ajoy Kumar, Singh, A. K., Kumar, R., Prakash, V., & Sundaram, P. K. (2017). Indian Cereals Saga: Standpoint and Way Forward. *Journal of AgriSearch*, *4*(1). https://doi.org/10.21921/jas.v4i1.7411

Singh, Anil Kumar, Upadhyaya, A., Kumari, S., Sundaram, P. K., & Jeet, P. (2020). Role of Agriculture in making India $5 trillion Economy under Corona Pandemic Circumstance. *Journal of AgriSearch*, *6*(02), 54–58. https://doi.org/10.21921/jas.v6i02.18097

Singh, K. M., Kumar, A., & Singh, R. K. P. (2015). Role of Information and Communication Technologies in Indian Agriculture: An Overview. *SSRN Electronic Journal*, *October 2017*. https://doi.org/10.2139/ssrn.2570710

Skitka, L. J., & Sargis, E. G. (2006). The Internet as psychological laboratory. *Annual Review of Psychology*, *57*(February 2006), 529–555. https://doi.org/10.1146/annurev.psych.57.102904.190048

Sran, A. K. (2019). Mobile Based Agricultural Management System for Indian Farmers.

In *Faculty of Business Administration*. https://doi.org/10.31826/9781463237813-toc

Staff, D. (2020). *As told to Parliament: 10,281 Indian farmers died by suicide in 2019*. DowntoEarth. https://www.downtoearth.org.in/news/agriculture/as-told-to-parliament-september-18-2020-10-281-indian-farmers-died-by-suicide-in-2019-73449

Stieger, S., Reips, U. D., & Voracek, M. (2007). Forced-response in online surveys: Bias from reactance and an increase in sex-specific dropout. *Journal of the American Society for Information Science and Technology*, *58*(11), 1653–1660. https://doi.org/10.1002/asi.20651

Sukhatame, P. V. (1950). Sample Surveys in Agriculture. *Proceedings Of The Thirty-Seventh Indian Science Congress*, 51–73.

Šūmane, S., Kunda, I., Knickel, K., Strauss, A., Tisenkopfs, T., Rios, I. des I., Rivera, M., Chebach, T., & Ashkenazy, A. (2018). Local and farmers' knowledge matters! How integrating informal and formal knowledge enhances sustainable and resilient agriculture. *Journal of Rural Studies*, *59*, 232–241. https://doi.org/10.1016/j.jrurstud.2017.01.020

Sumberg, J., Okali, C., & Reece, D. (2003). Agricultural research in the face of diversity, local knowledge and the participation imperative: Theoretical considerations. *Agricultural Systems*, *76*(2), 739–753. https://doi.org/10.1016/S0308-521X(02)00153-1

Sun, H., & Zhang, Y. (2010). Applying ergonomics to improve usability design of the interface of the "San Nong" (agriculture, rural areas and farmers) e-government website. *Proceedings of the International Conference on E-Business and E-Government, ICEE 2010*, 459–463. https://doi.org/10.1109/ICEE.2010.124

Tourangeau, R. (2004). Survey Research and Societal Change. *Annual Review of Psychology*, *55*, 775–801. https://doi.org/10.1146/annurev.psych.55.090902.142040

Treude, C., Barzilay, O., & Storey, M. A. (2011). How do programmers ask and answer questions on the web? (NIER track). *Proceedings - International Conference on Software Engineering*, 804–807. https://doi.org/10.1145/1985793.1985907

Tuten, T. L. (2010). Conducting online surveys. In *Advanced methods for conducting online behavioral research.* (pp. 179–192). American Psychological Association. https://doi.org/10.1037/12076-012

United Nations. (2019). World Population Prospects 2019. In *Department of Economic and Social Affairs, Population Division (2019). World Population Prospects 2019: Highlights (ST/ESA/SER.A/423)* (Issue 141). http://www.ncbi.nlm.nih.gov/pubmed/12283219

van de Gevel, J., van Etten, J., & Deterding, S. (2020). Citizen science breathes new life into participatory agricultural research. A review. *Agronomy for Sustainable Development*, *40*(5), 35. https://doi.org/10.1007/s13593-020-00636-1

Van Etten, J., Beza, E., Calderer, L., Van Duijvendijk, K., Fadda, C., Fantahun, B., Kidane, Y. G., Van De Gevel, J., Gupta, A., Mengistu, D. K., Kiambi, D. A. N., Mathur, P. N., Mercado, L., Mittra, S., Mollel, M. J., Rosas, J. C., Steinke, J., Suchini, J. G., & Zimmerer, K. S. (2019). First Experiences with a Novel Farmer Citizen Science Approach: Crowdsourcing Participatory Variety Selection through

On-Farm Triadic Comparisons of Technologies (TRICOT). *Experimental Agriculture*, *55*(S1), 275–296. https://doi.org/10.1017/S0014479716000739

Van Etten, J., de Sousa, K., Aguilar, A., Barrios, M., Coto, A., Dell'Acqua, M., Fadda, C., Gebrehawaryat, Y., van de Gevel, J., Gupta, A., Kiros, A. Y., Madriz, B., Mathur, P., Mengistu, D. K., Mercado, L., Mohammed, J. N., Paliwal, A., Pè, M. E., Quirós, C. F., … Steinke, J. (2019). Crop variety management for climate adaptation supported by citizen science. *Proceedings of the National Academy of Sciences of the United States of America*, *116*(10), 4194–4199. https://doi.org/10.1073/pnas.1813720116

Veeranjaneyulu, K. (2014). KrishiKosh: an institutional repository of National Agricultural Research System in India. *Library Management*, *35*(4/5), 345–354. https://doi.org/10.1108/lm-08-2013-0083

Venable, J. R., Pries-Heje, J., & Baskerville, R. (2017). Choosing a Design science research methodology. *Proceedings of the 28th Australasian Conference on Information Systems, ACIS 2017*.

Vogel, F. A. (1986). *Survey Design and Estimation for Agricultural Sample Surveys* (Issue May).

Vosough, A., Eghtedari, N., & Binaian, A. (2015). Factors Affecting ICT Adoption in Rural Area: A Case Study of Rural users in Iran. *Research Journal of Fisheries and Hydrobiology*, *10*(10), 611–616. http://www.aensiweb.net/AENSIWEB/rjfh/rjfh/2015/June/611-616.pdf

Weible, R., & Wallace, J. (1998). Cyber Research: The impact of the Internet on data collection. *Marketing Research*, *10*(3), 18–24.

http://dx.doi.org/10.1016/j.jaci.2012.05.050

White, A. (2019). *Local farmer knowledge of adaptive management on diversified vegetable and berry farms in the northeastern US*. https://scholarworks.uvm.edu/graddis/1019/

Williams, C. (2013). Crowdsourcing Research: A Methodology for Investigating State Crime. *State Crime Journal*, *2*(1), 30–51. https://doi.org/10.13169/statecrime.2.1.0030

Witte, J. C., Amoroso, L. M., & Howard, P. E. N. (2000). Research Methodology: Method and Representation in Internet-Based Survey Tools- Mobility, Community, and Cultural Identity in Survey. *Social Science Computer Review*, *18*(2), 179–195. https://doi.org/10.1177/089443930001800207

Wolfert, S., Ge, L., Verdouw, C., & Bogaardt, M. J. (2017). Big Data in Smart Farming – A review. *Agricultural Systems*, *153*, 69–80. https://doi.org/10.1016/j.agsy.2017.01.023

Wood, S. A., Jina, A. S., Jain, M., Kristjanson, P., & DeFries, R. S. (2014). Smallholder farmer cropping decisions related to climate variability across multiple regions. *Global Environmental Change*, *25*(1), 163–172. https://doi.org/10.1016/j.gloenvcha.2013.12.011

Wu, W., & Little, T. D. (2011). Quantitative Research Methods. *Encyclopedia of Adolescence*, *1*, 287–297. https://doi.org/10.1016/B978-0-12-373951-3.00034-X

Zhao, Z., Wei, F., Zhou, M., Chen, W., & Ng, W. (2015). Crowd-selection query processing in crowdsourcing databases: A task-driven approach. *EDBT 2015 - 18th*

International Conference on Extending Database Technology, Proceedings, 397–408. https://doi.org/10.5441/002/edbt.2015.35

Appendix

1. Informed Consent Form

Title: Design requirements for an online data exchange platform to bridge the gap between farmers and researchers in India

Researcher(s): Ashmean Kaur Sran, Faculty of Business Administration, Memorial University of Newfoundland, aksran@mun.ca

Supervisor(s): Dr. Jeffrey Parsons, Faculty of Business Administration, Memorial University of Newfoundland, jeffreyp@mun.ca

You are invited to take part in a research project entitled "Design requirements for an online data exchange platform to bridge the gap between farmers and researchers in India."

This survey is part of an investigation into developing design requirements for an online platform for exchanging agricultural data between farmers and researchers.

This form is part of the process of informed consent. It should give you a basic idea of what the research is about and what your participation will involve. It also describes your right to withdraw from the study. In order to decide whether you wish to participate in this research study, you should understand enough about its risks and benefits to be able to make an informed decision. This is the informed consent process. Take time to read this carefully and to understand the information given to you. Please contact the researcher, Ashmean Kaur Sran, if you have any questions about the study or for more information not included here before you consent.

It is entirely up to you to decide whether to take part in this research. If you choose not to take part in this research or if you decide to withdraw from the research once it has started, there will be no negative consequences for you, now or in the future.
The user gets the option to resume the survey from where they left by coming to the same survey link from the same device.
Please note that the responses will be anonymous, and your information will not be shared with any third party outside the research.

Introduction:

My name is Ashmean Kaur Sran, and I am a graduate student in the Faculty of Business Administration at the Memorial University of Newfoundland. As part of my master's thesis, I am conducting research under the supervision of Dr. Jeffrey Parsons.
This study aims at understanding the benefits of using a website-based online data exchange platform for agricultural data collection and dissemination over traditional methods. We made a prototype exchange platform to be tested by the sample users. Based on the feedback of the users for the platform, we will make recommendations for design requirements of similar data exchange platforms and how such a platform can be used by researchers in gathering data from remote areas that are hard to reach by field officers.

We also aim to share farm practices recommendations to farmers for the improvement of crop production and share information about the latest advancements in the agricultural sector.

By completing this survey, you will allow us to measure your trust and use of the online data exchange platform, which can result in the improvement of the online website for research purposes.

Purpose of study:

The purpose of the study is to gather general demographic and farm-related information along with crop-specific information from farmers without going in person to the farms to test the applicability of an online farm survey. We also ask the users to provide feedback about the design and usability of the website prototype. You will be asked to answer several standardized questions used by field officers for data collection and questions for website feedback. The survey fulfils the requirement of seeking quantitative information as a part of the investigation for the scope of a web-based online data exchange platform for farmers.

What you will do in this study:

In this study, you will be answering assessment questions presented to you in an online survey created for the research. You will be asked to answer several standardized demographic questions, questions concerning wheat production, your experience with field surveys, experience with various information sources available offline and online (through government or privately). The last portion of the survey asks for your feedback in using our prototype platform created for both data collection and data sharing with the farmers. Please try to answer all the questions while filling the survey. If at any point in time, you feel uncomfortable filling in the answers, you are free to withdraw by simply closing the survey tab.

Length of time:

The study will take approximately 20 minutes to complete.

Withdrawal from the study:

You may withdraw from the survey at any time simply by closing the survey tab or your internet browser. Once you hit the submit button, it will not be possible to remove your responses as the data will be completely anonymous. There are no consequences for withdrawing from the survey at any time.

Possible benefits:

You will have the opportunity to share your farm-specific problems and data directly with the agricultural researchers through our survey and get solutions as part of our report from their side. You will also get general information about government subsidies and schemes available for the farmers, along with direct links for weather information, Mandi (farmer market) rates, and other benefits. Lastly, you will be serving as a citizen scientist and be valuable for contributing to agrarian research.

Possible risks:

We request the participants to answer all the survey questions truthfully to the best of their knowledge; otherwise, there might be an accumulation of false data, which might hamper the research goals. Participation is completely voluntary. The data will be anonymous and confidential, so there are no social risks. There are no financial risks.

Confidentiality:

The ethical duty of confidentiality includes safeguarding participants' identities, personal information, and data from unauthorized access, use, or disclosure. Confidentiality is ensuring that the identities of participants are accessible only to those authorized to have access.

Only the researchers and authorized research assistants will have access to the data. Although the data from this research project may be published in journals and presented at conferences, the data will be reported in aggregate form so that it will not be possible to identify individuals. Moreover, the data is anonymous, and we are not collecting IP addresses. Please do not put your name or other identifying information in the survey.

Anonymity:

Anonymity refers to not disclose a participant's identifying characteristics, such as name or description of physical appearance.

There are no identifiers that will allow your data to be linked to you in the survey. This survey does not collect any identifying data (such as your name); however, it does ask for demographic data (such as age, level of education, etc.). Because names or specific identifying data are not collected as part of the main survey, your data will be anonymous and impossible to use to identify you.

Use, Access, Ownership and Storage of Data:

Questionnaires will be stored electronically on password-protected servers and computers (i.e., researchers' university laptops and desktop computers). No identifying information will be stored with the data or will be linked to the data files in any way (e.g., similar file names). The data will be kept for a minimum of five years, as per the Memorial University policy on Integrity in Scholarly Research. The data will not be used for archival purposes; rather, it will be maintained in case the research is "audited" by another researcher, or future analyses are required for revision purposes in the publication process.

Third-Party Data Collection and/or Storage:

Data collected from you as part of your participation in this project will be hosted and/or stored electronically by Qualtrics and is subject to their privacy policy and to any relevant laws of the country in which their servers are located. Therefore, anonymity and confidentiality of data may not be guaranteed in the rare instance, for example, that government agencies obtain a court order compelling the provider to grant access to specific data stored on their servers. If you have questions or concerns about how your data will be collected or stored, please contact the researcher and/or visit the provider's website for more information before participating. The privacy and security policy of the third-party hosting data collection and/or storing data can be found at: https://www.qualtrics.com/privacy-statement/.

Reporting of Results:

The collected data will be used in a thesis that will be published, submitted for journal publication, and potentially presented at conferences. The data will be reported without any personally identifying information. It will only be presented in an aggregated form. This thesis will be publicly available at Memorial University's QEII Library, which you can access using this URL: http://www.library.mun.ca/

Sharing of Results with Participants:

The feedback and results of the study will be available to the participants from the researcher's report. For more details, you can contact Ashmean Kaur Sran (aksran@mun.ca).

Questions:

We would be more than happy to answer any questions that you have about the study via email. If you would like more information about this study, please contact Ashmean Kaur Sran (aksran@mun.ca) or Dr. Jeffrey Parsons (jeffreyp@mun.ca).

The proposal for this research has been reviewed by the Interdisciplinary Committee on Ethics in Human Research and found to be in compliance with Memorial University's ethics policy. If you have ethical concerns about the research, such as the way you have been treated or your rights as a participant, you may contact the Chairperson of the ICEHR at icehr@mun.ca or by telephone at 709-864-2861.

Consent:

By completing this survey, you agree that:

- You have read the information about the research.
- You have been advised that you may ask questions about this study and receive answers prior to continuing.
- You are satisfied that any questions you had have been addressed.
- You understand what the study is about and what you will be doing.
- You understand that you are free to withdraw participation from the study by closing your browser window or navigating away from this page without having to give a reason and that doing so will not affect you now or in the future.
- You understand that once you hit the submit button, we will be unable to delete your data as it will be anonymous, and therefore, we cannot link individuals to their responses.

You can end your participation by simply closing your browser or navigating away from this page.

By consenting to this online survey, you do not give up your legal rights and do not release the researchers from their professional responsibilities.

Please retain a copy of this consent information for your records.

By clicking agree below and submitting this survey constitutes consent and implies your agreement to the above stipulations.

☐ I agree

☐ I do not agree

2. Website Feedback Survey Questionnaire

English and Punjabi translations provided)

GQ1) On a scale from 0-10, based on your experience today, how likely are you to recommend our website to a friend or colleague?

□ 0 □ 1 □ 2 □ 3 □ 4 □ 5 □ 6 □ 7 □ 8 □ 9 □ 10

GQ2) Overall, how satisfied or dissatisfied were you with your experience on our website today?

□ Extremely satisfied

□ Slightly satisfied

□ Neither satisfied nor dissatisfied

□ Slightly dissatisfied

□ Extremely dissatisfied

GQ3) What was the primary purpose of your visit to our website today?

□ I wanted to contribute towards data collection

□ I was just browsing

□ I was researching through the farming information

□ Other (specify)

GQ4) How likely would you be to return to this website?

□ Extremely likely

□ Slightly unlikely

□ Slightly likely

□ Neither likely nor unlikely

□ Extremely unlikely

GQ5) How much more time would you be likely to spend on this website in the future?

□ A great deal

□ A lot

□ A moderate amount

□ A little

□ None at all

GQ6) How willing would you be to seek farming information from this website?

□ Extremely willing
□ Very willing
□ Moderately willing
□ Slightly willing
□ Not willing at all

GQ7) Please share any additional feedback that could help us improve your experience of our website.

____

WN Please answer a few questions related to website navigation

WN1) Were you able to find links available on the web pages easily?

□ Extremely likely
□ Slightly likely
□ Neither likely nor unlikely
□ Slightly unlikely
□ Extremely unlikely

WN2) Were you able to navigate to other pages easily?

□ Extremely likely
□ Slightly likely
□ Neither likely nor unlikely
□ Slightly unlikely
□ Extremely unlikely

WN3) Did the links take you to the relevant pages?

□ Extremely likely
□ Slightly likely
□ Neither likely nor unlikely
□ Slightly unlikely
□ Extremely unlikely

WC Please answer questions about the content of the website

WC1) Did you find this website meaningful?

□ Extremely likely
□ Slightly likely
□ Neither likely nor unlikely
□ Slightly unlikely
□ Extremely unlikely

WC2) Did you find the content on the website relevant?

□ Extremely likely
□ Slightly likely
□ Neither likely nor unlikely
□ Slightly unlikely
□ Extremely unlikely

WC3) Could you search the content you were looking for?

□ Extremely likely
□ Slightly likely
□ Neither likely nor unlikely
□ Slightly unlikely
□ Extremely unlikely

WC4) On a scale from 0-10, based on your experience today, how likely are you to recommend our website to a friend or colleague?

□ 0 □ 1 □ 2 □ 3 □ 4 □ 5 □ 6 □ 7 □ 8 □ 9 □ 10

WC5) On a scale from 0-10, based on your experience today, how likely are you to recommend our website to a friend or colleague?

□ 0 □ 1 □ 2 □ 3 □ 4 □ 5 □ 6 □ 7 □ 8 □ 9 □ 10

WP Please answer a few questions related to the website performance

WP1) Did it take too long to load the website?

□ Extremely likely
□ Slightly likely
□ Neither likely nor unlikely
□ Slightly unlikely
□ Extremely unlikely

WP2) On a scale from 0-10, based on your experience today, how likely are you to recommend our website to a friend or colleague?

□ 0 □ 1 □ 2 □ 3 □ 4 □ 5 □ 6 □ 7 □ 8 □ 9 □ 10

Thank you very much!

GQ1) ਤੁਹਾਡੇ ਅੱਜ ਦੇ ਤਜ਼ਰਬੇ ਦੇ ਅਧਾਰ ਤੇ 0-10 ਪੈਮਾਨੇ 'ਤੇ ਤੁਹਾਡੀ ਆਪਣੇ ਦੋਸਤ, ਪਰਿਵਾਰ ਦੇ ਮੈਂਬਰ ਜਾਂ ਹੋਰ ਕਿਸਾਨ ਨੂੰ ਸਾਡੀ ਵੈਬਸਾਈਟ ਦੀ ਸਿਫਾਰਸ਼ ਦੀ ਕਿੰਨੀ ਸੰਭਾਵਨਾ ਹੈ?

□ 0 □ 1 □ 2 □ 3 □ 4 □ 5 □ 6 □ 7 □ 8 □ 9 □ 10

GQ2) ਕੁਲ ਮਿਲਾ ਕੇ, ਤੁਸੀਂ ਅੱਜ ਸਾਡੀ ਵੈਬਸਾਈਟ ਤੇ ਆਪਣੇ ਤਜ਼ਰਬੇ ਤੋਂ ਕਿੰਨੇ ਸੰਤੁਸ਼ਟ ਜਾਂ ਅਸੰਤੁਸ਼ਟ ਹੋ?

□ ਬਹੁਤ ਸੰਤੁਸ਼ਟ

□ ਥੋੜ੍ਹਾ ਅਸੰਤੁਸ਼ਟ

□ ਥੋੜ੍ਹਾ ਸੰਤੁਸ਼ਟ

□ ਬਹੁਤ ਅਸੰਤੁਸ਼ਟ

□ ਨਾ ਤਾਂ ਸੰਤੁਸ਼ਟ ਅਤੇ ਨਾ ਹੀ ਅਸੰਤੁਸ਼ਟ

GQ3) ਅੱਜ ਸਾਡੀ ਵੈਬਸਾਈਟ ਤੇ ਤੁਹਾਡੇ ਆਉਣ ਦਾ ਕੀ ਉਦੇਸ਼ ਸੀ?

□ ਮੈਂ ਡੇਟਾ ਇਕੱਠਾ ਕਰਨ ਲਈ ਯੋਗਦਾਨ ਪਾਉਣਾ ਚਾਹੁੰਦਾ ਸੀ

□ ਮੈਂ ਬੱਸ ਵੇਖ ਰਿਹਾ ਸੀ

□ ਮੈਂ ਖੇਤੀ ਬਾਰੇ ਜਾਣਕਾਰੀ ਦੀ ਖੋਜ ਕਰ ਰਿਹਾ ਸੀ

□ ਹੋਰ

GQ4) ਤੁਹਾਡੀ ਇਸ ਵੈਬਸਾਈਟ ਤੇ ਵਾਪਸ ਆਉਣ ਦੀ ਕਿੰਨੀ ਸੰਭਾਵਨਾ ਹੋ?

□ ਬਹੁਤ ਸੰਭਾਵਨਾ ਹੈ

□ ਸੰਭਾਵਨਾ ਨਹੀਂ ਹੈ

□ ਥੋੜੀ ਜਿਹੀ ਸੰਭਾਵਨਾ ਹੈ

□ ਬਿਲਕੁਲ ਸੰਭਾਵਨਾ ਨਹੀਂ ਹੈ

□ ਹੋ ਸਕਦਾ ਹੈ ਤੇ ਨਹੀਂ ਵੀ

GQ5) ਭਵਿੱਖ ਵਿੱਚ ਤੁਸੀਂ ਇਸ ਵੈਬਸਾਈਟ ਤੇ ਹੋਰ ਕਿੰਨਾ ਸਮਾਂ ਵਤੀਤ ਕਰੋਗੇ?

□ ਬਹੁਤ ਸਾਰਾ

□ ਬੋਹਤ ਘੱਟ

□ ਸੀਮਤ ਸਮਾਂ

□ ਕੋਈ ਵੀ ਨਹੀਂ

□ ਥੋੜਾ ਬੋਹਤ

GQ6) ਤੁਸੀਂ ਇਸ ਵੈਬਸਾਈਟ ਤੋਂ ਖੇਤੀ ਬਾਰੇ ਜਾਣਕਾਰੀ ਲੈਣ ਲਈ ਕਿੰਨੇ ਤਿਆਰ ਹੋ?

□ ਬਹੁਤ ਤਿਆਰ ਹਾਂ

□ ਥੋੜ੍ਹਾ ਜਿਹਾ ਤਿਆਰ

□ ਤਿਆਰ ਹਾਂ

□ ਬਿਲਕੁਲ ਵੀ ਤਿਆਰ ਨਹੀਂ

□ ਸੀਮਤ ਤਿਆਰ

GQ7) ਕਿਰਪਾ ਕਰਕੇ ਸਾਡੀ ਵੈੱਬਸਾਈਟ ਨੂੰ ਬਿਹਤਰ ਬਣਾਉਣ ਲਈ ਕੋਈ ਸੁਝਾਅ ਦੇ ਕੇ ਸਾਡੀ ਮਦਦ ਕਰੋ।

____

WN ਕਿਰਪਾ ਕਰਕੇ ਵੈਬਸਾਈਟ ਨੈਵੀਗੇਸ਼ਨ ਨਾਲ ਜੁੜੇ ਕੁਝ ਪ੍ਰਸ਼ਨਾਂ ਦੇ ਜਵਾਬ ਦਿਓ

WN1) ਕੀ ਤੁਸੀਂ ਵੈਬ ਪੇਜਾਂ ਤੇ ਉਪਲਬਧ ਲਿੰਕਾਂ ਨੂੰ ਅਸਾਨੀ ਨਾਲ ਲੱਭਣ ਯੋਗ ਸੀ?

□ ਬਹੁਤ ਸੰਭਾਵਨਾ ਹੈ

□ ਸੰਭਾਵਨਾ ਨਹੀਂ ਹੈ

□ ਥੋੜੀ ਜਿਹੀ ਸੰਭਾਵਨਾ ਹੈ

□ ਬਿਲਕੁਲ ਸੰਭਾਵਨਾ ਨਹੀਂ ਹੈ

□ ਹੋ ਸਕਦਾ ਹੈ ਤੇ ਨਹੀਂ ਵੀ

WN2) ਕੀ ਤੁਸੀਂ ਬਾਕੀ ਪੰਨਿਆਂ 'ਤੇ ਅਸਾਨੀ ਨਾਲ ਜਾ ਸਕੇ?

□ ਬਹੁਤ ਸੰਭਾਵਨਾ ਹੈ

□ ਸੰਭਾਵਨਾ ਨਹੀਂ ਹੈ

□ ਥੋੜੀ ਜਿਹੀ ਸੰਭਾਵਨਾ ਹੈ

□ ਬਿਲਕੁਲ ਸੰਭਾਵਨਾ ਨਹੀਂ ਹੈ

□ ਹੋ ਸਕਦਾ ਹੈ ਤੇ ਨਹੀਂ ਵੀ

WN3) ਕੀ ਲਿੰਕ ਤੁਹਾਨੂੰ ਸੰਬੰਧਿਤ ਪੰਨਿਆਂ ਤੇ ਲੈ ਕੇ ਗਏ?

□ ਬਹੁਤ ਸੰਭਾਵਨਾ ਹੈ

□ ਸੰਭਾਵਨਾ ਨਹੀਂ ਹੈ

□ ਥੋੜ੍ਹੀ ਜਿਹੀ ਸੰਭਾਵਨਾ ਹੈ

□ ਬਿਲਕੁਲ ਸੰਭਾਵਨਾ ਨਹੀਂ ਹੈ

□ ਹੋ ਸਕਦਾ ਹੈ ਤੇ ਨਹੀਂ ਵੀ

WC ਕਿਰਪਾ ਕਰਕੇ ਵੈਬਸਾਈਟ ਦੇ ਅੰਸ਼ ਬਾਰੇ ਪ੍ਰਸ਼ਨਾਂ ਦੇ ਜਵਾਬ ਦਿਓ

WC1) ਕੀ ਤੁਸੀਂ ਇਸ ਵੈਬਸਾਈਟ ਨੂੰ ਸਮਝ ਸਕੇ?

□ ਬਹੁਤ ਸੰਭਾਵਨਾ ਹੈ

□ ਸੰਭਾਵਨਾ ਨਹੀਂ ਹੈ

□ ਥੋੜ੍ਹੀ ਜਿਹੀ ਸੰਭਾਵਨਾ ਹੈ

□ ਬਿਲਕੁਲ ਸੰਭਾਵਨਾ ਨਹੀਂ ਹੈ

□ ਹੋ ਸਕਦਾ ਹੈ ਤੇ ਨਹੀਂ ਵੀ

WC2) ਕੀ ਤੁਹਾਨੂੰ ਵੈਬਸਾਈਟ ਦੇ ਅੰਸ਼ ਢੁੱਕਵੇਂ ਲੱਗੇ?

□ ਬਹੁਤ ਸੰਭਾਵਨਾ ਹੈ

□ ਸੰਭਾਵਨਾ ਨਹੀਂ ਹੈ

□ ਥੋੜ੍ਹੀ ਜਿਹੀ ਸੰਭਾਵਨਾ ਹੈ

□ ਬਿਲਕੁਲ ਸੰਭਾਵਨਾ ਨਹੀਂ ਹੈ

□ ਹੋ ਸਕਦਾ ਹੈ ਤੇ ਨਹੀਂ ਵੀ

WC3) ਕੀ ਤੁਸੀਂ ਜਿਸ ਅੰਸ਼ ਦੀ ਭਾਲ ਕਰ ਰਹੇ ਸੀ, ਉਸਨੂੰ ਲੱਭਣ ਵਿੱਚ ਸਫ਼ਲ ਰਹੇ?

□ ਬਹੁਤ ਸੰਭਾਵਨਾ ਹੈ

□ ਸੰਭਾਵਨਾ ਨਹੀਂ ਹੈ

□ ਥੋੜ੍ਹੀ ਜਿਹੀ ਸੰਭਾਵਨਾ ਹੈ

□ ਬਿਲਕੁਲ ਸੰਭਾਵਨਾ ਨਹੀਂ ਹੈ

□ ਹੋ ਸਕਦਾ ਹੈ ਤੇ ਨਹੀਂ ਵੀ

WC4) ਤੁਹਾਡੇ ਅੱਜ ਦੇ ਤਜ਼ਰਬੇ ਦੇ ਅਧਾਰ ਤੇ 0-10 ਪੈਮਾਨੇ 'ਤੇ ਵੈੱਬਸਾਈਟ ਦੇ ਅੰਸ਼ ਦੀ ਸਪਸ਼ਟਤਾ ਨੂੰ ਕਿੰਨਾ ਰੇਟ ਕਰੋਗੇ?

□ 0 □ 1 □ 2 □ 3 □ 4 □ 5 □ 6 □ 7 □ 8 □ 9 □ 10

WC5) ਤੁਹਾਡੇ ਅੱਜ ਦੇ ਤਜ਼ਰਬੇ ਦੇ ਅਧਾਰ ਤੇ 0-10 ਪੈਮਾਨੇ 'ਤੇ ਵੈੱਬਸਾਈਟ ਦੇ ਅੰਸ਼ ਦੀ ਸੰਜੋਗਤਾ ਨੂੰ ਕਿੰਨਾ ਰੇਟ ਕਰੋਗੇ?

□ 0 □ 1 □ 2 □ 3 □ 4 □ 5 □ 6 □ 7 □ 8 □ 9 □ 10

WP ਕਿਰਪਾ ਕਰਕੇ ਵੈਬਸਾਈਟ ਦੇ ਪ੍ਰਦਰਸ਼ਨ ਨਾਲ ਜੁੜੇ ਕੁਝ ਪ੍ਰਸ਼ਨਾਂ ਦੇ ਜਵਾਬ ਦਿਓ

WP1) ਕੀ ਵੈਬਸਾਈਟ ਨੂੰ ਲੋਡ ਕਰਨ ਵਿੱਚ ਬਹੁਤ ਜ਼ਿਆਦਾ ਸਮਾਂ ਲੱਗਿਆ ਹੈ?

□ ਬਹੁਤ ਸੰਭਾਵਨਾ ਹੈ □ ਸੰਭਾਵਨਾ ਨਹੀਂ ਹੈ

□ ਥੋੜੀ ਜਿਹੀ ਸੰਭਾਵਨਾ ਹੈ □ ਬਿਲਕੁਲ ਸੰਭਾਵਨਾ ਨਹੀਂ ਹੈ

□ ਹੋ ਸਕਦਾ ਹੈ ਤੇ ਨਹੀਂ ਵੀ

WP2) ਤੁਹਾਡੇ ਅੱਜ ਦੇ ਤਜ਼ਰਬੇ ਦੇ ਅਧਾਰ ਤੇ 0-10 ਪੈਮਾਨੇ 'ਤੇ ਵੈੱਬਸਾਈਟ ਦੇ ਪ੍ਰਦਰਸ਼ਨ ਨੂੰ ਕਿੰਨਾ ਰੇਟ ਕਰੋਗੇ?

□ 0 □ 1 □ 2 □ 3 □ 4 □ 5 □ 6 □ 7 □ 8 □ 9 □ 10

ਧੰਨਵਾਦ!