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MOBILE USER INTERFACE DESIGN FOR SMALLHOLDER AGRICULTURE TO BE A SMART FARMER: A SCOPING REVIEW

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Abstract:

Mobile user interface (UI) design plays a very important role in determining an application that can be adopted by all types of users, especially those residing in rural areas. This review aims to provide a mapping of previously published studies on mobile UI design application for smallholder agriculture to be a smart farmer. The focus of this scoping review is on the design elements of the proposed UI, strategies of inquiry used and to find out if there is a UI design that involves geospatial context by published articles. The results show that interview and observation are the most common field study methods used to obtain information in designing mobile UI, and the most widely applied UI elements are audio and Interactive Voice Response (IVR). There are many user interface elements that can be used by farmers who have different skills level in dealing with mobile technology. Icon interface is an important element in designing mobile UI for rural farmers based on previous results. Other than that, the use of location function in mobile UI design shows an upward trend where three recent articles used location function to report crop pest and disease and determine the nearest market location. In addition, there is a need to design geospatial elements such as map for mobile UI that match the skills of rural farmers to support the fourth Industrial Revolution in agriculture to be a smart farmer.

Keywords:

Mobile, User Interface Design, Agriculture, Rural Farmer

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Introduction

Agriculture is a form of plant-based activity such as cash crops (i.e., vegetables, fruits) and plantations (i.e., oil palm, rubber) that bring cash to growers and help in growing the economy of the country. ICT plays an important role in the agricultural sector in providing infrastructure and platform to support decision making by different stakeholders in this sector (Romani *et al*., 2015).

According to the High Level Panel of Experts on Food Security and Nutrition (2019), innovations in agriculture and food systems are different from other sectors, as process ecology and social interactions play a major role. Adaptation to local environmental and social conditions are critical in the innovation process. In this context, mobile devices are one of the powerful ICT tools for farmers to overcome digital and information barriers (Romani *et al*., 2015). Hence, it is important for rural farmers to participate in studies related to the use of mobile technology in agriculture.

Digital technology has changed the agriculture sector but so far, the process is not really systematic due to digital divide between urban and rural agriculture and challenges in the digitalization of agriculture and food value chain. As mentioned by Trendov *et al*. (2019), digital agriculture requires the cooperation of all parties directly and indirectly in the agricultural sector to exploit digital farming opportunities for rural farmers. Transformations must be carefully planned to avoid increasing digital divide between the economy and the sector and between those with different capabilities to adopt new technologies (OECD, n.d.).

A study by Cheboi *et al*. (2018) stated that there are cases of low mobile adoption by farmers due to the their lack of understanding in the user interface elements of their mobile devices (Admodisastro *et al.*, 2015; Jamali *et al*., 2017). Design using elements of user interface are the basic for building a knowledge-design mobile user interface for low literacy and low skills users (Belay *et al*. (2016), and should be different from that of literate users (Medhi *et al*., 2006; Gitau *et al*., 2010; Chaudry *et al*., 2012).

In addition, the use of location data in the era of ICT added a new value and spatial dimension to existing information. Having access to a user's location is crucial to achieve the goal of location analysis or effective location intelligence (Koohikamali *et al*., 2019). Geospatial functionality developed in mobile applications is very important and needs to be emphasized in terms of functionality and user interface as it provides useful guide for users to find a location for reports, near a place, etc.

Lee and Baharuddin (2018) stated that technology is a platform that can make agriculture more productive and sustainable. UI acts as a gateway for the system's interaction with users that can enrich user's experience, increase usability and promote the use of technology (Bayor *et al*., 2018).

Material And Methods

This scoping review framework is based on the study of Arksey and O'Malley (2005) with modifications suggested by Levac et al. (2010). There is no universally accepted definition nor purpose for scoping review (Levac et al., 2010; Pham et al., 2014). However, a key feature of this method is that it provides a broad overview of the topic (Pham et al., 2014; Moher et al., 2015), rather than depth of evidence (Davis et al., 2009; Joanna Briggs Institute, 2015).

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The general purpose of conducting a scoping review is to identify and map out the available evidence (Arksey & O'Malley, 2005; Anderson et al., 2008). Therefore, this scoping review was conducted to identify the design methods, recommended UI elements and examine whether there is geospatial context used in published articles related to smallholder farmers. Our review consists of five stages. Stage 1 involved the identification of research questions in which three research questions are developed for this scoping review. First, what are the UI design elements proposed by published articles? Two, what strategies of inquiry are used in published articles? Three, is there any location function used in mobile UI design in published articles?

Stage 2 involved the process of searching for relevant articles. Three databases were selected and search were done through Scopus, ProQuest and Google Scholar. Strategy for the search was comprehensive search string through keyword-title-abstract related to mobile, UI design, agriculture, rural farmer and geospatial combined with Boolean operators OR and AND (Table 1). Stage 3 involved selection of relevant articles in which articles were screened according to the order of title, abstract and then full text. Articles are included in this scoping review if they include the research terms as in Table 1. We limit our inclusion criteria only to English publications and no search restrictions are made on geographic location nor publication date.

Stage 4 involved data charting in which some of the data from the included articles are compiled into charting form (Table 2) for analysis. Information on the publication, study design and key findings are recorded in this form. Stage 5 involved consolidating, summarizing, and reporting results using data charting form. The results were presented using a narrative approach in which the findings explore the relationships within and between studies to provide a synthesis of relevant literatures.

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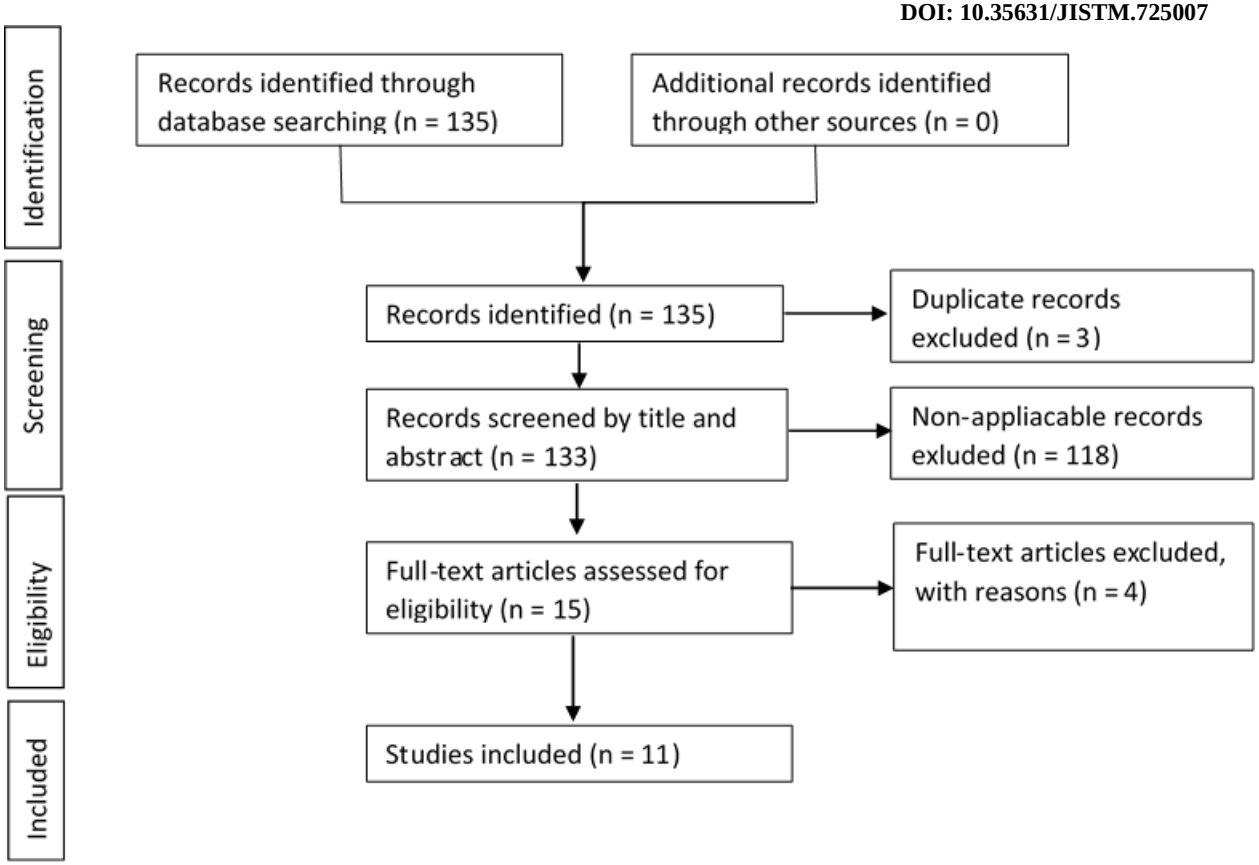

Figure 1: Flow Process For Study Selection Using Preferred Reporting Items For Systematic Review (PRISMA)

Source: (Shamseer Et Al., 2015)

Table 1: Search String Used In Scopus, Proquest And Google Scholar

Research components	Research terms
#1 Mobile	"mobile" OR "mobile location based services" OR "mobile GIS"
#2 User interface design	"user interface" OR "user interface design" OR "graphical user interface"
#3 Rural farmer	"rural farmer" OR "smallholder farmer" OR "small farmer" OR "small-scale agriculture" OR "agriculture"
#4 Combination	#1 AND #2 AND #3

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Table 2: Charting Form

Publication	Study design	Main findings related to mobile UI design	UI element in geospatial context
Macharia (2009)	Observation and interview	MobiFarmSupp is a mobile UI designed for phones that use traditional keypad. It displays information in text form on pests and diseases as well as prevention materials available in the market.	No
Penuel (2010)	Interview, benchmarking, background research, heuristic evaluation, persona, use cases, and prototype testing	M-Mkulima is an emergency system to help farmers manage pandemic crop diseases designed using tabs and text free UI elements.	No
Patel *et al.* (2010)	Interview, questionnaire, focus group discussion	Avaaj Otalo (literally, "voice stoop") is an interactive voice app for small-scale farmers in Gujarat, India. It uses forums to ask and browse questions and responses from others on various agricultural topics through Interactive Voice Response (IVR).	No
Rege and Nagarkar (2010)	Ethnographic, formative evaluation (scenario based testing)	KrishiMitra's UI is carefully designed using common audio-visual-text cues and high-capability metaphors that are easily understood by various types of users.	No
Dittoh *et al.* (2013)	Interview and questionnaire	Voice-based prototype development allows medium to large scale farmers in rural areas to place ads on the World Wide Web through the use of Interactive Voice Response (IVR) in local languages.	No
Cuendet *et al.* (2013)	Observation	VideoKheti is a mobile system using audio, graphics, icons and touch enabling low-literate farmers in rural India to interact in their own language and dialect.	No
Agrawal *et al.* (2013)	Observation	Designing mobile applications using image icons, buttons and audio recorder elements for the low literacy level of Indian farmers.	No
Medhi-Thies *et al.* (2015)	Interview using mediators	KrishiPustak allows farmers to make posts and reply to posts using audio-visual content.	No
Marques (2017)	Interview and observation	EyesOnFarm is a high-fidelity prototype mobile that uses a combination of several UI elements such as icons, buttons,	Yes

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		dropdown lists, text fields, toggles, search fields, date fields that use the Portuguese dialect.	
Vijayasekar (2018)	Interview	AgriICT uses a combination of UI elements such as icon, text-free, speech to text function, audio feedback including UI maps for text content such as place names and locations.	Yes
Masinde and Thothela (2019)	Questionnaire	UI of ITIKI Plus was developed to accommodate small rural and semi-literate farmers by using picture icons that are more familiar to farmers instead of plain text. However, the login section uses a text free form.	Yes (longitude and latitude are retrieved automatically)

Results And Discussion

Referring to Figure 1, there are 135 total publications obtained through database search. From this number, 3 articles were removed due to duplication, 118 articles were removed based on their titles and abstracts, and finally, 4 articles were removed after full review. Thereby, 11 articles were selected to be included in this scoping review using preferred reporting as in Shamseer et al. (2015) (Figure 1).

Classification Of Research Publications Based On Geographical Location

Based on geographical locations, the articles included in this review (see Table 2) include six from Asia (India), one from Europe (Portugal), and four from Africa (two from Kenya, one from Ghana and one from three African countries namely Kenya, Mozambique and South Africa). More than half (54.55%) of the publications are from India and 18.18% are from Kenya. Meanwhile Ghana, Portugal, and a combination of three countries mentioned earlier contributed 9.09% of publications for this research.

Strategies Of Inquiry For Published Articles

Seven out of eleven studies involved in this scoping review used more than one research methods. Interview is the most widely used method where seven studies (Macharia, 2009; Penuel, 2010; Patel *et al.*, 2010; Dittoh *et al.*, 2013; Medhi-Thies *et al.*, 2015; Marques, 2017; Vijayasekar, 2018) used interview as one of the methods in assessing the usability of mobile UI. According to Farrel (2016), interviewing people about their tasks and challenges gives very rich information. This is followed by observation method used by four studies (Macharia, 2009; Cuendet *et al.*, 2013; Agrawal *et al.*, 2013; Marques, 2017) and questionnaire method used by three studies (Patel *et al.*, 2010; Dittoh *et al.*, 2013; Masinde and Thothela, 2019).

Implementation Of Mobile User Interface Elements In Published Articles

As seen in the 11 papers given in Table 2, audio and Interactive Voice Response (IVR) are the most widely applied elements in designing UI either independently or combined with other UI elements. Furthermore, it can be seen that there is the use of various elements to design a mobile UI that is appropriate to the capabilities of rural farmers consisting of the diversity of users in these three studies (Marques, 2017; Vijayasekar, 2018); Masinde and Thothela, 2019). Illustrative or icon images are the main UI elements used in all three studies. According to Idris

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et al. (2017), image icons are one of the interface elements that correspond to semi-literate and illiterate users.

Geospatial Context In Mobile User Interface Design

Along with the development of mobile technology, the design of mobile UI has also changed where there is a need to include geospatial elements in the gadget. This is because there is a need for farmers to locate the areas that are vulnerable to pests and diseases threats as well as provide information on the location of crops invaded to relevant parties through a map embedded in mobile application

Such as studies by Marques (2017) and Masinde and Thothela (2019). Meanwhile, Vijayasekar (2018) used geolocation to inform farmers about price trend of agricultural products in different markets near the users' locations or find out the price trend in a selected location. These three studies provided a new dimension in designing mobile UI involving geospatial context by providing additional elements related to location.

UI applications with map embedded are better known as mobile location based services, mobile map or mobile GIS (Geographic Information System). Marques's (2017) study found that the design of mobile interface on the mapping part should also be emphasized to ensure that users are not confused while operating the mapping interface. Small screen size (Kuper, 2018; Ricker & Roth, 2018) is one of the constraints of map elements for mobile devices (Ricker & Roth, 2018) where the reduced display size can cause design problems for static and interactive maps (Roth *et al*., 2017). Therefore, it is important to understand farmers' skills in reading and manipulating digital maps on mobile device to empower them with digital technology to become smart farmers.

The exponential capabilities of mobile technology have made it possible to design mobile UI that suits target users such as rural farmers. Because interaction between people and mobile phones is becoming more complex with the continuous improvement of mobile phone technology (Cerny *et al*., 2015), UI greatly influences how people control and manipulate mobile phones. The design quality of the UI is a major factor in mobile phone design (Liu, 2016), and UI design should aim to make user interaction as simple and as efficient as possible (Kunjachan, 2010).

Danes *et al*. (2014) argued that mobile applications intended for farmers should have an easy-to-use design. Research also shows that there is low adoption of mobile applications by farmers because such applications are not user friendly (Awuor, 2013). A study by Rahim *et al*. (2018) showed that farmers are generally interested in adopting the right agricultural technology as they have a positive perception on the benefits of technology in agriculture (Ashari *et al*., 2015). Mahamood (2018) pointed out that innovation features influence technology adoption among farmers.

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