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Development of a mobile app for recording and management alert on-farm to supporting beef cattle smallholder farmers

Saengwong, S.[1*], Thannithi, W.[1], Intawicha, P.[1] and Porkaew, C.[2]

[1]Division of Animal Science, School of Agriculture and Natural Resources, University of Phayao, Phayao, 56000, Thailand; [2]Division of Software Engineering, School of Information and Communication Technology, University of Phayao, Phayao, 56000, Thailand.

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Abstract The results showed that the farmers were male (78%), and almost half (48%) of the respondents were over 51 years of age, with their highest education level of primary school (40%). Most of the farmers raised cattle in semi-intensive systems (76%) and 52% had small sized farms. 58% of the farmers had kept farm data records, and 100% of the farmers had not recorded to keep the system. In terms of mobile phone usage, 100% of the farmers had internet access, 58% had used their phones to update to new farming technologies. The main features of the app included an animal's individual information, breeding history, complete vaccination and treatment history, sale records, vaccination and deworming program. The users' completed satisfaction surveys, from a total of 50 respondents demonstrated that the overall satisfaction score was 4.13, which they satisfied with the beef cattle farm management recording system (BCFM) mobile app. Our findings suggested that farmers should be motivated to realize the advantages of farm record keeping and moblie app usage for the adoption of new technologies such as the use of sensors or Internet of Things (IoT) to start projects involving "Smart Cattle Farming" for smallholder farmers.

Keywords: Beef cattle, Mobile app, Notification, Record keeping, Smart farmers

Introduction

Beef cattle farm structures in Thailand can be classified which consisting of 4 groups, according to the number of cattle and size of the farms. In 2018, most beef cattle farmers were smallholders 96.28%, who raised 1-20 heads. Followed by farmers who raised 21-100 heads 3.59%, 101-200 heads 0.09% and more than 200 heads only 0.04%, respectively. The population of beef cattle decreased by approximately 3.15 million heads as compared with that of 2009; in the same way, the farmer population also decreased by approximately 40%. However, the annual beef consumption rate increased by approximately 5-10 percent per year and increased to a high rate (Osothongs *et*

[*] **Corresponding Author:** Saengwong, S.; **Email:** sureeporn.sa@up.ac.th

al., 2016; Angkuraseranee *et al*., 2019). The structure of Thai beef cattle production in 2018 was such that the northeastern region was the main source of beef cattle production followed by the central, northern and southern regions (48.76%, 19.38%, 17.00% and 14.85% respectively) (Department of Livestock Development, 2018b).

Thailand has made trade agreements with Australia and New Zealand (Thailand-Australia Free Trade Agreement: TAFTA; Thailand - New Zealand Closer Economic Partnership: TNZCEP), that reduces the tariffs put on frozen beef, which will remain at 0% until 2021. This may affect the price of beef and the quality of beef in the country may decrease. However, Thailand still has the potential to enhance the competitiveness of its beef cattle market, because the country is located at a key logistics hub near China and other countries in the ASEAN region, such as Malaysia, Cambodia, Laos, and Vietnam. Moreover, growing demand for beef in China is continuing to increase, whilst production levels there are inadequate. China was the second largest beef importer in the world in 2018, accounting for 14% of the world's beef imports (USDA, 2019). As a result of the above factors, the government has brought forward a policy to support farmers by helping to prepare and encourage them to comply with the Good Agricultural Practices (GAP) standard; this provides confidence among consumers that they are buying value-added products and it makes exporting to international markets an easier task (Department of Livestock Development, 2018a).

Record keeping on farms is an important aspect for achievement of the GAP standard, good records of an animal's individual information like its date of birth, breeding information, vaccination history, health problems, treatment given, purchases and sales, production cost, and profits, help in relation to assessment of production performance evaluation and production planning. Various farm management information systems have been developed to support the management of businesses or large farms. Smallholder farmers lack the tools to make informed decisions and do not record information about stock numbers, an animal's routine tasks, breeding information, health, diseases and treatment, production costs and farm profits etc. (Paraforos *et al*., 2016). A limited number of record keeping technologies are available to Thai beef cattle smallholder farmers. For instance, beef cattle smallholder farmers in northern Thailand found that about 52% of farmers keep records but that they recorded only an animal's individual information, such as its breeding date and date of birth (Saengwong *et al*., 2020).

Technology is changing the face of livestock farming by enabling farmers to increase production, reduce costs and amount of labor. Future farm operations will work differently from those of the past, primarily because of

advancements in new technology, including cloud technology, mobile technology, sensors, Artificial Intelligence, big data, blockchain, robotics and the Internet of Things (IoTs). Mobile phones provide an opportunity for farmers to increase their farm production rates because they can be used to communicate, disseminate, store and manage information (Lahan and Deka, 2019). Smallholder farming systems often lack access to agricultural input, credit, and have an inability to bear risks. Another major problem is the information and skills gap that constrains the adoption of available technologies and management practices, and a lack of knowledge about the adoption of ICT standards in the agricultural sector (Kabir, 2015; Ndekwa and Victor, 2018). New technologies provide new opportunities and a failure to adopt and accept them has become a significant problem for both farmers and researchers (Singh and Kameswari, 2019).

The researchers were motivated to develop a mobile app as a tool for record keeping systems, since mobile apps are relatively easy to adopt and because mobile phone technology has become increasingly available. The research aims were to investigate the characteristics of the farms under observation in terms of farm record keeping and mobile phone usage of the beef cattle farmers, to develop a mobile app that could be used as a tool for record keeping and to collect user satisfaction data with regards to usage of the beef cattle farm management recording system mobile app.

Materials and methods

Farm characteristics, farm record keeping and mobile phone usage survey of beef cattle farmers

The beef cattle farm management recording system (BCFM app) was created. The first step was developed a questionnaire survey with questions focused on farm characteristics, management information recording and the mobile phone usage of the beef cattle farmers. The survey was conducted from January to August 2019 through interviews with the 50 farmers. The selection of farms was done in the basis of the managed farms by smallholder beef cattle farmers in northern part of Thailand (Phayao, Chiangrai, Phare and Nan province). The questionnaire focused on various topics including the farmers socio-demographic characteristics: gender, age, and education level, each farm's characteristics (farm experiences, rearing systems, and farm sizes per household), each farm's recording tasks (what kind of data recording) and record keeping methods, and mobile phone usage (mobile phone type, operating system, mobile phone ownership, and enabled internet capacity).

Design and development of BCFM system

The BCFM system was developed in three parts as a mobile application, web application and restful api service. The mobile application and web application, for both the android and the iOS application systems, were developed using VueJS, VueX and Vuetify, which are well-known JavaScript frameworks for web application development. In particular, the Cordova version 9.0 program, a mobile application framework, was used for wrapping up the web application and to create the BCFM's mobile portion. With regards to the server, a restful api service was built using AdonisJS, a JavaScript/Nodejs web application framework, and the MySQL database. The system architecture of the BCFM system is shown in Figure 1.

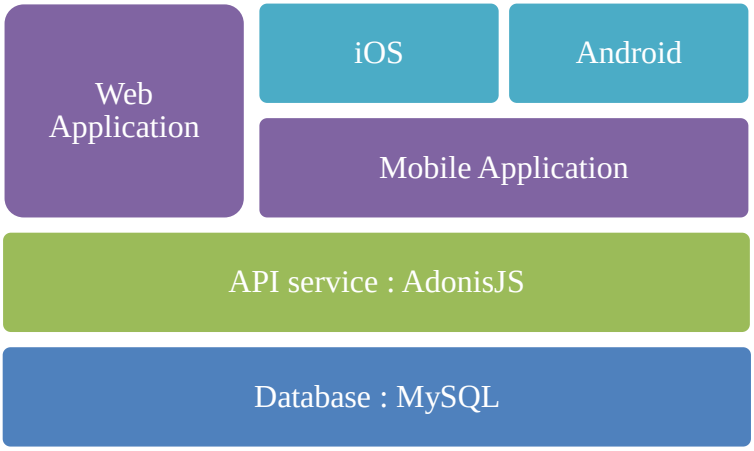


Figure 1. System Architecture

The BCFM record keeping system was developed in three phases. During the first phase, the information needs of the beef cattle farmers were studied in 4 provinces in the northern part of Thailand (Phayao, Chiangrai, Phare and Nan province) consulted to the authorities and veterinarians from the Department of Livestock Development. The second phase involved the design and development of the BCFM system, both in its mobile-based and web-based form. Finally, the third phase involved developing and testing methods of system implementation; the final version of BCFM mobile app is installed to a user's Android or iOS mobile phone and the web application on their PC. This stage was conducted to ensure the mobile and web-based app functioned properly.

Mobile application

The android and iOS based mobile apps, "BCFM mobile app", were designed and developed with due consideration for the most important aspects required by the beef cattle farmers and livestock authorities. It included the ability to input record keeping information about an animal's individual data, breeding, vaccine and deworming program, health care practices and sale reports in the Thai language. The motivation to develop both an android based and iOS based mobile app was so as to develop a handy and user friendly tool that would be able to collect farm data and schedule management activities, with regards to small beef cattle farms as well as offering other benefits, such an ability for the authorities to use data that farmers collect to support and predict production plans in northern Thailand. Figure 2. illustrates the main menu of the BCFM mobile app which consists of bull data, cow data, fatten data, calf data, distribution data and notifications.

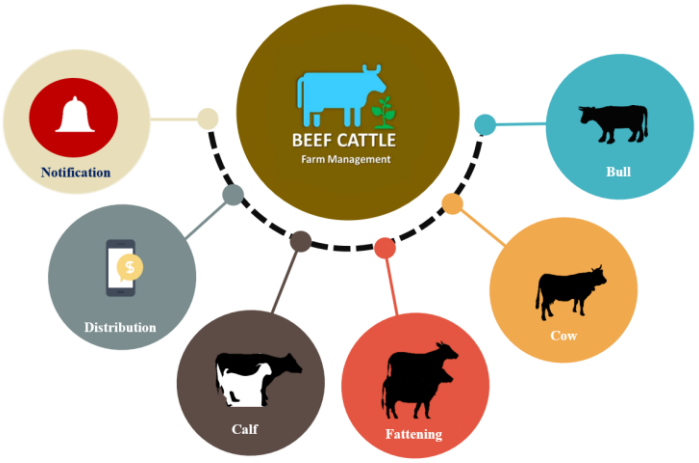


Figure 2. Main menu of the BCFM mobile application

Web application

The web version of the BCFM system can process data types, an animal's individual history and its activities history and this is integrated within the android and iOS applications. The web-based portion of the BCFM system allows for data from the mobile portion to be summarized and distributed directly after it is collected. Furthermore, the web-based portion has an interface for an overview of the number of farmers and number of beef cattle, which is separated in terms of the type of cattle being raised in 4 provinces.

Statistical analyses

Socio-demographic characteristics, farm characteristics, farm data recording and mobile phone usage information were used to develop descriptive statistics based on frequency and percentage. In terms of a user's satisfaction, mean and standard deviation were used to describe the results. To identify a user's satisfaction with the BCFM mobile app, a questionnaire was prepared and distributed to respondents. The questionnaire was distributed to 50 users who own a smartphone during the course of face-to-face interviews. The respondents were asked to provide their opinion using a 5-point Likert scale (5 = very satisfied, 4 = satisfied, 3 = neutral, 2 = unsatisfied, and 1 = very unsatisfied). User satisfaction was evaluated, with respect to the use of the BCFM app, for aesthetics and design, usage, efficiency and the validity of the application. After this, an overall satisfaction score was obtained. So as to measure the app users' satisfaction scores, intervals for the Likert scale (mean 1.00-1.80 = very unsatisfied, 1.81-2.60 = unsatisfied, 2.61-3.40 = neutral, 3.41-4.20 = satisfied, 4.21-5.00 = very satisfied) were used.

Results

Socio-demographic, farm management information recording and mobile phone usage survey of beef cattle farmers

The respondent characteristics are described in Table 1. Of the respondents, 78% were male. Almost half (48%) of the respondents were over 51 years of age, with regards to the respondents' highest education levels: 40% had gone through primary school, 30% high school, whilst 12% had obtained a vocational certificate, and 18% a bachelor's degree or higher. Regarding farming experience, the majority (48%), of the respondents had 5 years or less of farming experience. In terms of the rearing systems used, most farmers raised cattle semi-intensively (76%). With regards to the herd sizes of smallholder farmers defined as small (up to 5 heads), medium (6 to 10 heads), and large (over 10 heads). It was found that 52% of the respondents had small farm sizes, 30% of the respondents had medium farm sizes, whilst only 18% of the respondents had large farm sizes. In terms of farm record keeping, 58% of the farmers kept farm data recorded and farmers had kept both in terms of animal identification and animal health accounted for 62%. However, 100% of the farmers had not recorded in keeping system, they recorded data by hand only.

Table 1. Socio-demographic and farm management information recording characteristics survey of beef cattle farmers (n=50)

Characteristics	F	%	Characteristics	F	%
Gender			Rearing system		
Male	39	78	Intensive	9	18
Female	11	22	Semi-intensive	38	76
Age			Extensive	3	6
≤ 30 years	5	10	Farm size		
31-40 years	7	14	Small (≤ 5 heads)	26	52
41-50 years	14	28	Medium (6-10 heads)	15	30
51-60 years	15	30	Large (> 10 heads)	9	18
> 60 years	9	18	Farm record keeping		
Education level			No records	21	42
Primary school	20	40	Kept recorded	29	58
High school	15	30	Types of records kept		
Vocational certificate	6	12	Animals identification	8	28
High vocational certificate	0	0	Animals health events	3	10
Bachelor's degree or higher	9	18	Both	18	62
Farm experiences			Record keeping methods		
≤ 5 years	24	48	Hand-written	29	100
6-10 years	6	12	Computer Software	0	0
> 10 years	20	40	Mobile app	0	0

Table 2. Mobile phone usage survey of beef cattle farmers (n=50)

Characteristics	F	%	Characteristics	F	%
Mobile phone operation system			Mobile phone using		
Android	49	98	< 2 years	8	16
iOS	1	2	2-5 years	16	32
Enable internet access			6-10 years	12	24
Yes	50	100	> 10 years	14	28
No	0	0	Purposes of using mobile phone[1]		
Mobile phone services			To make or receive a call	40	48.19
Prepaid	21	42	Educational purposes	32	38.56
Postpaid	29	58	Entertainment	10	12.05
Ever use mobile phone for update new farming technology			Others	1	1.20
			Social media		
Yes	29	58	Facebook	28	56
No	21	42	Line	12	24

[1]: Means multiple responses

Android was the most widely used mobile phone operation system, rather than iOS (98% and 2%, respectively) as shown in Table 2. As expected, 100% of the farmers who took part in the study have internet access enabled, with 58% postpaid and 42% prepaid. It was found that more than half of the farmers (52%) had been using mobile phones for more than five years, followed by 32% who had been using their mobile phones for a period of 2-5 years, and 16% for a period of less than 2 years. The main reason they gave for

their use of mobile phones was made and received calls, educational purposes, entertainment, and others (48.19%, 38.56%, 12.05%, and 1.20%, respectively). Furthermore, the study also revealed that the social media sites of farmers are often visited Facebook and Line (56%, and 24%, respectively). In terms of using mobile phones for updating to new farming technologies, it was found that 58% had used them for this purpose whilst 42% had never done.

User interface

Mobile application

The researchers produced an online Android-based and iOS-based app that serves as a farm recording tool for beef cattle smallholder farmers in Northern Thailand, to improve their record keeping methods with regards to their animals' individual identification, farm tasks and activities alerts. The BCFM Android app can be downloaded from the Play Store or Google Play and the iOS app can be downloaded from the App Store. The following search terms were employed "BCFM mobile app" or "cattle mobile" or "cattle farm". The BCFM app was designed to enable farmers to record and monitor cattle management activities and consists of 5 recording menus: bull's record, cow's record, fatten cattle's record, calf's record, distribution and 1 task notification menu. The BCFM app was used on an actual beef cattle farm, and through its use, the researchers were able to collect information suitable for smallholder farmers' needs. This app can be used to record an animal's information and help in its management according to the type of beef cattle (bull or sire, cow, calf and fatten) including:

Bull or sire record: an animal's individual information: name, ear tag number, breed, birthdate, dam, sire, complete vaccination record, treatment history, sale record and vaccination and deworming program notifications.

Cow record: an animal's individual information: name, ear tag number, breed, birthdate, dam, sire, breeding and pregnancy information, complete vaccination record, treatment history, sale record and vaccination and deworming program notifications, as well as estimated calving date notifications.

Calf record: an animal's individual information: name, ear tag number, breed, birthdate, sex, dam, sire, birth weight, weaned date, start/finish weaned weight, treatment history, sale record and vaccination and deworming program notifications.

Fatten record: an animal's individual information: name, ear tag number, breed, birthdate, sex, dam, sire, start/finish fattening date, start/finish fattening weight, complete vaccination, treatment history, sale record and vaccination and deworming program notifications.

The first page of BCFM mobile app asks a user to set their username and password to confirm registration. After completion of the registration process, they will then see the home page of the app. The home page contains six major menus related to different types of beef cattle farming, distribution and notifications, as mentioned above (Figure 3A-H). The disease and treatment record for beef cattle deals with general information, signs and symptoms of disease, treatment methods and the results of treatment.

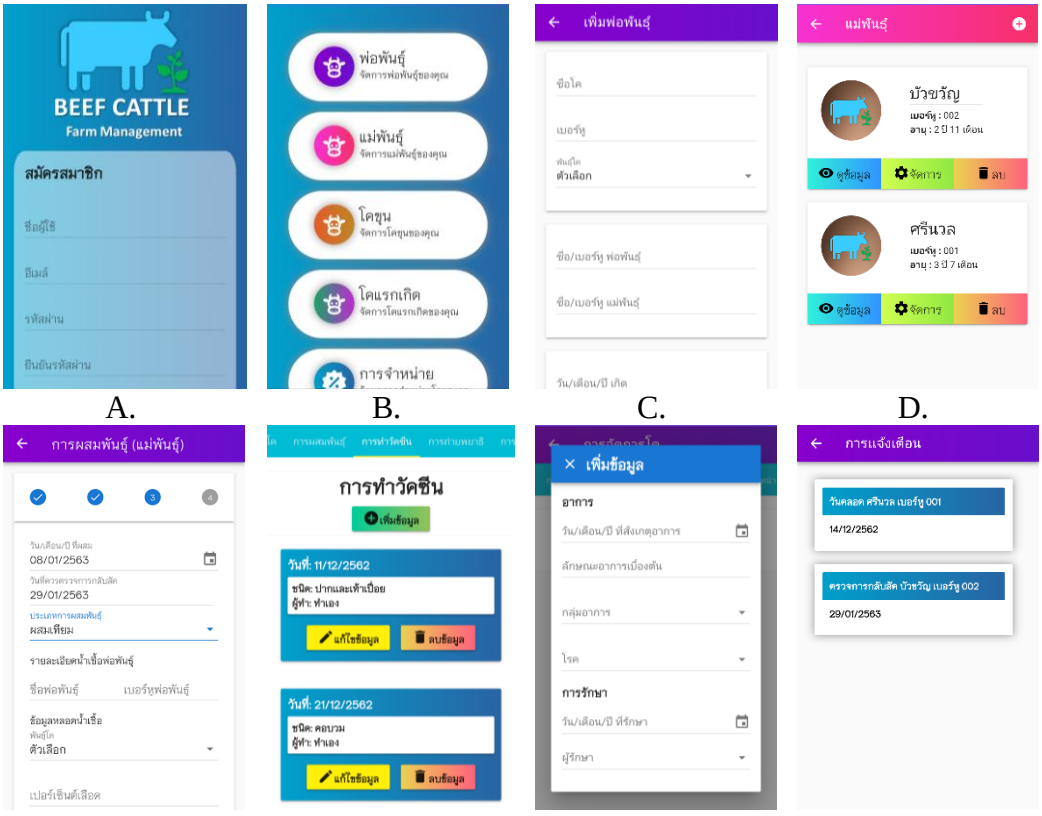
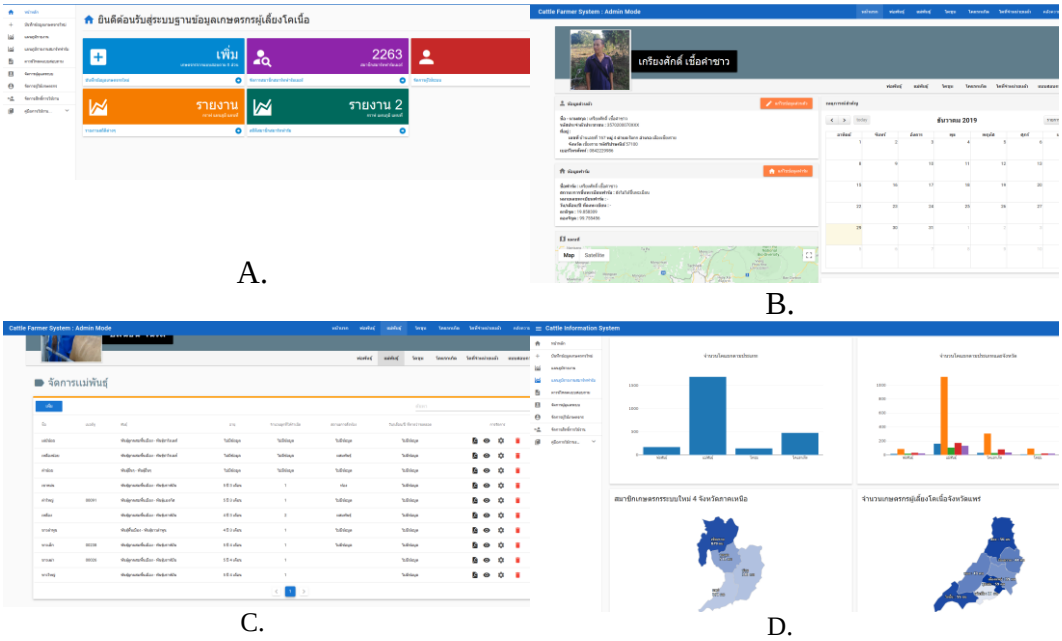


Figure 3. The user interface of the BCFM mobile app: (A) registration page, (B) main menu on application homepage, (C) added bulls' data screen, (D) list of cow screens, (E) cow's breeding screen, (F) vaccination screen, (G) disease screen and (H) notification screen

Web application

The web-based portion has an interface that is the same as that of the mobile portion and the same six menus are included; however, an added extra menu is there, which deals with reports on the numbers of beef cattle in the area and neighboring provinces. Farmers can see the number of beef cattle in 4

provinces divided into 4 types (bull or sire, cow, calf and fatten) for each province (Figure 4A-D).



A. B.

C. D.

Figure 4. User interface of BCFM web-based app: (A) main menu on web-based homepage (B) individual farmer's information (C) cow data reports and (D) report about the number of beef cattle

BCFM app user's satisfaction

For collecting and identifying user satisfaction levels, participants were asked to fill out a provided questionnaire survey form by answering the questions. The main goal was to evaluate the user interface through a 5-point Likert scale in four sections; aesthetics and design, usage, efficiency and validity of the application. A higher score indicated a greater satisfaction level for users. We summarized the mean score and the standard deviation with respect to each measurement and this is presented in Table 3. The user satisfaction analysis showed that out of all the respondents the overall average mean satisfaction score was 4.13, which implies they were satisfied and had a positive attitude toward the BCFM app. From the study it was found that the respondents were satisfied with the following aspects of the app components: validity, aesthetics and design, usage, and efficiency 4.20, 4.14, 4.11 and 4.09 respectively. When talking about how satisfied they were the participants were particularly positive about the following components: "the system can alert us

based on a specified time", "the system can calculate and display the date correctly", "the buttons are arranged in an orderly and uncomplicated way", "the information is correct and precise", and "I can access each different part within the application easily" (4.26, 4.24, 4.22, 4.22, and 4.21 respectively).

Table 3. Summary of user's satisfaction scores on BCFM app (n=50)

Criterion category	Mean	SD	Evaluation
The aesthetics and design			
1. The aesthetics of application.	4.17	0.74	satisfied
2. The letters within the application are easy to understand and read.	4.17	0.78	satisfied
3. Can adjust the font size as needed.	3.96	0.93	satisfied
4. The buttons are arranged in an orderly and uncomplicated way.	4.22	0.77	very satisfied
5. The meaning of the buttons is easy to understand.	4.20	0.80	satisfied
Average	4.14	0.80	satisfied
The usage of the application			
1. Can access each different part within the application easily.	4.21	0.85	very satisfied
2. The design of the user interface is appropriate.	4.03	0.81	satisfied
3. Users can easily add, delete or edit information.	4.13	0.84	satisfied
4. The application is clear and complete data display.	4.07	1.00	satisfied
5. The speed of viewing data is good.	4.09	0.85	satisfied
Average	4.11	0.87	satisfied
The efficiency of the application			
1. The notifications display clear headlines and details.	4.15	0.80	satisfied
2. The transaction history is kept and displayed clearly.	4.06	0.85	satisfied
3. Users can add various management information easily and quickly.	4.05	0.86	satisfied
4. Can upload images easily, not complicated.	4.02	0.82	satisfied
5. The application is stable and smooth.	4.15	0.91	satisfied
Average	4.09	0.85	satisfied
The validity of the application			
1. The information is correct and precise.	4.22	0.81	very satisfied
2. Searching for information is easy and convenient.	4.16	0.84	satisfied
3. The system can calculate and display the date correctly.	4.24	0.82	very satisfied
4. The system can alert us based on specified time.	4.26	0.75	very satisfied
5. Users can contact the administrator within the application.	4.13	0.84	satisfied
Average	4.20	0.81	satisfied
Overall average mean	4.13	0.83	satisfied

Discussion

The results of socio-demographic are in agreement with those found in many other countries where the majority of smallholder farmers are middle aged, and over half are educated only to primary level school (Dung *et al.,* 2019; Muleta *et al.,* 2019; Hernandez-Jover *et al.,* 2019; Haryadi *et al.,* 2019). In terms of individual farmers', adoption and perception of new technologies: Bucci *et al.,* 2019 found that adult farmers' familiarity with such technologies was greater than that of older farmers and similarly, that a farmer's education level significantly affects the level of computerization found in their farms; those with a degree or diploma are more used to using computers than those with a lower educational level. Regarding farm record keeping, recent studies focusing on the animal health management of cattle smallholder farmers in Australia have found that 54.8% of farmers keep records of animals with diseases and 63.5% keep records of animals that have died or been euthanased, and that 66.3% also keep records of routine treatments (Hernandez-Jover *et al.,* 2019). In contrast, only 10% of smallholder farmers in Thailand keep records of health events. This is in accordance with the results of studies done in Mexico, which reveal that over half (52.1%) of the beef farmers there do keep records, and that the most common method of smallholder farmers for recording farm data is writing it out by hand (44.5%), with only 2.1% using computers for the task (Gonz áez-Padilla *et al.,* 2019). Many studies about farm record keeping on dairy farms have shown that farm record keeping has had a positive influence on dairy farm performance, farmers that kept records had a higher monthly milk yield per farm and monthly milk yield per cow than on farms where records were not kept (Yeamkong *et al.,* 2010; Kataike *et al.,* 2018).

The results of mobile phone usage survey found that Android was the most widely used mobile phone operation system because Android is an open-source mobile operating system developed by Google and as of November 2019 there were 76.65% Android-based and 23.08% iOS-based mobile phone users in Thailand (Statcounter, 2019). The Android operating system is able to run key applications for farmer management systems because it is easy to use, convenient, flexible and provides an open platform for developers to create applications. The main reason for use mobile phones of smallholder farmers are accordance with Dharanipriya and Karthikeyan, 2019, it was found that more than half of the farmers were using smart phones only occasionally to make phone calls to progressive farmers, private input dealers, and extension officials. The study revealed that farmers often visited Facebook and Line social media because of good internet connectivity and ease of connecting with one other on these social media sites. The most frequently accessed ICT tool or

device they used to get access to agricultural information and knowledge was their mobile phone. This was because of, firstly, its effectiveness as an agricultural information source, and secondly, its usefulness for improving farming skills, and finally, its use as a source of timely and accurate information, when compared with other ICT tools. The factors that influence the use of ICTs in agriculture are: electricity, language barriers, limited knowledge and skills in using ICT tools, high costs, the limited availability of ICT tools, etc. (Luqman *et al.*, 2019; Raza, 2019; Raza *et al.*, 2020).

The result supported the fact that in this era of digitalization and ICTs, mobile apps can act as a bridging link between farmers and extension agencies for the better dissemination of agricultural information, agricultural knowledge and proven agricultural technologies (Sanga *et al.*, 2016; Shrija *et al.*, 2018; Trendov *et al.*, 2019). This study has a number of strengths, in that surveys were conducted to understand farm characteristics, record keeping and mobile phone usage data for smallholder farmers, for developing record keeping systems that are suitable for current technology, in a one touch on anytime and anywhere medium. In terms of limitations, an individual animal's identification and farm tasks were the most commonly identified categories of recorded need on farms. Common reasons for not using the app were a general lack of interest and unawareness of the benefits of collecting data. Many studies have indicated that rural farmers face the challenge of poor internet network coverage and poor infrastructure. To develop a farmer's ICT skills and increase the adoption rate of such data recording, it is recommended that government agencies and researchers assist in the acceleration of this by establishing information centers where knowledge about new technologies can be shared with local farmers and information exchanged (Dudafa, 2013; Chiwawa, 2019).

In terms of the future scope of this system, we will continue to include features that record costs and returns for analysis of farm profitability and provide market information. Moreover, the recording of information on animals and farms allows farmers or consumers to track a product from its origin along the entire value chain. Our findings also suggest that future study needs to be done to develop this system so it may be linked with sensor technologies such as radio-frequency identification (RFID) and near field communication (NFC), which make it easy to effectively collect data.

In summary, the advantage of using a mobile recording app for beef cattle smallholder farmers is not only due to the fact that they can record and monitor farm management, but also that they can help alert them to tasks that need to be done. The result of the user satisfaction survey was an overall average mean satisfaction rate of 4.13, which means that the participants felt satisfied with the BCFM app in term of its validity, aesthetics and design,

usage, and efficiency. We believe that the BCFM mobile and web application will be useful for those running small farms, because it can offer support for making decisions on farming operations. There will also be benefits for government agencies, as the information provided by this app's usage can be used for planning policy and marketing to further help farmers.

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References

Angkuraseranee, T., Somboonsuk, B., Sukhabot, S. and Nimsai, S. (2019). Market opportunities for Thai beef cattle exports to Yunnan province, China. International Journal of Agricultural Technology, 15:807-882.

Bucci, G., Bentivoglio, D. and Finco, A. (2019). Factors affecting ICT adoption in agriculture: a case study in Italy. Quality-Access to Success, 20:122-129.

Chiwawa, T. (2019). Integration of information and communication technology (ICT) in the development of a recordkeeping database of smallholder sheep farming systems in the Western Cape Province of South Africa. (Doctoral dissertation). Stellenbosch University.

Department of Livestock Development. (2018a). Number of livestock inventory in Thailand. Retrived from https://drive.google.com/file/d/1BQlR6_ponGMQrF6lp0k6eTERYcSIsUL

Department of Livestock Development (2018b). Beef cattle strategic 2018-2020. Retrived from http://planning.dld.go.th/th/index.php/th/policy-menu/193-2016-08-05-07-15-01.

Dharanipriya, A. and Karthikeyan, C. (2019). Use of smart phones by farmers as a tool for information support in agriculture. Journal of Krishi Vigyan, 7:251-256.

Dudafa, U. J. (2013). Record keeping among small farmers in Nigeria: problems and prospects. International Journal of Scientific Research in Education, 6:214-220.

Dung, D. V., Roub k, H. L., Ngoan, D., Phung, L. D. and Ba, N. X. (2019). Characterization of smallholder beef cattle production system in central Vietnam revealing performance, trends, constraints, and future development. Tropical Animal Science Journal, 42:253-260.

Gonz ález-Padilla, E., Lassala, A., Pedernera, M. and Gutierrez, C. G. (2019). Cow-calf management practices in Mexico: Farm organization and infrastructure. Veterinaria M éxico, 6:1-7.

Haryadi, F. T., Widiati, R., Kusumastuti, T. A. and Andarwati, S. (2019). Beef cattle farmers' group cohesion in Bantul and Sleman Regencies Yogyakarta special region, Indonesia. Journal of Agricultural Extension, 23:223-239.

Hernandez-Jover, M., Hayes, L., Woodgate, R., Rast, L. and Toribio, J. A. (2019). Animal health management practices among smallholder livestock producers in Australia and their contribution to the surveillance system. Fronttiers in Veterinary Science, 18:1-14.

Kabir, K. H. (2015). Attitude and level of knowledge of farmers on ICT based farming. European Academic Research, 2:13177-13196.

Kataike, J., Modekurti, D. P., Butali, E., Magumba, D., Mugenyi, A. R., Aine-Omucunguzi, A. and Gellynck, X. (2018). A parametric test evaluating smallholder farmers' training needs in Uganda: A case of dairy farmers in the Rwenzori region. Journal of Agribusiness in Developing and Emerging Economies, 8:537-553.

Lahan, R. R. and Deka, N. (2019). Application of Information and Communication Technology (ICT) in farm management in Jorhat district of Assam. Asian Journal of Agricultural Extension, Economics & Sociology, 26:1-6.

Luqman, M., Yaseen, M., Ashraf, S., Mehmood, M. U. and Karim, M. (2019). Factors influencing use of information and communication technologies among farmers in rural Punjab, Pakistan. Journal of Agricultural Extension, 23:101-112.

Muleta, B. G., Mummed, Y. Y. and Kurtu, M. Y. (2019). Assessment of beef cattle production and marketing practice in Eastern Oromia, Ethiopia. Food Science and Quality Management, 85:25-36.

Ndekwa, A. G. and Victor, P. M. (2018). Challenges facing adoption of ICT in rural areas of Tan-zania. International Journal of Economics, Business and Management Research, 2:343-359.

Osothongs, M., Khemsawat, J., Sarakul, M., Jattawa, D., Suwanasopee, T. and Koonawootrittriron, S. (2016). Current situation of beef industry in Thailand. Proceedings of International Symposium: "Dairy Cattle Beef Up Beef Industry in Asia: Improving Productivity and Environmental Sustainability, Thailand, 19:5-8.

Paraforos, D. S., Vassiliadis, V., Kortenbruck, D., Stamkopoulos, K., Ziogas, V., Sapounas, A. A. and Griepentrog, H. W. (2016). A farm management information system using future internet technologies. IFAC-PapersOnLine, 49:324-329.

Raza, H. (2019). Emerging trends and challenges in the use of ICTs for better access to agricultural information in the Punjab, Pakistan. (Doctoral dissertation). University of Agriculture, Faisalabad.

Raza, M. H., Khan, G. A., Shahbaz, B. and Saleem, M. F. (2020). Effectiveness of information and communication technologies as information source among farmers in Pakistan. Pakistan Journal of Agricultural Sciences, 57:281-288.

Saengwong, S., Thannithi, W., Wichaporn, J. and Intawicha, P. (2020). The study of rearing conditions, constraints and opportunities assessment of quality beef cattle production in Phrae province. King Mongkut's Agricultural Journal. (*In Press*).

Sanga, C., Mlozi, M., Haug, R. and Tumbo, S. (2016). Mobile learning bridging the gap in agricultural extension service delivery: Experiences from Sokoine University of Agriculture, Tanzania. International Journal of Education and Development using ICT, 12:108-127.

Shrija, S., Sankhala, G. and Lal, S. P. (2018). Exploring the perception of the dairy farmers in relation to different components of the android mobile app eco-dairy. International Journal of Agriculture Sciences, 10:5611-5613.

Singh, V. and Kameswari, V. L. (2019). Relationship between characteristics of farmers and impact of ICT enabled web portal (Krishinet). Asian Journal of Agricultural Extension, Economics & Sociology, 32:1-8.

Statcounter. (2019). Mobile operating system market share Thailand. Retrived from https://gs.statcounter.com/os-market-share/mobile/thailand.

Trendov, N. M, Varas, S. and Zeng, M. (2019). Digital technologies in agriculture and rural areas. Food and Agriculture Organization of the United Nations, Rome. Retrived from http://www.fao.org/3/ca4887en/ca4887en.pdf.

USDA (2019). World beef imports: ranking of countries. Retrived from https://beef2live.com/story-world-beef-imports-ranking-countries-0-106900. x/view.

Yeamkong, S., Koonawootrittriron, S., Elzo, M. A. and Suwanasopee, T. (2010). Effect of experience, education, record keeping, labor and decision making on monthly milk yield and revenue of dairy farms supported by a private organization in Central Thailand. Asian-Australasian Journal of Animal Sciences, 23:814-824.

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