Smart Buff Manager: A Co-Designed Mobile Application for Enhancing Buffalo Farm Management in Thailand

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Abstract: This study focuses on the co-design and development of a smartphone application, the "Smart Buff Manager," especially for smallholder buffalo farmers in Thailand. The application aims to meet the needs of buffalo farmers by providing an effective and user-friendly tool for record-keeping and farm management. We employed the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) instructional design method to ensure the application addressed the practical needs and preferences of the farmers. The primary features of the app include record-keeping, health monitoring, and breeding management, focusing on various issues faced by smallholder farmers. The user-centered design method provides an intuitive interface that gathers feedback from users, resulting in increased satisfaction and a higher tendency to recommend apps. Implementation of the app significantly improved farm management by enhancing operational efficiency, productivity, and animal welfare. Users of the application reported much greater compliance with vaccination schedules than non-users, potentially improving herd health and long-term production. This case study confirms the potential of mobile technology to improve farm operations and decision-making while also highlighting the essential role of involving end-users in the design process to develop appropriate and effective digital farming systems.

Keywords: ADDIE model, Farm management, Mobile apps, Satisfaction, Productivity, Usability.

1. INTRODUCTION

Buffaloes have a significant economic impact on rural communities and agricultural development worldwide, particularly in India and Southeast Asia. They contribute to food security, generate income, and increase agricultural productivity, proving them valuable assets for rural households. Similarly, buffaloes are essential for Thai agriculture's environmental sustainability, economic significance, and productivity improvement. According to the Department of Livestock Development, the nation's buffalo population was approximately 1.78 million in 2023. Buffalo farming is most prevalent in the northeastern region, followed by the northern, central, and southern regions. The majority of buffalo farms are small-scale farmers who depend on buffaloes for their income and livelihood. Most farmers raised buffalo 1–20 heads, accounting for 97.57%, followed by 21–100 heads, 101–200 heads, and more than 200 heads (2.39%, 0.04%, and 0.01%, respectively). The buffalo sector provides employment opportunities for people in rural areas. Buffalo farming requires effective farm management practices to promote animal health, productivity, and long-term sustainability. The key component is record-keeping, which involves the specific keeping of accurate records for each buffalo, including birthdates, bloodlines, health records, vaccination and deworming schedules, breeding and calving dates, and performance indicators. As buffalo farming continues to develop, modern methods and technologies are required to improve operations and increase productivity. The development of a mobile application for record keeping among buffalo farmers appears to be a viable solution. Accurate recording of farming-related information is crucial for enhancing decision-making, improving productivity, and ensuring profitability. Furthermore, accurate recording of buffalo farm information may assist farmers in improving animal welfare, ensuring food safety, following regulations, and implementing management decisions that promote profitability and sustainability.

Smartphones are now prevalent in modern society and have a wide variety of capabilities that have significantly influenced different sectors of our lives, including agriculture. Within the field of livestock farming, the number of smartphone programs (apps) developed to optimize farm management and improve efficiency has increased [1]. These applications use

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ISSN: 1927-5196 / E-ISSN: 1927-520X/24

mobile technology to provide farmers with up-to-date data, monitoring tools, and decision-support systems to promote more accurate livestock operations management [2-4]. In sub-Saharan Africa, where smallholder farmers produce 60-80% of food, ICTs show promise in enhancing agricultural information dissemination. Several mobile applications, including Esoko, iCow, and DigiFarm, have been developed to support smallholder farmers, though there is a need for more user-driven platforms that encourage farmer feedback and promote inclusivity [5]. Another significant advancement is the IVRI-Dairy Manager app, designed to offer farmers helpful access to scientific livestock management procedures and as a knowledge update for farmers and veterinarians. The app's ability to quickly and efficiently disseminate information through mobile technology has the potential to improve livestock productivity and increase farmers' income [6]. In addition to individual farm-level applications, data-driven marketing applications enable collective sales. These apps provide users with information about the locations of farmers, input dealers, buyers, and storage facilities, as well as price forecasts. These applications have been shown to assist farmers in obtaining higher prices in the market, highlighting the potential of mobile technology to streamline the agricultural value chain. An exemplary program, known as the Android-based Selling Cattle app, has been recognized as a vital instrument for enhancing the standards and results of livestock sales in rural areas. The software has enhanced the procedure of connecting farmers with potential buyers, resulting in enhanced income for livestock proprietors [1].

Smartphone applications have the potential to provide benefits for small-scale farmers in developing countries; however, evidence of their impact remains limited [7]. Despite challenges such as limited smartphone accessibility and low digital literacy, farmers typically have a positive view of agricultural applications [8]. Smartphone applications also allow researchers to collect real-time socioeconomic and agricultural data, which has the potential to enhance accuracy compared to conventional survey methods [9].

The ADDIE model is a systematic instructional design approach that offers numerous benefits in creating effective Smartphone app programs. The models include four phases: analysis, design, development, implementation, and evaluation, which ensure that the information users need is transformed into a technological product, enhancing the user experience and app effectiveness. This approach allows collaboration among experts, leading to the transformation of the necessary information into user-friendly technological results. The ADDIE model emphasizes the importance of analyzing user requirements, designing user-friendly interfaces, developing functional apps, implementing them effectively, and evaluating their impact on user skills and well-being. The ADDIE model is an effective framework for developing mobile applications that address specific educational and healthcare requirements, improving user experience while promoting self-care across various contexts [10-12].

We used the ADDIE educational model to develop buffalo farm management systems. The primary objective of this study was to co-design a smartphone application specifically for smallholder farmers in Thailand. The app aims to address the unique needs of buffalo farmers by providing an effective and user-friendly tool for record keeping and farm management. The specific objectives of this study were as follows:

1. Identify the needs and functions of buffalo farmers in Thailand, focusing on record-keeping, farm management, and productivity.

2. To engage buffalo farmers in the co-design process to ensure that the app meets their practical needs and preferences.

3. To design and develop key app functionalities, including record-keeping and decision-support tools.

4. Evaluating the impact of precise record-keeping may improve farm management, production, and efficiency in buffalo farming operations.

2. MATERIALS AND METHODS

2.1. Conceptual Framework for Mobile App Development Process

We conducted this study to develop a mobile application for recording buffalo farm activities, focusing on the specific needs of Thai farmers. The application was developed in the local language, Thai, to address the unique needs of Thailand's buffalo farming community, enhance usability, and ensure effective adoption by the target audience. The design and development of the application prototype in this study was based on the ADDIE instructional design

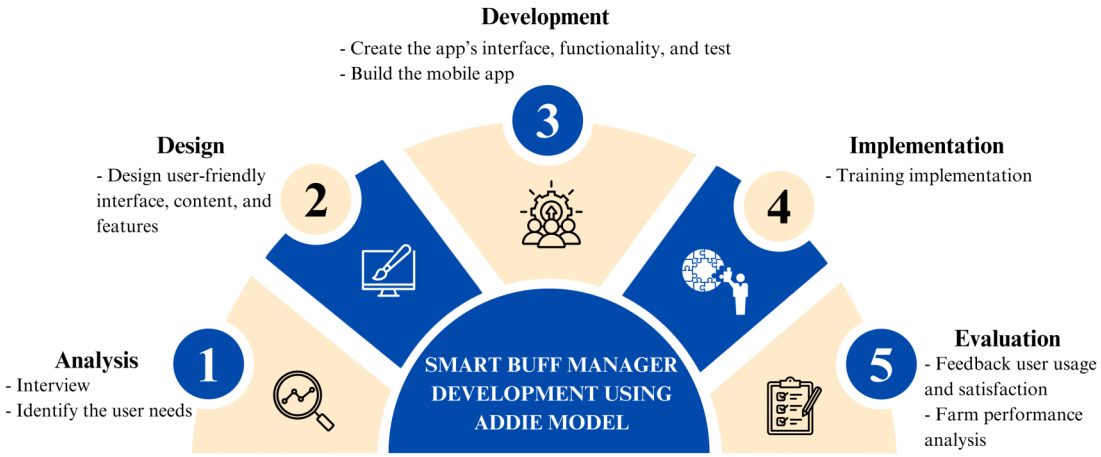

Figure 1: Analysis, design, development, implementation, and evaluation (ADDIE) model phases and steps in each phase.

model. The Analysis, Design, Development, Implementation, and Evaluation (ADDIE) instructional design process is a common approach widely used in developing instructional courses and training programs. While the ADDIE model is commonly used to design educational materials, it can also be applied to other instructional designs and development contexts. The ADDIE model provides a systematic framework for designing, developing, and evaluating various types of projects, including training and development, performance support, software development, and process improvement.

This framework was employed to structure the application's comprehensive design. The developmental process's outcomes were based on the ADDIE model, which encompasses the following stages: analysis, design, development, implementation, and evaluation (Figure **1**).

2.1.1. Analysis Phase

Following the user-centered approach to designing mobile applications, the researcher's focus in this phase is on users and project goals. The initial phase involves the identification of farmers' information tracking requirements, which are conducted through focus group interviews with buffalo farmers. This approach aims to gain insights into specific needs and obstacles. Furthermore, it is necessary to collect data related to using the internet and mobile technology.

We invited three experts to determine and categorize the appropriate practical content for the mobile app. Qualitative methods were used to analyze and categorize the resulting content requirements for farm management activities in record-keeping mobile apps. We incorporated interesting content presented in various formats (e.g., written text, images, infographics, and videos) to enhance the app's user experience.

Identifying the specific needs and requirements of smallholder buffalo farmers in relation to management activities involves understanding their specific conditions, goals, and challenges. The questionnaire comprised 4 areas of interest: 1) socio-demographics, 2) farm information and production characteristics, 3) smartphone usage, and 4) app design and feature needs. The questions were semi-closed, closed, multiple-choice, and open-ended.

2.1.2. Design Phase

This process includes responding to questions about how to carry out the objectives and strategies determined in the analysis phase: 1) designing the contents: The requirements of the contents in the app include information on buffalo individuals, health monitoring, breeding, performance analytics, alerts, and notification; and 2) designing the user interface, which focuses on creating a visually appealing and user-friendly interface that is intuitive and easy to navigate. Consider the app layout, color scheme, typography, and interactive elements. During this stage, the team utilized the data collected in the analysis phase to conduct analyses and design, with a primary focus on the conceptual development of the mobile application. This includes determining the app's environment, features, and appropriate methods to meet user requirements. The researchers collaborated with a software developer to produce the mobile app based on expert recommendations and user needs.

2.1.3. Development Phase

The present phase focused on developing the program material. The development phase of a mobile

app for buffalo management involves designing a user interface, writing the code for the app's features, and testing the app for errors and problems. During this phase, we created a PostgreSQL database and Android Studio to develop the "Smart Buff Manager" app based on the knowledge acquired from the analysis and design phases. The software developer worked closely with the researcher throughout the development of the mobile app. We developed the ".apk" file extension for direct download to the users' smartphones in the intervention group.

2.1.4. Implementation Phase

This implementation phase consists of two key components: deployment of the application and provision of user instruction and support for smallholder buffalo farmers to ensure access to the target audience. The application deployment process detects and identifies errors that occur during the process. The test was repeatedly conducted until any errors in the application were fixed and the test ran properly.

The next step involves training buffalo farmers on the proper use of this application, which requires a preliminary assessment of their digital literacy skills and a concise description of the app's use in their farming practices. Training the participating farmers by hands-on, step-by-step instruction delivered in small groups, utilizing simple language and visual aids, ideally in the farmers' Thai language. Feedback was collected to refine both the training process and app satisfaction, and long-term monitoring to evaluate its impact on farming practices.

The implementation phase included testing the app with 55 buffalo farmers, accompanied by training sessions to ensure its effective use. Farmers were provided with instructional materials and ongoing technical support to facilitate integration of the app into their daily farm management routines.

2.1.5. Evaluation Phase

The evaluation phase, which collects data on the app's usage by buffalo farmers, assesses its impact on their management practices and determines areas for improvement, is the final and essential part of the process. The assessment of the tool and program efficiency requires collecting feedback from participants concerning the content and user interface to achieve the system objectives. We developed applications to meet the needs of the users. The research team approved the project before transferring it to the end user, following the completion of all process testing, surveys, interviews, and other pertinent procedures.

This study employed a qualitative method through structured interviews with 5 experts and 55 users. Experts, selected according to similar characteristics and standards through non-random selection, were requested to evaluate and approve the application. During the interviews, data and information were collected from the perspectives and opinions of the selected groups.

This phase focuses on assessing the effectiveness of the mobile app for smallholder buffalo farmers. This included usability, satisfaction, and farm performance assessments.

2.2. Data Collection and Analysis

Several methods were used to analyze the survey data, including SPSS and Microsoft Excel.

2.2.1. Socio-Demographic and Smartphone Usage

Qualitative and quantitative data were collected to evaluate the participants' socio-demographics and smartphone usage through focus groups and individual face-to-face interviews. Frequencies and percentages were used to perform the descriptive statistics.

2.2.2. App Design and Feature Needs

This part surveyed 2 groups of participants, experts, and smallholder farmers. In the questionnaire, participants were asked to rank the importance of app attributes in relation to their actual use of buffalo farming activity apps. The first part surveys the app features needed, including 10 topics: animal individual information, health monitoring and tracking, breeding monitoring and tracking, performance analytics, alerts and notifications, access to market information, educational resources, tracking income and expenses, connecting with other farmers and experts, and share farm news and updates with the group. The participants were asked to rank the app's features in relation to their routine activity records. The importance levels were categorized as follows: 1 = not important, 2 = somewhat important, 3 = important, and 4 = very important, and then classified into three categories: Most, Medium, and Low.

2.2.3. Usability and Satisfaction

The evaluation of usability and satisfaction conducted by 55 users focused on 3 major factors: 1) the features and functioning of the app, 2) the user

interface, the clarity of information, and the interactivity, and 3) the overall satisfaction and the likelihood of recommending the app. The measurement used rating scales to assess usability and satisfaction with the presented features. The responses ranged from 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree. Descriptive statistics were calculated using the mean and standard deviation.

2.2.4. Farm Performance Comparative

Data were collected through follow-up interviews, surveys, and app usage analysis. The evaluation provided insights into the app's strengths and areas for further improvement, which will inform future tool iterations. The evaluation focused on users and non-users to assess the impact of the app on farm management practices. The selected key performance indicators consisted of 4 aspects: 1) productivity performance (calving interval, birth rate, and conception rate); 2) economic performance (income from buffalo farming and healthcare expenses); 3) operational efficiency (time spent on record-keeping tasks and labor costs), and 4) animal welfare (health problems and compliance with vaccination and deworming schedules). Descriptive statistics, including averages and standard deviations, were used to understand the trends in KPIs for both groups. A one-way ANOVA was conducted to compare the means of the KPIs between users and non-users to determine whether the observed differences were statistically significant.

2.3. Ethics Approval

Participants in the pre-and post-test surveys provided informed consent. The University of Phayao Human Ethics Committee approved the study protocol.

3. RESULTS

3.1. Socio-Demographic of the Participants

Table **1** presents a survey of the demographic and farming characteristics of 55 buffalo farmers. Farmers were 52 years old on average. Most farmers were between the age range of 51-60. This indicates that the buffalo farming community primarily comprises middle-aged and older individuals. 81.82% of the farmers were male, while 18.18% were female. The distribution of education levels among the respondents showed that 38.18% had completed primary school, 29.09% had completed high school, and 32.73% had earned a Bachelor's degree. Regarding farm experience, 41.82% of the respondents had been farming for 1-5 years, 23.64% for 6-10 years, and 34.55% for more than 10 years. The survey revealed that nearly half of the respondents (49.09%) managed farms with more than 10 buffalo heads. Those with 6-10 heads constitute 29.09%, while 21.82% operated smaller farms with 1-5 heads. The average herd size was 10 heads, indicating that the farmers primarily maintained small herds. Approximately 94.55% of farmers used a semi-intensive rearing system, whereas only 5.45% chose an extensive system. The primary focus of these farms appears to be meat production, as indicated by 80% of farm types being for meat production, 1.82% for breeding, and 18.18% for both reasons.

Table 1: Demographics and Farming Characteristics Survey of Buffalo Farmers (n=55)

Items	Frequency	%
Age		
Under 30	5	9.09
31-40	3	5.45
41-50	12	21.82
51-60	18	32.73
61 or older	17	30.91
Gender		
Male	45	81.82
Female	10	18.18
Education level		
Primary school	21	38.18
High school	16	29.09
Bachelor's degree	18	32.73
Farm experience		
1-5 years	23	41.82
6-10 years	13	23.64
> 10 years	19	34.55
Farm size		
1-5 heads	12	21.82
6-10 heads	16	29.09
> 10 heads	27	49.09
Rearing system		
Semi-intensive	52	94.55
Extensive	3	5.45
Farm type		
Meat production	44	80.00
Breeding	1	1.82
Both	10	18.18

3.2. Smartphone Usage of the Participants

Table **2** presents the results of a survey of buffalo farmers (n = 55) regarding smartphone usage. Most

Table 2: Survey of Buffalo Farmers' Smartphone use (n=55)

Items	Frequency	%
What operating system does your device use?		
Android	49	89.09
iOS	6	10.91
Does your mobile phone have an internet connection?		
Yes	46	83.64
No	9	16.36
Have you used mobile apps for farm management or similar purposes before?		
Yes	12	21.82
No	43	78.18
How often do you use mobile phone in your daily life?		
< 1 hour	9	16.36
1-2 hours	16	29.09
> 3 hours	30	54.55

respondents (89.09%) used Android as their mobile operating system, whereas a smaller portion (10.91%) used iOS. The sample demonstrates a high level of digital access, with 83.64% of the farmers owning smartphones connected to the internet. However, 16.36% of the respondents reported that their mobile phones did not have Internet connectivity. Despite the high rate of Internet connectivity, only 21.82% of the respondents used mobile applications for farm management or similar purposes, whereas 78.18% did not engage in such practices. The frequency of mobile phone use in daily life varies widely among farmers. Of the respondents, 16.36% used their phones for less than one hour per day, 29.09% for 1-2 hours daily, and 54.55% for more than three hours per day.

3.3. App Design and Feature Needs

In the analysis phase, expert and farmer surveys helped determine the optimal app content and features that should be included in the app. Table **3** illustrates the survey results that compared the perceived significance of several app features between buffalo experts (n=5) and farmers (n=55). The significance of each characteristic was evaluated using a rating scale ranging from 1 (low) to 5 (most). The table highlights the differences and similarities in the ranking of application characteristics between the two groups. Both groups focused on recording individual animal information, health monitoring, and breeding tracking, with evaluating these features as the most important. While there was a general alignment in the rankings,

Table 3: The App Features Need a Survey of Buffalo Expertise (n=5) and Farmers (n=55)

App feature needs	Expertise (n=5)		Farmer (n=55)	
	Importance scores mean	Importance category	Importance scores mean	Importance category
1. Animal individual information	5	Most	4.8	Most
2. Health monitoring and tracking	4.7	Most	4.5	Most
3. Breeding monitoring and tracking	4.6	Most	4.2	Most
4. Performance analytics	3.8	Medium	4.0	Medium
5. Alerts and notifications	3.9	Medium	3.9	Medium
6. Access market information	2.0	Low	3.2	Medium
7. Educational resources	3.6	Medium	3.6	Medium
8. Track income and expenses	1.9	Low	1.9	Low
9. Connect with other farmers and experts	1.9	Low	1.5	Low
10. Share farm news and updates with the group	1.6	Low	1.6	Low

*Ranking: 1 = not important, 2 = somewhat important, 3 = important, 4 = very important; Importance category: 1.0-2.0 = Low, 2.1-4.0 = Medium, 4.1-5.0 = Most.

with both groups rating performance analytics and alerts as moderately important, experts tended to place a slightly higher emphasis on technical features. However, farmers prefer practical aspects such as market information. Both groups considered community-oriented features, e.g., connecting with others and sharing farm news, the least important one.

Table **4** provides a comparative analysis of the app design preferences, visual elements, layout, and navigation preferences between the two groups, experts and farmers. This analysis highlights the important aspects of mobile app design that these two groups of users consider visually attractive, user-friendly, and functional. Within both groups, the color scheme was considered the most visually appealing

Table 4: App Design Needs a Survey of Buffalo Expertise (n=5) and Farmers (n=55)

Items	Expertise (n=5)	Farmer (n=55)
1. App design preferences		
What design elements do you find most visually appealing in a mobile app?		
Color scheme	3	25
Icons	2	18
Typography (font style)	0	12
What is your preferred design?		
Minimalist and clean app design	2	32
More colorful and visually rich design	3	23
How would you describe your ideal app layout?		
Simple	2	29
Intuitive	1	8
Organized	3	18
How important is the design of a mobile app to you when using it for a specific purpose?		
Very important	4	38
Important	1	17
Neutral	0	0
Not very important	0	0
Not important at all	0	0
2. Visual elements and aesthetics		
What design elements in a mobile app's user interface (UI) do you find visually appealing?		
Color scheme	2	15
Icons	1	17
Typography (font style)	0	10
Images and illustrations	2	13
Do you prefer a minimalist and clean app design or a more colorful and visually rich design?		
Minimalist	2	30
Colorful and visually rich	3	35
3. Layout and navigation		
Which type of navigation menu or structure do you find most user-friendly in a mobile app?		
Side menu	3	21
Bottom navigation	2	20
Tabs	1	14
4. Data presentation		
How do you prefer data related to a specific task or information to be presented in a mobile app?		
Forms	1	22
Graphs and charts	4	20
Lists	0	13

aspect, with 3 out of 5 specialists and 25 out of 55 farmers reporting this preference. Icons were the second most popular choice and were preferred by two experts and 18 farmers. Typography, precisely font style, receives less focus, as it is seen as attractive by only 12 farmers and without expert recognition. Regarding design style preferences, there was a choice between minimalist/clean designs and more colorful/rich designs. Most participants from both groups expressed a preference for minimalist and clean app designs. The user offers the alternatives simple, intuitive, "simple," "intuitive," and "organized" organized when showing their preferred app layout. Both groups indicated a tendency towards simplicity and organization; however, their preference for a structured layout was especially apparent among farmers. Participants rated the importance of mobile app design when using the app for a specific purpose. Experts and farmers have accepted the significance of design, with a substantial majority responding that it is either "important" or "very important." Regarding specific UI elements, the replies indicated various preferences for specific visual aspects of the user interface within the app, such as the color scheme, icons, typography, and images/illustrations. Color schemes and icons were the preferred visual features in both groups. The participants evaluated various navigation methods, including the side menus, bottom navigation, and tabs. Experts did not show a significant preference for a specific type, but farmers generally favored side menus. The survey also investigated individuals' preferences for data presentation types such as forms, graphs, charts, and lists. Experts mainly supported graphs and charts as their preferred mode of data presentation, whereas farmers displayed a slight tendency towards forms.

Overall, although experts and farmers share an appreciation for common characteristics such as color schemes and simple layouts, their preferences differ in terms of design complexity, navigation structures, and specific user interface elements. These insights are critical in designing mobile apps that meet the needs of various user groups.

3.4. User Interface Design and Main Menu of the Smart Buff Manager

The primary interface of the Smart Buff Manager comprises 6 components: 1) Farm info. menu: 2) Activities record menu; 3) Notification menu; 4) Farm performance menu; 5) Farm financials menu; and 6) Support menu. The user interface design and description of each menu are shown in Figure **2** and Table **5**, respectively.

3.5. Usability and Satisfaction

A usability and satisfaction test of the Smart Buff Manager application was conducted by collecting responses from 55 users, as shown in Table **6**. The evaluation focused on three major factors. The evaluation criteria included 1) the features and functioning of the app, 2) the user interface, the clarity of information, and the interactivity, and 3) the overall satisfaction and the likelihood of recommending the app.

The results indicated that users particularly appreciated the app's ability to manage breeding

Figure 2: Smart Buff Manager app example page.

Table 5: User Interface Design and Menu of the Smart Buff Manager App

Menus	Modules	Description
Farm info. menu	Farmer profile	Basic farmer profile such as name, age, gender, experience, etc.
	Farm profile	Basic farm details, including the farm name, location, size, and type of buffaloes raised.
	Buffalo inventory	A list of all buffaloes on the farm, with key information including age, health status, and identification numbers.
Activities record menu	Health and veterinary records	Health activities, including vaccinations, treatments, deworming program, and health checks.
	Breeding and calving records	Details on breeding schedules, pregnancy monitoring, and calving records.
Notification menu	Task reminders	Notifications for upcoming or overdue tasks, such as feeding, health checks, deworming, and vaccinations.
	Breeding alerts	Reminders for breeding cycles, expected calving dates, and post-birth care.
Farm performance menu	Production performance	Data on growth rates of buffaloes, with options to view trends over time.
	Health and mortality rates	Statistics on the health of the herd, including illness frequency, recovery rates, and mortality data.
	Breeding performance	Success rate of breeding programs, including conception rates and calving intervals.
Farm financials menu	Income tracker	Records of all income sources, such as meat sales, manure, and breeding services.
	Expense tracker	Expenses cost including feed costs, veterinary services, labor, and equipment maintenance.
	Profitability analysis	A summary of the farm's financial performance, showing profit margins, and cash flow.
Support menu	App support	Contact options for technical support.

Table 6: Usability and Satisfaction of the App (n=55)

Items	Mean (SD)
1. App features and functionality	
1. The app's navigation is easy to understand.	4.33(0.70)
2. The app has helped me manage buffalo health monitoring.	4.13(0.90)
3. The app's features made it easy to manage my buffaloes' feed and feeding schedule.	4.04(0.74)
4. I was able to use the app to manage my breeding information records efficiently.	4.40(0.68)
5. The app's alerts and notifications helped me with managing tasks and events on the farm.	4.35(0.70)
6. The app helped me analyze the farm's performance	3.96(0.74)
7. I find the features related to educational resources helpful.	3.87(0.94)
8. The report's features are ease of use and helpfulness.	4.20(0.73)
2. User interface, clarity of information, and interactivity	
1. The app's user interface is well-designed and makes it a pleasure to use the app.	4.02(0.78)
2. The information presented on the app is clear and understandable.	4.16(0.76)
3. I find the interactive elements of the app (buttons, menus, etc.) highly intuitive.	3.98(0.73)
4. The app's layout is easy to understand and navigate.	4.20(0.70)
5. The app's fonts and icons are easy to read.	4.27(0.78)
3. Overall satisfaction and likelihood of recommending	
1. Overall, I am satisfied with this app.	4.07(0.72)
2. I would recommend the app to other buffalo farmers.	4.18(0.75)

*These statements received responses ranging from 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree.

Table 7: Comparative of the Key Performance Indicators of a Smart Buff Manager App for Users and Non-Users

Key Performance Indicators	Users (n=10)	Non-users (n=10)	P value
1. Productivity performances			
- Calving intervals (month)	12.70±0.75	13.00±0.66	0.35
- Birth rates (%)	44.32±20.81	46.87±24.06	0.81
- Conception rates (%)	55.79±22.51	47.27±17.03	0.36
2. Economic performances			
- Income from buffalo farming (USD/animal)	552.34±217.72	441.87±179.18	0.31
- Healthcare expenses (USD/animal/year)	12.29±6.18	16.60±8.58	0.21
3. Operational efficiency			
- Time spent on record-keeping tasks (minute/time)	6.50±2.41	10.00±5.27	0.08
- Labor costs (USD/animal)	100.72±46.56	117.75±48.93	0.43
4. Animal welfare indicators			
- Health problem (%)	10.51±2.83	13.28±6.16	0.45
- Compliance with vaccination schedules (%)	93.00±4.83	88.00±4.21	0.02
- Compliance with deworming schedules (%)	90.00±6.66	87.00±4.83	0.26

information (4.40±0.68) and its ease of navigation (4.33±0.70), while the clarity of presented information (4.16±0.76) and readability of fonts and icons (4.27±0.78) were also highly rated. Although the interactive elements (3.98±0.73) and farm performance analysis features (3.96±0.74) were rated slightly lower, they still reflected a positive user experience. Overall satisfaction with the app was high (4.07±0.72), and the likelihood of recommending the app to other buffalo farmers also received a strong endorsement (4.18±0.75). These results suggest that users are generally satisfied with the app's performance and inclined to recommend it to their peers.

3.6. The Comparative of Key Performance Indicators of Smart Buff Manager Users

Table **7** presents a comparative examination of key performance indicators (KPIs) between users and non-users of the "Smart Buff Manager" application. The results indicate multiple positive trends for app users related to productivity, economic performance, operational efficiency, and animal welfare indicators. Users showed a slight decrease in calving intervals, higher conception rates, and higher revenues from buffalo farming. Furthermore, they spend less time on record-keeping activities, highlighting their enhanced operational efficiency. The results indicated the potential benefits of using the app, especially in terms of time management and productivity in farming; however, the majority of changes were not statistically significant.

One exception was significantly greater adherence to vaccination schedules among app users, which could improve herd health and long-term productivity. Users exhibited significantly higher following vaccination schedules (93.00±4.83%) compared to non-users (88.00±4.21%), with a statistically significant difference (P=0.02). Nonetheless, factors such as healthcare costs, labor costs, and health problems showed no significant differences between the two groups. This indicates that although the app provides benefits in specific areas of farm management, its overall influence on the overall economic and welfare results requires further investigation, especially with larger sample sizes, to more accurately assess its effectiveness.

4. DISCUSSION

4.1. Principal Findings

Farmers in Thailand, particularly young farmers, increasingly use the internet for agricultural activities, assisted by smartphone technology and social media platforms. Popular applications for agricultural communication include LINE and Facebook, whereas YouTube is frequently used to gather information [13]. Similarly, the adoption of smartphone apps in agricultural management has grown progressively. This trend is important to improve farming practices and productivity. Key factors influencing smartphone technology utilization include age, education, and contact with agricultural extension officers. Understanding these factors can help to enhance

agricultural practices and productivity. Young farmers with higher education levels are more inclined to use smartphones for agricultural purposes, although gender has no significant effect on adoption. However, farm size and diversity positively influence smartphone usage [14]. Some research indicates that many smallholder farmers lack adequate digital skills to use smartphone applications efficiently, which is essential for modern farming. Furthermore, insufficient training programs and resources for farmers to learn about new technologies have resulted in poor adoption rates [15].

The "Smart Buff Manager" app was developed on the adaptation of the ADDIE model to meet the specific needs of buffalo farmers, focusing on improvements in record-keeping, health monitoring, and breeding management. Both farmers and experts provided suggestions for the app's design, which led to a preference for straightforward, user-friendly interfaces and intuitive navigation. Farmers, primarily middle-aged men managing small-to-medium herds for meat production, have fewer skills in using smartphone apps for farm management despite widespread smartphone ownership. A small proportion of farmers used technology for farming-related purposes, illustrating the need to develop a simple and accessible tool. The design components of the app, including clear data display and user-friendly navigation, received positive feedback, especially for its breeding management features. Farmers expressed considerable satisfaction with the app and an increased tendency to suggest it to others, highlighting its usefulness in daily farming tasks.

In addition to usability and satisfaction, the app assesses significant improvements in farm management efficiency. Users of the app experienced better operational outcomes, such as improved herd health and reduced record-keeping labor costs. The co-designed approach, which integrated feedback from both buffalo farmers and agricultural experts, was key to ensuring the relevance and effectiveness of the app. As a result, the app enhanced the management of buffalo herds and demonstrated the potential of mobile technology to increase farm productivity, optimize management procedures, and support decision-making. This case study highlights the critical role of farmer involvement in the app development process, ensuring that the final product effectively meets farmers' needs and improves their overall farm performance. However, this study was limited to short-term outcomes and user experiences during the initial implementation phase. Future research should involve larger and more diverse sample populations to validate and generalize these findings. Additionally, we need long-term studies to evaluate the "Smart Buff Manager" app's sustained impact on productivity, operational efficiency, and animal welfare over time.

4.2. Challenges and Limitations

The adoption of mobile apps for farm management by smallholder farmers in rural areas faces several challenges and limitations, including 1) inadequate digital infrastructure with limited Internet access effect on information transfer for farming practices, 2) lack of the necessary digital skills to utilize smartphone applications effectively, 3) insufficient training programs and resources for farmers to learn about new technologies, contributing to low adoption rates, and 4) high costs associated with smart farming equipment and technology with limited financial resources [13, 15, 16].

Enhancing the adoption of mobile applications by smallholder farmers to improve farm productivity and efficiency. The application development process should focus on the real needs of the user, providing user-friendly applications that are simple to use, straightforward, and supported by tutorials or hands-on training. Farmers and experts may employ a co-design approach to address specific needs within an application context [17, 18]. Moreover, understanding mobile device usage behavior and technology literacy is crucial for designing and promoting app adoption. Factors such as age, education, farm information, and smartphone usage background were used to identify the entry points for new farming-related applications. Younger farmers show a greater willingness to embrace technology than older farmers, who often prefer traditional methods [19]. Furthermore, even when technology is available, the level of digital literacy among smallholder farmers remains a significant limitation. Many farmers lack the knowledge and skills to use mobile apps effectively, which can further hinder their ability to access and utilize the information and tools provided.

To address unfamiliar new technology problems, introducing new technology requires support, such as training programs, user guides, or even community-based peer learning, where experienced farmers help train others. This builds confidence in the use of mobile applications and improves their effectiveness. Enhancing the knowledge of mobile application benefits through community engagement and

instruction can significantly impact adoption rates. Perceived utility and social impact are key factors in farmers' willingness to adopt new technologies [20].

5. CONCLUSION

A user-centered co-design method that incorporated buffalo farmers and agricultural experts effectively designed the "Smart Buff Manager" application. The ADDIE instructional design approach offered a systematic framework for the development of the app, ensuring consistency with the real requirements of buffalo farmers. Key features, including record-keeping, health monitoring, breeding management, and notifications for upcoming tasks, were developed to address the specific problems faced by smallholder farmers. The app, which was designed for simplicity and ease of use, receives positive feedback from users, enhancing satisfaction and adoption rates. Implementation of the app resulted in considerable improvements in farm management practices, especially in terms of operational efficiency, productivity, and animal welfare. The "Smart Buff Manager" apps illustrated the potential of mobile technology to improve farm production and decision-making by decreasing labor expenses, increasing birth rates, and reducing calving intervals. This case study emphasizes the importance of involving end users in the development process to provide a tool that is relevant and successful in addressing their specific requirements, thereby encouraging the adoption of digital farming solutions.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ACKNOWLEDGEMENT

The authors express gratitude to the Program Management Unit on Area-Based Development, the University of Phayao, and the Thailand Science Research and Innovation Fund (Fundamental Fund 2024) for funding this study. We also extend our deep appreciation and gratitude to the farmers who participated in collecting field information and provided valuable responses.

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Received on 03-10-2024 Accepted on 26-11-2024 Published on 11-12-2024

https://doi.org/10.6000/1927-520X.2024.13.19