DEVELOPING A DATA COLLECTION APPLICATION FOR FOLLOWING UP THE SMALL-SCALE DAIRY FARMS' PERFORMANCE IN RURAL AREAS

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SUMMARY

The mobile application is an effective tool for data collection of performance in agriculture, particularly for small and geographically scattered farms. This study aimed to develop an economical and straightforward application to monitor small dairy herds performance with the flexibility to collect data remotely. The developed mobile application was designed using the MIT App Inventor. Where, the application explores icons of different farm management practices that are reported by farmers through touching the screen. Each icon is linked with an informative SMS, which was received by the mobile phone of the collection technician. We randomly selected and followed 18 farmers to test the application for one year. The main results were recognized the false SMS decreased as farmers took enough time for training in the software. Furthermore, most of sent SMS were for milk yield event. Age, level of education and land size had no significant effect on correct SMS sent by farmers, while herd size showed a significant effect. In conclusion, mobile application could be developed for continuous data collection and following up small dairy farms in rural areas. Also, the validity test for the developed mobile application confirmed that farmers were able to use the new technology regardless their age and educational level.

Keywords: Mobile application, Android, Small dairy farms, rural areas

INTRODUCTION

In Egypt, the dairy sector comprises approximately one-third of the value of all national agriculture (FAO, 2017). In 2015, livestock production contributed approximately E£ 73.5 billion to the national economy, representing 2.2 % of the GDP, 23 % of which was from milk production (FAO, 2017). A family farming system based on integrated crop and livestock production is the norm (95 % of total cattle and buffalo), wherein 85% of farmers have fewer than 10 head (Abdel-Salam *el al.,* 2009). For most of these small landholders, no data is recorded on their farming activity (production, reproduction, or farm practices). Until recently, there has been limited investment from governmental institutes or agencies to produce statistics on these populations. There are limited data and consolidated statistics available at the regional or national level to support policymakers or dairy processing companies in the dairy development sector in Egypt. Without these data, it is difficult to design relevant policies to support small-scale family farming systems that are often extremely vulnerable.

In this context, the establishment of a monitoring system in Egypt is urgently needed. This recording system could provide reliable information on dairy cattle and buffalo productivity for all types of farms and, consequently, could significantly improve planning, agricultural policies and marketing development. Indeed, monitoring herds can help farmers and agricultural advisors to design technical options for the real-world context of the farms (Martin *et al.*,2013). As such, productive and reproductive parameters are the basic prerequisites to identify problems affecting productivity. However, monitoring systems are often difficult to implement in dairy farms to capture frequent periodical data. The main obstacles to conducting monitoring are the cost and time of data collection from farms and the infrastructure that constrains access to rural areas.

Monitoring animal performance and herds are costly for implementation and realisation in scattered herds. The main cost of monitoring or traditional extension for small herds are salary and transportation of data collectors to conduct face to face interviews (Cornou and Kristensen, 2013 and Belakeri *et al.,* 2017). Moreover, the frequency of the data collection in monitoring is also important to improve accuracy (Cornou and Kristensen, 2013), while the cost of data collection is increased. A biweekly milk recording scheme for 24 hours provided lower error in milk yield prediction compared with monthly tests (Wabe and Asmare, 2015), although the correlation between monthly milk recording and actual milk yield was 0.97. High accuracy of milk yield can be achieved with monthly data collection schemes (Norman *et al.,* 1999), wherein periodical milk collection decreases the cost of recording.

Jain *et al.* (2015) reported that, agricultural information system needs to be developed based on the mass communication technology like mobile systems. In the last decade, innovative approaches to collect data in small landholder farms have been developed using a mobile phone (Herrick *et al.,* 2013). The FAO (1990) indicated that appropriate new technologies ought to be technically feasible, economically attractive and culturally accepted. In Egypt, farmers are reluctant to allow frequent visits to collect data, especially in case of outbreaks. Furthermore, most of the farmers are equipped with mobile technology. In addition, information and communications technology improves the recording system in terms of time consumption for data entry.

In Malaysia, a recording system, the International Committee for Animal Recording System (ICARS) was designed by Maxvet© to record data in small scale dairy farms to improve their management (Jeyabalan, 2010). More recently, in 2013, Korea used a real-time livestock monitoring system to diagnose cattle oestrus and diseases in the early stages. This system was based on biometric and image data using platform information (Hwang *et al.*, 2013). In 2014, a mobile application for Android was used for livestock disease extension purposes as well as disease diagnostic tools for early stages (Hwang *et al.,* 2014). A mobile application was developed in Korea to monitor cattle feeding behaviour to identify animal health status and detect diseases in early stages (Sivamani *et al.,* 2015). However, these variousused applications contain texts, so only those farmers able to read texts could use these applications.

The main problem that facing scattered and small herds was the shortage of accurate and continuous data about livestock. Moreover, the lake of technology with simplified user interface that can farmers use it taking into account heterogeneity of farmers categories. In this study, pilot mobile application software for recording productive and reproductive data in farms was tested to collect farm data remotely. The main objectives of this study were to developdata collection software matched with small scale characteristics. Also, this study tried to test the validity of developed mobile application to be used in the real circumstances.

MATERIALS AND METHODS

Different recording systems are not equal in popularity and accuracy. Also, some farmers are not able to use mobile application software based on texts. This study will help multiple farmers collaborate to source data, taking into account young farmers' preference; there is a need for a tool to involve young farmers in data collection to guarantee sustainability where young farmers tend to leave the farming profession. Developing tools for monitoring in addition to visits makes monitoring systems flexible enough to be used, particularly in a crisis. In the studied area, farmers varied in level of education attained, and a high proportion of them are not able to read and write, so there was a need for an easy tool using a graphic interface to enable the data collection process. In addition, farmers tend to be unreceptive to data collectors, particularly during disease outbreaks.

Study area:

The Socioeconomic Impact Assessment of the Danone-Egypt Ecosystem Project (SIADEEP) included a proposal to develop a system to monitor and understand the farm practices and, eventually, to identify the farmers' needs throughout the year. Targeted farmers were small and holders near the milk collection centre project in Beni Suef Governorate, located 120 km south of Cairo. The sample consisted of 18 randomly selected small landholders aged 15 to 65 (Table 1).

Table 1. Farm sample statistics for the group

Category	No.	Mean	SE	C.V %
Age (year)	18	35.38	3.71	44.56
Land (ha)	18	0.56	1.94	25.76
Herd (Head)	18	4.88	0.5	43.75

ha: Hectare, SE: standard error and C.V.: coefficient of variability.

Data collection:

Bi-monthly visits were conducted, wherein technical data were recorded, including herd composition, feeding practices and herd dynamics (entry and exit). These data were collected to assess dairy animal performance. The laser monitoring system (Lesnoff *et al.,* 2014) was used as a guide in developing an application that fits small herd conditions. The farmers' interest was first tested for these specific data collections through on-farm visits. Data were recorded at the animal level, so each animal was identified individually using an identification number that hung around the neck by the rope used in the existing tying system to avoid any changes that could disturb farmers. Mobile applications were developed to allow data collection between the farm visits. All data required for monitoring farms were shown in Table (2). The animal identification system used an ID number or a picture of the animal.

Table 2. Data collected through the mobile application

Trait	Data
Birth	Date of birth, identification of dam, the ID of the calf and sex of the calf
Milk production	Date of milk production, animal identification and quantity of milk production
Drying date	Date of drying off, animal identification
Insemination	Date of insemination, animal identification
Pregnancy diagnosis	Date of palpation, animal identification and result
Purchasing	Date of purchase, animal identification, purchasing status (dam only, dam with calf, calf only)
Selling	Date of sale, animal identification
Feed formulation	Date of a mix, type of ingredients and quantity

Program development:

The software developed linked each graphic interface with SMS (Short Message Service) generation. The developed mobile application was designed using MIT App Inventor, the process of which is shown in Figure (3). To test the application on the farm, Android mobile phones were first distributed to farmers with the application installed if the farmers did not have a mobile phone with an Android system. The mobile application model was based on the Android operating system' with a CPU that operated at 1.2 GH. Each farmer had an application updated with its herd's data: animal identification, size of the herd and global positioning system (GPS).

The mobile application was designed to send SMSs for each event to data collector, where the collector entered these data into a database. The pre-test of developedmobile application was conducted, where a demo version was initially developed to test functionality with farmers before launching the autonomous experimentation in the field. The main objectives of the pre-test process were to determine the perception feedback of farmers and their interaction with the software and to identify any program errors. False and correct SMS information were recorded through the validity test period. During the six-month test of the applications in farms, a bi-monthly visit was conducted to validate the data received by the SMS and provide technical reports to farmers (Figure 1). False SMS could be defined as SMS massage that was not matched withthe real data that collected through field visits. While SMS considered correct SMS when the SMS massage was matched withthe real data that collected through field visits.

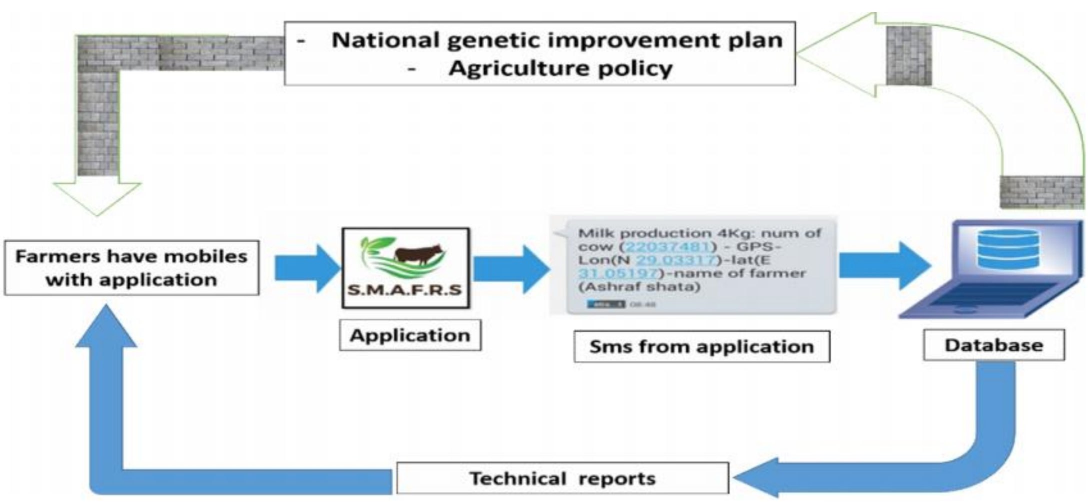

Figure 1. Description of the application development process and data pathway.

Event workflow and interactions:

The application was designed to include the most important events in small dairy farms including animal birth, veterinary visit, feed formulation with different ingredients, purchased animals, sold animals, milk yield for each animal, dates of drying off, insemination dates for animals and palpations. The application considers the relationship between all events.

Event of calving and its relationship with milk production:

In the workflow of calving, the cow ID is shown automatically in many events such as milk production (Figure 2), and the app will generate a new ID for the calf and send the information via SMS to the supervisor containing the name of the farmer, cow ID, calf ID and sex of the calf (Figure 3).

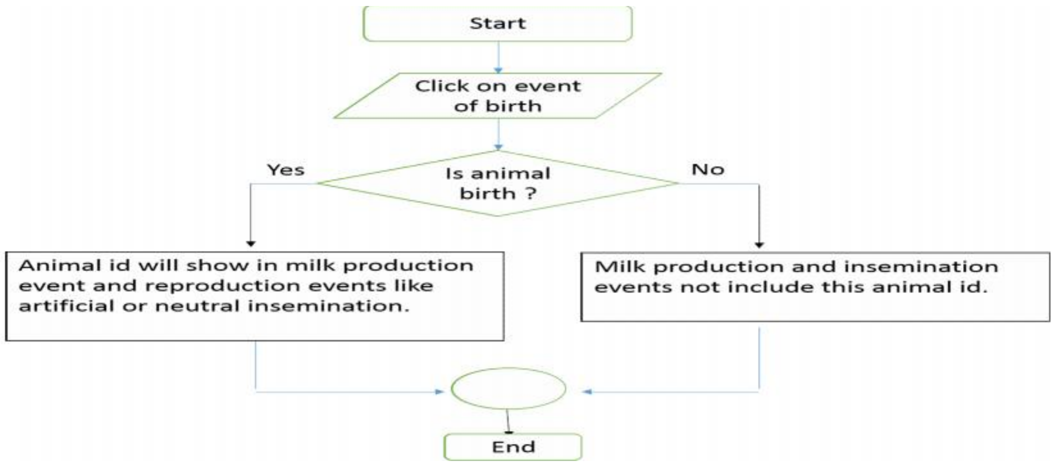

Figure 2. Event flow diagram of a calving event.

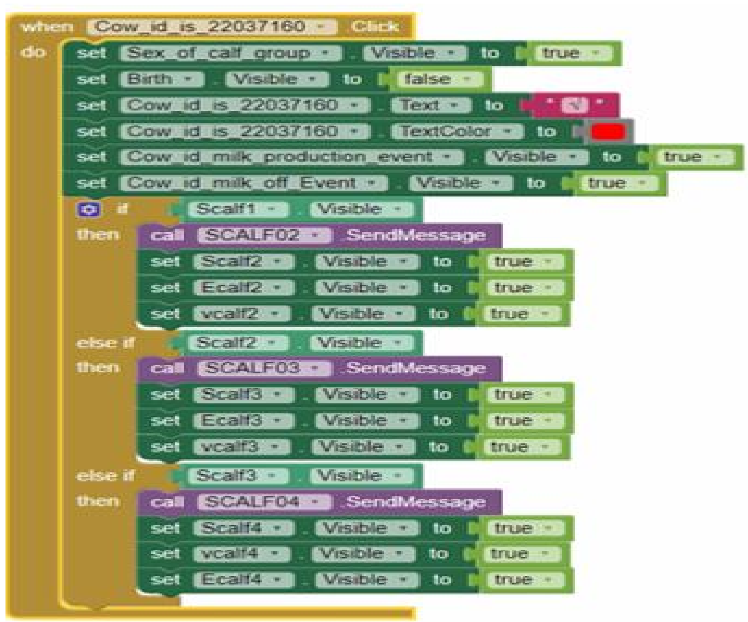

Figure 3. Workflow of calving and its interaction with other events by code.

Each recorded event was converted and displayed using a picture (Figure 4). Icons were used to facilitate the use of a mobile touch screen by all farmers. The size of a graphic icon was more than 150 mm to be usable by different aged farmers (Pijukkana and Sahachaisaeree, 2012).

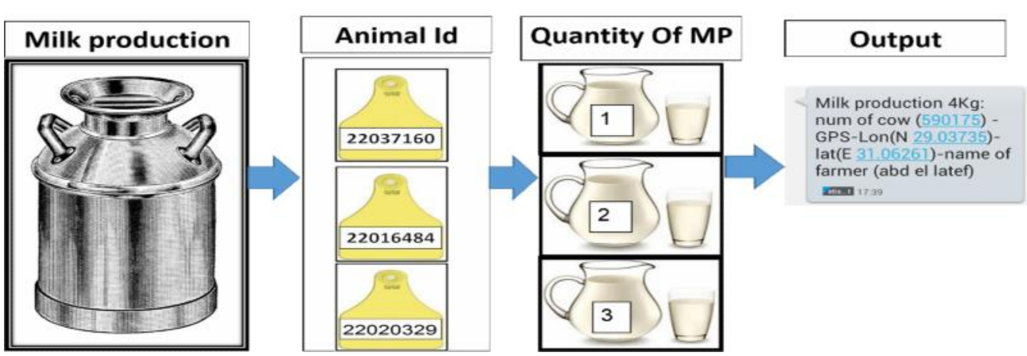

Figure 4. Workflow of milk production event by application icons.

Event of drying off and its relationship with milk production:

The workflow of the drying offevent has a relationship with the milk production event; in the dry period, the cow ID will disappear from the milk production event (Figure 5).

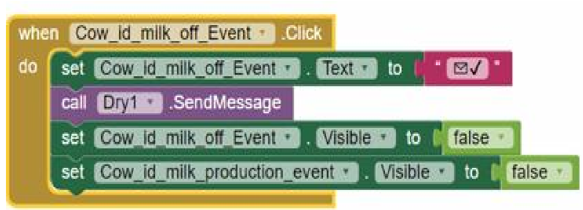

Figure 5. Workflow of drying off event and its interaction with other events by code.

Event of selling animals and its relationship with other events:

The workflow of selling animals has a relationship with milk production, drying off and reproduction events; when the cow is sold, the cow ID disappears from other events (Figure 6).

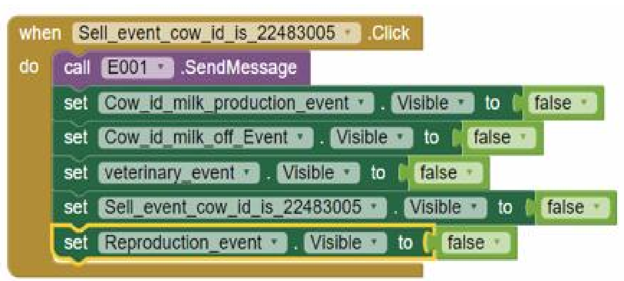

Figure 6. Workflow of a selling event and its interaction with other events by code.

Statistical analysis:

The effects of education level, farmer's age, herd size and land size on the SMS send rate were tested. The data analysis was performed with the statistical package of R language using proc GLM, where the following model was used:

$Y_{ijklm} = \mu + E_i + A_j + H_k + L_l + e_{ijklm.}$

which Y_{ijklm} is the average number of SMSs sent per month, μ is the overall mean, E_i is the level of education from 1 to 4, where 1 cannot read and write, 2 is the primary stage, 3 is the secondary stage, and 4 has a technical diploma, A_j is the age of farmers, H_k is the herd size where k is between 2 to 8 animals, L_l is the land size where L is between 0.39 to 0.85 ha, and e_{ijklm} is random error.

RESULTS

Types of events sent through the mobile application.

Figure (7) showed that 79% of information sent via SMS to the supervisor, which were for milk yield messages, while 21% of the other SMS information concerned all other events related to pregnancy diagnosis, including animals drying off, feeding, insemination, palpation, health status as well as animals purchased and sold. The farmers' experience improved through the 6 months of the trial period. Indeed, a significant decrease in the rate of incorrect information sent via SMS was recognised by two months (Figure 8).

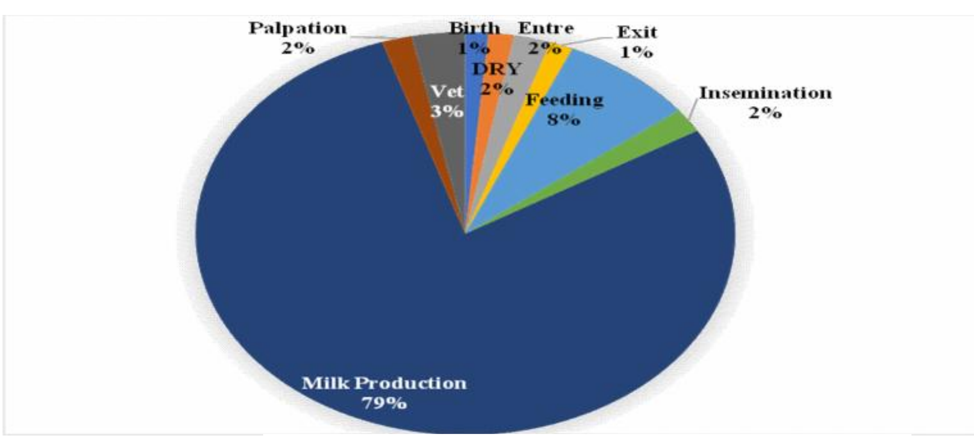

Figure 7. Percentage of milk production and other events recorded,

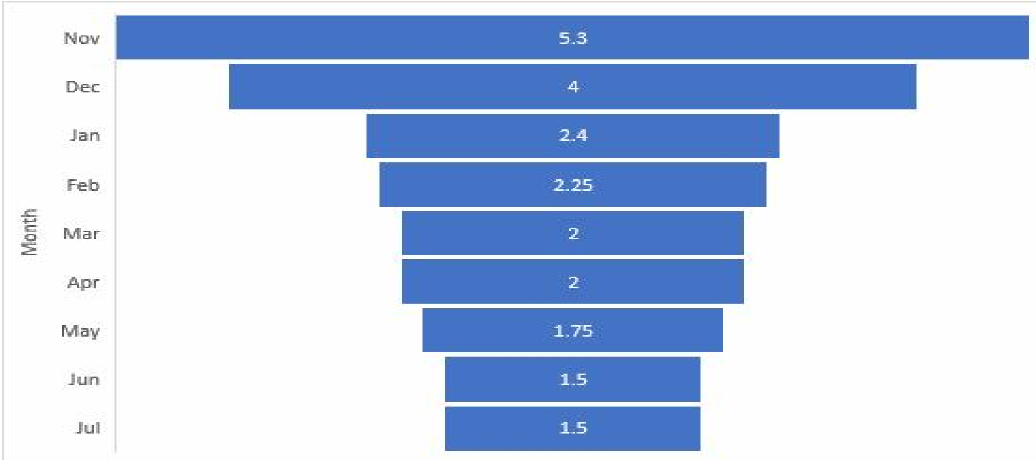

Figure 8. The average number of false SMSs sent by farmers through the testing period from November to July (*n* = 18 farmers).

Effect of farmer and farm characteristics on SMS send rate:

The level of education, age of farmers andland size had no significant effect on the SMS send rate. However, the rate was significantly affected by herd size (P <0.05) (Table 3). Larger farms tended to show a high rate of SMS use by farmers where the land size and herd size increased, the number of events sent also increased.

Table 3. Effect of educational level, age of farmer, land size and herd size on SMS send rate (*n* = 18)

Factor	Mean Squares	F-Value	Pr > F
Educational level	8.01	2.26	0.13
Age	1.21	0.34	0.56
Herd size	18.17	5.12	0.04*
Land size	15.82	4.46	0.06

*Factors that significantly (P < 0.05) affected the dependent variable (SMS send rate).

DISCUSSION

The developed SMS mobile application allowed farmers to use a touch screen with graphic interface design and send data as SMSs for the supervisor. Manual data recording of these SMS was an obligatory step, which could increase the cost of data collection. According to Figure (7) the SMS related to milk yield recorded the highest percentage of messages because it'sa daily event. Feeding event isa daily event also but did not take the same trend, where the quantity and components of feed weren't changed a lot through the year. The main changes are related to seasonal forages along the year. Other events like birth, insemination, palpation and vaccination were also seasonal events that happened during specific times during the year.

Moreover, Figure (8) confirms the previous observation of El Rafei *et al.* (2014) where the rate of false messages sent decreased over time, as farmers' skills of sending information improved, asthe number of false messages decreased. Also, the Accuracy of data increased during the data collection period, where farmers got trend through training period before data collection.

Table (3) shows the ability of farmers at different ages and educational backgrounds to use the technology in an efficient way. The results proved that the application could be used by different farmers' categories, as shown previously by Page (2014). Illiterate farmers can use the touch screen mobile phone through an interface with graphic design. This phenomenon was also well described by Medhi *et al.* (2011) and Knoche *et al*. (2012), who recommended using graphic design and voice operation for efficient use by illiterate people. However, our results showed that land size and herd size had a significant effect on the SMS sending rate by farmers.

The SMS application program related to system analysis studies will help agricultural policymakers to deal with challenges such as genetic improvement programs (identification of outstanding individuals) or dairy productivity improvement. This type of application can also interest dairy plants that invest in rural areas to collect milk from small scale farmers, notably in inclusive dairy businesses (Daburon 2017). Data collected could also help to improve farmer management decisions such as accurate timing of vaccination and insemination, prediction of calving dates and subsequently required management practices and formulation of balanced rations.

Generally, mobile applications might play an important role in rural development in the near future, wherein all farmers, particularly youth, have mobile phones and tend to be more familiar with this communication technology. Moreover, reporting to farmers could encourage them to sustain the use of the mobile application in farm data record keeping. It could help to improve the efficiency of crop-livestock farming systems and thus could help to maximise farmer profit (Gichamba and Lukandu, 2012 and Sivamani *et al.,* 2015), improve social networking between farmers, while reducing the environmental hazards of agriculture.

CONCLUSION

The developed mobile application as data collection tool was able to send data required for monitoring the productive and reproductive performance of small dairy herds. The cost of data collection using the mobile application could be reduced markedly compared with traditional farm visits. This program facilitates data collection from small dairy farms remotely through crises or outbreaks. Developing another version of this application capable of directly storing data in a database through the internet could decrease data entry costs and would be a promising pathway toapply. The efficiency of using the application was not affected by farmer age, land size or level of education.

CONFLICT OF INTEREST

The authors certify that there is no conflict of interest with any financial, personal, or other relationships with the other people or organizations related to the material discussed in the manuscript.

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REFERENCES

Abdel-Salam, S.A.M., S. Abou-Bakr, M.A.M., Ibrahim, R. R. Sadek and A. S. Abdel-Aziz, 2009. Estimation of breeding values of total milk yield of Egyptian buffalo under different production systems. ICAR Technical Series. 13:167-172.

Belakeri, P., C.K. Prasad, S. Bajantri, M.T. Mahantesh, S.T. Maruthi and G.N. Rudresh, 2017. Trends of mobile applications in farming. International Journal of Current Microbiology and Applied Sciences, 6 (7): 2499-2512.

Cornou, C. and A.R. Kristensen, 2013. Use of information from monitoring and decision support systems in pig production: Collection, applications and expected benefits. Livestock Science. 157(2-3):552-567.

Daburon, A., 2017. Propositions de construction territorialisée de business inclusifslaitiers à l'aide de la gestion de la qualité du lait. Une approche multi-scalaire à partir d'un casd'étudeégyptien. Thesis of Doctorate, CIRAD, ABIES, Sarclay University. https://tel.archives-ouvertes.fr/tel-01748956

El Rafei, M., G. Kamal, R. Mohamed, and O. Nour Eddin, 2014. Country Study Summary: the Arab Republic of Egypt, IFAD-UNESCO Global Seminar on "Learning knowledge and skills for agriculture and improving rural livelihoods," Paris, France, 27-28 Feb.

FAO, 1990. Livestock systems research manual. Volume 1.

FAO, 2017. Livestock production systems spotlight cattle and buffaloes, and poultry sectors in Egypt manual.

Gichamba, A. and I.A. Lukandu, 2012. A model for designing M-agriculture applications for dairy farming. The African Journal of Information Systems. 4(4): 120:136.

Herrick, J.E., K.C. Urama, J.W. Karl, J. Boos, M.V.V. Johnson, K.D. Shepherd, J. Hempel, B.T. Bestelmeyer, J. Davies, J.L. Guerra, and C. Kosnik. 2013. The global Land-Potential Knowledge System (LandPKS): supporting evidence-based, site-specific land use and management through cloud computing, mobile applications, and crowd sourcing. J. Soil Water Conserv. 68(1):5A–12A.

Hwang, J., H. Jeong, and H.Yoe, 2013. A Study on the Real-Time Livestock Monitoring System using Mobile Platform 2. Mobile platform. International Journal of Smart Home. 7:137–145.

Hwang, J., H. Jeong and H. Yoe, 2014. Livestock disease counseling system using an Android smartphone. Mobile platform. International Journal of Smart Home. 7:137–45353–9. doi:10.14257/astl.2014.51.76.

Jain, L., H. Kumar, and R.K. Singla, 2015. Assessing mobile technology usage for knowledge dissemination among farmers in Punjab. Information Technology for Development 21(4): 668-676.

Jeyabalan, V., 2010. Individual cow recording and analysis system for small scale dairy farmers in Malaysia. International Journal of Computer Applications. 8(11):33–38. doi:10.5120/1247-1621.

Knoche, H. and J. Huang. 2012. Text is not the enemy: How illiterates use their mobile phones. NUIs New Worlds New Interact. Forms Interfaces Mob. Appl. Dev. Ctries. -CHI'2012 Work. 1–6.

Lesnoff, M., R. Lancelot, C.H. Moulin, S. Messad, X.Juanès and C. Sahut. 2014. Calculation of Demographic Parameters in Tropical Livestock Herds: A discrete time approach with LASER animal-based monitoring data. Springer, United States.

Martin, G., R. Martin-Clouaire and M. Duru, 2013. Farming system design to feed the changing world. A review. Agronomy for Sustainable Development. 33(1):131-149.

Medhi, I., S. Patnaik, E. Brunskill, S. N. Gautama, W. Thies, and K. Toyama. 2011. Designing mobile interfaces for novice and low-literacy users. ACM Transactions on Computer-Human Interaction (TOCHI). 18(1):1-28.

Norman, H.D., P.M. VanRaden, J.R. Wright,andJ.S. Clay,1999. Comparison of test interval and best prediction methods for estimation of lactation yield from monthly, a.m.-p.m., and trimonthly testing. J. Dairy Sci. 82:438–444. https://doi.org/10.3168/jds.S0022-0302(99)75250-1

Page, T., 2014. Touchscreen mobile devices and older adults: a usability study. Int. J. Hum. Factors Ergon. 3(1):65-85. doi:10.1504/IJHFE.2014.062550

Pijukkana, K. and N.Sahachaisaeree, 2012. Graphical Design and Functional Perception on Technology-Driven Products: Case Study on Mobile Usage of the Elderly. Procedia - Social and Behavioral Sciences, ASEAN Conference on Environment-Behaviour Studies (AcE-Bs), Riverside Majestic Hotel, 7- 8 July 2010, Kuching, Sarawak, Malaysia 42, 264–70. https://doi.org/10.1016/j.sbspro.2012.04.190.

Sivamani, S., H. Kim, M. Lee, C. Shin, J. Park and Y. Cho. 2015.An Android-based feed behavior monitoring system for early disease detection in livestock, In: Park D-S, Chao H-C, Jeong Y-S, Park JJ Editors, Advances in computer science and ubiquitous computing. Springer Singapore, Singapore. pp. 79–84.

Wabe, O. and K.Asmare, 2015. Lactation yield: Interval level comparison of milk records for genetic improvement in Friesian vs Arsi crossbred cows in the highlands of south eastern Ethiopia. Ethiopian Veterinary Journal 19:105-116. https://doi.org/10.4314/evj.v19i2.7.

تطوير تطبيق لجمع البيانات لمتابعة أداء مزارع الألبان الصغيرة في المناطق الريفية

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يعد تطبيق الهاتف المحمول أداة فعالة لجمع البيانات المزرعية، خاصة للمزارع الصغيرة المتباعدة جغرافيًا. كان الهدف من هذه الدراسة هو تطوير تطبيق اقتصادي ومباشر لمتابعة أداء قطعان الألبان الصغيرة مع توفر المرونة في جمع البيانات عن بُعد. تم تصميم تطبيق الهاتف المحمول المطور بإستخدام (MIT App Inventor). والذي يتضمن رموز لكل الممارسات المزرعية المختلفة والتي يتم التحكم بها من خلال لمس الشاشة حيث تم ربط كل رمز برسالة نصية قصيرة (SMS)، والتي يتم استلامها بواسطة الهاتف المحمول الخاص بالمطور (الباحث). تم إختيار ١٨ مزرعة بشكل عشوائي في محافظة بني سويف - مصر ومتابعتها لإختبار التطبيق لمدة عام. كانت النتائج الرئيسه هي إنخفاض عدد الرسائل الخاطئة مع توفر الوقت الكافي لممارسة التطبيق من قبل المزارعين. علاوة على ذلك، كانت معظم الرسائل القصيرة المرسلة تتعلق بعملية إنتاج اللبن.أثبتت الدراسة انة لم يكن لعمر المزارعين ومستوى تعليمهم ومساحة الأرض الزراعية أي تأثير معنوي على صحة الرسائل المرسلة من المزارعين، بينما أظهر حجم القطيع تأثير معنوي. من خلال الدراسة تم إستنتاج أنه يمكن تطوير تطبيقات الهاتف المحمول لجمع البيانات بشكل مستمر ومتابعة أداء مزارع الألبان الصغيرة في المناطق الريفية. كما أكد اختبار الصلاحية لتطبيق الهاتف المحمول المطور وقد تمكن المزارعين من استخدام التكنولوجيا الجديدة بغض النظرعن أعمارهم ومستوى تعليمهم.