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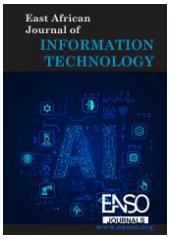

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Original Article

A Contextualized Farm Management Information System

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ABSTRACT

Various Information Communication Technology (ICT) Agricultural initiatives implemented in Kenya have largely concentrated on the general farming set ups, ignoring the specific farm and Agricultural activities contexts. Literature review, sampling of ICT for Agriculture initiative (ICT4Agri) reports, and our knowledge on existing Agricultural Management Information Systems (AMISs) showed that a majority of the ICT4Agri for various farm management were general in nature and mostly facilitated information push towards farmers as opposed to allowing for a bidirectional flow of information. Only a few personalized and contextualized MISs for day-to-day management of farms existed. Besides their abundance, adoption, and use, challenges still exist due to the generalized nature in which system designers and developers conceptualize the ICT4Agri artefacts. With the objective of finding out if a more contextualized Agricultural farm Management Information System was better than the generalized Agricultural systems, we carried out an analysis of the current situation and designed, implemented, and tested a new integrated ICT4Agri dairy farm Management Information System. The system was co-designed with five purposefully selected ICT literate dairy farmers from the North rift counties of Kenya. Besides the presentation of the developed artefact, this paper presents the study results which showed that there is still need for compatible ICT agricultural systems which can allow farmers to process their own data by being allowed to have bidirectional movement of data and being able to create and use their own data. As a result, it was noted that there still exists a lot of opportunities for Agricultural digitization, especially if contextualization was to be factored in.

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INTRODUCTION

There are several Agricultural information systems and applications developed over the last decade in Kenya and in Africa. While some of these ICT4Agri initiatives have been beneficial to the target group, a good percentage has not gone beyond the evaluations stage. These systems include web portals, mobile-based applications, and application of big data analytics (Akuku et al., 2019).

Despite their existence, these systems have not been fully adopted by the low-income farmers due to a myriad of reasons. An attempt to answer the question of why these systems have not been fully adopted proofed a challenging task because of the many reasons, among other known challenges is the fact that these systems are disparate; incomplete; a limited number of them having clear evaluation report; farmer technological, literacy or capacity challenges and infrastructure challenges (Viatte, 2001). Our review of literature and the documentations of such systems intimidated that many agricultural digital ICT services largely concentrated on the general farming set ups and ignored the specific contexts of farmers. Further, most of the applications or systems out there were donor or private sector supported. Since it has been argued that it is difficult to measure the success of an initiative which is still running on donor funds, these initiatives cannot be classified as successes because a lot of times such projects have incentives which are likely to be lost after funding (World Bank, 2011).

It was also noted that a majority of the ICT4Agric initiatives were market information access by farmers and have been in place for long enough as witnessed in reports and papers such as that of Muriithi et al. (2009) where they talked about SMS –SOKONI as early as 2009. The other fact about existing ICT4Agric initiatives is that many of them do not go beyond pilot stage. From published reports and papers and the systems/apps we were aware of, it was hard to know if there exist systems which have gone beyond the pilot stage because many pilots fail (Bansler & Havn 2010). This is a fact also observed by World Bank and FAO report on ICT and Agriculture (World Bank, 2011). Further, it was noted that ICT agricultural initiatives have not been adopted because the development process was not participatory (Barakabitze, et al., 2017).

On the types of existing systems, we noted that they are largely mobile payment systems and mobile information services (referred to as advisor systems), and usually provides access to important information such as weather, prices, disease outbreak, and helpline services (World Bank, 2011). Such systems are usually information push making farmers information consumers only, an exercise which may not be sustainable without farmers being involved in generating the information they consume.

Problem Statement

Even though there is no shortage of technology use by farmers in Kenya (GeoPoll, 2020), such

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ICT4Agric initiatives are largely not contextual and mostly provide information push to farmers. From our preliminary study, a few of the existing systems provide individualized farm management functionalities usually provided by MIS systems. This was corroborated by the World Bank Group Field Survey Report Number 103186-Ke of 2016 on a summary of ICT services in agriculture in Kenya, which showed that none of the ICT services are information management (Ngari et al., 2016). In the same report, early warning accounted for 80% of the systems, climate predictions 78%, weather forecasts 55%, Agro-weather advisories 70%, Government policies 45%, insurance derivations 45%, climate projections 30%, transport safety advisories 30%, airspace forecasting 21%, and those classified as others accounted for 14%.

Secondly, farmers have limited access to good personalized systems which allow them to keep records of production at the same time carrying out day-to-day management of their farms. This is despite many findings indicating that such systems can be beneficial. For example, (Akuku et al., 2019, page 21) indicated that *'Management systems are becoming increasingly important to support agri-businesses in their day-to-day management of the supply chain*'. The third issue is that countries, and by extension farmers are yet to capitalize on the use of M-apps and systems developed so far and that developers should seek to engage a broad range of users (Baumüller, 2016). Even though a majority of the M-apps available are crop and livestock management (Makini et al., 2020), a majority of these apps were at the development and deployment stages described as unknown. As such, it becomes difficult to assess and give a generalised view of Agricultural digital services based on such reports. It is also equally difficult to download, install, and evaluate such systems as they either require a lot of data, long registration process, or even lack usable installation and user manuals, as noted by Makini et al. (2020) report.

Another challenge associated with ICT4Agric is that while there are so many initiatives, many of them are too complicated to farmers, take a top-down approach, or are spearheaded by none farmers. As a result, even though some of these initiatives are beneficial to farmers, most of them do not easily meet farmer expectations such as increasing yields, lowering costs, reducing losses, and increasing income (Akuku et al., 2019).

Further, there is still a tendency to use the old ICT as indicated by (Ayim et al., 2020) who said that the main ICT technologies adopted are text and voice-based services targeting mobile phones and radio, corroborating the point that most of the initiatives are for information dissemination towards farmers and less bi-directional.

Justification for a New Farm MIS

In light of the aforementioned issues on ICT4Agric initiatives, the task to obtain the contributing factors towards minimal impact of the farming information systems and applications was hindered. This necessitated a design, implementation, testing, and evaluation of a new integrated farm management system. The system development process was then, together with a review of the existing systems used to identify the current state of the ICT systems/applications and their important components/functionalities required for a successful use of Agricultural systems. This paper reports the outcome of the existing ICT4Agri initiatives and the resultant system developed.

The justification to develop the new system described in this paper was juxtaposed with findings from reviewing existing ICT4Agric initiatives which brought out the following compelling reasons for a new farmer personalised MIS:

Firstly, even though global general data is good for Agriculture, personalised products which give individualized data management (inputs and outputs) complements the existing general systems. Secondly, besides the existence of many Market information systems, weather predictions and early warning systems among others, there are still a few known good personalized MIS systems which allow farmers to keep records of production at the same time carry out day to day management of their farms. The personalized MIS are few and still come with a number of challenges in their adoption and use due to user related factors. To mitigate these factors, the system being presented was developed with farmers who had no or limited technological, literacy, capacity, or infrastructural challenges. This model of developing for specific group of farmers eliminates intermediaries, hence allowing for

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'Aligning the needs of users with the technical possibilities to mitigate the risks of failure and adoption' as has been noted by (Akuku et al., 2019, page 24) and (Pignatti et al., 2015), who introduced user knowledge as one of the key factors of adoption in ICT systems in Agriculture. It has also been argued that many users, and mostly small-scale farmers are unaware of the existence and importance of such systems (Akuku et al., 2019). The need to ensure that the target users were aware of the potential use and importance of such systems was another driving force. Besides, studies such as Akuku et al. (2019) have indicated that there exist doubts on the ability of Kenyan farmers to adopt mobile technology in Kenya. To reduce the risks of such a general conclusion, there was need for us to test the developed system using farmers with all the prerequisite factors envisioned by many studies.

Another view is that some works reviewed have taken an approach which assumes that only governments, established organizations, and development partners can propel Agricultural ICT sector. We have the view that individualized contextualized approach is another way. As such, individual efforts can contribute to the global, agricultural sector lagging behind in digitization (Gandhi et al., 2016). Further, it has been argued that to enhance ICT services in all the sectors, an enabling ecosystem, which has among others users as key players, must be put in place (Makini et al., 2020).

Besides the justifications related to existing knowledge on ICT4Agric, there is the overriding principle of the need to contribute to existing knowledge. There is need to grow ICT initiatives in Agriculture to the level of other sectors such as finance. This is because despite Agriculture having been among the key sectors digital ICT has focused on over the last decade, it is still lagging behind. One way to deal with this is service digitization (Makini et al., 2020), largely because there exists a clear indication that there are gains in digitizing agricultural services (Asiedu-Darko & Bekoe, 2014). As such, there is still room to try out Agricultural digitization as Agriculture is the least digitized sector in the world (Akuku et al., 2019).

STUDY METHODOLOGY

Overview of the Methodology

Pragmatism, which entails identifying a problem and dealing with it in its context was employed. The key task was to understand the problems faced by farmers in managing their farms in the absence of a suitable ICT support. A mixed method approach was the key methodology applied. The study journey had three main steps, namely: Information gathering, under which fact finding was the key mission. The second activity was to select farmers to carry out the study with and finally the development and testing of the prototype system followed as discussed below.

Information Gathering

The objective for this task was to establish the current status of the ICT4Agruculture initiatives in Kenya with a specific focus on the kind of ICT systems or applications currently in the space. Three simple steps were followed. The first one was to collect secondary data from various published reports, papers, documents, and relevant web pages of leading institutions such as Kenya Agricultural and Livestock Research Organization (KALRO) and Kenya's Ministry of Agriculture. This was in line what other similar studies, such as (Makini et al., 2020) have done before. The fact finding included a review of literature on existing ICT4Agri initiatives in Kenya where we reviewed various reports and papers. The search process of the reports and papers adopted a snowball approach.

In the next step, which was guided by the preliminary findings of the understanding of the ICT4Agric initiative space, the selection of farmers to work with was carried out. We chose to work with only 10 farmers, who were purposefully selected. The purposeful selection of the farmers was necessitated by, among others, the need to work with farmers who had sufficient technical literacy and aware of the potential use and importance of ICT4Agri initiatives. This is mainly because it has been argued that aligning the needs of users with the technical possibilities together with ensuring that target users are aware of the importance of such initiatives mitigates the risks of failure and low adoption often witnessed with technologies. As

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such, all the selected farmers had access to all infrastructure services required to use such systems, mainly end user devices (smart phones, tablets, laptops, and desktop computers) and internet connectivity. They also had access to the traditional ICTs such telephone, radio, and TV. Additionally, they had full access to electricity to operate the ICT devices. In terms of literacy, the farmers had all forms of literacy (computer, ICT, information, and media literacy) as listed by Law et al. (2018). These farmers also had the capacity to invest on the applications or agricultural services for their farms.

In summary, the farmers were small scale in nature and five out of ten were telephone farmers (individuals who resided away from their farms). The remaining five farmers were home based. Out of the 10, six of them were doing zero grazing dairy farming, while four (4) were involved in free range farming. The number of cows was from three (3) to 21 with between one (1) and three (3) farm employees. The farms were in Uasingishu, Elgeiyo-Marakwet, and Nandi counties of Kenya. Three of the farms were in the metro-Politian areas of the main towns of these counties.

The data collection methods from the selected farmers were mainly chit-chats, structured interviews, and brainstorming. We had several informal meetings where we discussed the challenges associated with dairy farming and where ICTs could be applied to mitigate these challenges. Field notes were taken and specifically each of the farmers was asked to indicate (analyse and design) how they wanted the system to be like. As a subsistence farmer, the author was also involved in thinking through the system analysis in the eye of a farmer.

Figure 1(a): Example field notes from participant one

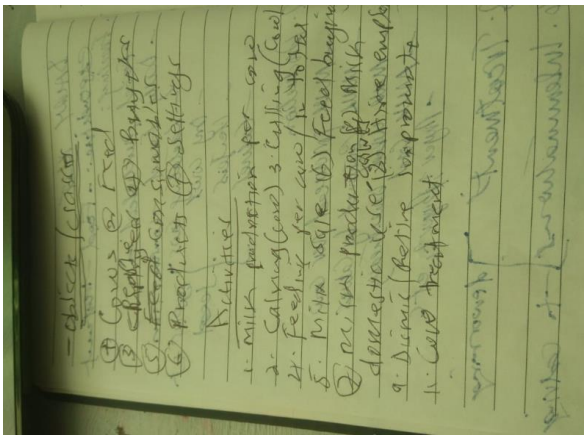
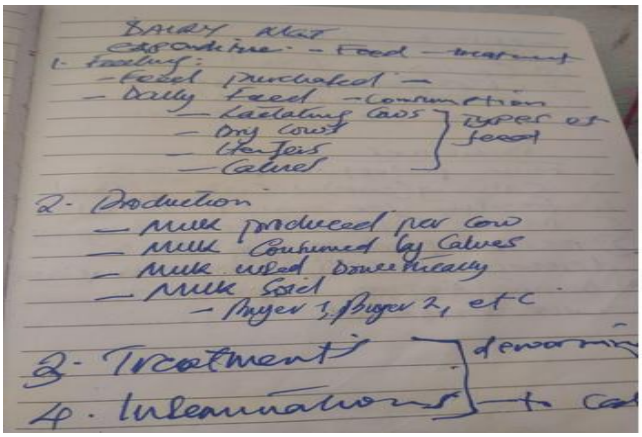


Figure 1(b): Example field notes from participant two



System Development Approach

The primary approach employed for this work was pragmatism (Redmond-Pyle, 1996), which required that the selected farmers be involved in the system analysis and design. The first stage was to confirm the status of adoption and use of ICT4Agriculture initiatives among the small-scale farmers. Information gathering was done through a review of reports, some of which had descriptions of many ICT4Agric systems, such as (Makini et al., 2020), web search on Agricultural digital services, where we looked at another 21 digital initiatives besides the 72 discussed by Makini et al., (2020). A table summarizing the 21 ICT Agricultural systems we reviewed is included as an appendix.

To understand the existing ICT4Agric initiatives, especially the Farm systems and applications, we went through each of the identified systems or applications with a view of finding a convergence on their common characteristics. We also engaged our respondents to describe any kind of system they might have been aware of during the time of the study.

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The next task, after information gathering was to carry out the analysis and design of the proposed system. The analysis revealed that most of the initiatives were biased towards generalized systems, with a majority of them lacking in personalized system features, such as record keeping, for farm management. Our design of the new farm system led us into an MIS for farmers, a case study of small scale to medium sized dairy farming.

The development model was rapid application development (RAD) applying bottom-up approach (Thomas & McGarry, 1994). Each unit, split as a main function, was developed first before combining it with the others. RAD was chosen because of its numerous advantages when compared to the other software development models (Amlani 2012).

RESULTS AND DISCUSSIONS

The study results follow from the tasks carried out in the study. They include: (a) a description of the existing ICT4Agriculture initiatives, mainly systems and applications used in farming (b) the findings on the adoption and use of these initiatives by targeted audience and (c) the developed farm management information system. These are described in the following sections.

Existing ICT4DAgri Initiatives

The study applied a similar approach to other studies such as the World Bank and FAO funded initiatives. Most of the descriptions on the various initiatives were from their websites, with a few coming from reports or research papers. Similarly, the presentations of the outcome followed a template similar to previous studies.

Besides Table 2 (attached as an appendix), which shows some of the sampled ICT4Agriculture initiatives, we point out that there are additional (more than 70) and complimentary descriptions by World Bank (2011); Makini et al. (2020); Akuku et al. (2019); Graduate Farmer (2018); Founder360 (2018), which were also studied.

From the sampled ICT4Agriculture initiatives, the most important finding was that a majority of the existing systems were cloud based and technologically complicated in nature. Such systems, to ordinary farmers, would lack in transparency of where data is stored, who owns the systems or data, and even who performs the data entry task. This finding was observed in most of the sampled systems and even in other reports such as World Bank (2011) which indicated that out of the 20 initiatives listed, only one (icow*) was described as a kind of MIS for farmers. The rest were either general portals for farmers, information exchange applications, or educational content or systems. It was also noted that the main uses of ICT in agriculture are for financial access, Agricultural advisory services, linkages to markets, and supply chain management (Makini et al., 2020; Kiambi, 2018). Further, Akuku et al. (2019) identified ICT-services for farmers based on different data inputs as weather forecast, crop selector, crop monitoring and calendaring, fertilizer planner, pest and disease alert, salinity advice, extreme weather risk, water usage and irrigation, AgriCoach, mobile learning, and market information. This classification clearly shows that a majority of the ICT4Agriculture services out there are warning and advisory, perpetuating our observation that there is a clear indication that other forms of ICT4Agriculture such as personalized agricultural management systems/apps and those featuring technical functionalities of systems are few in number (Byun et al., 2020).

Despite these numerous initiatives, digitization in Agriculture is still slower compared to other sectors (Akuku et al., 2019). Further, the existing initiatives are largely controlled by external bodies such multinationals, governments, and donors. As such, these initiatives rarely get adopted as the funding usually goes up to evaluation stage of the development. This brings in a bottleneck because farmers, and any other system users, are unlikely to adopt ICT systems especially when such systems are still under development. This is largely because such systems do not work optimally while at development stage (Akuku et al., 2019). As a proposed enhancement to the strides already made in ways strengthening the capacity of farmers by digitizing Agriculture to give farmers accurate, reliable, and timely information to enable them to make informed decisions (GeoPoll, 2020), we postulate that it is also important to give them ability to be part of direct contributors of such data. We

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envisioned that one way to contribute is to have an MIS for small scale farmers.

In summary, it was observed that even though there exist several ICT4Agriculture initiatives, there is still need to speed up the digitization initiatives. This was largely because the adoption and use of the existing systems was seen to be limited, a majority of the systems were largely data or information push to the users (Kiambi, 2018). A limited number of them were transactional MIS systems. In addition, there exists few technologies featuring technical functionalities of systems (Byun et al., 2020). In fact, going forward, studies in this area should embrace continues Systems development across various fronts of ICT4Agriculture facets such as MIS, information sharing, and the use of the most current and high-tech technologies such as Precision Agriculture Technologies (PAT) among other approaches.

Use of existing ICT4DAgri Initiatives

The outcome of the engagement with the participants of the study indicated that they were aware of the existing systems. They however reported that they had not adopted them because of various reasons, among them the trust on the freely available applications. They also reported that a majority of the applications had so much functionalities than required and hence more often introduced a steep learning curve. The same initiatives were said to lack flexibility when it came to configuring them to suit once requirements, especially where one wanted to use only a few functionalities. For example, one responded wanted a system which would allow him to generate drilled down reports up to a level such as produce per animal per session.

Besides configuration, one salient outcome was the need to access records anywhere without being constrained by a device. A majority of the respondents were interested in an ICT initiative which would allow them manage their farms through the mobile device and at the same time generate detailed reports via a web-based user interface. Equally important to the farmers involved, and missing in the existing systems, was the need for an integrated system which allowed for recording of almost all the farm services, production, consumables and report generation within one system.

With a myriad of limitations of the existing systems, the need to design, implement and test a new artefact with the characteristics described by the respondents therefore arose.

The Developed Artifact

The integrated farm management information system was designed as a responsive web-based system to enable it run on various platforms such as mobile devices and desktop computers. It is an integrated system giving users an end-to-end control of their farm activities by giving them a platform to capture their farm details such as the farm animals, productions, consumables, workers, and service providers.

The resultant artifact is portable and can be configured to run a small or medium size animal or crop farm. The examples used here describe a small-scale dairy farm configuration.

When configured to work for animal or crop farming, the various modules provide various functionalities as briefly described below.

Animal/Farm Input Control, Stocking, and Capital Expenditure

This is where recording of the cost of animal acquisition or farm inputs take place. This functional unit is meant to capture any initial expenditure related to the farm. Examples of the capital cost include purchasing a new cow or farm inputs such as machinery, fertilizer, or seeds. Figure 2 shows an example flow of the system menus.

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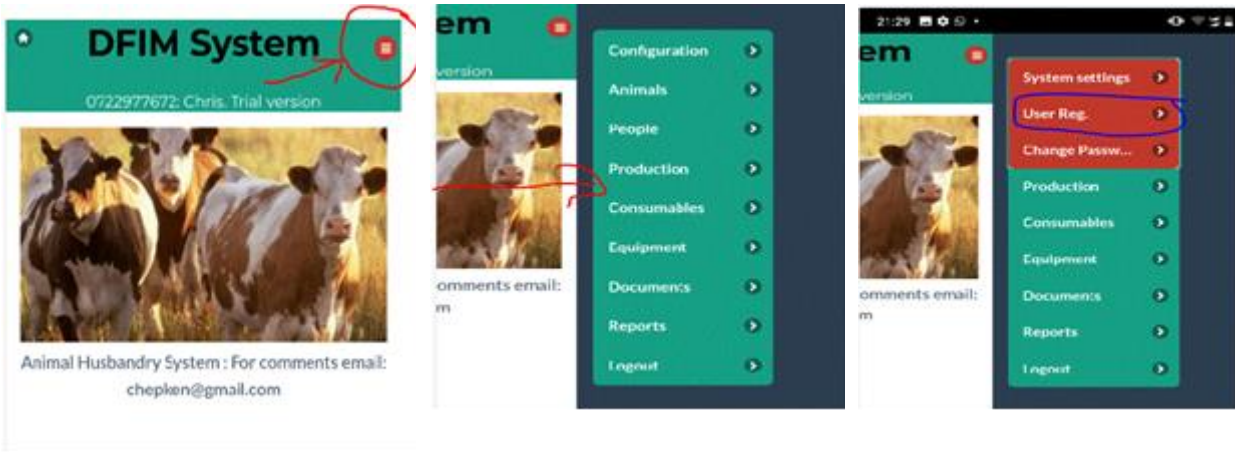
Figure 2: The system menus



Human Resource Management

The human resource functionality allows for capturing of human resource details such as their national identification numbers, worker earnings, names, and cadre. The captured details are used when estimating the financial health of the farm among other HR related activities.

Animal/Farm Production Management

Farm produce is captured per unit of production. For example, in a dairy farm, milk recording is done per cow hence monitoring production per animal per milking session. Together with consumption (such as food and farm inputs) and services rendered to the farm (e.g., animal treatment) as system inputs, production records are used to gauge the performance of the farm in the short term when used in a simple profit-loss calculation. Figure 3 (a) and 3 (b) shows the submenus associated with animal and worker management respectively.

Figure 3(a): Animal sub menus

Figure 3(b): Worker submenus

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Consumables Recording

Alongside stocking and capital expenditure, there is need to capture routine consumables. Recording of consumable's inventory and service consumption per specific animal is facilitated by the consumables functionality of the system.

Equipment

The acquisition of farm equipment is recorded as capital expenditure. Once acquired, records for maintenance and servicing are captured through the equipment module. Capital expenditure on the farm equipment can also be recorded for proper valuation of the farm when need arises such as in a in case where there is need to attach it for a loan facility or for the general valuation of the farm.

Document Management

In many cases, farmers may be required to produce receipts or any other documents to proof purchase or sale of items in the course of their farming business. This becomes a challenge in most cases because physical copies tend to get lost or get damaged due to poor storage conditions such as lack of document cabinets in a small scale farm. To remedy this, the developed system has a functionality to allow for scanning and uploading of documents using phone camera. Uploaded documents may be restored on need basis and used as proof of expenditure or income.

Buyer Registration and Rating

One of the challenges associated with small scale farming is the presence of middlemen buyers or brokers who are usually regarded to be unfair to farmers. These kinds of buyers move from one farm to another and hence may not be easily earmarked for rating. The system developed allows for buyers to be registered so that in case they are identified as not being fair, they could be reported to other farmers. The other significance of this functionality is that it reduces the risk of farmers losing buyers contacts as with this functionality farmers record buyers contact, which they can search when need arises.

System Reporting

Under reporting component of the system, the users can generate simple reports from the various core functionalities. Available reports are categorized as stock, products, consumables, services, history, and people. Under each of these categories, the user is able to dig deeper to specific production or consumption per animal reports. Examples of reports options are given in Figure 4 (a) and 4 (b). Reports generated can either be printed as PDF, excel/CSV, or send directly to the printer.

Figure 4(a): Report sub menus

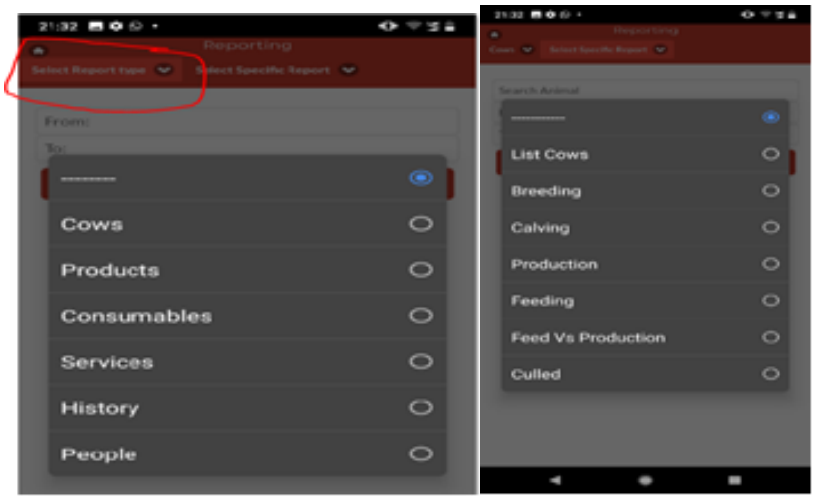

Figure 4(b): Sample report

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CONCLUSION

Drawing from findings, by reviewing existing ICT4Agricultaral initiatives, it was concluded that there are a lot of ICT4Agriculture initiatives most of which are Market information systems, weather predictions and early warning systems among many information push towards the farmer's initiatives. These initiatives have been touted to benefit farmers by, for example, facilitating them close the yield gap, an initiative which is yet to be achieved fully. Most of these existing systems are disparate, incomplete, with a limited number of them having clear evaluation reports and not well documented. It was also noted that the target users were general (all categories of farmers) in nature and most of the time, adoption and use was hindered by literacy and technological challenges associated with a majority of the farmers. To avoid these pitfalls, there was need to try other approaches of developing an MIS for and with technology literate farmers.

Even though there are still a few known good personalized MIS systems for farmers which allow them to keep records of production at the same time carry out day-to-day management of their farm activities, a majority of these systems render farmers information consumers as opposed to being both producers and consumers. Consuming information which is not generated by the farmers may make such information incompatible. This may slow down the adoption and use of the digital Agricultural initiatives mainly because compatibility has been cited as one of the key factors in adopting and benefiting from ICT4Agri initiatives (Yoon et al., 2020). The need to have compatible systems and those that allow farmers to input and process their own data and information, together with the conclusions made by other works of ICT4Agri initiatives, demonstrate that there is still room to continue digitizing Agriculture especially for small scale farmers in Kenya. This conclusion was also evidenced by the outcome of the development process, testing and evaluation of the MIS presented in this paper, which showed that there is still more functionality required for an MIS system for small scale farmers.

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