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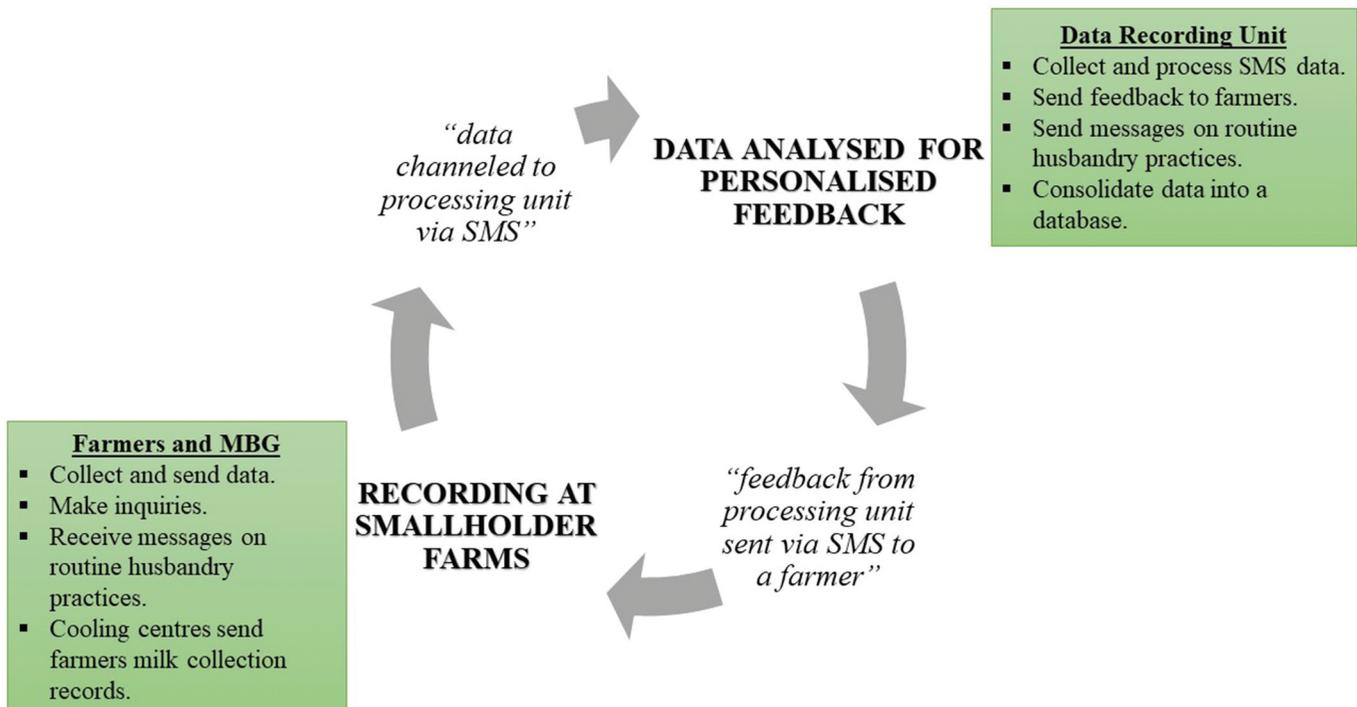
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## ANIMAL HUSBANDRY & VETERINARY SCIENCE | RESEARCH ARTICLE

# Enhancing knowledge exchange and performance recording through use of short messaging service in smallholder dairy farming systems in Malawi

Daniel Chiumia<sup>1,2\*</sup>, Timothy N. Gondwe<sup>2</sup>, Liveness J. Banda<sup>2</sup>, S. N. Sivaselvam<sup>3</sup>, Susanne E. Ulbrich<sup>1</sup> and Mizeck G.G. Chagunda<sup>4</sup>

**Abstract:** Monitoring animal performance is a challenge due to lack of systematic recording in the smallholder dairy sector in Malawi. A mobile recording system using short messaging service (SMS) was therefore trialled for data capturing and subsequent feedback provision to farmers following analyses and interpretation. This study aimed at drawing lessons regarding use of SMS recording system among dairy farmers. Of the 210 participants, 85% were farmers and 25% were other dairy value chain players. Farmers were from eight intervened (monitored for 18 months) and eight control Milk Bulking Groups (MBG). There are three regions in Malawi and Central region had the highest participants [59% (124)] than Northern [23% (49)] and Southern [1% (2)] regions submitting data using SMS. Milk production was the most recorded data and analyses showed that mean yield in litres per cow ( $10.7 \pm 0.14$ ) was similar to average estimate in literature for Malawi ( $10.4 \pm 1.57$ ). Household daily milk consumption ( $1.2 \pm 0.04$ ), milk sold through formal market ( $610.0 \pm 55$ ) and amount of milk rejected per day per MBG ( $5.9 \pm 0.86$ ) in litres were captured. Farmers asked questions and received timely feedback via SMS. Therefore,

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### PUBLIC INTEREST STATEMENT

Monitoring dairy cattle milk production performance is an important activity for dairy farmers as well as other value chain players in the dairy industry. However, due to lack of systematic recording in the smallholder dairy sector in developing countries such as Malawi, record keeping remains a challenge. Our study has shown that a mobile telephone short messaging service recording system (mSMSRS) captures accurate data from farmers and reduces time and cost of transport. Therefore, promotion of record keeping using short message service (SMS) based technology among the smallholder dairy farmers would allow generation of data useful for monitoring animal performance and breeding analyses to inform decision-making among the stakeholders in the dairy value chain in developing countries. The mSMSRS is preferred as it is quick, cheap and enable timely provision of feedback to farmers in case of questions and majority of households have access to a basic mobile telephone.

it is possible to capture quality data using SMS technology that is adequate for conducting analyses to inform decision-making.

**Subjects: Agricultural Development; Human Computer Interaction; Real-Time Systems; Communication Technology; SustainableDevelopment; Research**

**Keywords: AgriTech; extension services; ICT; sustainable farming; SMS**

## 1. Introduction

Despite efforts to enhance access to technical, extension and other services by different stakeholders in the dairy industry in Malawi to improve dairy cattle milk production, the performance of animals kept by smallholder farmers, who dominate the dairy sector, is far from satisfactory. Substandard sources of improved animal genetics, poor animal health, feed shortage, poor prices for milk and poor animal performance monitoring, constitute fundamental constraints resulting in inefficiencies among the smallholder dairy farmers (Kawonga et al., 2012a; Tebug et al., 2012a). The smallholder dairy farmers contribute more than 60% of the milk processed in the country (Chagunda et al., 2007). The smallholder dairy sector in Malawi is well structured from farm gate to consumers and for the past decades, it has received diverse initiatives by different dairy value chain players that has resulted in the intense increase in number of smallholder dairy farmers and number of dairy cows (Chindime et al., 2016) estimated to be more than 21,000 and 98,000 as of year 2020, respectively. This smallholder dairy sector is as well expanding to farming communities outside the traditional milk-producing areas called milk sheds areas. The milk shed area in Malawi context means an area of high concentration of milk production for commercial markets designated according to regional set up of the country. At smallholder farm level, the herd size ranges from one to four cows with differences attributed to gender of household head in favour of male-headed family, farming experience and feeding system (Tebug et al., 2012a). The direct implication of this increase in number of smallholder dairy farmers is a simultaneous growth in demand for access to critical services such as extension, health, breeding and finance services; factors that are associated with dairy cow management and fertility (Banda et al., 2012). In the case of extension services, one of the notable impacts of high population of agrarian farmers and institutional extension reforms is a low ratio of the extension staff to farmers estimated at 1: 2700 for Malawi (Baur et al., 2017). Comparing to other agricultural sub-sectors, the latter factor has resulted in a substantial negative impact in the smallholder livestock sector in Malawi.

With respect to dairy cow management at farm level, recording is one of the critical activities to enhance monitoring of management and breeding strategies (Kawonga et al., 2012a). Record keeping is however generally weak among smallholder dairy farmers in Malawi (Kawonga et al., 2012b). One reason is that according to farmers, it is not easily evident how record keeping contributes to overall farm performance. Previous efforts to introduce recording using forms at smallholder farm level were constrained by failure to timely conduct analysis and subsequent utilisation of records. It is as well costly to frequently visit farms, collect records, take them to a recording unit, perform analysis and provide feedback to farmers for them to mitigate problems and hence improve herd productivity. To mitigate this problem and re-introduce recording, the use of a mobile telephone short messaging service recording system (mSMSRS) to enhance recording on farms, transmission of data to a recording unit and provision of feedback to the farmers was proposed and trialled. The mSMSRS was therefore preferred, as it would provide quick, cheap and timely feedback to farmers. Noting that majority of the smallholder dairy farmers have access to a basic mobile phone, it was therefore as well worthy testing the mSMSRS. Use of information and communication technology (ICT) has already been demonstrated to be helpful in Sub-Saharan African countries such as Kenya (e.g. iCow) and South Africa in improving the quality of public services by making them faster, dependable, available in real-time, and more citizen-centred (Blessing & Julius, 2010). Martin et al. (2020) indicated that mobile phone technologies are one of the important tools for improving nutritional security especially in the rural areas. The use of ICT based technologies in smallholder dairy farming especially in Malawi is relatively new and its

potential benefits, pitfalls and ease of integration in the smallholder sector based on field experience have not been assessed. Interestingly, there has been an increase in number of dairy farmers owning mobile phones, estimated at 42% in 2017 for Malawi (Arne, 2018), and this constitute fundamental factors to create a favourable environment for integrating ICT related technologies in day-to-day farming activities. As part of implementation and monitoring, a pilot project was conducted to draw lessons through assessing integration of a mSMSRS among the smallholder dairy farmers in Malawi. Further, we tested the hypothesis that data collected through SMS is dependable to inform decision-making.

## 2. Materials and methods

### 2.1. Mobile SMS recording system

The mSMSRS used in this study was an interactive and easy to use system. The central principle of the mSMSRS was the ability to allow either the researcher or the farmer to initiate a conversation through SMS. This new system was developed to help smallholder farmers and other value chain players to share information and/or get quality and reliable information through SMS by optimising time and enhance farmers rapport with relevant experts in the dairy sector. Prior to mSMSRS, the existing telecommunication technologies in Malawi were the regular one-way SMS services from telecommunication companies which were not addressing the need for convenient data collection. Thus, mSMSRS was an innovation that leveraged advances in internet of things to bring an interactive data collection system through SMS. All the participants gave consent to participate in the study during induction sessions or following communication through print media.

Smallholder dairy farmers took records and sent data through SMS via a short code to a data recording unit that was based at Bunda College Campus of Lilongwe University of Agriculture and Natural Resources (LUANAR) in Lilongwe district in Malawi. In addition, farmers were able to submit additional information related to their day-to-day farming activities including asking questions related to general livestock farming practices. The submitted data were recorded online before downloading and used for further analyses. From the data recording unit, feedback based on outcome of data analyses was sent to farmers via SMS. In addition, the data recording unit periodically was sending general SMS to all registered farmers to remind them on recommended routine livestock husbandry practices. The dairy husbandry information disseminated through the mSMSRS was based on the national agricultural calendar. Figure 1 shows a conceptual framework of the recording system that was implemented using the mSMSRS technology.

**Figure 1. Conceptual framework of the mobile telephone short messaging service recording system trialled with smallholder dairy farmers and Milk Bulking Groups (MBG) in Malawi.**



## 2.2. Data collection and management

As a component of monitoring the implementation, the study was conducted between September 2013 and February 2015. Data captured through the mSMSRS via a short code came from the three regions of Malawi (Southern, Central and Northern). To ensure that the influence of this SMS-based recording technology was determined, eight Milk Bulking Groups (MBGs) were strategically selected. The MBGs are smallholder dairy cattle farmer groups formed to facilitate selling of chilled fresh milk in bulk to processors in an organised and regulated manner. The farmers from the selected MBGs went through an induction training session on how to use the system and were followed up every 3 months to get feedback on how they were using the system and also as a reminder to use the system. Out of the eight groups chosen for monitoring, five MBGs selected (*Bua, Bunda, Chitsanzo, Dzaonewekha* and *Magomero*) were located in the Central region. The remaining three MBGs (*Doroba, Kavuzi* and *Lusangazi*) were in Northern region. No training and regular contact were conducted in the Southern region in order to leave it as the control group in the study. There was no interference in the activities of all the MBGs and dairy value chain players. During the study period, the system could only accept SMSs from one of the two major network service providers in Malawi. Once an SMS was sent to the system, it was automatically acknowledged and the personnel from the study team received an alert to enable them to assess the message and determine the kind of feedback the sender needed. Data collected through mSMSRS was routinely downloaded and added to a database. For the individual farmers, data mainly comprised daily milk yield, milk supplied to the MBG, milk consumed, and questions. At MBG level, data included milk bulked and milk rejected. Before a farmer delivers milk at MBG, a milk buyer at the MBG conducts a number of quality control tests before weighing the milk. The milk is tested for adulteration or sourness and once the milk fails to pass the tests it is returned to a farmer without weighing. The data were managed and analysed using IBM SPSS Statistics for Windows, Version 22.0 (Armonk, NY: IBM Corp).

## 2.3. Data analysis

One sample t-test was used to assess the quality and reliability of the selected variables. Statistical differences were considered significant when  $P < 0.05$ . Quantitative and qualitative data analyses on number of entries segregated by predefined categories of data such as registration, milk production and marketing, and its adequacy to inform decision-making were conducted. Stakeholders were coded using the lowest possible description and some of the codes included dairy farmer, farmers association, academician, MBG milk buyer, non-governmental organisation, and where possible their location of operation. Graphs were plotted using GraphPad Prism for Windows, version 7.03 (GraphPad Software, La Jolla California USA).

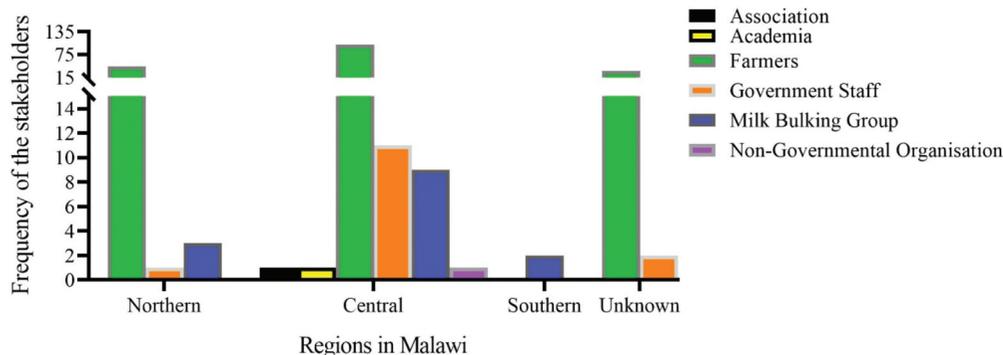
## 3. Results and discussion

### 3.1. Information acquisition

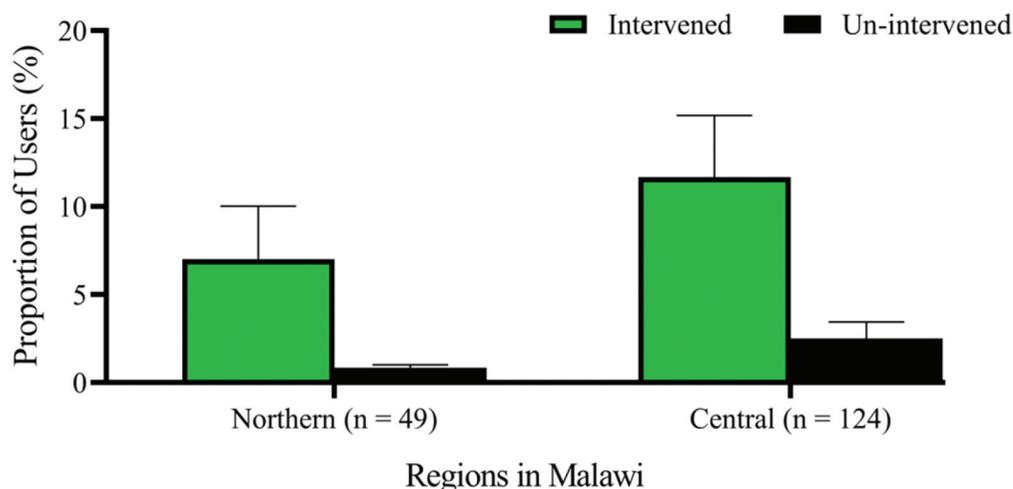
A total of 210 individuals comprising smallholder dairy farmers (85%), government staff (7%), MBG staff (7%), academicians, national association and non-governmental organisation (NGO), the latter three categories each had 1% proportion, participated in this study. Excluding the 17% of the stakeholders who did not indicate their district of origin and place of operation when registering into the system, the majority of the remaining 83% with known districts were from Central region that had the highest recorded number of stakeholders submitting registration data [59% (124)], than Northern [23% (49)] and Southern [1% (2)] regions. The frequency distribution by stakeholder category is shown in Figure 2. The differences in the level of responses by the stakeholders on the use of the mSMSRS were attributed to routine monitoring and induction sessions conducted in the Central and Northern regions. Clearly, the sensitisation and monitoring intervention had a substantial influence especially on farmer's motivation to use the system.

Comparing the intervened and un-intervened groups in the Northern and Central regions, the intervention had influence on the number of participants registered in the mSMSRS, Figure 3. Smallholder dairy farmers ranked high among the dairy industry stakeholders who registered and were submitting data as expected. However, variations were observed when comparing the

**Figure 2. Dairy industry stakeholders who registered in a mobile telephone short messaging service recording system. Stakeholders who did not indicate their location are displayed as Unknown.**



**Figure 3. Users of the mobile telephone short messaging service recording system in Malawi comparing users from intervened and un-intervened dairy farmers groups.**



respective 15 MBGs that participated in this study. *Chitsanzo* MBG in the Central region had the highest number of individuals registered (20%) followed by *Bunda* MBG (15%). *Lusangazi* MBG located in the Northern region of Malawi recorded the third in ranking based on the number of farmers who participated (13%) and the remaining groups had less than 6% representation of all the 210 participants.

Though the Northern region recorded a lower number of farmers (49) than Central region (124), it was noted that most of the dairy farmers in the Northern region were using a mobile number from a different telecommunications service provider, which during this study period, the system was not configured to accept data sent through its network. Therefore, it is possible that this contributed to the low number of individuals who participated from the Northern region than expected when compared to Central region where we also performed induction training sessions and periodic monitoring. Since one of the sensitisation approaches was through print media, we recorded users (n = 37) from the Southern region of Malawi and these users were included in the un-intervened group where necessary in the analysis.

Further analysis showed that, of the total 1,310 entries recorded in the mSMSRS, the highest entry category of data was for milk production (701), then 294 entries related to registration process and 179 entries on milk marketing information. Queries and reporting of incidences had 122 entries and data on reproduction (e.g., calving and insemination dates) recorded by farmers had the lowest number of entries (14). Farmers mainly submitted most of the data as expected and this showed that this SMS recording technology has the potential of being integrated in their day-to-day farming

activities and consequently benefit the farmers and subsequently the rest of the stakeholders in the dairy industry. The participation of the other dairy value chain players demonstrated that the system is likely to contribute to enhancing sharing of information among stakeholders and thus enhance networking, knowledge transfer and coordination among them.

### 3.2. Quality of sourced data

The system recorded daily milk production performance data of 61 lactating dairy cows and on average, each cow was producing  $10.7 \pm 0.14$  l of milk per day, Table 1. Farmers had liberty to choose the frequency of submitting milk production data either on daily basis or on weekly basis. Very few [34 (5%)] farmers preferred submitting the records on weekly basis. However, it could not be established if this was the result of positive attitude and motivation to use the mSMSRS along with the real time feedback to their questions where it was applicable.

The average daily milk production estimated in this study was within the national estimate for Malawi reported in literature and was within the range. The range is from 5 to 15 l of milk per cow per day for improved dairy breeds (Chagunda et al., 2016; Kawonga et al., 2012b; Tebug et al., 2012b). Pure and crosses of Holstein-Friesian and Jersey are the common dairy breeds kept among the smallholder dairy farmers in Malawi (Chagunda et al., 2016; Heifer International, 2015). However, no information regarding type of breeds in use by smallholder dairy farmers was sourced. We did not make a deliberate inquiry to assess farmers knowledge regarding the breeds of the cows they had at the time of the study.

The estimated milk rejection rate due to sourness was  $5.9 \pm 0.86$  at MBG level and it was not significantly different ( $P = 0.187$ ) from rate of milk rejection values reported during similar period of 7% (Civil Society for Agricultural Network [CISANET], 2014). The milk rejection rate based on the data recorded in mSMSRS was between 1 and 40%. CISANET (2014) conducted their study during a similar period to our study and reported milk rejection rates ranging from 7 to 17%. The difference could be due to our observation that most of the MBGs do not measure the quantity of sour milk rejected at the cooling centres. This is the routine procedure in all MBGs and it is therefore difficult to quantify the exact amount of fresh milk rejected at MBG level. The processors conduct similar tests as well from the bulked milk at cooling centres before collection. The amount of fresh milk chilled and collected daily by processors per day per group was estimated at  $610 \pm 55$  l and the estimate was lower than the daily milk collection in litres reported during the similar period in different study, a range from 700 to 5000 (Thomson et al., 2013). Thomson et al. (2013) reported that milk production volumes in Malawi are seasonal dependent and conducted the study between May and August 2013. We covered at-least one full season from September 2013 to February 2015. This possibly explains also the wide range for some of the parameters such as total milk output per month per farm (household) (150 to 549 l) and total-chilled milk collected by

**Table 1. Smallholder dairy farmer production statistics analysed from the data captured through a mobile telephone short messaging service recording system in Malawi**

Fresh milk parameter	Entries	Mean $\pm$ SEM
Yield per cow per day (litres)	478	$10.7 \pm 0.14$
Yield per week per farm (litres)	34	$65.7 \pm 4.84$
Consumed per day per household (litres)	204	$1.2 \pm 0.04$
Sold in the formal market per Milk Bulking Group (litres)	179	$610.0 \pm 55$
Rejected per day per MBG due to sourness (litres)	61	$26.4 \pm 3.85$
Rejection rate per day per MBG due to sourness (%)	53	$5.9 \pm 0.86$

a processor per day at MBG level (63 to 3845 l). The number of farmers delivering milk to a MBG during a specific period is another possible confounding factor that could have influenced the wide range of the volume of chilled milk collected by processors per day in our study.

Apart from submitting milk production and marketing data, farmers were requesting information of which 106 inquiries were recorded. The most requested information was related to animal health (30%), reproduction (26%) and general husbandry information (11%). Six percent of the inquiries were complaints that the farmers submitted when there was a delay in receiving a feedback to their respective inquiries. The Malawi dairy industry is constrained by various factors of which animal health, reproduction and breeding are among the highest (Banda et al., 2012; Chagunda et al., 2016; Kawonga et al., 2012b; Tebug et al., 2012a). We suggest that some of these challenges are indirectly exacerbated due to poor recording among the farmers and low number of extension staff to provide adequate and quality support though the latter requires further investigation. We further suggest that the low number of queries on reproduction can be due to limited technical knowledge and skills among the smallholder farmers. It appears farmers are more concerned and immediately seek veterinary services when they observe an animal health-related issue on their farm. Possibly this could be in fear of losing the animal unlike asking for general husbandry information when the animal is in good health condition or just for the sake of improving their farming practices. Nevertheless, our results show that the information recorded through the SMS reflected the situation on the ground and it can help other dairy value chain players such as non-governmental organisations, academia, research institutions and processors who constantly work with smallholder dairy farmers to identify critical entry points for diverse innovative developmental interventions. The cumulating data can also later allow genetic analyses, which is missing in the smallholder sector. In rare cases, the questions were not related to dairy farming but general livestock production and this demonstrated that the system has the potential to be adapted for use in other agricultural sectors.

### **3.3. Opportunities for success**

Smallholder dairy farmers showed interest and we observed that there was a potential for the farmers to adopt the mSMSRS as one of the credible sources of agricultural information. The level of use of the system, nevertheless, varied considerably across regions. Complaints received when farmers were not satisfied with the service mainly related to delays in receiving feedback. This indicated a potential perceived benefit of the system to the farmers. The mSMSRS was not accepting all the telecommunication service providers inputs and as such, this likely had a negative influence on the number of users of the system due to the limitation of requiring a change of the telephone number. Further, literacy level, poor record keeping at farm level, low response if not periodically reminded and the technical know-how of using some models of telephone constitute critical pitfalls to enhance integration of such type of technologies as mSMSRS in the smallholder dairy sector in Malawi. During induction sessions, we observed that though some of the farmers had a mobile telephone but they could not operate the phone. If in need of sending a text message, farmers without the technical know-how to use the phone reported consulting children, relatives or neighbours for assistance. It is therefore paramount that the system be adapted to such needs to improve its chances of adoption and impact such as integration of voice and image messaging.

In areas where the study team collaborated with government technical field officers, it had the highest number of smallholder dairy farmers submitting data. This may indicate that diversity in stakeholders' participation in using mSMSRS is of importance and can influence the rate of acceptability of the system by farmers and its sustainability. Likely, the other dairy value chain players serve to provide constant reminders and encouragement. This underscores the need for public-private partnership model when integrating ICT technologies in smallholder dairy farming. The public-private partnership model contributes to enhanced diversified income and nutrition security of rural farming communities in the dairy sector (Gondwe et al., 2013) and would be critical in promoting ICT technologies among smallholder dairy farmers. In addition, the potential to adopt the mSMSRS and the ability of the smallholder farmers to pay for the SMS information service depends on the context (GSMA, 2017). In this study, the farmers did not pay for the service.

The extent to which bundling of information with finance-oriented services to enhance the capacity of farmers to finance the SMS-based services in Malawi awaits further investigations.

#### 4. Conclusion

The study has shown that data collected through mSMSRS is dependable to inform decision-making. The system allowed any stakeholder across the dairy value chain to initiate a conversation, which was the key principle of the system. The results following the analyses of the data captured using the system did not contradict with literature. In addition, farmers were receiving feedback in real time to guide management practices and a database of records could be developed that would subsequently allow other analyses such as genetic evaluation. The need to adapt some of the features of the mSMSRS to increase ease of use by farmers who are illiterate was observed. The capacity of the farmers to finance the service and the motivation thereof are some of the areas requiring further research.

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#### Competing interests

The authors declare no competing interests.

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