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Constraints limiting the improvement of manure management as climate smart technology for smallholder dairy farmers

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The global quest for a sustainable bio-economy has brought to the fore importance of engaging agricultural systems in the production and in practice change. There have been issues limiting farmers from improving the practice of manure management as smart climate technology. The objective of this paper was to highlight the constraints, type, and valuation of manure types and information sources that smallholder dairy farmers find it useful to change practices regarding manure management. In this present study, 336 smallholder dairy farmers were surveyed on various constraints the farmers faced and, on the type, and value of different manure types and information on manure management received by the farmers. The study used descriptive statistics for the variables and compared them using frequency tables. The key findings from this study would support information to stakeholders in inducing climate-smart manure management practices as a climate adaptation practice. The study highlights the type of information systems that determine areas for further investigation as drivers of practice change for smallholder dairy farmers. The paper focuses on these constraints and synthesizes them into factors that determine practice change on manure management by smallholder dairy farmers in order to improve manure management.

Key words: Manure management, agricultural information, smallholder dairy farmers, practice change, information value.

INTRODUCTION

The global quest for a sustainable bio-economy has brought to the fore importance of engaging agricultural systems in production and in practice change by farmers (Adeyemo et al., 2019; Ribaudo et al., 2014; Tanner et al., 2001). Climate-smart agriculture (CSA) has been named as a new approach to guide farmers to the needed changes in agricultural systems that can address food security and climate change (FAO, 2013). This use of CSA's approach has been realized partly through targeted farmer information to the extension workers, subsequently reaching the targeted farmers (Ndambi et al., 2019; Snapp et al., 2002; Staal et al., 2002). In Sub-

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Saharan agricultural areas, smallholder farmers being the majority, have a need for agricultural information with them facing many challenges in production (Almagro and Martínez-Mena, 2014; Tanner et al., 2001). These smallholder farmers have been described as mixed farmers due to their wide variety of economic activities (Chagunda et al., 2016; Marenya et al., 2012). There is the use of manure from the dairy livestock on farms in smallholder mixed crop-livestock systems as a source of crop nutrients (Castellanos-Navarrete et al., 2015; Delve, 2001; Zake et al., 2010). Farm size and farm uses have been used to define smallholder farmers with few studies looking for other definition areas (Cohn et al., 2017; Herrero et al., 2014; Samberg et al., 2016). The common characteristic that smallholder farmers use manure leads to improved manure management as a key recommendation in many studies on smallholders (Paul et al., 2013; Rufino et al., 2006). The focus on improved manure management has also been observed as the potential to minimize greenhouse gasses emissions as well as also minimizing nutrient losses (Markewich et al., 2010; Pelster et al., 2016; Rosenstock et al., 2016).

The practice changes for various smallholder farmers have been observed to have constraints (Ongeri, 2014; Ouédraogo et al., 2017). The focus on the constraints is due to the realization that for smallholder farmers, climate change has and is causing them to experience challenges due to these demographic being highly susceptible to climate change impacts on weather patterns (Ara Parvin and Reazul Ahsan, 2013; Bellarby et al., 2014). There have been issues limiting smallholder farmers from improving the practice of manure management as smart climate technology. Few studies focus on these constraints as there is more research on ways to improve practices that lead to increased production by smallholder farmers (Gibbons et al., 2014; Zingore et al., 2007). The key drivers affecting smallholders farmers ability to manage and use manure on own farms as fertilizer that have been observed from studies to be land, labour, number of livestock, lack of knowledge, inadequate funds and level of education (Ilukor et al., 2019; Jolliffe, 2004; Lekasi et al., 2001; Mutoko et al., 2015; VanLeeuwen et al., 2012). This, however, has led to the observation of the need to use this and other variables to observe the key information drivers in terms of constraints that affect smallholder farmers from improving their manure management. Information is needed on community practices and perceptions to manure management, and this specifically needs to be focused on manure removal from livestock housing systems, barriers to manure handling, and source of awareness of farm practices (Lekasi et al., 2001; Waithaka et al., 2007). Different information on barriers to improvements in practices by smallholder farmers, aside from manure management practices and livestock housing need be assessed (Mutoko et al., 2015). Further studies have also been needed on community constraints and drivers of practice change for manure management by smallholder dairy farmers. Besides, just the knowledge of the constraints key should be to determine the value of information sources to these farmers.

This study seeks to derive the constraints to improved manure management and describe through analyses information sources to improved manure management by the smallholder dairy farmers in Nandi County. Therefore, the specific objectives were (i) to determine the constraints to improving manure management by smallholder dairy farmers, (ii) to determine the sources and value of these sources of information on manure management to the smallholder dairy farmers of Nandi County.

MATERIALS AND METHODS

Study area

The field study was conducted on smallholder dairy farmers within Nandi County, Kenya (0.565°N, 34.736°E, 0.565°N, 35.437°E, 35.437°E, 0.118°S, 34.736°E, 0.118°S). The mean annual temperatures range from 18- 22°C, with temperatures at lower elevations (<1400 m) going as high as 26°C. Altitude ranges from approximately 600 m a.s.l. in the South to over 2200 m a.s.l. in the Northeast of the county. The highlands are recognized for their high agricultural potential (GOK, 2015; Mudavadi et al., 2001). However, livestock and crop farming are mainly subsistence, with average land sizes of approximately 4.5 ha per household. Dairy production is common throughout the county, with tea as a major cash crop, and maize as the primary staple crop (GOK, 2015).

Field survey

This study utilized a household survey that was done using a questionnaire tool customized from the Integrated Modelling Platform for mixed Animal Crop systems (IMPACTlite). IMPACTlite was modified from IMPACT to collect household-level data detailed enough to capture within-site variability on key indicators of technical, socio-economic, and institutional constraints as well as evaluating the value of the different types of manure and information sources received and found effective by smallholder dairy farmers. The household questionnaire was completed through face-to-face interviews using the Open Data Kit (ODK) platform (ODK, 2017). In case of absence of the household head, the most senior member available or the household member responsible for the farm was interviewed. In the course of the actual household survey, after interviewing the first household, skipped the third, and interviewed the fourth household. This continued until the computed sample size was done. This was done to ensure quality data collection. The study population was the community in Nandi County, while the target population was the dairy cattle farmers households. The unit of analysis was the household, and in order to get a good representative of the targeted population, the procedure and formula below were employed. The sample size was computed using the simple random sampling technique to draw a sample size of 400 respondents for the survey using Fischer's formula as described by Mugenda and Mugenda (2003).

$$n = \frac{N}{1+Ne^2} \quad (1)$$

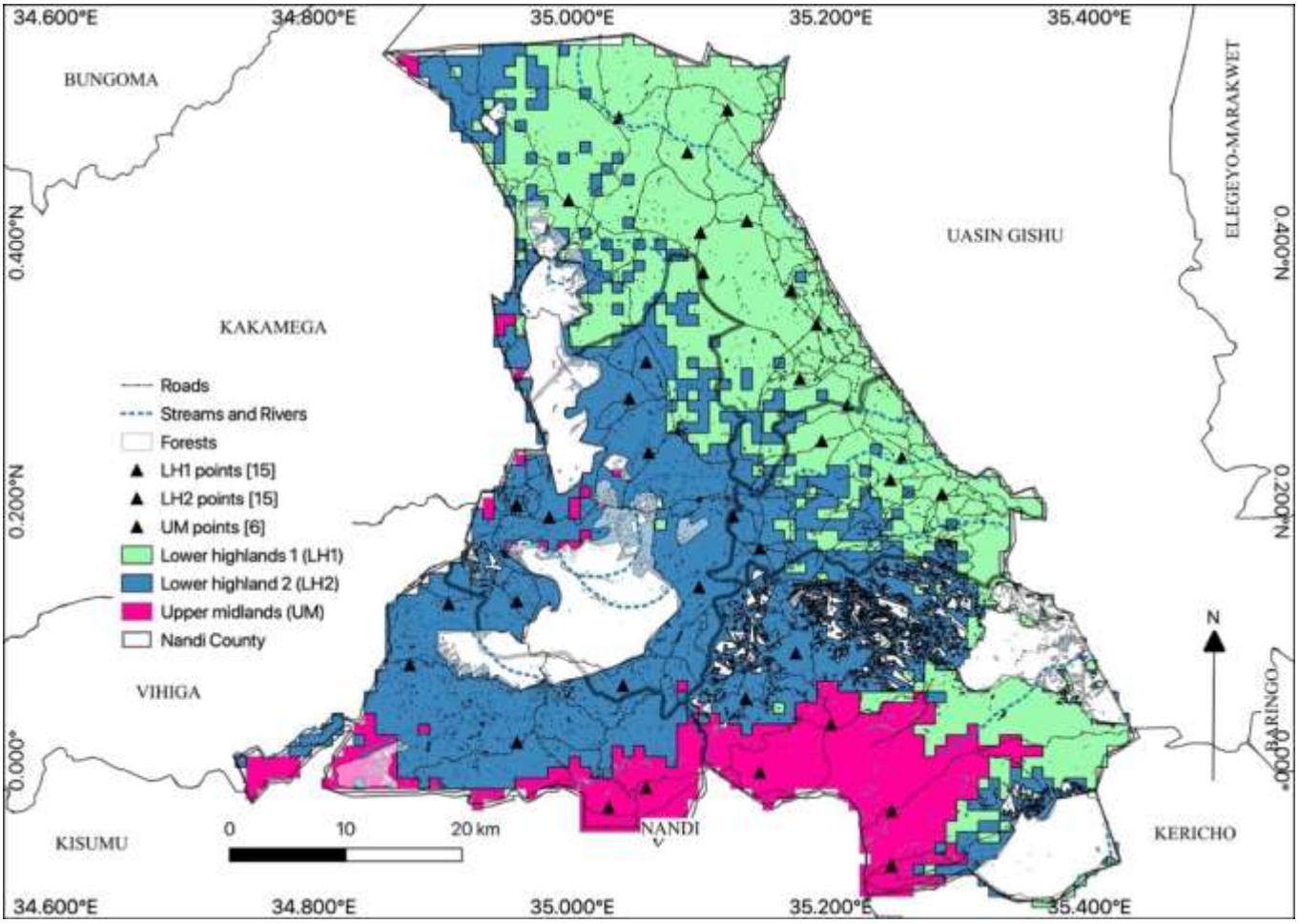

Figure 1. Sampling map showing Nandi County with the 36 sampling points in the derived biophysical zones (Lower highlands 1, Lower Highlands 2, and Upper Midlands).

Where n is the sample size, N is the targeted population (N= 41311 ≈7- adult population of Nandi County removing youth below 15 years 45% of total population (KNBS, 2010; NCPD, 2017) and e the desired confidence level (e=5%) of the sample population of 336 households.

The population of Nandi County, which is 751129 (KNBS, 2010), removing 45% who are youth below the age of 15 (NCPD, 2017), gives 413117, which was considered the study population in the computation of the sample size. The confidence level was taken to be a 5% level of significance with the calculation shown. Random sampling points were generated using QGIS in the three Ago-Ecological Zones of Nandi County and distributed by a fraction of the land area (Figure 1). At each of the 36 random points, about 11 farmers were targeted and interviewed to generate a sample size of 396 households, of which 336 were interviewed. The actual study response rate was 84.8%. The data was found to be sufficient for analysis since it was above 80%, according to Babbie (2013), who considers a response rate above 70% to be very good. The dataset comprised household survey results where both descriptive and inferential statistics were performed using Base R Package (RStudio V 1.1.442) (Rstudio Team, 2016). The variables on constraints, awareness, and source of information on manure management were then analyzed using frequency tables and descriptive statistics.

RESULTS AND DISCUSSION

Technical, socio-economic and institutional constraints

Technical and socio-economic constraints to farmers that hinder improvement to manure management were analyzed and shown in Table 1. The results of these constraints show that the lack of farm labour had a majority (52%) citing it as a very important factor limiting improved manure management. The constraint with the least important was the view that manure had too low benefits when used as fertilizer, compared to the benefits when used as a fuel (dung cakes) with 99% thinking it is not important/ irrelevant. An assessment of institutional constraints that affect the smallholder dairy farmers in Nandi County from improving manure management is tabulated in Table 2. The majority view lack of information to improve manure from institutions (85%), lack of access to available information (86%), lack of access to loans (63%), and lack of access to required equipment (53%) as major constraints.

Table 1. Frequency of technical and socio-economic constraints to smallholder dairy farmers to improve manure management in Nandi County by Agro-Ecological Zones (Lower Highland 1, Lower Highland 2 and Upper Midlands) and gender (percent per constraint is 100%).

Issue and importance	LH1_Male (%)	LH1_Female (%)	LH2_Male (%)	LH2_Female (%)	UM_Male (%)	UM_Female (%)	Total
Lack of farm labour							
Very /important	12.90	9.30	15.00	8.10	5.40	1.80	52.30
Not so important	9.60	8.10	13.40	8.40	6.30	2.10	47.80
Lack of manure collection capacity							
Very /important	12.90	10.50	12.60	8.70	3.30	1.50	49.20
Not so important	9.60	6.90	15.80	7.80	8.40	2.40	50.70
Lack of manure storage capacity							
Very /important	6.00	3.90	6.00	4.80	3.00	0.60	24.20
Not so important	16.40	13.40	22.40	11.60	8.70	3.30	75.80
Lack of manure treatment capacity							
Very /important	2.70	1.20	4.80	3.00	1.20	0.90	13.70
Not so important	19.70	16.10	23.60	13.40	10.40	3.00	86.30
Lack of manure transport capacity							
Very /important	3.60	2.10	7.20	3.90	3.00	0.60	20.30
Not so important	18.80	15.20	21.20	12.50	8.70	3.30	79.70
Lack of suitable equipment to apply manure							
Very /important	3.30	2.70	3.30	1.80	1.50	0.00	12.50
Not so important	19.10	14.60	25.10	14.60	10.10	3.90	87.50
Lack of land to apply manure, because there is none available							
Very /important	1.20	1.20	0.30	0.30	0.90	0.00	3.90
Not so important	21.20	16.10	28.10	16.10	10.70	3.90	96.10
Lack of land to apply manure, because the prices of land are too high							
Very /important	1.20	0.90	0.30	0.00	0.30	0.00	2.70
Not so important	21.20	16.40	28.10	16.40	11.30	3.90	97.30
Not enough collateral to get credit for investments?							
Very /important	3.90	3.00	6.90	4.20	0.60	0.00	18.50
Not so important	18.50	14.30	21.50	12.20	11.00	3.90	81.50

Table 1. Contd.

Too high transport costs, compared to the use of mineral fertilisers							
Very /important		1.50	1.20	2.70	0.60	0.00	0.00	6.00
Not so important		20.90	16.10	25.70	15.80	11.60	3.90	94.00
Too high labour costs, compared to the use of mineral fertilisers							
Very /important	6.60		5.40	8.70	4.20	2.10	1.20	28.10
Not so important	15.80		11.90	19.70	12.20	9.60	2.70	71.90
Too low benefits when used as fertiliser, compared to the benefits when used as a fuel (dung cakes)							
Very /important	0.90		0.30	0.30	0.00	0.00	0.00	1.50
Not so important	21.50		17.00	28.10	16.40	11.60	3.90	98.50

The study found similar observations to Mutoko et al. (2015) and Mwirigi et al. (2014) who all found the availability of funds to farmers as being major limiting factors to the improvement of farm practices. The results of this current study show that farmers, including smallholder farmers, do have an opinion on the constraints that affect their practice. That aside from lack of finances, these farmers is aware of related concerns to finance and that there are other constraints that have been highlighted. This observation is also alluded to in other studies to be a solution space (Greenhalgh et al., 2019; Ouédraogo et al., 2017). The expectation that institutions are the best way to offer solutions and extension, and this current study offers opportunities for the private sector to fill such gaps on information dissemination especially if backed up with financial support and incentives (Abebe et al., 2013; Jensen et al., 2019).

Smallholder farmers perception of the value of the type of manure as a fertilizer on own farm

Smallholder dairy farmers were assessed for the value of slurry from dairy cattle and from other animals. Slurry from dairy cattle (16%) was perceived very/important than from other livestock (8%) (Table 3). A similar analysis of farmers' perception of the importance of solid manure from dairy livestock and compared to other livestock is shown in Table 3. The majority (94%) thought solid storage from dairy cattle was very important. The farmers found solid manure from dairy cattle and other livestock very important with higher margins compared to slurry from similar livestock. The smallholder dairy farmers responded to being asked if they had spent any time/money in the last five years to improve manure management at their households. These results were tabulated in Table 4 below, where the majority (60%) of the smallholder dairy farmers spent time and money to improve manure treatment. Analysis of areas that these farmers spent time/money on in terms of manure collection, storage, treatment, transport, and the application was done and tabulated in Table 4. This table showed that the majority (96%) made improvements in terms of manure treatment with the same farmers' transportation and storage (both at 76%), manure collection (61%), and least was an application (57%).

The importance of manure to farmers has been highlighted in many studies, especially the use of own farm manure to return nutrients (Diogo et al., 2013; van Wijk et al., 2009). Such studies also have shown how to improve productivity. This present study shows the focus of smallholder farmers on improving manure thus highlighting key gaps that can be filled in regard to improved manure management (Jensen et al., 2019; Van Der Wolf et al., 2019). The show that the farmers

Table 2. Frequency institutional constraints to smallholder dairy farmers to improve manure management in Nandi County by Agro-Ecological Zones (Lower Highland 1,Lower Highland 2 and Upper Midlands) and gender (percent per issue is 100%).

Issue and importance	LH1_Male (%)	LH1_Female (%)	LH2_Male (%)	LH2_Female (%)	UM_Male (%)	UM_Female (%)	Total
Lack of information to improve the manure management							
Very /important	17.60	13.20	23.20	15.60	11.40	3.90	84.90
Not so important	4.80	4.20	5.10	0.90	0.30		15.30
Lack of access to available information							
Very /important	17.90	13.80	23.50	15.90	11.40	3.90	86.40
Not so important	4.50	3.60	4.80	0.60	0.30		13.80
Lack of access to loans for the required investments							
Very /important	14.10	9.30	17.70	13.20	7.50	1.20	63.00
Not so important	8.40	8.10	10.70	3.30	4.20	2.70	37.40
Lack of access to required equipment and machines							
Very /important	10.80	7.20	17.60	10.50	6.00	0.90	53.00
Not so important	11.60	10.10	10.70	6.00	5.70	3.00	47.10
Lack of trading infrastructure							
Very /important	8.70	6.90	16.10	11.10	3.60	0.90	47.30
Not so important	13.70	10.40	12.20	5.40	8.10	3.00	52.80
Lack of regulations, leading to possible privileging of groups							
Very /important	4.20	2.70	9.90	6.00	4.20	1.80	28.80
Not so important	18.20	14.60	18.50	10.40	7.50	2.10	71.30
Spatial separation of livestock farms and arable farms due to specialization							
Very /important	3.00	2.10	2.40	1.50	0.60	0.00	9.60
Not so important	19.40	15.20	26.00	14.90	11.00	3.90	90.40

Table 3. Frequency of the value of slurry and solid manure to smallholder dairy farmers in Nandi County by Agro-Ecological Zones (Lower Highland 1, Lower Highland 2 and Upper Midlands) and gender (percent per manure type is 100%).

Issue and importance	LH1_Male (%)	LH1_Female (%)	LH2_Male (%)	LH2_Female (%)	UM_Male (%)	UM_Female (%)	Total
Slurry from dairy cattle							
Very/ Important	3.30	1.80	6.60	2.10	2.10	0.30	16.20
Not so important	19.10	15.50	21.80	14.30	9.60	3.60	83.90
Slurry from other livestock							
Very/ Important	1.20	0.90	2.40	0.90	0.30		5.70
Not so important	21.20	16.40	26.00	15.50	11.30	3.90	94.40
Solid manure from dairy cattle							
Very/ Important	21.20	17.00	24.20	16.10	11.10	3.90	93.50
Not so important	1.20	0.30	4.20	0.30	0.60	0.00	6.60
Solid manure from other cattle							
Very/ Important	17.00	15.30	19.40	14.10	9.00	2.40	77.20
Not so important	5.40	2.10	9.00	2.40	2.70	1.50	23.10

in this current study have spent money on improving their practices does show the willingness to pay and also awareness of challenges that these farmers go through.

Considerations to improve manure management

The reasons for these farmers' improving manure management were asked to the farmers, and the results categorized and tabulated in Table 5. The results focused on on-farm hygiene, water quality, nutrition to crops (Navaratne et al., 2019; Odendo et al., 2009).

Information to improve manure management

The number of smallholder dairy farmers whoreceived the information within the last five years on improving manure management were analysed and tabulated in Table 6. The table showed that the majority (80%) received information. Table 7 looked at the perception in the value of the information source on improving manure management. The table showed the smallholder farmers' value for other farmers' information led (12%) terms of the source of information to improve manure management. Table 8 analysed the media that influence farmers' behaviors in terms of manure management, and these were tabulated by gender of the farmer and the AEZ that the farmer has. Local radio (75%) was very/ important for manure management information for smallholder dairy farmers in Nandi County.

Billboards/posters were found to be least effective as a source of information on manure management. These findings were in concurrence with Mutoko et al. (2015) whose observations included increasing and motivating farmer trainers to train more groups and using diverse techniques lie field days and learning tours. Studies on information systems to farmers are varied in their focus, with most agreeing on the importance of agricultural information to farmers (Hochman et al., 2017; Kante et al., 2017; Makawia, 2018; Moglia et al., 2018). This study evaluation of the value of information and sources also agrees with such studies and also focuses on the smallholder farmers' perception of the sources of agricultural information and its value to them. The movement beyond just climate change as a key constraint is best demonstrated with knowledge of the value of farmers give to various sources of information (Maguire-Rajpaul et al., 2020). The findings from this present study disagree with other recent

Table 4. Frequency of smallholder dairy farmers in Nandi County investment of either Time or Money to improve manure management and aspects of improvement of manure management within the last five years.

Issue	LH1_Male (%)	LH1_Female (%)	LH2_Male (%)	LH2_Female (%)	UM_Male (%)	UM_Female (%)	Total
Invested							
Yes	15.50	11.60	14.60	8.70	6.60	3.30	60.30
No	6.90	5.70	13.70	7.80	5.10	0.60	39.80
Manure collection							
Yes	15.50	11.90	14.60	8.70	6.60	3.30	60.60
No	6.90	5.40	13.70	7.80	5.10	0.60	39.50
Manure storage							
Yes	17.90	14.60	19.10	11.90	9.30	3.30	76.10
No	4.50	2.70	9.30	4.50	2.40	0.60	24.00
Manure treatment							
Yes	21.20	17.00	26.00	16.10	11.60	3.90	95.80
No	1.20	0.30	2.40	0.30	0.00	0.00	4.20
Manure transport							
Yes	19.10	14.60	20.00	12.20	6.90	3.60	76.40
No	3.30	2.70	8.40	4.20	4.80	0.30	23.70
Manure application							
Yes	14.30	17.60	10.70	7.20	3.60	3.60	57.00
No	3.90	3.00	10.80	5.70	4.50	0.30	28.20

This is aggregated by Agro-Ecological Zones (Lower Highland 1, Lower Highland 2, and Upper Midlands and gender (Total for all is 100%).

studies focusing on ICT as the next frontiers for farmer information being most beneficial, this study shows that smallholder farmers prefer medium that is more local thus these technologies would need to be localised (Hartmann et al., 2020; Mereu et al., 2018).

This study revealed that access to information on manure management was a major constraint to improving manure management. Those farmers sited lack of labour and lack of manure collection capacity as major technical and socio-economic constraints. The study also found a lack of information from institutions on manure management and lack of access to information on manure management as major important institutional constraints. The farmers also cited a lack of loans in terms of capital and lack of access to equipment and services for manure management in relation to installing biogas systems as major institutional constraints. These findings agreed with Chibanda et al. (2009); Mudavadi et al. (2001) and Waithaka et al. (2007) who also found that smallholders in these areas were initially major cash crop producers and by moving to milk the commercialization was of key importance with lack of institutions focussing on manure management, they also found labour availability is a constraint.

Table 5. Frequency of smallholder dairy farmers in Nandi County consideration to improve manure management within the last five years.

Issue and importance	LH1_Male (%)	LH1_Female (%)	LH2_Male (%)	LH2_Female (%)	UM_Male (%)	UM_Female (%)	Total
Improve on-farm hygiene, considering human health							
Very/ Important	6.30	4.80	13.80	7.80	4.50	0.60	37.80
Not important/irrelevant	16.10	12.50	14.60	8.70	7.20	3.30	62.40
Improve on-farm hygiene, considering animal health							
Very/ Important	5.70	5.10	13.50	7.80	5.10	0.60	37.80
Not important/irrelevant	16.70	12.20	14.90	8.70	6.60	3.30	62.40
Improving on water quality, from the point of view of human health							
Very/ Important	6.30	4.80	12.60	7.80	4.50	0.60	36.60
Not important/irrelevant	16.10	12.50	15.80	8.70	7.20	3.30	63.60
Improving on water quality, from the point of view of animal health							
Very/ Important	6.30	5.10	11.70	7.80	4.50	0.30	35.70
Not important/irrelevant	16.10	12.20	16.70	8.70	7.20	3.60	64.50
Abatement of odour problems, also for neighbours							
Very/ Important	4.50	4.50	10.50	6.00	4.20	0.60	30.30
Not important/irrelevant	17.90	12.80	17.90	10.50	7.50	3.30	69.90
Improving fertiliser value (nutrients) for their own crops							
Very/ Important	3.90	4.20	9.90	4.80	3.90	0.60	27.30
Not important/irrelevant	18.50	13.10	18.50	11.70	7.80	3.30	72.90
Improving fertiliser selling value (income) when sold to other farms							
Very/ Important	3.90	4.20	9.90	4.80	3.90	0.60	27.30
Not important/irrelevant	21.80	16.40	26.30	15.60	11.70	3.90	95.70
Incentive measures by the government and/or other institutions							
Very/ Important	0.30	0.00	0.30	0.00	0.00	0.00	0.60
Not important/irrelevant	22.10	17.30	28.10	16.40	11.70	3.90	99.50
Restrictive measures by the government and/or other institutions							
Very/ Important	0.30	0.00	1.20	0.00	1.20	0.00	2.70
Not important/irrelevant	22.10	17.30	27.20	16.40	10.50	3.90	97.40

This is aggregated by Agro-Ecological Zones, Gender and confinement systems (Total for each issue is 100).

Table 6. Frequency of smallholder dairy farmers who have received information on manure management in the last 5 years aggregated by Agro-Ecological zone and gender (Total is 100%).

Response	LH1_Male	LH1_Female	LH2_Male	LH2_Female	UM_Male	UM_Female	Total
Yes	19.40	13.10	20.90	13.40	9.60	3.30	79.70
No	3.00	4.20	7.50	3.00	2.10	0.60	20.40

Table 7. Frequency of smallholder dairy farmers in Nandi County value of information sources on manure improvement aggregated by agro-ecological zone and gender.

Issue and importance	LH1_Male (%)	LH1_Female (%)	LH2_Male (%)	LH2_Female (%)	UM_Male (%)	UM_Female (%)	Total
Value of another farmers information							
Very/ important	2.7	2.4	3.9	2.4	0.6	0.3	12.3
Not important/irrelevant	19.7	14.9	24.6	14.0	11.0	3.6	87.8
Value of government extension workers							
Very/ important	0.9	1.2	3.0	1.5	0.3	0.0	6.9
Not important/irrelevant	21.5	16.1	25.4	14.9	11.3	3.9	93.10
Value of non-commercial advisors							
Very/ Important	0.3	0.9	0.6	0.0	0.0	0.0	1.80
Not important/irrelevant	22.1	16.4	27.8	16.4	11.6	3.9	98.20
Value of commercial/private advisors							
Very/ important	1.8	1.2	3.0	1.5	0.3	0.3	8.10
Not important/irrelevant	20.6	16.1	25.4	14.9	11.3	3.6	91.90
Value of local teachers and trainers							
Very/ important	2.1	1.2	3.6	1.5	0.9	0.0	9.30
Not important/irrelevant	20.3	16.1	24.8	14.9	10.7	3.9	90.70
Value of any other actor							
Very/ important	2.7	2.1	3.6	0.6	0.3	0.3	9.60
Not important/irrelevant	19.7	15.2	24.8	15.8	11.3	3.6	90.40

Table 8. Frequency of smallholder dairy farmers sources of information about manure management aggregated by Agro-Ecological Zones, gender and Livestock confinement systems.

Issue and importance	LH1_Male (%)	LH1_Female (%)	LH2_Male (%)	LH2_Female (%)	UM_Male (%)	UM_Female (%)	Total
National television							
Very/ important	5.40	3.90	11.10	4.50	3.60	1.20	29.70
Not important/irrelevant	17.10	13.50	17.40	12.00	8.10	2.70	70.80
Local television							
Very/ important	7.80	4.80	9.90	3.90	3.30	1.20	30.90
Not important/irrelevant	14.70	12.60	18.60	12.60	8.40	2.70	69.60
National radio							
Very/ important	6.3	3.9	13.1	6.9	6.0	1.8	38.00
Not important/irrelevant	16.20	13.50	15.20	9.60	5.70	2.10	62.30
Local radio							
Very/ important	16.80	13.20	21.20	10.80	9.00	3.60	74.60
Not important/irrelevant	5.70	4.20	7.20	5.70	2.70	0.30	25.80
National newspaper							
Very/ important	5.10	2.40	7.50	2.10	1.20	0.60	18.90
Not important/irrelevant	17.40	15.00	20.90	14.40	10.50	3.30	81.50
Local newspaper							
Very/ important	3.00	1.20	3.60	1.20	1.20	0.00	10.20
Not important/irrelevant	19.40	16.10	24.80	15.20	10.50	3.90	89.90
Farmers' magazines							
Very/ Important	2.40	1.50	3.90	1.80	0.90	0.30	10.80
Not important/irrelevant	20.00	15.80	24.50	14.60	10.80	3.60	89.30
Farmers' group meetings							
Very/ important	10.50	7.20	8.40	3.30	2.40	1.20	33.00
Not important/irrelevant	12.00	10.20	20.10	13.20	9.30	2.70	67.50
Field excursions/farm visits/open days							
Very/ important	7.80	6.30	10.50	5.40	3.30	0.60	33.90
Not important/irrelevant	14.70	11.10	18.00	11.10	8.40	3.30	66.60

Table 8. Contd.

Individual meetings							
Very/ important	8.40	5.70	13.10	5.10	4.50	0.60	37.40
Not important/irrelevant	14.10	11.70	15.30	11.40	7.20	3.30	63.00
Billboards/posters							
Very/ important	0.30	0.30	0.30	0.00	0.30	0.00	1.20
Not important/irrelevant	22.10	17.00	28.10	16.40	11.30	3.90	98.80
Pamphlets/leaflets/brochures							
Very/ important	1.80	0.90	3.60	0.30	0.30	0.00	6.90
Not important/irrelevant	20.60	16.50	24.80	16.10	11.40	3.90	93.30
Videos							
Very/ important	0.60	0.30	0.30	0.30	0.60	0.00	2.10
Not important/irrelevant	21.80	17.00	28.10	16.10	11.00	3.90	97.90
Internet							
Very/ important	1.80	0.30	3.30	1.20	1.20	0.30	8.10
Not important/irrelevant	20.60	17.00	25.10	15.20	10.50	3.60	92.00
Social media							
Very/ important	0.90	0.00	2.40	0.00	0.60	0.30	4.20
Not important/irrelevant	21.50	17.30	26.00	16.40	11.00	3.60	95.80

CONCLUSION AND RECOMMENDATIONS

The study demonstrated key constraints as access to information on manure management and manure collection capacity, which are subject to labour availability and financial capital for smallholder dairy farmers. The institutional constraints that matter most to these farmers were access to information on manure management, access to financial capital, and equipment and services for manure management. This creates a mix of agricultural and financial information that was preferred by smallholder dairy farmers. These farmers felt that such information would enable them to manage their manure better, thereby mitigating Greenhouse gas emissions while minimizing nutrient losses through managed manure.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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