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Determinants of dairy cattle breed biodiversity in rural traditional smallholder farms: Case of Kibugu in Kenya

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Abstract

The livestock biodiversity suffers a threat from human civilization through abandonment and/or intensification of agricultural activities. This paper documents dynamism of dairy breed biodiversity and its determinants. Data was collected by surveying 93 households and five key informants using semi-structured questionnaires, interviews and observations. The nonparametric *Data Envelopment Analysis (DEA)* was used to determine the dairy practice frontier on breed conservation. The average farm size was 0.5-1 acres of land and 53.3% of the respondents perceived this to be small for dairying but majority (67.8%) still practiced the enterprise despite also majority (72%) feeling it wasn't worthy. The 10-year dynamism indicated that 19% of the respondents intensified on dairying while 13% abandoned the enterprise in favour of other livestock. In a scale of 1-6, dairying was ranked 6 as a source of income, 6 as a symbol of society status and 1 on ease of care for the enterprise. Big breeds (Friesian, Ayrshire and Guernsey) were perceived highly (6-4) as symbols of beauty and society status while small breeds (Jersey and crossbreeds) were ranked highly (6-5) on ease of care and disease tolerance. Intensification and/or abandonment of the dairy practice as influenced by societal expectations and/or challenges of farming were noted to be the main determinants of the dynamisms of the breed biodiversity in Kibugu; intensification caused a positive externality on breed biodiversity while abandonment caused the negative externality on breed biodiversity. This serves to providing evidence to inform policy decisions that support sustainable dairying in rural areas.

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Introduction

Livestock sector in developing countries have experienced rapid growth of about 33% and its share of the agricultural GDP continues to rise (Thornton, 2010). The expansion is attributed to increasing demand for livestock products and services, which, in turn, are driven by a burgeoning human population, rapid urbanization, and increasing affluence (FAO, 2017).

This expansion ("livestock revolution") could either represent challenges in terms of production capacities and efficiency, or emerging economic opportunities for farmers (Fonderflick *et al.,* 1982).

This situation is likely to be experienced more so in smallholder animal production, in which systems animals serve various purposes: wealth creation and risk reduction, food security, traction power and nutrient inputs (Thornton, 2010).

In the humid Central Highlands of Kenya, where Kibugu is located, land is sustainably used for mixed crop-livestock smallholder system (Bebe *et al.,* 2003).

The regions are well-suited for dairy farming, where a close integration of cows with mixed crop farming exists with each household owning between one and five cows (McDermott *et al.,* 2010).

In Kenyan highlands the tea/coffee-cow system of farming evolved from a prior system of communal land ownership that practiced extensive grazing of indigenous livestock species (Muriuki, 2011).

After independence in 1964, a transition toward individual landholding for smallholder farming and introduction of exotic livestock breeds occurred (Lesschen, *et al.,* 2004).

A major shift in cattle breed biodiversity took place when artificial insemination (A.I.) services were introduced to upgrade local cattle breeds (Lesschen *et al.,* 2004; Muriuki, 2011).

In addition, as the keeping of cows became more commercialized (cows becoming source of cash), the local breed biodiversity became more threatened; replaced with exotic breeds because they were deemed valueless despite being disease tolerant (Jahnke and Jahnke, 1982; Murithi, 1998; Thorpe *et al.,* 2003; Muriuki, 2011).

Thus, in Kenyan smallholder farming communities like Kibugu, there are dynamic shifts on the dairy cattle breed biodiversity that are likely to be determined by relatively homogenous set of decisions made within households (Lambin and Meyfroidt, 2010).

The focus of this research was to understand which of these decisions affected the dairy breed biodiversity and the dynamics of the breed biodiversity existing within these traditional farms.

The theoretical context of the study assumed that such system land use faces two possible alternatives of either intensification or abandonment (Kuemmerle *et al.,* 2004; Kleijn *et al.,* 2009).

Intensification of dairy farming would likely cause breed biodiversity conservation (positive environmental externalities), whereas abandonment would act in the opposite direction (negative environmental externalities) (Van Huelenbroeck and Whitby, 1999; Kleijn *et al.,* 2009).

The purpose of this research was to analyze the household determinants that influence the dynamics of dairy cattle breed biodiversity in traditional smallholder dairy farms.

The study was carried out in several villages of Kibugu location in Embu County, Kenya (Fig. 1).

The area lies in the foothills of Mount Kenya ascending north-west towards the mountain and sloping down south-eastwards. Annual precipitation is 1,700 mm in a bimodal rainfall pattern: a long rain season between March and June and a shorter around November and December.

Temperatures range from a minimum 15°C in July to a maximum of 30°C in September, averaging at 21°C.

There is however localised climate in some parts of the Southern region due to their proximity to the mega dams.

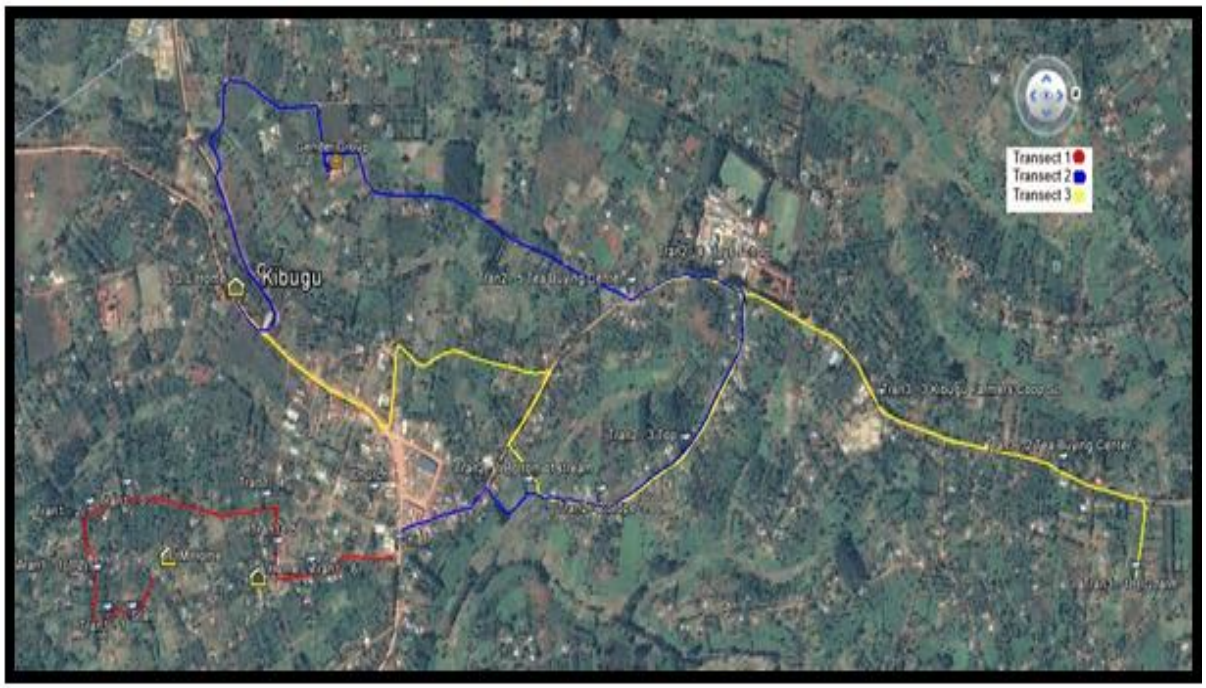

Fig. 1. Transects line sections of Kibugu location along which the study was conducted (sourced and adopted from Google maps, 2016).

Data Envelopment Analysis

(DEA) method was used to evaluate environmental impacts of human activities on the breed biodiversity (Reinhard *et al.,* 2000; De Koeijer *et al.,* 2002; Sipiläinen *et al.,* 2008). In brief DEA method compares various organizational units (farms) with multi-inputs and -output production options as it is the case in the study area.

Determinants are considered as relatively homogenous set of decisions within units (Boussonfiane *et al.,* 1991). DEA constructs the determinant frontier (the most preferred combinations of decisions of the unit and takes into account the impacts of the decisions on farming practice (De Koeijer *et al.,* 2002).

Household surveys were conducted in Kibugu location so as to analyse the prevailing dairying management decisions that affected the production itself, and the influence on the breed biodiversity (Solovyeva *et al.,* 2011).

The framework of the research tried to present the possible theories of statistical variety of the farms/households types of the chosen region (Fare and Grosskopf, 2004).

Ninety three (93) households were surveyed and five (5) key informant interviews were conducted. The main prerequisite for choosing households for the survey was ownership of a dairy farm. Factors considered included the type of farming practice, different dairy breeds kept and challenges of keeping the preferred breeds, breed biodiversity shifts in 10-year period, and factors that influenced the biodiversity dynamics.

The questionnaire included various topics: size of land owned at present and 10 years ago, the preferred cattle breed and the process of breeding, and breed biodiversity dynamics within the farming system.

In the survey open and closed questions as well as qualitative and quantitative questions were used (Jahnke and Jahnke, 1982; Fare and Grosskopf, 2004).

The sustainable land use component, which is incorporated into the research model as an output, represents the Cattle breed biodiversity. The influence of agricultural activity and in particular of farming (intensification/abandonment) (Kuemmerle *et al.,* 2008), on this biodiversity became the focus of the research. In the considered theoretical context, depending on what biodiversity parameters are chosen, the results are quite different (MacDonald et al., 2000; Tasser and Tappeiner 2002; Dullinger *et al.,* 2003,). Therefore, for this study the authors suggest an aggregated breed biodiversity index that combines the quantitative and qualitative evaluation that includes the following parameters differently weighed: percentage of the breeds kept, breeds preserved and presence of rare indigenous breeds (Kuosmanen and Kortelainen, 2004 and 2005). The indicators were weighed on a scale of 1-6 according to their importance on dairy breed biodiversity. Chi-square statistical analysis was used to test for significance (n=93, P≤0.05).

Results and discussion

The summarized results are presented in Tables (1-4) and Figures (3-4).

From the data presented in tables and figures, the average farm size (Fig. 3) was 0.5-1 acres of land and 53.3% of the respondents perceived their farm sizes to be small for dairying but majority (67.8%) still practiced dairying despite also majority (72%) feeling the practice is not worthy (Table 1).

Table 1. Respondents perceptions, attitudes and practices on agricultural activities that promote dairy breed biodiversity conservation (n=93).

Parameter	Yes (Positive) (%)	No (Negative) (%)
Have enough land to practice dairying	53.3.4±2.11[a]	46.7±2.17[b]
Keep dairy cattle for status in society	67.8±1.89[a]	32.2.8±1.90[b]
Dairy practice is worthy for family	28.0±2.05[a]	72.0±2.11[b]

[a, b] Different letters in the same row differ statistically by Chi-square, P<0.01; differences in practices were noted for different purposes of biodiversity conservation. Fifty three percent (53.3%) of the respondents perceived their farm sizes to be small for dairying but majority (67.8%) still practiced dairying despite also majority (72%) feeling the practice is not worthy for the family.

In addition, as shown in Table 2 and Figure 3, the 10-year dynamism of dairy farming indicated that 19% of the respondents intensified on dairying activity while 13% abandoned the enterprise in favour of other livestock. Table 3 shows the various breed kept in Kibugu and the reason why farmers kept them.

Table 2. Respondents practices that affected dairy breed biodiversity conservation in a 10-year period (n=93).

Parameter	Yes (Positive) (%)	No (Negative) (%)
Continued to practice dairying to meet society expectation	92.5±0.78[a]	7.5±0.97[b]
Intensified dairying	19.3±2.42[a]	80.7±1.83[b]
Abandoned dairying because it was a burden	12.9±1.07[a]	87.1±1,65[b]

[a, b]Different letters in the same row differ statistically by Chi-square, P<0.01; differences in practices were noted for different purposes of biodiversity conservation. The dynamism of dairy farming indicate that within 10-year period, 19% of the respondents would intensify on dairying activity while 13% would abandon the enterprise altogether.

In a scale of 1-6 (Table 4), dairying was rated 6 in terms being a source of income, 6 in terms of being a symbol of society status and 1 in terms of ease of care for the enterprise. On the cattle breed biodiversity, big breeds were perceived highly (6-4) in terms of beauty and symbols of society status while small breeds (Jersey and crossbreeds) were ranked highly (6-5) in terms of ease of care and disease tolerance.

Table 3. Respondents keeping various breeds of dairy biodiversity conservation reason for the practice (n=93).

Breed	Respondents rearing them (%)	Reason for rearing them
Friesian	49.4±0.89[a]	Being beautiful and for recognition in society
Jersey	17.2±2.71[b]	Eats the least and cheap to maintain
Ayrshire	15.0±1.07[b]	Eats less than Friesian and also seen as beautiful
Guernsey	5.4±1.23[c]	Eats a lot and not beautiful like Friesian
Crossbreeds	12.9±0.86[b]	Eats less than Friesian and disease tolerant

[a, b, c] Different letters in the same column differ statistically by Chi-square, P<0.01; different breeds were kept for different purposes. Most respondents kept Friesian breeds (49%), followed by Jerseys (17%), Ayrshire (15%), cross breeds (13%) while the least kept breed was the Guernsey (1%).

These results show that there were differences in distribution of the breed within households of Kibugu based on the respondent's perceptions, attitudes and practices. Similar results have been reported in other rural villages in Kenya where dairying practice was characterized by different drivers and conditions (Jahnke and Jahnke, 1982; Cooper *et al.,* 2002).

Table 4. Respondents rating on the dairy practice and for various breeds of dairy biodiversity conservation and reason for the rating (n=93); Scale of 1-6: where 6 denote highly ranked.

Parameter (Practice itself/Breed reared)	Rank (1-6)	Attribute ranked (Respondents perception on practice itself/breed)
Dairy practice	6	Source of household income and society status
Dairy practice	1	Ease of care for the enterprise
Friesian	6	Beautiful cows and symbol of society status
Friesian	1	Ease of care for the cow
Jersey	3	Beautiful cows and symbol of society status
Jersey	6	Ease of care for the cow
Ayrshire	4	Beautiful cows and symbol of society status
Ayrshire	2	Ease of care for the cow
Guernsey	4	Beautiful cows and symbol of society status
Guernsey	2	Ease of care for the cow
Crossbreeds	2	Beautiful cows and symbol of society status
crossbreeds	5	Ease of care for the cow

In a scale of 1-6, the dairying was rated 6 as a source of income for the household, 6 as symbol of society status and 1 on ease of care for the enterprise. Big breeds (Friesian, Ayrshire and Guernsey) were ranked highly (6-4) as symbols of beauty and society status and low (1-2) on ease of care while small breeds (Jersey and crossbreeds) were ranked highly (6-5) on terms of ease of care and disease tolerance but low (3-2) on beauty.

The results also indicate that in Kibugu smallholder farms, like in other rural villages in Kenya, society status of the household head appears to be the most critical production factor that drives land use practice like dairying (Jahnke and Jahnke, 1982). However, labour burdens and inefficiencies of such unsustainable practices caused in time environmental externalities like abandonment of the enterprise as it was observed in Kibugu, It was apparent that the dependency burden rearing the big breeds had a

negative impact on breed biodiversity conservation, especially as observed in Kibugu that labour factor was quite equivocal as also observed previously (Mutembei *et al.,* 2015).

Based on the theoretical context of the DEA method (Cooper *et al.,* 2002), there was household decisions that determined the observed type of dairying practice in Kibugu and not necessarily based on efficiency. The breeds kept in the farm were not necessarily the most efficient in terms of their ease of care. Such scenarios have been reported before as determinants of biodiversity in rural areas (Kuosmanen and Kortelainen, 2004).

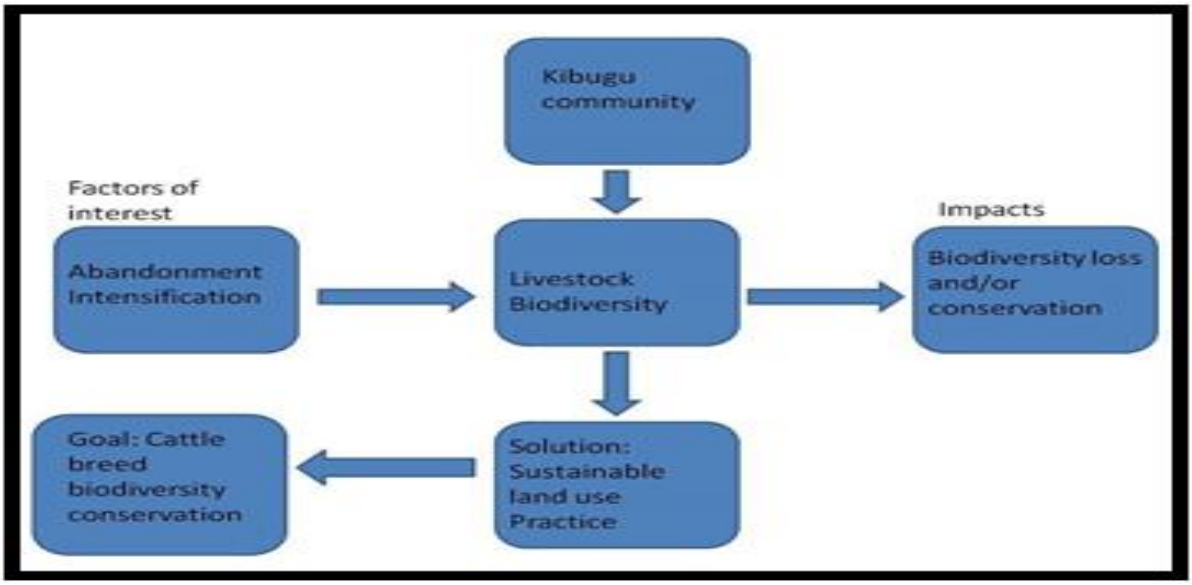

Fig. 2. Conceptual frameworks of the research in Kibugu location on dairy cattle breed biodiversity (developed by Mutembei, 2017).

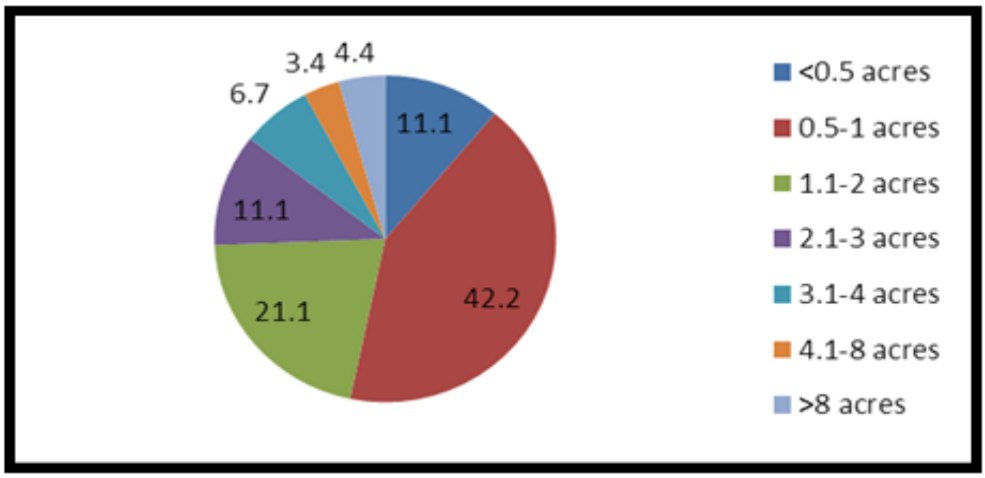

Fig. 3. Pie chart of the percentage land sizes used for dairy farming in Kibugu location.

As rightly noted in Kibugu, abandonment of farming enterprises resulting from challenges of farming have been demonstrated as negative environmental externalities that impact negatively on biodiversity conservation (Reinhard *et al.,* 2000). In Kibugu human activities driven by household decisions on land use impacted not only the producer but also the produced breed causing the observed dynamisms of breed biodiversity; a mix of negative and positive effects. Similar observations have been reported by other authors (Van Huylenbroeck and Whitby, 1999; Schader, 2009).

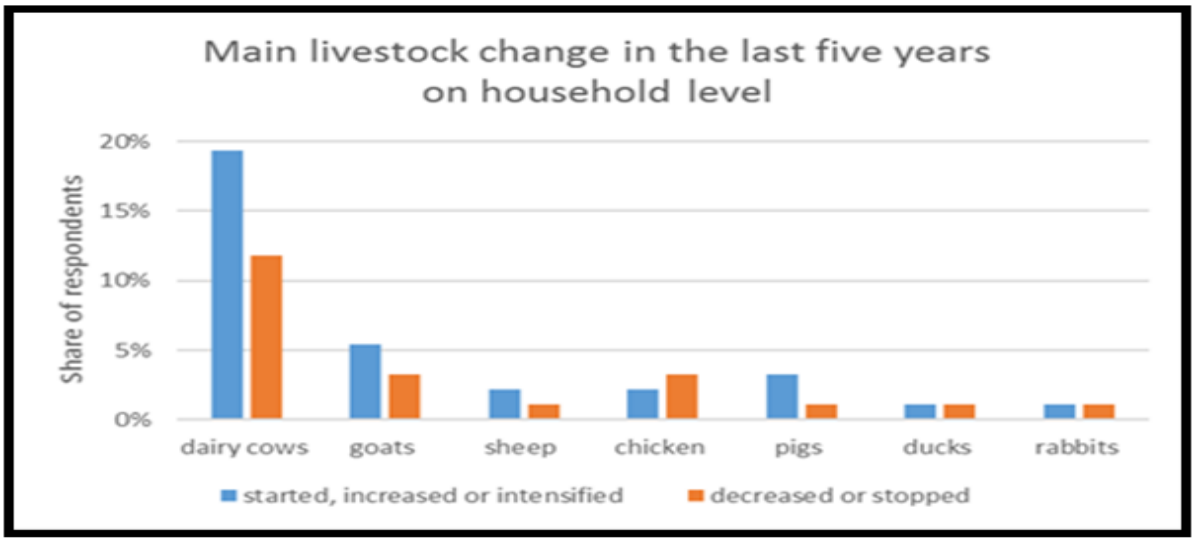

Fig. 4. Histogram showing the dynamism of a 10-year shift in livestock practice for land use in Kibugu.

The data indicate that dairying in Kibugu is very dynamic. This may be explained in that sustainable dairying is managed using tradition practices whose interest is likely also to be influenced by both society and household needs. The two needs would basically push household willingness to incur extra costs of maintaining the practice while at the same time the unsustainable burden of costs pushing for abandonment of the practice. As reported previously, dairying in Kibugu would therefore face two possible alternatives of either intensification or abandonment.

As explained previously by other authors (Kleijn *et al.,* 2009; Van Huelenbroeck and Whitby, 1999), intensification as noted for some respondents led to breed biodiversity conservation (positive environmental externality) while abandonment, as also noted for others would act in the opposite direction (negative environmental externality). Similar observation has been documented (Kleijn *et al.,* 2009; Van Huelenbroeck and Whitby, 1999).

However, in this case study, the thresholds of the research conceptual framework (Fig. 2), must be put into consideration when explaining the entire scenario in Kibugu. Abandonment of the livestock keeping due to inability of the farmers to adapt the land management to social and economic pressures could, as also documented by MacDonald *et al.* (2000), cause changes in breed landscape mosaic.

This explains why the dynamisms of the dairy practice itself and the breed biodiversity changed a lot in a period of 10 years. Abandonment probably caused loss of unique local breed biodiversity, loss of service providers for the remaining breed biodiversity resulting disappearance of certain dairy breeds and total loss of the affected biodiversity. Similar trends have been noted previously (Solovyeva *et al.,* 2011). On the other hand increased intensification of dairying might have caused the opposite effects leading to conserved biodiversity within farms. Conservation, as also documented by Solovyeva *et al.* (2011) would guarantee stability of the biodiversity by attracting a strategy for proper breeding services.

Conclusion

The data shows that the main household decisions for dairy farming in Kibugu were inherently connected to society-specific status expectation. Therefore, dairy breed biodiversity conservation dynamisms were influenced by local characteristics.

This shows that dairy farm management efficiency was conditioned to household decisions and not the natural adaptive characteristics of the breed itself. This finding threatened sustainability of dairying Kibugu because the practice failed to consider farm management in relation to efficiency of breeds kept; farmers succumbed to societal expectations at the expense of keeping the most efficient breeds.

Recommendation

The results of this research can contribute to sustainable dairy practice by providing evidence to inform policy decisions for design of suitable dairy support measures in respect to dairy farm economics and performance, and also for education of farmers that need such support.

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