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# A cluster analysis of variables essential for climate change adaptation of smallholder dairy farmers of Nandi County, Kenya

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## 1. Introduction

i. Smallholder farmers play a key role in development in Africa and are always characterized based on land size.
ii. Climate change adverse impacts are heavily felt by the smallholder farmers, while there exists great diversity in smallholder farmers.
iii. Smallholder dairy farmers‘ adaptation to climate change would need the characterization of these farmers with more variables other than farm size as the only limiting factor.
iv. These characterisation should use robust unsupervised models and integrated systems research to show natural groupings of smallholder dairy farmers to allow the policy makers to promote climate change adaptation practices.
v. The lack of a characterisation of smallholder farmer with robust inclusion of key variables based on land survey limits options for policy makers as farm size reduces over time.
vi. This study sought to use cluster analysis to characterize smallholder dairy farmers of Nandi County Kenya.

## 2. METHODS

i. Site classification by Agro-ecological zones (AEZ) on basis of altitude, rainfall, temperature and predominant land use.
ii. A participatory mapping exercise was conducted using experts‘ knowledge to predict whether there were differences in dairy production systems across the AEZs.
iii. The household surveys were done using a questionnaire tool customized from the Integrated Modelling Platform for mixed Animal Crop systems (IMPACTlite).
iv. Unsupervised learning algorithm was used for cluster analysis.

Production cluster outputted from the clustering algorithm was validated in three ways:

(1) assessment of cluster robustness,
(2) comparison of the cluster membership reallocation (differential allocation of households to clusters for training and testing datasets), and
(3) evaluation of the proportion of variation explained by the clusters.

**Table 1.** Variables as features used in cluster analysis of smallholder dairy farmers of Nandi County, Kenya.

| S/N | Feature name | Type | Range |
|---|---|---|---|
| 1 | Agro-ecological Zone | Discrete | 1 (LH1), 2 (LH2)-3(UM) |
| 2 | Relationship to household head | Discrete | 1 (Head), 2 (Spouse), 3 (Child)-4 (Others) |
| 3 | Gender | Boolean | 1 (Male)- 2 (Female) |
| 4 | Age of farmer | Continuous | 18-79 |
| 5 | Education level | Discrete | 1(No formal and illiterate), 2( No formal but literate),3 (Primary School), 4 (High school), 5 (College)-6 (University) |
| 6 | Total labour available | Continuous | 1-13 |
| 7 | Total time labour required | Continuous | 0-26 |
| 8 | Household area acreage (Hectares) | Continuous | 0.05-15 |
| 9 | Cash crop area acreage (Hectares) | Continuous | 0-100 |
| 10 | Horticulture acreage (Hectares) | Continuous | 0-8 |
| 11 | Grazing area acreage (Hectares) | Continuous | 0-48.5 |
| 12 | Acreage for trees (Hectares) | Continuous | 0-180 |
| 13 | Total farm acreage (Hectares) | Continuous | 0.2-210 |
| 14 | Main Income category | Discrete | 1 (Crop), 2 (Pigs), 3 (Poultry), 4( Beef), 5(Dairy)-6 (Other) |
| 15 | Total number of dairy cattle | Continuous | 1-223 |
| 16 | Total number of beef cattle | Continuous | 0-2 |
| 17 | Total number of sheep/goats | Continuous | 0-42 |
| 18 | Total number of poultry | Continuous | 0-740 |
| 19 | Total number of other livestock | Continuous | 0-8 |
| 20 | Number of months milking | Continuous | 0-12 |
| 21 | Use of milk commercial/noncommercial | Discrete | 1 (Use 100%), 2(Sell >25%), 3 (Sell 25%-75%) -4 (Sell >25%) |
| 22 | Number of hours livestock in confinement | Continuous | 0-24 |
| 23 | Number of hours livestock out confinement | Continuous | 0-24 |
| 24 | Livestock confinement system | Discrete | 1(Fence Only), 2(Fence and Roof), 3 (Fence and Floor)-4 (Fence, Roof and Floor) |
| 25 | is water used in cleaning | Boolean | 0(No) -1(Yes) |
| 26 | Is bedding removed during cleaning | Boolean | 0(No) -1(Yes) |
| 27 | Number of manure management systems in use | Discrete | 0-4 |
| 28 | Do the farmers feed concentrates to livestock | Boolean | 0(No) -1(Yes) |

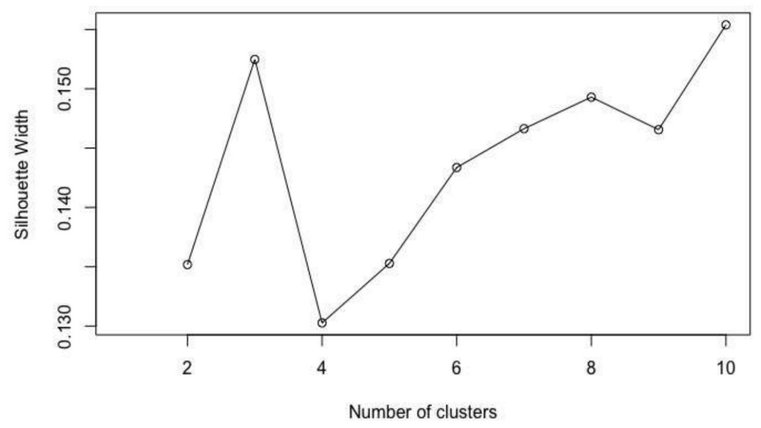


**Figure 1.** Results of silhouette plot analysis for the Nandi County dataset showing the optimal four clusters.

## 3. Results

**Table 2.** Variables and their statistics in the four clusters of smallholder dairy farmers of Nandi County, Kenya.

| Cluster number 1 | Variables from Table 1 | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | 9 | | 10 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| n=84 | | Mean | 2 | Mean | 2 | Mean | Male | Mean | 44.94 | Mean | High School | Mean | 2.81 | Mean | 7.107 | Mean | 0.4387 | Mean | 3.206 | Mean | 0.3821 |
| Cluster number 2 | Variables from Table 1 | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | 9 | | 10 | |
| n=95 | | Mean | 2 | Mean | 2 | Mean | Male | Mean | 43.94 | Mean | High School | Mean | 3.011 | Mean | 7.611 | Mean | 0.4079 | Mean | 5.158 | Mean | 0.3789 |
| Cluster number 3 | Variables from Table 1 | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | 9 | | 10 | |
| n=83 | | Mean | 1 | Mean | 2 | Mean | Female | Mean | 42.05 | Mean | Primary School | Mean | 2.47 | Mean | 6.952 | Mean | 0.8482 | Mean | 3.128 | Mean | 0.462 |
| Cluster number 4 | Variables from Table 1 | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | 9 | | 10 | |
| n=74 | | Mean | 2 | Mean | 2 | Mean | Male | Mean | 43.96 | Mean | High School | Mean | 3.203 | Mean | 9.297 | Mean | 0.6372 | Mean | 2.172 | Mean | 0.2014 |
| Cluster number 1 | Variables from Table 1 | | | 11 | | 12 | | 13 | | 14 | | 15 | | 16 | | 17 | | 18 | | 19 | |
| n=84 | | | | Mean | 3.885 | Mean | 2.774 | Mean | 10.685 | Mean | Dairy | Mean | 8.512 | Mean | 0.05952 | Mean | 3.119 | Mean | 13.51 | Mean | 0.1786 |
| Cluster number 2 | Variables from Table 1 | | | 11 | | 12 | | 13 | | 14 | | 15 | | 16 | | 17 | | 18 | | 19 | |
| n=95 | | | | Mean | 1.829 | Mean | 0.3516 | Mean | 8.127 | Mean | Crop | Mean | 11.41 | Mean | 0.01053 | Mean | 2.526 | Mean | 27.92 | Mean | 0.08511 |
| Cluster number 3 | Variables from Table 1 | | | 11 | | 12 | | 13 | | 14 | | 15 | | 16 | | 17 | | 18 | | 19 | |
| n=83 | | | | Mean | 3.814 | Mean | 2.558 | Mean | 9.106 | Mean | Dairy | Mean | 8.892 | Mean | 0.03614 | Mean | 2.422 | Mean | 19.24 | Mean | 0.1084 |
| Cluster number 4 | Variables from Table 1 | | | 11 | | 12 | | 13 | | 14 | | 15 | | 16 | | 17 | | 18 | | 19 | |
| n=74 | | | | Mean | 1.852 | Mean | 0.2905 | Mean | 5.153 | Mean | Dairy | Mean | 4.324 | Mean | 0.01351 | Mean | 1.541 | Mean | 9.689 | Mean | 0.1081 |
| Cluster number 1 | Variables from Table 1 | | | 20 | | 21 | | 22 | | 23 | | 24 | | 25 | | 26 | | 27 | | 28 | |
| n=84 | | | | Mean | 9.893 | Mean | Sold >75% | Mean | 22.33 | Mean | 1.667 | Mean | Fence Only | Mean | 0.05952 | Mean | 0.0119 | Mean | 1 | Mean | Yes |
| Cluster number 2 | Variables from Table 1 | | | 20 | | 21 | | 22 | | 23 | | 24 | | 25 | | 26 | | 27 | | 28 | |
| n=95 | | | | Mean | 8.2 | Mean | Sold <25% | Mean | 21.27 | Mean | 2.474 | Mean | Fence Only | Mean | 0.09474 | Mean | 0.02105 | Mean | 1 | Mean | Yes |
| Cluster number 3 | Variables from Table 1 | | | 20 | | 21 | | 22 | | 23 | | 24 | | 25 | | 26 | | 27 | | 28 | |
| n=83 | | | | Mean | 10.73 | Mean | Sold >75% | Mean | 13.96 | Mean | 10.33 | Mean | Fence Only | Mean | 0.04819 | Mean | 0.0241 | Mean | 1 | Mean | Yes |
| Cluster number 4 | Variables from Table 1 | | | 20 | | 21 | | 22 | | 23 | | 24 | | 25 | | 26 | | 27 | | 28 | |
| n=74 | | | | Mean | 9.135 | Mean | Sold 25-75% | Mean | 12.97 | Mean | 11.03 | Mean | Fence Only | Mean | 0 | Mean | 0 | Mean | 0 | Mean | No |

## 4. Conclusion and recommendation

i. The major result of this study was that with as many as 28 variables the cluster analysis revealed only four distinct natural groupings.
ii. This study shows how to form similar sets of variables about natural groupings of smallholder dairy farmers
iii. The nature of the key variables used in these groupings.
iv. Hierarchical clustering was appropriate for and could also be applied to qualitative variables.

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