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# Characterization of Pasture Production Systems in Makueni County of Kenya

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**Abstract:- Livestock feed is a key factor influencing animal production and productivity as evidenced by the increased demand for animal source foods (ASFs) to feed a growing human population in Kenya. However, there exists untapped potential of pasture commercialization and hence the need to harness the social, economic and environmental benefits in the ASALs for overall rural development. A study was conducted to characterize the existing pasture production systems in Makueni County. A purposive random sampling of 300 respondents drawn from 3 Sub-counties and 12 wards was conducted in Makueni County in January, 2021. The study aimed to characterize existing pasture production systems using a structured questionnaire. Data were analyzed using descriptive and inferential statistics. Multivariate statistical techniques; principal Component Analysis (PCA) and Cluster Analysis (CA) were used to determine whether or not there were significant differences in the pasture production systems in Makueni County. Results of the study showed that majority (97%) of the farmers were small scale farmers (SSFs) who dedicated less than 5 acres of their land to pasture production. The mean age of small-scale farmers was 52 years compared to 55 years for the large-scale farmers (LSFs). Most of the households were male headed (83%). Most of the SSFs household heads had primary level of education level or lower while most of the large-scale household heads had secondary education and above. Majority (35%) of SSFs owned the land under pasture without a title while most of the LSFs had a title. The land under pasture for SSFs was about 2 acres with an average of 102 bales per season while LSFs had about 23 acres under pasture and produced about 1,762 bales per season. Majority (92%) grew local grass varieties and sold their pasture in form of a bale. 58% of SSFs sited NGOs as their main source of grass seeds while LSFs mainly sourced from agrovets Results of PCA revealed that 6 of the 17 components had eigen values greater than 1 and accounted for 58% of the total variance. Based on Euclidian distance, six clusters were determined using the agglomeration schedule. ANOVA analysis of the six profiles were estimated to have p-values of 0.000, suggesting the existence of significance difference between cluster 1 to 6 in relation to the 6 profiles and hence concluding the existence of variations in pasture production systems in Makueni County. Development strategies should focus on knowledge of and improved access to grass seeds to farmers as well as development of standards of the mode of sale of pasture.**

***Keywords***:- *Pasture, PCA, CA, HCI, Feed Balance, Small Scale Farmers, Large Scale Farmers.*

## I. INTRODUCTION

Animal feed scarcity is the key constrain facing livestock production which accounts for 80 percent of the leading causes of starvations in Kenya (Karega et al., 2019). There is currently a high livestock feed demand that is driven by the increased demand for animal source foods (meat, milk and eggs) (National Animal Feed Strategy 2022-2032). According to the National Feed Inventory and Feed Balance Assessment Report, Makueni County feed balance stands at a livestock feed demand of 0.7 million metric tons (MT) against an actual feed supply of 0.35 million metric tons (MT). Approximately 46 percent of post-harvest feed resources are lost due to alternative uses and waste, impacting negatively on the availability of livestock feed. (Karega *et al*., 2019).

Efforts have been undertaken to promote pasture production as a commercial enterprise in the Arid and Semi-Arid Lands (ASALs) regions of Kenya. Previous studies have shown pasture production has the potential for improving household incomes and contribute to improved feed and nutrition security (Omollo et al., 2017; Sala *et al.*, 2019). However, there exists a knowledge gap with regard to characteristics of pasture production systems and their influence on the final productivity level of pasture production. For effective strategic interventions, it is important to understand the dynamics of pasture by characterizing the existing pasture production systems in Makueni County.

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## II. MATERIALS AND METHODS

➢ *Study Area*

Makueni County is one of the prominent pastures producing counties located in South Eastern part of Kenya. The county consists of six sub-counties and is classified among the ASALs in Kenya. It lies at an altitude of about 1218 M and covers an area of 7699 KM². The county has a population of 987,653 people according to the 2019 KNBS Human Census. The key players in the feed value chain include; pasture farmers, traders, government and development partners.

➢ *Survey Methodology*

A purposive random sampling of 300 respondents: 100 farmers each from Kibwezi East, Kibwezi West and Kilome sub-counties and across four wards in each sub-county was conducted in Makueni county in Kenya between 15th and 27th January, 2024. Pasture farmers were selected from the intensive pasture farming zones and especially those who were organized into pasture groups. The study tool was administered through face-to-face interviews with pasture farmers, Focus Group Discussions (FGDs) and key informant interviews (KIIs) were also conducted.

➢ *Data Collection*

Data collection was conducted using a pre-tested, structured questionnaire which was administered to each farmer. The study was mainly quantitative and adopted the use of quantitative approaches to collect primary data. Primarily, the study used questionnaires, FGDs and KII's especially pasture producers and other actors along the livestock feed value chain. A total of six FGDs were held to understand the nature of pasture production, inputs sources, preferred grass seed varieties, motivation for growing pasture, marketing channels used, institutional support and overall challenges faced by pasture producers. Ten KIIs were held among county agricultural and extension officers, research institutions and development partners supporting pasture production.

➢ *Statistical Analysis*

Characterization of pasture production systems was done by use of descriptive analysis and multi-variate statistical analysis (PCA and CA) to check for any variations in pasture production systems.

The following equation was used in calculation of the principal components;

$PC1 = a_{11}x_1 + a_{12}x_2 + \cdots + a_{1n}x_n = \sum_{j=1}^{n} a1jx_{ji}$..... (Equation 2.1)

$PC2 = a_{21}x_2 + a_{22}x_2 + \cdots + a_{2n}x_n = \sum_{j=1}^{n} a2jx_{ji}$ ..... (Equation 2.2)

Where $x_1, x_2, \ldots x_n$ is the original variables and $a_{ji}$ are the eigenvectors. The variances of PCs are represented by the vectors. The covariance or correlation matrix of the data set derives the coefficients $a_{ji,}$ which are the eigenvectors. The correlation matrix of the data set is calculated thus;

$|C-\lambda 1| = 0$ ..... Equation 2.3

Where $C$ is the correlation matrix, $\lambda$ is the eigenvalue, and $I$ is the identity matrix. The PC coefficients in the PCs are given by equation 2.4.

$|C - \lambda 1|x_{jj} = 0$ ..... Equation 2.4

Therefore, in the Principal Component Regression (PCR) analysis, the PCs are used as the predictor variable in the Multiple Linear Regression (MLR). The PCR model is as shown in the equation 2.5.

$Y = \alpha + \beta_1 PC1 + \beta 2PC2 + \cdots \beta_n PC_n$ ..... Equation 2.5

Y is the Explained variable, $\alpha$ is the model intercept, $\beta s'$ are the regression coefficients.

The study then employed cluster analysis (CA) after the principal components were established. Cluster Analysis involves the use of an extensive range of methods to explain the groups into data sets.

## III. RESULTS AND DISCUSSION

*A. Characterization of Pasture Production Systems*

The study identified two types pasture production systems namely small scale and large scale which are mainly defined by the size of land established with pasture cropping, Household and Farm characteristics as well as Institutional factors. Characterization of pasture production systems was done through descriptive analysis, tables and graphs. Multivariate Statistical Techniques (PCA and CA) were used to test the hypothesis that were no variations in the characteristics of pasture production systems in Makueni County. Most of the farmers (97%) were mainly small-scale farmers, dedicating less than 5 acres of their land to pasture production. The mean HCI was 0.5 while the average for small scale producers was 0.46 while large scale producers

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had 0.52, implying that large scale producers are more commercially oriented.

- *Small Scale Production System*

Small scale production system consisted of mainly small-scale pasture farmers, dedicating less than 5 acres of their land to pasture production. The mean Household Commercialization Index (HCI) of small-scale producers was 0.46, implying that they are moderately commercialized. The average number of years farmers had practiced commercial pasture farming was 4 years. This indicated that farmers had moderate experience in pasture farming. Small scale farmers owned about 5.7 acres of land and dedicated about 1.5 acres to pasture production, equivalent to 25 percentage of the total land size. The output in bales averaged 102 bales per season.

Majority (34.7%) of the small-scale farmers owned without a title the land they allocated for commercial pasture farming. However, 28% indicated that the lands were family land. 1% had leased the land under pasture production. Generally, these findings revealed that majority of the respondents owned the land that they allocated for commercial pasture farming. A title deed gives a sense of security for investments and can be used as collateral when acquiring loans or credit (Omollo *et al.,* 2017). Results on the reasons behind the respondents' decision to undertake pasture farming show that for small scale farmers, those driven by multiple factors included the majority (32%) who engaged in pasture production for consumption and income purposes. This was followed by 20% of respondents who were driven by multiple factors including consumption, income, lease and climate change needs and those who were driven by consumption, income and climate change respectively.

Majority of small-scale farmers (90%) grew local grass species while 6.3% grew both local and improved pasture varieties. Local grass varieties were preferred because of the tolerance to the area conditions and availability of seeds. From the results, majority of the small-scale farmers (58%) obtained their grass seeds from various NGOs as free start up seeds. The findings further show that 93% of the respondents indicated that they grew and harvested pasture two times a year, after each of the two rainy seasons typical of ASALs. Furthermore, 67% of the small-scale farmers had increased their land allocation for pasture production in the previous 2 years. However, 21% had decreased the land under pasture production. This can be attributed to land fragmentation through inheritance. Furthermore, the most used mode of sale of pasture was in form of bales (61%) while cart/pick-up full was least used. However, 24% of the small-scale farmers used traditional means of measuring a hand full. The mode of sale was however determined by the buyers demands. There was however no standard size of the bale or hand full size of pasture.

- *Large Scale Production System*

Large scale production system consisted of mainly large-scale pasture farmers, dedicating more than 5 acres of their land to pasture production. The mean HCI of small-scale producers was 0.52, implying that large scale producers are more commercially oriented. The average number of years farmers had practiced commercial pasture farming was 5 years. This indicated that farmers had moderate experience in pasture farming. The average land size of large-scale producers was 34 acres while 23 acres was dedicated to pasture production, accounting for 67 percentage of the land. This shows that large scale pasture producers dedicated more than half of their land to pasture production. The output in bales averaged 1762 bales per season.

Majority of the large-scale farmers had a title for the land dedicated to pasture production or land was family owned. This implies that majority of the respondents owned the land that they allocated for commercial pasture farming. A title deed gives a sense of security for investments and can be used as collateral when acquiring loans or credit (Omollo *et al.,* 2017). Results on the reasons behind the respondents' decision to undertake pasture farming show that for large scale farmers, those driven by multiple factors including consumption, income, climate change and leasing were the majority. The reason for growing is important in determining the level of commercialization of the output.

Majority of large-scale farmers (2%) grew local type of grass varieties and 1% grew improved type of pasture. Local grass varieties were preferred because of their tolerance to the area conditions and availability of seeds. From the results, most of the large-scale farmers (0.7%) sourced grass seeds from agrovets. Furthermore, majority of the large-scale farmers had increased their land allocation for pasture production in the previous 2 years. The most used mode of sale of pasture was in form of bales while cart/pick-up full was least used. The mode of sale was however determined by the buyers demands. There was however no standard size of the bale or hand full size of pasture.

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**Table 1: Characteristics of Pasture Production Systems**

| **Continuous Independent Variables** | **Small Scale (1-5 acres) N= 291** | **Large Scale (>5 acres) N= 9** | **Total N= 300** | **Std. Deviation** |
|---|---|---|---|---|
| Household Commercialization Index (HCI) | 0.46 | 0.52 | 0.5 | 0.4 |
| Pasture Area (acres) | 1.5 | 23 | 2 | 4.603 |
| Years growing pasture (years) | 4 | 5 | 4 | 3.181 |
| Total production (bales) | 102 | 1762 | 152 | 407.134 |
| **Categorical Independent variables** | | | | |
| **Variable** | **Category** | **Small Scale N= 291** | **Large Scale N= 9** | **Total N= 300** |
| | | | | |
| **Farm Characteristics** | | | | |
| Type of tenure for commercial pasture land | Own land (with title) | 99 (33) | 5 (1.7) | 104 (34.7) |
| | Own land (without title) | 104 (34.7) | 1 (0.3) | 105 (35) |
| | Rented/leased | 3 (1) | 0 | 3 (1) |
| | Family land | 85 (28.3) | 3 (1) | 88 (29.3) |
| Reason for growing pasture | Consumption, Income, Lease, Climate change | 59 (19.7) | 2 (0.6) | 61 (20.3) |
| | Consumption, Income, Climate change | 59 (19.7) | 2 (0.6) | 61 (20.3) |
| | Consumption, Income | 97 (32) | 1 (0.3) | 97 (32.3) |
| | Consumption | 32 (10.7) | 1 (0.3) | 33 (11) |
| | Income | 14 (4.7) | 1 (0.3) | 15 (5) |
| | Climate change | 21 (7) | 1 (0.1) | 22 (7.3) |
| | Income, Climate change | 8 (2.7) | 1 (0.3) | 9 (3) |
| | Consumption, Lease, Climate change | 1 (0.3) | 0 | 1 (0.3) |
| | Consumption, Income, Lease | 1 (0.3) | 0 | 1 (0.3) |
| Type of pasture grown | Local | 272 (90.1) | 6 (2) | 277 (92.3) |
| | Improved | 0 | 3 (1) | 1 (0.3) |
| | Both | 19 (6.3) | 0 | 22 (7.3) |
| Grass seed sources | Agro-vet<br>NGOs<br>KALRO<br>Neighbour<br>Re-seeding harvested Grass seeds | 6 (2)<br>174 (58.1)<br>2 (0.6)<br>40 (13.3)<br>69 (23.1) | 5 (0.7)<br>2 (0.6)<br>0<br>0<br>2 (0.6) | 11 (3.7)<br>176 (58.7)<br>2 (0.7)<br>40 (13.3)<br>71 (23.7) |
| Times pasture is harvested | One time | 7 (2.3) | 0 | 7 (2.3) |
| | Two times | 279 (93) | 8 (2.7) | 287 (95.7) |
| | Three times | 3 (1) | 1 (0.3) | 4 (1.3) |
| | Four times | 2 (0.6) | 0 | 2 (0.6) |
| Mode of sale | Bale<br>Hand full<br>Cart/pick-up full | 126 (60.7)<br>47 (24.5)<br>7 (3.7) | 7 (3.8)<br>0<br>2 (1.3) | 133 (70.5)<br>47 (24.5)<br>9 (5) |
| Land allocation for pasture | Increased | 202 (67.4) | 7 (2.3) | 209 (69.7) |
| | Decreased | 63 (21) | 0 | 63 (21) |
| | Remained the same | 26 (8.8) | 2 (0.6) | 28 (9.3) |

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*B. Principal Component and Cluster Analyses*

The results of PCA show that of the 17 components, only 6 had eigen values above 1. This was done by use of Kaiser's eigen values criterion which states that only components with eigen values greater than 1 should be extracted. The 6 extracted components were then rotated in line with varimax rotation method. The results of the rotation showed that the percentage of the total variance of the 6 extracted components when summed up account for 58% of the total variance. This shows that the 6 extracted components account for more than half of the observed variables.

Table 3 provides the variable loadings of each variable on the components extracted after rotation. Examination of component 1 revealed high positive loadings in pasture area (0.890) and total pasture production/ output (0.879). This component was characterized with high agricultural productivity and efficient pasture management. This implied that households that had a higher agricultural output and a higher pasture area, had a higher likelihood of having a strong presence in this Profile/ Component (Agricultural Productivity Profile).

Component 2 was found to better relate with the gender and marital status variables. High positive loadings of 0.923 and 0.917 were observed for gender and marital status respectively. This indicated that households with higher scores in this profile were likely to be married and headed by a male head. This component represented a household demographic and structure profile. Component 3 was found to have an association with source of market information, reason for growing pasture and source of agricultural information. Source of market information, reason for growing pasture and source of agricultural information had high positive loadings of 0.821, 0.707 and 0.443 respectively. Households with higher scores in this profile are likely to be well informed in matters of pasture production.

Component 4, was found to have higher loadings with type of tenure (0.823) and land allocation for pasture (0.672) reflecting a secure pasture land allocation profile. Households scoring higher in this profile have a higher likelihood of having a secure land tenure and allocate a significant portion of their total land size to commercial pasture production. On the other hand, component 5, recorded relatively high positive loadings with times pasture is harvested (0.646), and distance to the market (0.492) and a high negative loading with group membership (-0.524). Households in this profile with higher scores, are likely to harvest pasture more frequently, but may not be part of a group.

Lastly, component 6 had an association with age of household head, household size and years of growing pasture highlighting an experienced household profile. High positive loadings of 0.690, 0.651 and 0.521 were estimated for age of household head, household size and years of growing pasture respectively. Households scoring high in this component were likely to have older household heads, larger household sizes and more experienced in pasture farming.

As stated, the following equation was used in calculation of the principal components;

$PC1 = a_{11}x_1 + a_{12}x_2 + \cdots + a_{1n}x_n = \sum_{j=1}^{n} a1jx_{ji}$ ..... (Equation 2.6)

$PC2 = a_{21}x_2 + a_{22}x_2 + \cdots + a_{2n}x_n = \sum_{j=1}^{n} a2jx_{ji}$ ..... (See Equation 2.7)

Therefore, using the above equations, the following six equations were generated for the six components extracted in this analysis.

- *PC1 = 0.890(Pasture Area) + 0.879(Total production)*
- *PC2 = 0.923 (Gender Household Head) + 0.917 (Marital Status)*
- *PC3 = 0.821 (Source of Market Information) + 0.707(Reason for growing pasture) + 0.443 (Source of Agricultural Information)*
- *PC4 = 0.823 (Type of tenure) + 0.672 (Land allocation for pasture)*
- *PC5 = 0.646 (Times pasture is harvested) – 0.524 (Group membership) + 0.492 (Distance to market)*
- *PC6 = 0.690 (Age of Household head) + 0.651 (Household size) + 0.521 (Years growing pasture)*

Based on Euclidian distance, 6 clusters were determined using the agglomeration schedule. ANOVA analysis of the 6 profiles were estimated to have p-values of 0.000, suggesting the existence of significance difference between cluster 1 to 6 in relation to the 6 profiles. Thus, there exists significant variations in pasture production systems in Makueni County. The calculated components loadings, eigen values, total variance and cumulative variance are shown in table 2 and 3 with the scree plot of the eigen values of observed components depicted in figure 1.

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**Table 2: Total Variance Explained**

| Total Variance Explained | | | | | | |
|---|---|---|---|---|---|---|
| | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | |
| Component | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 2.309 | 13.585 | 13.585 | 2.309 | 13.585 | 13.585 |
| 2 | 1.850 | 10.881 | 24.466 | 1.850 | 10.881 | 24.466 |
| 3 | 1.679 | 9.877 | 34.343 | 1.679 | 9.877 | 34.343 |
| 4 | 1.464 | 8.611 | 42.953 | 1.464 | 8.611 | 42.953 |
| 5 | 1.331 | 7.828 | 50.781 | 1.331 | 7.828 | 50.781 |
| 6 | 1.157 | 6.806 | 57.587 | 1.157 | 6.806 | 57.587 |
| 7 | .992 | 5.835 | 63.422 | | | |
| 8 | .926 | 5.449 | 68.872 | | | |
| 9 | .902 | 5.305 | 74.176 | | | |
| 10 | .869 | 5.109 | 79.285 | | | |
| 11 | .815 | 4.796 | 84.081 | | | |
| 12 | .765 | 4.499 | 88.580 | | | |
| 13 | .685 | 4.031 | 92.612 | | | |
| 14 | .494 | 2.904 | 95.515 | | | |
| 15 | .416 | 2.445 | 97.960 | | | |
| 16 | .205 | 1.208 | 99.167 | | | |
| 17 | .142 | .833 | 100.000 | | | |
| | | | | | | |

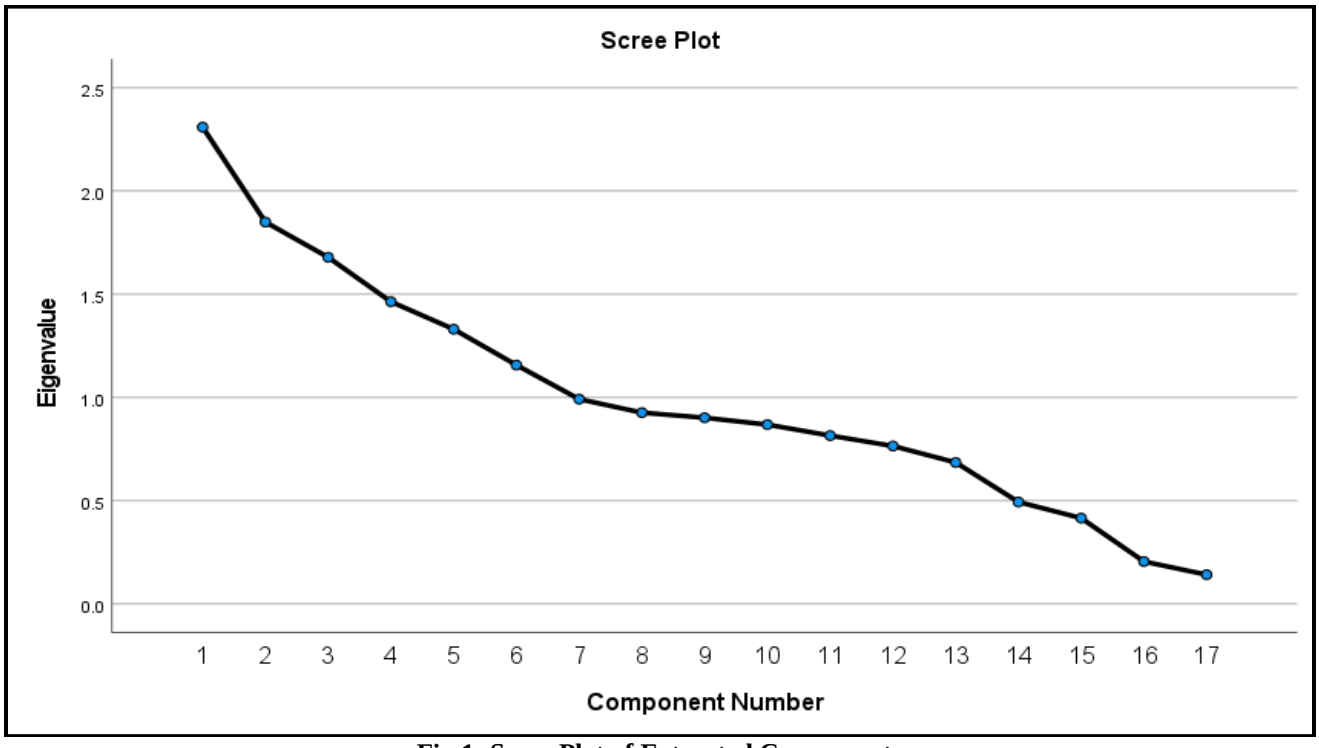


**Fig 1: Scree Plot of Extracted Components**

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**Table 3: Rotated Component Matrix**

| Rotated Component Matrix[a] | | | | | | |
|---|---|---|---|---|---|---|
| | Component | | | | | |
| | 1 | 2 | 3 | 4 | 5 | 6 |
| Pasture Area | .890 | .019 | .164 | .016 | -.016 | .078 |
| Total production (Output) | .879 | .054 | .134 | .010 | -.048 | .134 |
| Household Head Education Level | .443 | -.074 | -.163 | -.130 | -.002 | -.044 |
| Household Head Gender | -.003 | .923 | .070 | .040 | -.047 | .031 |
| Marital status | -.004 | .917 | -.013 | -.089 | .031 | .010 |
| Source of market information | .162 | .017 | .821 | -.119 | .056 | -.009 |
| Reason for growing pasture | .022 | .088 | .707 | .030 | -.194 | .029 |
| Source of Agricultural Information | -.152 | -.288 | .443 | -.046 | .352 | -.137 |
| Type of tenure | -.055 | .033 | .100 | .823 | .074 | -.112 |
| Land allocation for pasture | -.003 | -.077 | -.234 | .672 | -.095 | .087 |
| Times pasture is grown/ harvested | .160 | -.068 | -.123 | -.159 | .646 | -.162 |
| Group membership | .109 | .063 | .099 | .022 | -.524 | -.213 |
| Distance to market | -.171 | .186 | .261 | .246 | .492 | .083 |
| Pasture Type | .374 | .136 | .142 | .207 | .392 | -.193 |
| Age Household Head | .052 | .100 | -.035 | -.377 | .008 | .690 |
| Household size | -.058 | -.031 | .056 | .106 | -.094 | .651 |
| Years growing pasture | .259 | .042 | -.084 | .074 | .297 | .521 |

## IV. STUDY IMPLICATIONS FOR THE FEED VALUE CHAIN IN KENYA

Available studies show that pasture production is a viable venture which can be used as a means of livelihood diversification especially in the ASALs. There is currently a high feed demand as driven by the increased demand for Animal Source Foods (ASFs). However, the animal feed balance of Kenya stands at a feed demand of 55 million MT against a supply of 25 million MT. An in depth understanding of the characteristics of pasture production systems can assist in policy implementation and planning in the feed value chain hence leading to the twin benefits of increased feed availability and contribution to improved food and nutrition security as well as livelihoods.

## V. CONCLUSION

The pasture production practices in Makueni County depend on the type and level of production system. Small scale production system is characterized by; minimal allocation of land towards pasture (< 5 acres) limited acquisition of grass seeds, low uptake of improved grass varieties and minimal access to credit services with regard to pasture production. Large scale production system involves allocation of large tracks of land to pasture (>5 acres). There is however low uptake of improved grass varieties and limited access to credit. Overall, there is lack of standardized mode of sale of pasture. Implications from the study findings are that there is need for interventions with regard to improving pasture production by; developing strategies to increase land under pasture production, increasing availability and access to improved grass seed varieties and developing a standardized mode of sale of pasture.

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## VI. RECOMMENDATIONS

There is need to developing strategies to improve farmers access to grass seeds and especially improved varieties for small scale farmers. Additionally, knowledge and information on existing grass seed varieties especially drought tolerant species and climate smart agriculture practices should be disseminated to farmers. This can be done through extension via farmer groups and cooperatives. Additionally, there is need to have financial services such as credits and loans aimed at supporting pasture farmers in undertaking pasture production. Specifically, the large-scale farmers need to have enhanced access to improved grass varieties. Generally, there is need to develop standards of the mode of sale of pasture; for example, the standard weight of a bale of hay or the pricing elements/indicators of a bale.

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