**Perceived effects of land fragmentation on grass seed banks adaptation intervention among women in Kuku Ward, Kajiado County, Kenya**

**ABSTRACT**

Land fragmentation poses a growing challenge to sustainable land management and ecological restoration in arid and semi-arid regions. In the Chylu landscape land fragmentation has increasingly threatened the viability of land-based adaptation intervention such as grass seed banks. Despite their ecological significance, limited research has examined how social and land-use drivers influence land fragmentation and the subsequent implications for seed bank interventions, especially from a gendered perspective. This study aimed to assess the effects of land fragmentation on the feasibility and sustainability of grass seed bank interventions among women in the Kuku landscape, by looking into the key drivers of land fragmentations, and challenges faced by women in adopting grass seed bank interventions.

Using a **mixed-methods approach**, data were collected from **101 women** through structured surveys and 11 key informant interviews. A **multiple linear regression analysis** was conducted to determine the influence of selected variables such as **inheritance, fragmentation of group ranches, conversion of grasslands to farmlands, land sales, infrastructure development, and other socio-economic drivers** on land fragmentation and grass seed bank intervention. Trends in population growth and per capita land availability from **1987 to 2023** were also analyzed using interpolated time series and regression modeling. The regression results revealed that **inheritance (β=0.714, p<0.001)** and **conversion of grasslands to farmlands (β=0.699, p=0.001)** were statistically significant contributors to land fragmentation. Although factors like **land sales** and **fragmentation of group ranches** had positive coefficients, they were not statistically significant.

Findings showed that land per person decreased from **52.8 ha in 1987 to 3.5 ha in 2023**, driven by a rising population in the study areas. These trends significantly constrained land availability for **pasture restoration**, **hay preparation**, and **grass seed banking**, with women expressing strong agreement on these impacts (mean scores>3.8). The study highlights the need for **community-based seed banks**, **land-use zoning**, and **policy interventions** that integrate gender-sensitive approaches and indigenous knowledge to ensure the long-term viability of seed bank projects in fragmented landscapes.

In conclusion, from the findings land fragmentation is a major impediment to ecosystem restoration strategies such as grass seed banks. Targeted land-use planning, secure land tenure, and inclusive adaptation policies are essential to enhancing ecological resilience and livelihoods, particularly for women in dryland regions like Kuku.

Keywords; Land fragmentation, land use, grass seeds, land degradation, land restoration.

**INTRODUCTION**

With over 60% of the world's population predicted to live in urban areas by 2030, land fragmentation is still a major problem and concern among policymakers and economists (Cherotich *et al.,* 2024). Rangelands and agricultural lands are majorly affected by population growth, which puts pressure on the need for development and fragmentation of land (Abdel et al.,2023). Declining agricultural output, farm efficiency, and ongoing issues with food security, particularly in emerging nations, are the causes of the growing worry (Food and Agricultural Organization (FAO), 2020). According to Asiama *et al.,* (2021), land fragmentation in the Sub-Saharan region has always been prevalent especially in the agricultural ecosystem in recent years. Customary or traditional land tenure systems and agricultural systems have been cited as the major causes of land fragmentations in the Sub-Saharan region. The customary land tenure system is identified as one of the major causes of land fragmentation caused by inheritance and fragmentation to current generations (Mwendwa et al., 2024). Shift cultivation is a predominant agricultural system of customary lands, which causes land fragmentation in sub-Saharan Africa.

Pastoralists in Kajiado County are known to own large portions of land that have enabled their way of living over decades. Land fragmentation in Kajiado began with the creation of a few private, individual land holdings allocated to political and community leaders just before independence (Unks et al., 2023). Large sections of customary land were also appropriated by the government and converted into national parks, reserves, and forests. In 1968, land fragmentation took up a faster pace with the enactment of the Group Representatives Act of 2012. This led to the establishment of group ranches to further strengthen, and commercialize livestock production and facilitated the registration of traditional community land as private community property (Mbudzya et al., 2022). The security of land tenure has been a major source of conflict on group ranches during the past 25 years, particularly for young people, creating a demand for sub-division a process that has now begun on these lands and is likely to affect all land uses in the area (Kareri, et al., 2024). Among these are the Maasai pastoral system and wildlife, which rely on the existence of expansive landscapes that support both cattle and wildlife, (Unks et al., 2023).

Climate change among other factors including population growth have affected animal pastures and led to land degradation affecting the quality of local grass seeds in Kajiado (Nafula *et al*., 2023). This has led to the establishment, evolution, and sustainability of seed banks in many parts of the county. Seed banks play a crucial role in maintaining and preserving plant genetic resources, contributing to the resilience and sustainability of agricultural systems. Wambugu *et al.,* (2023) cited that community grass seed banks, through their effective management, responsiveness to local needs, and facilitation of seed and information flow, make important contributions to local seed security. According to Vernooy *et al.,* (2024), seed banks do not only provide farmers with access to diverse and locally adapted seeds but also serve as knowledge hubs, empowering farmers with the necessary information to enhance agricultural productivity. In Kuku ward, organizations are using grass seed bank technology as an adaptation, which is often used in landscapes that are characterized by degrading rangelands to produce grass seeds and hay (Monica, 2021). The organizations often use structured women's groups to implement grass seed bank technology. Jusdiggit, (2021), points out that the women practice the grass seed bank intervention as a source of income through the sale of grass seeds and hay. They also store some hay to be used in times of drought to mitigate the effects of climate change. The grass seeds are used for the restoration of landscapes with quality pasture reducing the migration of livestock by pastoralists in search of pasture.

Continuous land fragmentation has affected the grass restoration approach affecting the livelihoods of women and their families (Mayele, 2024). The establishment of grass seed banks on different small landholdings can increase transport costs especially when plots are located far from the home, and far from each other. Additionally, scattered plots pose challenges in management and supervision Gornish et al (2020). As land fragmentation increases, land plots become more dispersed in space, leading to lower efficiency in the use of agricultural tools and labor input (Lanoi, 2022). Fragmentation of land gives leeway for fertile lands and landscapes meant for the establishment of seed banks and restoration to be used for other economic activities, (Kinuthia, 20218).

Land ownership systems in Maasai land commonly favoring men, placing them as decision-makers on how the land is utilize (Gara et al., 2017 and Tikwa, 2021). For group ranches depending on member’s lands, the reliability for permission for use from men who own them threatens the success of the seed banks managed by women.

For this reason, the study investigates the challenges facing grass seed banks in Kajiado County, particularly focusing on land fragmentation and its impact on women's participation focusing on the drivers of land fragmentation in the study area, and its effects on the adoption of grass seed bank technology.

# **2. METHODOLOGY**

## **2.1 Study Area**

The Chyulu Landscape lies within the heart of the Tsavo-Amboseli ecosystem in South West Kenya at the foot of Mount Kilimanjaro and the Chyulu Hills. It covers 110,945 ha, of which the protected of approximately 7,895 ha, and the buffer zone is 103,050 ha. The grass seed bank projects are located within the Kuku ward, which is still under the group ranch land tenure system, in the chyulu landscape, Kajiado South sub-county in Kajiado County. Kuku Group Ranch covers an area of 1,200 km2 and is inhabited heavily by the Maasai community who heavily depend on the land. Additionally, the ranch is an important wildlife corridor between the national parks (Tsavo West, Chyulu Hills and Amboseli National Park) and other protected areas in the region.

## **2.2 Study Design**

This study adopted a descriptive approach research design to assess drivers and effects of land fragmentation on the grass seed banks intervention. The quantitative and qualitative data were also used to help give insight on the issues surrounding land fragmentation, including its causes and extent. The research design was based on the use of questionnaires, focus group discussions, and field observation as the data collection instrument.

## **2.3 Target Population**

The target population included made up of women living in the Kuku group ranch and practicing grass restoration. 104 women, from different locations in the area, including Olkaria, Enkusero, Inkisanjani, Enkii, Olorika, and Nolasiti, were sampled and interviewed. Additionally, the purposive sampling technique was used to select officials from the County Department including Lands and physical planning, Environment and Climate Change, Agriculture and Livestock, water and administration, and officials from the local partners who provided information on land and fragmentation, livestock yields, grass seed banks intervention.

Ethical clearance to conduct this study was obtained from the Ethics and Review Board of Kenyatta University. With a research approval license from NACOSTI, Ref No: 919543

## **2.7: Data analysis**

Prior to data analysis, the data obtained from the field using questionnaires was cleaned, coded, and entered the Statistical Package for Social Sciences (SPSS) version 26. Data analysis was done by both descriptive and inferential statistics. A multiple linear regression model was used to investigate the significance of the relationship between land fragmentation-predictors (as independent variable) and grass seed bank adaptation intervention (as dependent variables) based on data obtained from the primary data. The analysis used **standardized beta coefficients, t-statistics, and p-values** to evaluate the strength and statistical significance of each variable and their effect on fragmentation and adoption of the grass seed banks, with a significance level set at **p < 0.05**, enabling the identification of key drivers behind land fragmentation.

To test the hypotheses, the P-value threshold of 0.05 was used.

* Beta coefficients with P values above 0.05 resulted in the hypotheses being rejected; while beta coefficients with P values below 0.05 will result in the hypotheses not being rejected.

# **RESULTS AND DISCUSSIONS**

## 3.1 Demographic characteristics

The study achieved 89.51% (111) response rate of the targeted respondents including 101 women who are involved in the GSB and 10 KII. The survey on women collected demographic characteristics of the respondents including age, education level, income level, main occupation, land size, land ownership, and land use, to provide a comprehensive understanding of the study population.

The women interviewed had stayed in the study area for an average of 24.26 years with older respondents, having stayed in the area longer (an average of 32.06 years) than the young respondents. The data also suggests a potential positive relationship between education level and household income. The main occupation practiced by women was livestock keeping with 71% of the total respondents. 70% of the respondents keep goats as the predominant or most abundant type of livestock with 12% keeping cattle and 10% keeping sheep as the most preferred livestock. Despite crop production being the lowest activity performed by the women; it emerged as the highest earning sector with a mean monthly income of 11537.50 Kenya shillings while income from livestock is at 6166.67 Kenya shillings monthly. Women with primary level education were the most dominant group at 43.2% practicing livestock keeping. Livestock keeping was the largest land use, implying that most of the land by owned respondents was designated for livestock’s as pasture land. Out of the total land size (995 ha) livestock keeping occupied 68.54%.

## **Drivers of Land Fragmentation**

Results in Figure 1 indicate that there has been a general increase in fragmentation of land. Land inheritance, Conversion of grassland to farming, and informal sale of land were mentioned by most of the women (93%, 70%, and 57%) respectively as the leading causes of land fragmentation. Other factors studied as the main causes of land fragmentation with most women indicating that they had been increasing in the past 15 years, however, for fragmentation of ranches, women indicated that ranches had experienced no changes in the size (55%) yet since the allocation of land and formal documents of the land subdivided into an individual parcel of land have not yet been issued.

Figure 1: Causes of land fragmentation

Further results presented in Table 1 illustrated more on how different factors had resulted in more land being fragmented in the past 15 years generated from the Likert scale. The ranking scale used to assess the impact of different variables on land fragmentation ranges from 1-1.75, indicating an increase in fragmentation, 1.76-2.5 implying a decrease, 2.6-3.25 suggesting no change, and 3.26-4 indicating no significant change.

Table 1: Drivers of Land Fragmentation

|  |  |  |  |
| --- | --- | --- | --- |
| **Land Use** | **Mean** | **Std. Deviation** | **Rank** |
| Inheritance | 1.22 | 0.76 | Increased |
| Sub-division of group ranches | 3.11 | 1.22 | Neutral |
| Infrastructure development  Conversion of grassland to farming | 2.46  1.21 | 1.22  0.88 | Decreased  Increases |
| Sale of land to individuals | 2.02 | 1.35 | Decreased |
| Other uses | 1.98 | 1.16 | Decreased |

Conversion of grassland to farming had a mean scale of 1.21, with a standard deviation of 0.88 indicating an increase in land fragmentation due to the land use shift. Over-exploitation of grasslands by agricultural activities often leads to fragmentation of the land into smaller plots for crop farming. The conversion of grasslands to croplands converts the ecosystem into a net carbon emitter, especially when management practices are insufficient to retain the sequestered carbon in soil (Zhang *et al.,* 2021). Inheritance that results primary from increased population, Mwendwa et al., (2024), had a mean scale of 1.22, with a standard deviation of 0.76, an implication that inheritance has increased land fragmentation based on the respondent’s perception. This suggests that the process of dividing land among heirs, often leading to smaller, less efficient land parcels, is a significant factor in the fragmentation observed.

There a clear trend of increasing population and decreasing land availability per person in Kuku land from 1987 to 2023. In 1987, the population was 1,817, with each individual having access to approximately 52.8 hectares of land. By 2023, the population had grown to 12,614, reducing the land available per person to just 3.5 hectares. The trend suggests that as the population increases, land fragmentation through inhretance increase, reducing the per capita land size and potentially leading to challenges in sustainable land management presented in table 3.

Figure 2 Trend of increasing population and decreasing land availability per person in Kuku land

The results of the multiple linear regression analysis in Table 2 further reveal that several predictor variables have a statistically significant effect on Land Fragmentation. The coefficients for Inheritance, fragmentation of group ranches, conversion of grasslands to farmlands, Sale of land to individuals, and other causes are positive, indicating that an increase in these variables is associated with an increase in Land Fragmentation.

**Table 2: Multi-linear regression of Causes of land fragmentation**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
| B | Std. Error | Beta |
| Yes | (Constant) | .721 | .065 |  | 11.061 | .000\*\* |
| Inheritance | .241 | .023 | .714 | 10.678 | .000\*\* |
| Sub-division of group ranches | .014 | .014 | .067 | 1.003 | .319 |
| Infrastructure development | -.007 | .014 | -.031 | -.471 | .638 |
| Conversion of grasslands to farmlands  Sale of land to individuals | .256  .021 | .021  .013 | .699  .109 | 6.975  1.647 | .001  .103 |
| Other causes | .037 | .015 | .167 | 2.474 | .015 |
| a. Dependent Variable: Land Fragmentation | | | | | | |

The standardized coefficient (Beta) for Inheritance is 0.714, indicating that for every one-standard-deviation increase in Inheritance, Land Fragmentation is expected to increase by 0.714 standard deviations. The t-statistic for Inheritance is 10.678, and the p-value is 0.000, indicating that the coefficient for Inheritance is statistically significant at the 0.05 level. The standardized coefficient for the Conversion of grassland to farmlands is 0.699, indicating a positive relationship to land fragmentation. The t-statistic for conversion of grassland to farmland is 6.975, and the p-value is 0.001, indicating that the coefficient for Conversion of grassland to farmlands is statistically significant at the 0.05 level. The coefficient for the Sale of land to individuals and Sub division of group ranches was 0.021 and 0.014, indicating a positive relationship between the Sale of land to individuals and sub division of group ranches and Land Fragmentation. However, these associations were not statistically significant at the 0.05 significance level. This may be due to the process of settlement of families and processing of land ownership documents (title deeds) not yet concluded in the region. A statistically significant positive relationship was also observed between other causes with a p-value of 0.015 and Land Fragmentation at the 0.05 level. The coefficient for other causes of land fragmentation is 0.037, indicating a positive relationship between them and Land Fragmentation. Infrastructure development was the only factor that was negatively associated with land fragmentation with a negative coefficient of -0.007 although it is not statistically significant. The results align with the respondents’ perceptions presented in Table 3 that infrastructure development did not result in any land fragmentation.

From the KII, respondents indicated that the subdivision will not only result to land fragmentation but also have an influence in the sustainability of the banks.

*“…Land subdivision has a potential to affect the GBS. For old seedbanks, one might be affected during the subdivision. Ownership of may lead individual taking the banks from women…” R1*

*"…Subdivision may lead to land allocation to individual who may not want to continue with the GSB…"R3*

Comparing these findings with other studies, such as those analyzing landscape fragmentation metrics in watersheds with diverse land uses in Iran (Alaei *et al.,* 2022) or the spatio-temporal characteristics of cultivated land fragmentation in rapidly developing regions like Guangdong Province, China (Wu, 2021), reveals a common theme of land fragmentation being influenced by a variety of factors, including inheritance, infrastructure development, and changes in land use. Additionally, findings by Moiko, et al, land use transformation in Kajiado County, Kenya. Indicated that besides climate change, inheritance has resulted to over 50% of the land subdivisions.

## Effects of land fragmentation on requirements of developing seed banks

Respondents were presented with a range of scenarios illustrating the different effects of land fragmentations on the requirements for the success of grass seed banks and were asked to indicate their level of agreement with the statements related to these effects (table 3 and 4). The ranking scale used to evaluate the statements ranges from 1-1.8 for strong disagreement, 1.9-2.6 for disagreement, 2.7-3.4 for neutral, 3.5-4.2 for agreement, and 4.3-5 for strong agreement.

**Table 3: Effects of land Fragmentation on Requirements of developing Seed Banks**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Land fragmentation on development of seedbanks** | **N** | **Mean** | **SD** | **Value** |
| Reduced land for the establishment of seed banks | 101 | 3.88 | 1.227 | Agree |
| Reduced land for restoration of pasture | 101 | 4.68 | 0.468 | Strongly Agree |
| Reduced land for hay and grass seeds preparation and storage | 101 | 3.94 | 0 | Agree |
| Reduced access to water sources | 101 | 2.41 | 0 | Disagree |
| Improved access to markets | 101 | 4.16 | 0 | Neutral |
| Improved modern technology for intensive farming | 101 | 4.19 | 0 | Agreed |

The mean score of 3.88, and 3.94 indicates a agreement level that the land **fragmentation** has reduced the land available for establishing seed banks, and preparation and storage of hay, limiting the space available for creating and maintaining seed banks--crucial for the conservation of seed banks.

Mean scores of 4.68 points to strongly agreement that the land **fragmentation** has reduced the land available for restoring pastures. This indicates that the **fragmentation** of land into smaller, less efficient parcels has hindered efforts for rangeland restoration and rehabilitation through re-seeding and in turn grass seed banks that provide seeds for the same. These rangelands are essential for maintaining biodiversity and supporting livelihoods.

Reduced access to water sources: The mean score of 2.41, with a standard deviation of 0, indicates a disagreement with the statement that land fragmentations have reduced access to water sources. The results agree further with the finding indicated in Table 3. that access to water sources as a requirement was the list of the requirements needed to establish seed banks with only 18.8% of the respondents suggesting it as a requirements. This suggests that while land fragmentation may have other negative impacts, its direct effect on water access is not as significant or is not perceived as such by the respondents.

With a mean score of 4.16, the women were neutral on the statement that land fragmentation has improved access to markets. This indicates that the fragmentation of land does not have a clear positive or negative impact on market access, suggesting that other factors may be more influential in determining market access. The findings from the Chyulu landscape align with broader concerns highlighted by the Food and Agriculture Organization (FAO), which emphasizes the need for integrated land-use planning to address the multifaceted challenges of fragmentation, Guo et.al., (2023) and Elseroad et al., (2020), on the recommendation for sustainable ecosystem restoration.

**Table 4: Multilinear regression (Coefficients****for effects of Land Fragmentation on the Development of Seed Banks**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
| B | Std. Error | Beta |
| 1 | (Constant) | .978 | .054 |  | 18.217 | .000 |
| Inheritance | -.052 | .019 | -.283 | -2.816 | .003\*\* |
| Sub-division of group ranches | -.012 | .012 | -.107 | -1.059 | .292 |
| Conversion of grasslands to farmlands  Infrastructure development | -.045  .007 | .016  .011 | -.190  .060 | -2.456  .601 | .004\*\*  .549 |
| Sale of land to individuals | .017 | .010 | .165 | 1.658 | .101 |
| Other causes | .004 | .012 | .036 | .355 | .723 |
| a. Dependent Variable: grass seed bank adaptation intervention | | | | | | |

The results point that inheritance and conversion of grass land to farmlands has statistically significant effect on the grass seed bank adaptation intervention, with a negative coefficient (-0.052 and -0.45) indicating that an increase in inheritance and conversion of grazing lands to farmlands is associated with a decrease in the intervention. The standardized coefficients (Beta) indicate that for every one-standard-deviation increase in inheritance and conversion of grass lands to farm lands, the grass seed bank adaptation intervention is expected to decrease by 0.283 and -0.190 standard deviations. The t-statistic for Inheritance is -2.816, and the p-value is 0.003, and the t-statistics for conversion of grasslands to farmlands is -2.456, and the p-value is 0.004 indicating that the coefficient for Inheritance and conversion of grasslands to farmlands is statistically significant at the 0.05 level.

Sub division of group ranches had negative relationship with adoption of grass seed banks with Coefficient of is -0.107 (Beta), which means that for every one-standard-deviation increase fragmentationof ranches, the Grass seed bank adaptation intervention is expected to decrease by the coefficient values. However, sub division of group ranches do not have a statistically significant effect on the dependent variable with a significance of 0.292. Inheritance of land by women gives them more freedom and rights to make decisions on how to utilize land.

Three out of the 6 causes of land fragmentation studies had a positive standardized coefficient (Beta) towards grass seed bank adoption. Sale of land to individuals, Infrastructure development, and other courses had coefficients of (0.165, 0.060, and 0.036) receptively, which implied that for every one-standard-deviation increase in sale of land or infrastructure development and other uses, the grass bank intervention is likely to increase by the values indicated in table 4.

Comparing these findings with other studies, such as Gouranga *et al.,* (2023), who examined the effects of land fragmentation on biodiversity and ecosystem services in different regions reveals a common theme of land fragmentation having a multifaceted impact on ecosystems.

Challenges affecting development of seedbanks.

Grass seed banks, while valuable for landscape restoration, face other challenges apart from diminishing land and degradation. These challenges may include drought, invasive species, livestock and wildlife invasion, and social challenges such as farmer's knowledge, experience, finances, and access to technical expertise. The study investigated these challenges since they complement the issue of land fragmentation and may act as enablers for the failure of the seed banks. Respondents were given an opportunity to highlight other challenges they face alongside land fragmentations. The results are presented in Figure 3.

Figure 3: Challenges facing the development of seed banks

In Figure 3, the women highlighted several challenges that they are experiencing while practicing the intervention. All the women agree that frequent droughts are a significant challenge to the grass seed banks, which are entirely dependent on rainfall. When rains fail, and droughts are harsh, most seed banks fail to produce substantial yields, affecting their income since they have to reinvest what little they earn back into the banks.

Furthermore, 87% of the respondents agree that over-reliance on rainfall, with no access to irrigation, is also a threat to the grass seed banks if the climate continues to change. The long seasons between harvests pose an additional challenge for the women who have no alternative sources of livelihood. Land ownership is another significant challenge, with 75% of the respondents agreeing that the current land ownership system hinders the success of grass seed banks. In the community, men own the land, and the group ranch has men as the legal owners, disadvantaging women from ownership. The women's groups have to go through the group ranch to be allocated land for establishing the seed banks, and in case of any substantiated reasons, the seed banks can be reallocated to different areas, paving the way for other activities by the group ranch. Moreover, 76% of the respondents attribute the failure of grass seed banks to land sizes, as individuals and groups with large lands are more likely to produce more yields.

The lack of modern farming technologies is also a significant hindrance, with 67% of the women pointing out that it may hinder the attainment of the objective of the grass seed banks. The work in the grass seed banks is intensive, starting from planting, weeding, and harvesting, and most groups do this manually. Considering that many group members are elderly or disabled, the work becomes tiresome for the remaining members. Farm tools are also inadequate, and some are broken. Additionally, pastoralism as a way of life is a significant hindrance to the intervention, as it took a while for the community to adopt the grass seed banks initiative since they were used to migrating from one place to another during drought seasons. Some households still practice pastoralism and have not adopted the technology of reseeding and buying hay for their livestock.

Access to adequate information is another challenge, with 71% of the respondents explaining that low financial and marketing literacy, coupled with access to inadequate information, has hindered them from marketing their produce and achieving full commercialization. Furthermore, 98% of the women interviewed have no access to credit facilities, which they attribute to inadequate finances in savings with the credit providers since most of them live from hand to mouth.

On the other hand, 80% of the respondents disagree that access to agricultural extension services is a hindrance to the success of grass seed banks, attributing their opinion to the availability of extension services especially from the local organization personnel supporting them. However, 20% of them agree that it might be a challenge, attributing it to the unavailability of sustainable government extension services that they may need in the absence of the supporting organization.

Lastly, 81% of the respondents disagree that farm experience is a hindrance to the success of grass seed banks, attributing this to the frequent farm technical training provided by the supporting organization.

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# **4. SUMMARY, CONCLUSION AND RECOMMENDATIONS**

## **4.1: Summary of the findings**

### **2: Drivers of land fragmentation**

Inheritance (98%) and rate of increase in conversion of grazing land to farmland (70%) were identified as the major causes of land fragmentation with odd ratios. There was also a positive relationship between the Sale of land to individuals and the sub-division of group ranches and Land Fragmentation indicating that an increase of the two will lead to an increase in land fragmentation. However, these associations were not statistically significant to the 0.05 significance level. This may be due to the process of settlement of families and processing of land ownership documents (title deeds) not yet concluded in the region. However, the respondents expressed their concerns about the variables bringing a significant effect after the completion of the fragmentation. Infrastructure development was the only factor that was negatively associated with land fragmentation indicating that it did not result in any land fragmentation although it is not statistically significant.

### **5.1.4: Effects of land fragmentation on grass seed banks**

Reduced land for restoration of pasture due to land fragmentation was the popular opinion with 100% of the respondents agreeing. The women perceived that land for the establishment of grass seed banks and preparation and storage was also affected with 80% and 82% noticing a reduction of land allocated for duplication of the said activities. This suggests that the fragmentation of land into smaller parcels has limited the space available for creating and maintaining seed banks, which are crucial for the establishment of seed banks and the restoration efforts to rangeland through re-seeding. These rangelands are essential for maintaining biodiversity and supporting livelihoods. However, respondents indicated that land fragmentation effect on water access was not as significant. The women were also neutral on the statement that land fragmentation has improved access to markets and improved modern technology for intensive farming. This indicates that the fragmentation of land does not have a clear positive or negative impact on market access or on the adoption of modern farming technologies.

## **4.2: Conclusions**

Common challenges for maintaining and upscaling community seed banks in the Kuku ward include improving the mechanisms of controlling land fragmentation and mechanisms that contribute to a more secure and diversified supply of high-quality seeds adapted to local conditions and developing incentives for farmers, particularly women and younger generations, to continue their seed-banks efforts. This can be achieved through the strengthening of grass seed banks' community ownership, and financial power, the introduction of more efficient and effective systems to acquire and exchange seeds, better seed conservation and multiplication practices for a broad range of grass, and training in grass improvement practices. Women in the grass benefit a lot from the grass seed banks, especially from income and hay for their livestock. Community seed banks would benefit from targeted technical and financial support from the government, organizations, and private sectors and solve the issues of livestock loss due to drought. The analysis of factors contributing to land fragmentation in Kajiado reveals that the conversion of grassland to farming and inheritance are the primary drivers. The significant mean scales of 1.21 and 1.22, respectively, highlight the critical role these factors play in exacerbating fragmentation, with a substantial portion of respondents acknowledging their impact. The shift from grasslands to croplands not only leads to the fragmentation of larger plots but also poses ecological risks by transforming the ecosystem into a net carbon emitter. In contrast, infrastructure development appears to have a limited effect on land fragmentation, as indicated by the low percentage of respondents attributing fragmentation to this factor.

The Grass Seed Banks initiative has proven to be a transformative program for the women in the community, significantly enhancing livestock survival and improving household incomes. The ability to store and utilize hay as fodder during droughts has played a crucial role in preventing livestock losses, while increased milk production from improved feeding practices has contributed to better nutrition and financial stability for families. Moreover, the initiative supports environmental sustainability through the promotion of quality grass seeds, which aid in rangeland restoration and help mitigate human-wildlife conflicts. The diversification of income-generating activities, such as beekeeping and poultry farming, further strengthens the resilience of these women against the challenges posed by drought.

The findings from the assessment of the impact of land fragmentations on seed banks in the Kuku ward reveal significant concerns regarding the availability of land for conservation efforts. The strong agreement (mean score of 3.88) that fragmentation has reduced the land available for establishing seed banks highlights a critical challenge in maintaining the GSB programs. The unanimous agreement among respondents on the necessity of land restoration for pasture further emphasizes the need for larger, contiguous land areas to effectively establish grass seed banks.

## **4.3 Recommendations**

1. The study strongly recommends the development of a comprehensive land use plan that takes into account the needs and perspectives of women involved in grass seed bank adaptation intervention.
2. To address the issue of land fragmentation, the study recommends the implementation of land consolidation programs that can help to reduce the number of small, scattered plots of land and increase land availability for women involved in grass seed bank adaptation intervention.
3. The study emphasizes the need for capacity-building programs that focus on skills development, entrepreneurship, and leadership for women involved in grass seed bank adaptation intervention.

**COMPETING INTERESTS DISCLAIMER:**

Authors have declared that they have no known competing financial interests, non-financial interests, or personal relationships that could have appeared to influence the work reported in this paper.

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