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Factors Influencing Adoption of Management and Control Technologies for Prosopis juliflora in Marigat, Baringo County, Kenya

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Abstract
Prosopis juliflora is an invasive woody plant that was introduced to Marigat Sub County of Baringo County in 1970s and over the years its spread has altered the livelihoods of the pastoral communities who are the majority in most of the affected areas. This is because *Prosopis juliflora* invasion has reduced available dry season grazing fields, chocked river banks and interfered with access roads. To control its spread several management and control technologies were promoted in Marigat Sub-County in early 2004 that included clearing and planting pasture, charcoal production and killing of cut stumps with chemicals among others. However, the interventions have not yielded the desired results for the species has continued to spread into newer areas and intensifying their presence in already invaded areas. A study was initiated in 2017 to determine the factors influenced the local households to adopt the promoted management and control technologies in Marigat Sub-county one of the areas of original introduction and most affected by the infestations. The study was done through socio-ecological survey using questionnaires and checklist administered to 337 households. The factors considered were Socio-economic (education, land size income) and demographic (gender, age, household size). Data collected was then processed and analyzed using descriptive and inferential statistics of SPSS. The inferential tools used were chi-square analysis, regression and correlation analysis and Pearson Moment Correlation analysis. The results showed land size, incomes from Prosopis products, age and household size significantly influenced adoption of management and control technologies for Prosopis in the study area. The adoption rates association direction depended mostly on labour availability and incomes to hire extra labour for undertake the arduous job of Prosopis clearing and control of reinvasions. Level of education of the respondents had no significant effect on the adoption rates of the various control measures.
Keywords: Adoption, *Prosopis juliflora*, Management, Invasion and Household

1. INTRODUCTION

Prosopis species is listed among the world's most worst 100 species (Lowe *et al*., 2000 and Zeila, 2011). There are 44 *Prosopis* species as recorded but two of these species *Prosopis juliflora* and *Prosopis pallida* are exclusively tropical (Pasiecznik *et.al*, 2001). They are native to arid and semi- arid zones of America, Africa and Asia and are in the family Leguminosae (Fabaceas*)*. The *Prosopis juliflora* was first introduced in Africa through Senegal in 1822, South Africa in 1880 with subsequent introduction to Egypt in 1900. It is hardy and can tolerate harsh climatic conditions with rainfall as low as 150mm. Its introduction in Kenya was done in the early 1970s to address the increasing demands of forest resources and to improve vegetation cover (Esbenshade and Graige, 1980, Choge *et al.,* 2007 and Sirma *et al.,* 2008). The species adopted and naturalized very easily in Kenya, especially along the coastal region. *Prosopis juliflora* was introduced in Baringo County in the early 1980s with the good intentions of curbing soil erosion and to safeguard the existing indigenous vegetation from overexploitation by the local population as firewood (Lenachuru, 2003 and Choge, *et al.,* 2007). It was part of the Kenya government policy of enhancing sustainable management of the drylands woodlands.

Aboud, *et al.* (2007) lists some seventeen (17) ecological and socioeconomic beneficial traits of *P.juliflora* based on surveys conducted in Marigat sub-county that include contribution towards rehabilitation of degraded areas and provision of timber, fuel, income and fodder to the local community (Mwangi and Swallow, 2005 and Sang, 2009). However, the rapid growth and spread of the species has reduced the available land for pasture in wetlands and many complaints from the local communities on its injurious attributes prompted the Government to declare the species a noxious weed in 2008 under the Noxious Weeds Act CAP 325. The declaration came to force in 2009 after its publication in the Kenya gazette notice no 184 (GoK, 2009). In the National Environmental Policy 2012, *Prosopis juliflora* is listed among the main contributor to loss of biodiversity and it is recommended to be controlled and contained to protect the environment in arid and semi -arid areas.

Despite the measures to control *Prosopis juliflora* in many parts of the drylands it has continued to spread invading more areas especially along rivers and roads (Richardson, 2001 and Shackleton *et al.*, 2015). *Prosopis juliflora* like other invasive species are most of the time introduced intentionally or accidentally in an area before eliciting their negatively effect on the environment affecting social economic activities in the areas which they

invade. The speclies like most other invasive species is prolific seeder hence can easily establish in degraded environments. Currently *Prosopis* is reported to have invaded millions of hectares of land in arid and semi-arid continents of Asia, Africa, Australia and Americas. In Africa, it is believed to have invaded over 4 million hectares; threatening crop and rangeland production; desiccating water resources; and displacing native flora and fauna (Zimmermann *et al*., 2004 and Witt, 2010).

The government through Kenya Forestry Research Institute (KEFRI) in collaboration with Kenya Forest Service (KFS) and technical support from FAO initiated various trials ob management and control of *Prosopis juliflora* in Marigat in Baringo County in 2007. Some of the key interventions developed were based mostly on mechanical and chemical methods. Through Farmer Field Schools approach many stakeholders were trained on the harvesting and utilization of on *Prosopis juliflora* which contributed significantly to the improvement of their livelihood (Pasiecznik *et al.,* 2001 and Choge *et al.,* 2006). Forest Act No. 7 of 2005 section 59 provided rules and regulations on the production, transportation and marketing of charcoal under the Forest (charcoal) rules 2009 that legalized the use of *Prosopis* species in charcoal production with the aim of controlling its spread and intensification.

The adoption of innovations and technologies are evaluated through many scientific models including the diffusion theory (Rogers, 1995). Many studies emphasize have pointed the that the socioeconomic status of local communities is one of the great contributor to poor or lack of adoption of innovations (Hassan *et al.*, 2002) and Hassan, 2008). They argue that socioeconomic factors greatly influence the types of activities people are engaged in as well as their interaction with natural resources including the way they think, perceive and behave towards adoption of innovations. This study therefore aimed at identifying the socioeconomics and demographic factors that influence the people's adoption of management and control innovations to control the spread of *Prosopis juliflora* in Marigat. The findings of the study was aimed at isolating key factors that can be used by government policy makes and local agencies to enhance adoption of various management and control innovations to control Prosopis spread in the study areas. The results from the study are therefore useful in enabling relevant authorities to influence adoption of various management and control innovations to control the spread of methods while enhancing their livelihoods.

2. MATERIALS AND METHODS

2.1 Description of the study site

This study was undertaken in Marigat Division in Baringo County, Kenya one of the fourteen administrative divisions in the county. The county is located between latitudes 0°12' and 1°36' N and longitudes 35°36' and 36°30' East (Magut *et al.*, 2015). The study area ranges between 900 and 1200 m above sea level and is generally hot and dry throughout the year (Saina *et al.*, 2012). The annual and inter-annual precipitations are highly variable with an annual precipitation of 650mm (Magut *et al.*, 2015).

2.2 Specific Objectives

The specific objectives of the study which were:

1. To determine the socio-economic factors that influence the adoption and utilization of Prosopis control measures among the households,
2. To determine the demographic factors that influence the adoption and utilization of Prosopis control measures among the households

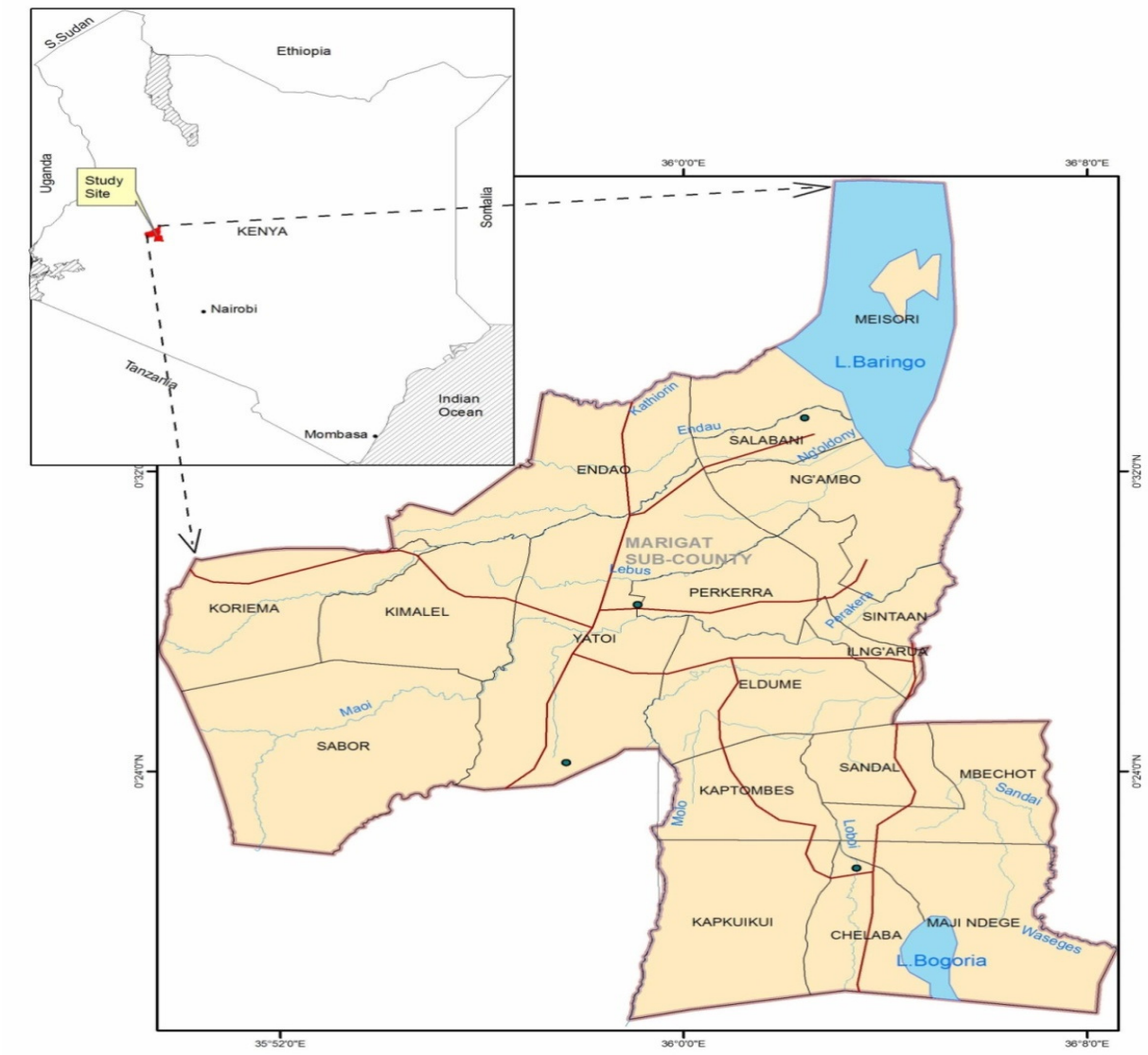

Figure1: Map of study area

2.2 Study design

Socio-ecological survey was used in this study. Survey instruments used included a semi-structured questionnaire, interviews and focused group discussions. This method was found to be appropriate because the data that was collected composed of self-declared responses of the heads of households.

2.3 Sample size for household survey

The sample was determined using the Mugenda and Mugenda, (1999) formula, and calculated as follows:

$$n_o = \frac{Z_{\alpha/2}\, p(1-p)}{d^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{I}$$

Where n_o =sample size, p=estimated population proportion of farmers who have adopted *Prosopis juliflora* utilization techniques introduced by the government and other organization and d = the absolute precision defined and SE is the standard error.

$$d = Z_{\alpha/2} SE$$

Where SE is the standard error; and the taking α=0.05, estimated the population proportion of farmers adopting the intervention techniques as = 0.09, absolute precision d=0.03, the sample size is calculated as given below. Z= the standard normal deviation, set at 1.96 which corresponds to 95% confidence level

Sampling procedure
Simple random sampling technique was used to select household heads in Marigat sub-county.

2.3 Data Analysis
The quantitative data was analyzed using both descriptive and inferential statistics. The descriptive statistics was used to describe and summarize the data inform of graphs, tables, frequencies and percentages. The inferential statistics (chi-square analysis, regression and correlation analysis -Pearson Moment Correlation analysis) was used to help make inferences and draw conclusions.

Table 1: Summary of data analysis

Research objectives	Variables	Statistical Tools
To find out the socio-economic factors that influence the adoption and utilization of *Prosopis* among the households	Socio-economic factors - Education - Land size - Income	Descriptive statistics - Frequencies - Percentages - Pie chart - Line graph - Bar graph - Cross tabulation Inferential statistics - Chi-square
To determine the demographic factors that influence the adoption and utilization of *Prosopis* among the households	Demographic factors - Gender - Age - Household size	Descriptive statistics - Frequencies - Percentages - Pie chart - Line graph - Bar graph - Cross tabulation Inferential statistics - Correlation coefficient - Chi-square

3.0 RESULTS
The following sections present the results of the findings of this study in accordance to the specific objectives of the study.

3.1 Socio-economic factors that influence the adoption and utilization of *Prosopis*
The results of the socio-economic factors of the household including education, land size and income influencing the adoption and utilization of *Prosopis juliflora* are presented as follows.

3.1.1 Education
The findings in Table 2 indicate that most of the respondents accounting for 78% had primary and secondary education. The results show that there is no association between the education of household head and adoption of techniques of utilization of *Prosopis juliflora* since the p-value of 0.311 is greater than expected p threshold of 0.05.

Table 2: Cross tabulation of adoption of techniques levels vs. education levels

	Education levels % (N)				
Adoption of intervention techniques levels	**Informal education**	**Primary**	**Secondary**	**Tertiary**	**Total**
High degree (8 to 10 techniques adopted and used)	16.30 (15)	45.65(42)	32.61(30)	5.43(5)	100(92)
Low degree (1 to 3 techniques adopted and used)	18.18(19)	46.46(49)	32.32(32)	3.03(3)	100(103)
Moderate degree (4 to 7 techniques adopted and used)	18.46(24)	43.08(56)	33.08(43)	5.38(7)	100(130)
No utilization (0 techniques adopted and used)	8.33(1)	75(9)	8.33(1)	8.33(1)	100(12)
Grand Total	17.51(59)	46.29(156)	31.45(106)	4.75(16)	100(337)
Tests statistics	Chi-Square= 10.51, df=9, p-value= 0.311				

3.2.3 Land size of the respondents
Table 3 show that majority of the respondents (98.2 %) owned land that ranged from 0-1.2 hectares (48.4%), 2.8-4 hectares (12.17%) and greater that 4 hectares (5.34%). The results indicate that the level of adoption of control innovations reduces with increase in land sizes owned. The p-values are less than 0.05 indicating that land size

was significant factor in adoption of *Prosopis juliflora* control innovations. The interpretations is that those farmers who owned less land were likely to adopt control measures to minimize the invasion of Prosopis and compared to large land owners.

Table 3: Cross tabulation of adoption of techniques levels vs land sizes

	0-3 Acres	4-6 Acres	7-10 Acres	10 +acres	Total
Adoption of intervention techniques levels	% (N)	% (N)	% (N)	% (N)	% (N)
High degree (8 to 10 techniques adopted and used)	53.76 (50)	31.18(29)	8.60 (8)	6.45(6)	100(93)
Low degree (1 to 3 techniques adopted and used)	29.41(30)	46.08(47)	20.59(21)	3.92(4)	100(102)
Moderate degree (4 to 7 techniques adopted and used)	60.00(78)	27.69(36)	6.15(8)	6.15(8)	100(130)
No utilization (0 techniques adopted and used)	41.67(5)	33.33(4)	25(3)	0(0)	100(12)
Total	48.37(163)	34.42(116)	11.87(40)	5.341(18)	100(337)
Test statistics	χ^2=43.82, p=0.001<0.05				

3.1.3 Income from *Prosopis juliflora*

Figure 2 shows that income from *Prosopis* was highly associated with the levels of innovation adoption with high adaptors generating grater incomes as compared to non-adopters. This is exhibited by the chi-square results indicate that there is an association between the incomes from the sale of *Prosopis* products and the level of adoption and utilization of techniques (χ^2= 22.76, df=9, p-value= 0.006<0.05). Therefore, income from *Prosopis* influences the level of *Prosopis juliflora* adoption and utilization of management and control innovations.

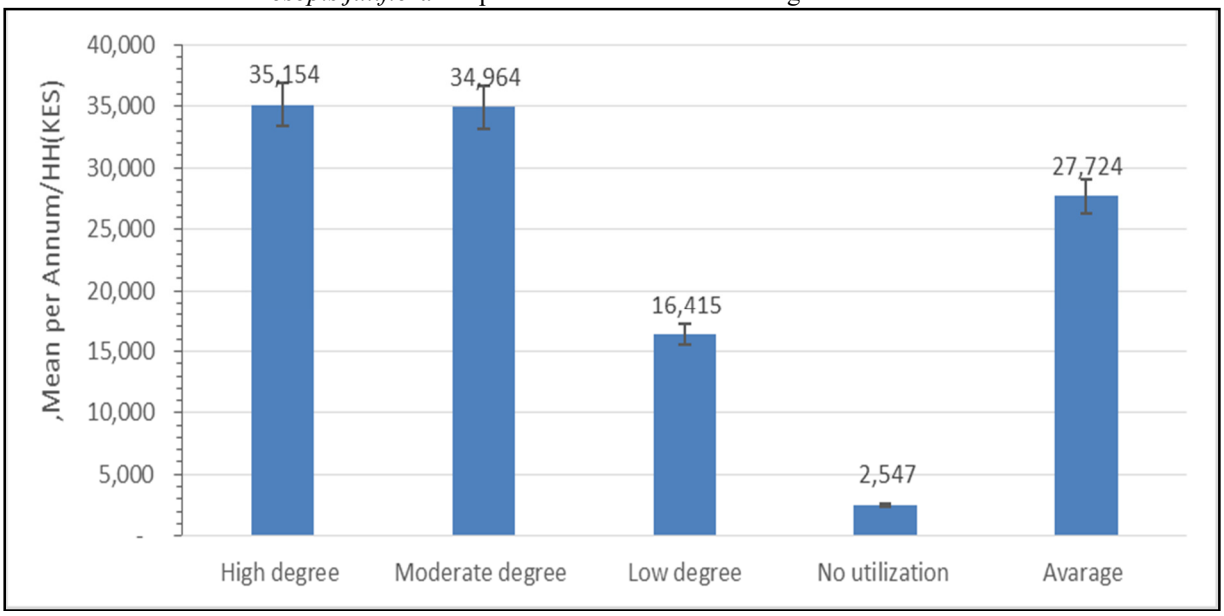

Figure 2: Amount per household per year

3.1.4 Gender of the respondents

The male headed households respondents were more accounting for 71.5% as compared to female headed (28.5%). There cross tabulations results in Table 4 show that the statistical association between gender of the household's head and adoption of management and control innovations was significant (p=0.01<0.05). The male headed households were better adopters of innovations at all selected levels of adoption as compared to their female counterparts. This could be attributed to the fact that in the community the roles and responsibilities on were differentiated by gender with female being mainly in domestic work and men outside work including charcoal production. Hence the gender is a factor in the management and control of *Prosopis juliflora* and by extension adoption and utilization of the promoted intervention innovations.

Table 4: Cross tabulation of adoption of intervention techniques levels Vs gender

Adoption of intervention techniques levels	**Female**	**Male**
High degree (8 to 10 techniques adopted and used)	8.93%	91.07%
Low degree (1 to 3 techniques adopted and used)	26.44%	73.56%
Moderate degree (4 to 7 techniques adopted and used)	28.43%	71.57%
Grand Total	23.14%	76.86%
Test statistics	χ2= 8.680, df = 3, p-value= 0.01	

3.1.5 Age of the respondents

Majority of respondents in the study fell in the middle and lower ages with 25- 35 years being 34%), 36-45 years (25.8%), 27.6% having 46-60 years (27.6%) and 4.5% over 60 years (4.5%).

Table 5 shows that age of household head was a significant factor that influenced adoption and utilization of

Prosopis juliflora (p =0.04<0.05).

Table 5: Age groups of the respondents

Adoption of intervention techniques levels	Mean Age of HH Head
High degree (8 to 10 techniques adopted and used)	36
Moderate degree (4 to 7 techniques adopted and used)	39
Low degree (1 to 3 techniques adopted and used)	43
Test statistics of age categories $\chi 2=20.88$, df=8, p =0.04<0.05).	

3.1.5 Household size of the respondents

Table 6 shows that the household size was statistically significant factors influencing the adoption of management and control innovations the chi-square test analysis ($\chi^2=41.217$, df=24, p = 0.016<0.05). The adoption of intervention measures increased with increased average number of household members indicating that the intervention measures were labour intensive activity.

Table 6: Household size of the respondents

Adoption of intervention techniques levels	Average of HH Members
High degree (8 to 10 techniques adopted and used)	6.5
Moderate degree (4 to 7 techniques adopted and used)	5.7
Low degree (1 to 3 techniques adopted and used)	4.4
Test statistics	$\chi^2=41.217$, df=24, p = 0.016<0.05

4.0 Discussions

Although the respondents with primary education were higher in all the adoption levels reflecting the education status of the sample population but level of education of the respondents was found to have no significant effect on the adoption and utilization of management techniques of *Prosopis juliflora* in Marigat. These findings were in contrast with those of Okuthe *et al.* (2013) who indicated that there is a relationship between the levels of education the adoption of the agroforestry practices. The results might have been different given that *Prosopis* is an invasive species and the farmers would like to eradicate it but most of the technologies for its management are labour intensive and might not depend on the level of education directly.

Land is a critical factor in land use decisions in Kenya and therefore is expected to play a key role in adoption of technologies. The results confirmed that land size was in an important factor that influenced of adoption of management and control innovation for *Prosopis juliflora* in Marigat. There adoption rates decreased with increasing land sizes indicating that farmers whose land areas were able to intensify management and control measures to ensure their land remained available for other agricultural purposes. These findings are in agreement with those of Styger and Fernandes (2006) that found that the size of land had strong relationship with adoption of the farm practice technologies but also contrasts to findings by Pisanelli *et al*. (2008) that found little influence of farm size on adoption of management technologies. Therefore adoption of technologies is a complex issues and depend on many factors in relation to land size that include inputs requirement intensity for the current case labour availability.

The study found that magnitude of incomes from Prosopis products sale had significant influence on the adoption of management and control innovations. Two factors into play in explaining the importance of income in adoptions rates the labour requirements have to be paid for hence high production is associated greater incomes. Similarly, given that there are limited opportunities for households in the dry areas like Marigat charcoal production there remains one of the fall back activities during the dry seasons. The study is in agreement with that done by Admasu (2008) who found out that households involved in charcoal production and sale obtained good income and had diversified their livelihood base to better cope with severe weather conditions.

Gender issues were more complex due to many factors involved that include land tenure, power relation and cultural norms. The study found low adoption rates for female members of household as compared to male that may be tied with local cultural norms that dictate the gender roles in charcoal production. These results were in line with findings by Kabwe (2010) stated that men were more likely to try improved technologies than their female counterparts.

The study results also showed that age of the household head was a significant factor in adoption of management and control innovations for *Prosopis juliflora*. The higher adopters fell within the mean age category of 36 who are strong and active to participate controlling wild thickets *Prosopis juliflora.* The findings were in agreement with Amos (2007) who found out that new technologies such as artificial insemination were adopted faster and better by the young farmers (Sezgin *et al.,* 2011).

The study found positive influence of household size on management and control of Prosopis that is labour intensive activity indicating land owners with less family per invested areas were less likely adopt the unless they can hire extra labour. The study is in line with Madalco and Tefera (2016) and Bzung *et al.* (2012) who revealed a positive correlation between household size and agro forestry adoption in Ethiopia.

5.0 Conclusion and Recommendation

This study confirms that management and control of Prosopis is a labour intensive activity that requires higher household labour inputs, higher income disposal to hire extra labour and more active younger labour force. Similarly, larger land sizes meant higher areas under invasions hence greater labour force from households or to be hired. The study informs policy makers that to control Prosopis invasions Baringo and other counties where invasions are widespread should encourage local households and other investors to channel greater resources and technologies to enhance success. In addition, the local community groups should be encouraged to form producer groups to leverage on labour shortage, price negotiations and overall incomes opportunities to enhance their capacities on technology adoption and to control the spread *Prosopis juliflora* in the drylands in Kenya.

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