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THE STATUS OF THE TERRESTRIAL PLANT SPECIES AVAILABLE IN HAMISI SUB-COUNTY, VIHIGA COUNTY, KENYA

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Abstract:
Most of the earth's ecosystems have been dramatically transformed through anthropogenic actions. Unfortunately, some of these transformations represent a loss of diversity rather than enriching it. Habitat loss due to large-scale conversion of land to agriculture and settlement, infrastructure establishment, the introduction of invasive species and overexploitation of biological resources are among the global key drivers of terrestrial plant species diversity loss all of which have their origin in human demands placed on the terrestrial ecosystems. In Vihiga County, Hamisi sub-county, the rate of terrestrial plant diversity decline has increased in the recent past due to human actions; however, little is known about the effects of anthropogenic activities on terrestrial plant species diversity. The purpose of this study was to examine the status of the terrestrial plant species available in Hamisi Sub County of Vihiga County. The study was based on

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the ecological period between 1985 and 2015. The mixed research method design was adopted and a sample size of 201 household heads was selected from a study population of 17095. The sub-county was stratified into two divisions purposively selected for the administration of questionnaires, then the target household heads population was selected through simple random sampling. Key informants such as KWS officers, local administrators, agricultural officers, environmental officers and CBO leaders were selected through purposive sampling. Primary data was obtained through direct field observation, photography, satellite images, questionnaire administration, interview of key informants and focus group discussion. Secondary data was obtained from documented material; textbooks, journals, magazines, published and unpublished government reports and websites. Data from questionnaires were analyzed descriptively (frequencies with their percentages, means and standard deviation) using SPSS and presented in form of tables, charts and graphs and discussion essays. The other quantitative data analysis was performed using ArcGIS Desktop tools and presented as satellite images, GIS plates and photographs. Qualitative data was analyzed from emerging themes. The study findings revealed that: The terrestrial plant species had declined to a large extent while others disappeared completely. This information was expected to be used by decision-makers to ensure a high percentage of terrestrial plant species diversity is restored for human well-being.

Keywords: terrestrial plant species; earth's ecosystems; Hamisi Sub-County

1. Introduction

Globally, anthropogenic activities have been known to transform the earth's surface leading to the loss of plant species diversity (MEAB, 2005). In the absence of human influence, vegetation covered approximately half of the earth's surface (CBD, 2006). However, after thousands of years of human activities, statistics show that this plant cover extent has been reduced to approximately 30 percent (CBD, 2006) such that, in the recent past, the species decline and extinction rates are now as much as 1000 times the background rates in the earth's history (CBD, 2006; IUCN, 2006). This has become a matter of global concern and given the importance of plant species diversity to basic human well-being, there is an urgent need to come up with mechanisms that can reverse this trend. Among the global key drivers of plant species, diversity loss is an expansion of human settlement and infrastructure as well as increasing demand for food and agricultural products (FAO, 2009; IUCN, 2010).

In Africa, a recent assessment by CBD between 1990 and 2005 revealed that the largest area under plant cover converted to other land uses was in the tropics and more so, developing or low-economy countries (FAO, 2015; Rodney & Keenan, 2015). This is a clear pointer to the narrowing development options hence the increased poverty index. Thus, rich biodiversity in a country represents a capital asset (MEAB, 2005). Plant cover is a home for two-thirds of both plant and animal species (FAO, 2010; IUCN, 2010). The more the plant cover is destroyed, the more we lose other biological components.

Estimates show that Kenya lost 62,000 hectares of plant cover between the years 2000 and 2005 (FAO, 2005). This loss is attributed to illegal logging, encroachment, excision for settlement, cultivation, charcoal burning and firewood which are cited as the key drivers of plant cover loss in Kenya (Mahiri *et al*. 2001; UNEP, 2009; GoK 2010). These anthropogenic activities peg the national annual net loss at 5000 hectares (GoK, 2010). Consequently, the rising population has resulted in high demand for plant products. This situation is likely to generate land use conflicts and environmental degradation as more land is cleared to make way for human settlements and agriculture (UNEP, 2009a). This trend is likely to impact the country's economy and livelihoods negatively exposing more than 23 percent of rural communities to desertification (UNEP, 2011). However, most of these statistics in terms of acreage are more or less associated with the loss within the forested areas rather than the entire plant cover which include open land vegetation. Therefore, the information available is relatively insufficient.

The proximity of Vihiga County Hamisi Sub-county to Kakamega Tropical Rainforest creates the impression that the region is endowed with rich plant species diversity. However, while that should be the case, the situation in the region is the exact opposite and a clear picture of the impact of anthropogenic activities on the extent of plant species diversity.

Plant cover is very essential to human well-being in the provision of countless irreplaceable goods and services (CBD, 2010). For instance, plants play a major role in the regulation of both heat and water exchange within the atmosphere as well as carbon storage, hence influencing climate (UNEP 2007; FAO 2009). Plant species diversity is also linked to high food production. Thus, research shows that wild relatives of domestic crops provide genetic variability that can be crucial for overcoming outbreaks of pests and pathogens and new environmental stress (MEAB 2005, CBD 2009).

For more than 20 years the international community has demonstrated its concern about deforestation, forest degradation and the consequent loss of forest biodiversity (FAO, 2009). However, the same initiative has not been directed towards plants in the open land, an ecosystem that is equally important. Towards the end of the last decade, the Kenya Forest Service (KFS) began a project of planting 6 million trees around the country (UNEP, 2011). This could be an acknowledgement of the fact that the plant cover is very important. This urgency is also addressed by Kenya s' new constitution which seeks to achieve and maintain a tree cover of at least 10 percent of the country's total land area (GoK, 2010).

A review of related literature on the region revealed that there was no research carried out in the open land to establish the status of plant species diversity. Much of the research work mainly focused on the major forested areas. This is because forested areas are believed to possess the highest level of biodiversity hence the need for intensified conservation. The best examples are the studies of the human impact either on plant species diversity, biodiversity or such related research within Kakamega Forest (Althof, 2005; Wawire, 2007, Mutiso *et al.*, 2013).

2. Literature Review

Biodiversity is the variability among living organisms on the earth's surface including interlia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and ecosystems (MEAB 2005, CBD, 2009).

The total number of species on the earth's surface is not clear (Heywood *et al.* 2003; Keenan *et al.* 2015). However, it is estimated to be between 13 to 14 million (UNEP 1995; CBD 2006). Roughly, 1.75 million, an equivalent of 13 percent is said to have been scientifically described (UNEP, 1995). Statistics show that 50 percent of the terrestrial species are found within the tropical rainforest which forms only 7 percent of the earth s' land area (Myers, 1988). Some global wetlands are estimated to be in excess of 1,280 million hectares equivalent to 1.2 million km^2 (MEAB, 2005). While others are in woodlands, grasslands and within the soil. Sources from different institutions indicate that of the 1.75 million species named and documented, around 250,000 are plants (Corker, 2003). However, generally, the status of terrestrial plant diversity may not be accurately described because there are some habitats that are less explored, while others undergo degradation leading to the extinction of some of the species before they are documented. The IUCN (2006) s' red list entries of threatened species that include 5624 vertebrates, 2101 invertebrates and 8390 plants is an underestimation of the reality. Thus, many species in the so-called 'hot spot' areas are more complex to understand due to the rich life forms that exist in such areas. These are the most threatened parts of the world (Kuper *et al.*, 2004).

There has been a significant global increase in the extent of protected areas from about 7 percent in 1987 to 13 percent in 2006 (UNEP, 2007; CBD, 2009). The birth of CBD at Rio Janeiro Brazil 1992 Earth Summit was a major stride towards the conservation of biodiversity. Since Rio, many countries were said to have improved their understanding of the status and importance of biodiversity (Bendall, 1996).

However, despite all this effort and progress, the assessment carried out by UNEP, revealed that ecosystems of all kinds were still under pressure worldwide. Coastal and lowland areas, wetlands, native grasslands and many types of forests and woodlands had been particularly affected or destroyed (UNEP, 1995). A report from UNEP shows that in the early to mid-1980s humid tropical forests were declining at an alarming rate of nearly 25 million acres annually. Globally, the net rate of conversion of some ecosystems has begun to slow (MEAB, 2005). But this is ironic, thus, the slow rate could be because in some regions little or no habitat remains for conversion.

There is also concern that the distribution of species globally, regionally and locally is becoming more homogenous, thus the differences between the set of species at one location and another are on average diminishing. This trend is associated with high rates of extinction and new species invasion. Today, the invasion of species seems to be overshadowing species extinction. When the native species disappear either through extinction or exclusion by the invasive species, then biological options are diminished (MEAB, 2005).

Between 2000 and 2010, Africa is said to have lost an average of 3,414 hectares of forest annually, equivalent to just under 0.5 percent of its forest cover (FAO, 2010). These statistics give us the impression of the intensity of large-scale destruction of plant species diversity while on the other hand underscoring the implication of the effect of loss to specific plant species which is a measure of richness. The report also doesn't capture the loss of millions of other plant species in none forested areas such as open-land. This in itself portrays a lack of clear information on the extent of loss at a regional level. Loss of such massive hectares of forested areas also implies the loss of millions of animal species that are part of such habitats and rely exclusively on the destroyed plant species. High biodiversity in any area may imply that the interrelationship between organisms is very complex. Thus, when one organism is affected ten or even hundreds of other species may be destructed or destroyed due to high interaction changing the whole ecosystem completely (Tschakert *et al.*, 2014).

In Kenya, on average, 5000 hectares of forest cover are lost every year through direct human interference (GoK, 2010). In addition, an estimated 3000 hectares of state forest are also lost to fire annually (UNEP, 2009a). The sum total of these two scenarios over the decades culminates into huge biodiversity losses that are irreversible. The reports portray a clear image of the rate of plant species decline. However, they fail to capture many other areas that are fundamentally important in understanding the extent of plant species diversity in a locality or country. Such include, wetlands, grasslands, semi-arid areas and farmlands (open-lands). The information from such areas is scanty exposing it to high chances of species decline hence the need for a comprehensive study on open-land species diversity.

Little is known about the status and conservation of open-land plants in Hamisi Sub-county Vihiga County, Kenya. Sources from Kenya Forest Department and National Museums of Kenya show that plants like *Indigofera trit, Premna ango, Acacia laha, Albizia cori, Cordia afri* among others existed in the 1980s and 1990s (Beentje, 1994). However, currently in the region, one can rarely come across such plants. Various reports show that the pieces of land that were initially rich in such plant species are currently occupied by maize and tea plantations (MDP 2013; Hamisi Sub-county Agriculture Office Report 2015). This may imply that this plant species has either declined immensely in its population or worse off become extinct. If no effort is done to reverse this trend, then the region is likely to have very minimal biotic options putting human well-being at risk.

In essence, plants play a major role in climate change mitigation, however, their capacity to adapt to pressure has been diminished by the loss of biodiversity (UNEP, 2011). For instance, plants contribute to precipitation through transpiration. The pattern of rainfall will have to change drastically with the change in plant cover. The change may also accelerate increased Carbon (IV) oxide in the atmosphere (UNEP 2007; FAO 2009).

This is because the percentage of plant cover that plays the role of the sink of carbon in the atmosphere will have been reduced. Plant species diversity is also linked to high food production. Thus, research show that, wild relatives of domestic crops provide genetic variability that can be crucial for overcoming outbreaks of pest and pathogens and new environmental stress (MEAB 2005, CBD 2009). Many agricultural communities consider increased local diversity a critical factor for the long-term productivity and viability of their agricultural systems (MEAB, 2005). In addition, plants also provide nutrient cycling, soil formation, and oxygen production besides being a genetic stock. If the status of plant cover is drastically degraded without proper conservation measures like in the case of Hamisi Sub-County, then all these countless benefits are completely lost.

Several studies have been carried out both internationally and locally on the status of plant species diversity due to human actions. For instance, there was a study carried out in the Mediterranean region of Turkey on plant diversity, land use and degradation (Ozturk, 2002). The study explored how the rich plant species diversity has been affected by anthropomorphic pressure. A similar study was also carried out by Morris (2010) which was about the anthropogenic impacts on tropical forest diversity. The study looked at biodiversity as a whole and how it is affected by human actions. Both of these studies give a detailed account of how human actions affect plant cover with a major focus on primary forests. However, these studies tend to be limited in their scope on assessment of plant species diversity status with regard to their conservation. Ozturk focuses on general land use while Morris looks at the primary forest; both fail to address the actual status of open-land plants.

In Africa, Hawthorne *et al.* (2011) carried out a study on The Impact of Logging Damage on Tropical Rainforest, their Recovery and Regeneration. This was a project carried out to improve people s’ knowledge of the negative impact of logging. It also looked at forest regeneration after logging. Its area of study was mainly in Ghana. The other similar study was on canopy development (Lowman *et al.*, 1993). It focused on the development of forest canopy in undisturbed tropical rainforests. The study explored, different stages of canopy development to understand interconnection and plant networking. Both studies were mainly interested in forested areas completely overlooking open-land plants.

In Kenya, Mutiso, *et al.* (2015) carried out a study on the Mau Forest where the focus was to evaluate the floristic composition affinities and plant formation. In their study, they were able to acknowledge that the wide range of disturbances was majorly anthropogenic in nature. While the findings of their study may aid in furnishing this study with information on aspects of anthropogenic influence on some specific tree species, their scope of study equally excludes open-land plants raising more concern. In western Kenya Busia County, Mutavi (2012) carried out a comprehensive study on the effects of anthropogenic activities on terrestrial biodiversity conservation in Matayos Division. She explored biodiversity as a whole including open-land plants. However, the depth of study is broad and does not exclusively focus on open-land plants hence failing to capture some important aspects like species richness. There was no any clear record of any study of the open-land plant species diversity loss and any conservation effort in Hamisi Sub-county. This study sought to establish the status of plant species diversity with a view to safeguarding them against anthropogenic effects.

3. Research Methodology

A mixed method design was used in this study. The mixed research method focuses on collecting and analyzing both quantitative and qualitative data in a single study to provide a better understanding of the research problem (Creswell & Plano, 2011). This method was suitable for this study because the nature of data required was both quantitative and qualitative. The quantitative helped to calculate species composition, distribution and richness at the time of study while the qualitative helped to capture the chronological descriptions of events and accounts that are likely to have contributed to plant species diversity loss.

The target population was 32,096 households (HH) from four divisions, namely; Tambua, Shamakhokho Shaviringa and Jepkoyai. The study also targeted four environmental related Community Based Organizations (C.B.O), two sub-county agriculture officers, two sub-county environmental officers, two KWS sub-county officers as well as four Assistant County Commissioners (ACC) of the four divisions.

There are many approaches to determinizing the sample size. However, Yamane (1967) presents a more simplified formula that this study adopted. It was ideal because it deals with a finite target population size like the case of this study. It also creates a clear relationship between precision (error), accuracy and sample size which are crucial to any research work. Therefore, the following formula was applied.

$$n = N/1 + N (e)^2$$

Where:
n is the sample size,
N is the population size, and
e is the level of precision.

Two divisions; Shaviringa and Jepkoyai were purposively sampled because they seemed to have the highest level of anthropogenic activities. Thus, from a total of 32,096 households, 17,095 total households were selected. The breakdown for the two divisions is shown below.

Table 1: Number of Household per Division

Division	Shaviringa	Jepkoyai	Total
Number of Households	8,182	8,913	17,095

Source: KNSB (2010).

Thus, the total number of households being 17,095 with a confidence level of 93% while the precision level purposively assumed to be 7% then n will be:

$$n = \frac{17095}{1 + 17095\,(.07)^2}$$

$$n = \frac{17095}{1 + 83.7655}$$

$$n = \frac{17095}{84.7655}$$

n = 201 households.

Therefore, from 201 households 201 household heads were sampled using simple random sampling technique which were further proportionally divided between the two divisions as follows.

$$\text{Sample size per a division} = \frac{\text{Total number of household heads per division}}{\text{Sum total number of households}} \times \text{Sample Size}$$

Shaviringa Division sample size: 8182/17095 X 201= 96 Household Heads
Jepkoyai Division Sample Size: 8913/17095 X 201 = 105 Household Heads

Apart from the household heads, the following were purposively sampled out as key informants: two heads of CBOs one per division, one sub-county head of KWS, one sub-county agricultural officer and one sub-county environmental department officer as well as the two Assistant County Commissioners (ACC) of each of the two divisions.

Data for analysis in this study was yielded from questionnaires, Focus Group Discussion, Key-informant interview schedule, Observation guide, Photographs, satellite images and GIS plates, text books, journals, magazines, government report and websites.

3.1 Pilot Testing

This study adopted Isaac & Michael's (1995) piloting study sample of 10% of the sample size. The sample size of this study was 201 household heads, therefore 10% of 201 were:

10/100 X 201 = 20

The pilot sample was 20 respondents, that is, 10 household heads respondents per division were conveniently sampled within the area of study. The convenience sampling technique was suitable because it provided room to take advantage of those respondents who happened to be available at the moment of study hence avoiding unnecessary delays. The responses were keenly scrutinized and the questions were re-adjusted accordingly depending on the outcome to suit the four objectives of the study.

3.2 Validity of Research Instruments

Validity is the confidence with which conclusions can be drawn from an analysis (Kirk & Miller, 1986). Kothari (2004) consequently suggests the use of content analysis. In this case he suggests the use of a panel of persons who judge how well the measuring instruments meet the standards. In this study, the researcher designed the instruments and then gave them to other researchers including his supervisors and other specialists. They in turn criticized them and made necessary corrections. This was also enriched by the outcome of the pilot test.

3.3 Reliability of the Research Instrument

Reliability is conceptualized as the consistency with which a research procedure evaluates phenomena in the same way over several attempts (Hayashi et al., 2019: Kirk & Miller, 1986). In order to ascertain if the instruments were reliable in this study, the consistency and frequency rates were determined through pre-testing. In this study, the instruments were made precise, clear and self-administered to avoid variation from one person to another. Lastly, the instruments used during key informant interviews were used to measure the reliability of the responses obtained through the administering of questionnaires.

3.4 Data Analysis

The filled questionnaires, other interview data, observation photographs and field notes were carefully checked, selected and arranged systematically. Then, the questionnaires were coded for easy handling. Patterns and themes were created to assist in analyzing descriptive data while quantitative data was analyzed using averages and percentages. SSPS was used for quick analysis. Verification and digitization of maps were done. Using ArcGIS tools, maps, polygon and point shape files were linked to create a geodatabase that generated GIS plates which were compared with questionnaire responses, and satellite images alongside current field observations hence informing the conclusions.

3.5 Presentation

The findings were presented in form of discussion, essays, graphs, charts, tables, photographs, satellite imageries and GIS plates.

4. Results and Discussion

This section presents the findings of the research. This study sought to establish the status of the terrestrial plant species available in Hamisi Sub-county.

4.1 Status of the Terrestrial Plant Species Diversity

The respondents were therefore asked to respond to a questionnaire which sought information on the same. Their responses were measured on a five-point Likert scale where 1 represented none, 2 represented small extent, 3 represented averagely, 4 represented large extent and 5 represented a very large extent. The study findings were presented in table form using frequencies and percentages as well as means. Table 2-6 shows the study findings.

Table 2: Respondents' perception of the existence of terrestrial plant species

Statement	None	Small extent	Averagely	Large extent	Very large extent	Mean	Std. dev.
Existence of the indigenous plants?	3(1.9)	124(78.5)	16(10.1)	14(8.9)	1(0.6)	2.278	.676
Mixed strand	5(3.2)	124(78.5)	19(12.0)	8(5.1)	2(1.3)	2.227	.647
Pure strand	15(9.5)	115(72.8)	20(12.7)	5(3.2)	3(1.9)	2.151	.706

Source: Field data (2019).

The study findings in Table 2 revealed that in Hamisi Sub-County, indigenous plants were in existence to a small extent. This was indicated by most of the respondents 124(78.5%) who agreed that the population of the indigenous plants was to a small extent (M=2.278, SD=.676). Furthermore, the majority of the respondents, about three-quarters 90.5% (n=143) agreed that to a small extent, the indigenous plants exist in mixed strands. Having a mean of 2.151, it was evident from the study findings that the indigenous plants existed in pure strands to a small extent. The responses from this and the previous about the existence of indigenous plants in mixed strands support the fact that indigenous plants in Hamisi Sub County were on the decline; in other words, their population was just but to a small extent. These findings resonate with the previous assessment by UNEP (1995) that revealed extensive destruction of ecosystems. In essence, the existence of indigenous plants to a small extent in mixed strands implied a complete loss of species richness and ultimately biodiversity.

From the FGD, this was observed:

> "*There used to be indigenous trees in this region, but right now, many of them are disappearing*." Focus group discussion member (17th October 2019).

Table 3: Respondents' perception of trends in the population of terrestrial plant species

Statement	None	Small extent	Averagely	Large extent	Very large extent	Mean	Std. dev.
Been reducing	3(1.9)	12(7.6)	27(17.1)	90(57.0)	26(16.5)	3.784	.876
Existed but have disappeared	5(3.2)	12(7.6)	23(14.6)	95(60.1)	23(14.6)	3.753	.907

Source: Field data (2019).

As is revealed in Table 3, the majority of the respondents 90(57.0%) with a mean of 3.784 reported that the indigenous plant species had been reducing to a large extent. In addition to that, 95(60.1%) respondents with a mean of 3.753 agreed that there were indigenous plants that existed but had disappeared. However, there were few who said that the disappearance of some indigenous plants was on average and small extent and some said none of them had disappeared. The findings were in agreement with the sources from Kenya Forest Department and Museum as stated by Beentje (1994). These sources revealed that some plants that existed in the 1980s and 1990s had completely disappeared. It was also consistent with the Hamisi Sub-county Agriculture Office Report (2015) which confirmed that pieces of land that were initially rich in such plants were currently occupied by maize and tea. This implied that indigenous plants had been excluded completely.

One Shaviringa Division CBO leader had the following to say:

> *"There are plant species that existed but as at now, they have become extinct. Some are reducing with time. There are some plants that existed in pure strands like Murembe (Erythrinaabys), Munyama (Trichilia emet), Munyenya (Acacia laha), Muperi (Albizia Cori) among others which now they are either extinct in some places and where they are, they are very few in number. Other plant species like Amuuta (Pavetta tern), Ikhomo (Chaetacmearis), Mutoto (Ficusnata) are completely extinct in the sub county. The most common plant species in the region are: Indulandula (Solanuminca), Lusiola (Markhamia lute), Musutsu (Croton macr), Lipera (Gardenia tome), Olunani (Caesalpiniadeca), shiloka (Shiloka) and Mnamsai (Madagascaharungana)."* CBO leader (18th October 2019)

Table 4: Respondents' perception of selected anthropogenic factors as cases of indigenous mass loss

Statement	None	Small extent	Averagely	Large extent	Very large extent	Mean	Std. dev.
Farming affects indigenous plant loss	2(1.3)	8(5.1)	22(13.9)	97(61.4)	29(18.4)	3.905	.796
Human settlement indigenous plant loss	1(0.6)	7(4.4)	30(19.0)	99(62.7)	21(13.3)	3.835	.730
Farms near forests and thickets have more indigenous plants than those far	3(1.9)	12(7.6)	31(19.6)	60(38.0)	52(32.9)	3.924	1.00

Source: Field data (2019).

With regards to farming affecting indigenous plant species loss, it was sighted by most respondents 126(79.8%) that the loss of indigenous plants was associated with farming and with M=3.835 and SD=.730, it was evident that human settlement contributed to the loss of the natural plant species. In support of the fact that human activities were associated with indigenous plant loss, it was shown from the study findings that farms near the forests and thickets had more indigenous plants compared to those that were far. In relation to this, 60(38.0%) respondents said that to a large extent, this was the case (M=3.924, SD=1.00). This implied that near the forests and thickets, there was a limited human settlement and therefore not much interference with the indigenous plant species whereas the places that were far away had much human settlement and hence immense anthropogenic activities like farming which accelerated the decline in the population of indigenous plant species. The above findings were also used to ascertain that open lands that were now under active cultivation were once rich in the native plants that still existed in the neighbouring forests and thickets. This was founded on the premise that they are under the same ecological niche.

The findings concurred with MDP (2013) that estimated the land under farming in Hamisi Sub-county to be roughly 98% being an indicator of extensive farming hence the high rate of indigenous plant species decline. MFW (2013) survey also affirmed this by providing statistics of a countrywide increase in the acreage of some crops definitely implying a high rate of native plant species decline and loss countrywide. However, the findings disagree with the report of MEAB (2005) which pointed out that the net rate of ecosystem conversion had started to slow down globally.

From the ministry of Agriculture:

"Indigenous plant species in this sub-county have been cleared and replaced by exotic plants due to increasing population and therefore demand for land use; need for farming, settlement and infrastructural development." Head of Ministry of Agriculture (22nd October 2019)

Table 5: Respondents' perception of the benefits of terrestrial plant species

Statement	None	Small extent	Averagely	Large extent	Very large extent	Mean	Std. dev.
Indigenous plants have benefits		4(2.5)	9(5.7)	103(65.2)	42(26.6)	4.158	.633
There are negative effects when indigenous plants reduce	2(1.3)	5(3.2)	15(9.5)	101(63.9)	35(22.2)	4.025	.748

Source: Field data (2019).

The study findings from Table 5 showed that the indigenous plant species have benefits to man; 103(65.2%) and 42(26.6%) respondents agreed that indigenous plants to a large and very large extent had benefits (M=4.158, SD=.633). Therefore, most of the respondents; 101(63.9%) and 35(22.2%) said that to a large extent and to a very large extent, there was danger when the indigenous plants reduced (M=4.025, SD=.748). This concurred with the previous assessment reports of CBD (2009) and MEAB (2005) that underscored the immeasurable value of indigenous plants in relation to the productivity and viability of agricultural systems among others.

Likewise, the FGD in Jepkoyai Division results concurred with the quantitative findings;

"The people of this region get a lot of benefits from the indigenous plants; herbs, firewood, timber for construction among others." FGD findings (17th October 2019)

In general, from the study findings, it was clear that the indigenous plant species in Hamisi Sub County had reduced whereby the extent to which they were declining was large, their existence in pure and mixed strands was to a small extent and there were those plants that existed but had disappeared therefore leading to a generally small population of the indigenous plant species. This decline in the population of the indigenous plant species was attributed to human activities such as farming and human settlement. This shows that there is increased demand for land use by humans due to increased population which forces the clearance of ecosystems and in the process, indigenous plants are also cleared in the long run leading to their loss.

From the direct field observation, the following data was gathered which correlates exactly with the information gathered from questionnaires and interview schedules.

Table 6 was used to identify and calculate the actual plant species diversity of purposively selected regions in Hamisi Sub-county. It helped to ascertain the actual current state of species diversity for generalization purposes.

Table 6: Plant species diversity by Shaviringa Division

No.	Species Name		Number of individuals (n)	n(n-1)
	Luhya	English / Botanical		
1	Amuuta	Pavetta tern	0	0
2	Apacha	WarburgiaUgan	5	20
3	Bukarambi	Flacourtiaindi	0	0
4	Embano	Dracaena frag	0	0
5	Enguu	Microglossapyri	2	2
6	Eshimwani	Garciniabuch	0	0
7	Ikhomo	Chaetacmearis	0	0
8	Ikoyi	Artabotrysliki	0	0
9	Indulandula	Solanuminca	16	240
10	Isambakhulu	Boehmeriamacr	3	6
11	Itikwa	Rutideaorie	2	2
12	Kegoyogoyo	Indigofera trit	2	2
13	Kisagula	Premna ango	0	0
14	Kisasari	Flueggaciaviro	3	6
15	Kumototo	Ficusnata	0	0
16	Kumuchanjasi	Eucleadiri	0	0
17	Kumufungu	Kigelia afri	0	0
18	Kumufwora	Annonasene	3	6
19	Kumugumu	Lanneaschi	0	0
20	Kumuimbi	Hymenodyctionflor	2	2
21	Kumukhomeli	Garciniabuch	0	0
22	Kumukhondo	Acacia macr	0	0
23	Kumukhuyu	Ficus Sur	0	0
24	Kumukomosi	Vangueriaapic	2	2
25	Kumulinda	Parinaricura	0	0
26	Kumulondang'ombe	Brideliamicr	2	2
27	Kumunyenya	Acacia laha	2	2

28	Kumuperi	Albizia Cori	2	2
29	Kumurembe	Erythrinaabys	2	2
30	Kumusemwa	Syzygiumguin	2	2
31	Kumusilamosi	Senna sing	0	0
32	Lihori	Critalarialach	2	2
33	Likhomolo	Chaetacmearis	0	0
34	Lirakalu	Acanthus pube	13	156
35	Lisala	Clerodendrum john	0	0
36	Lisebesebe	Maesaian	0	0
37	Lukhuba	Dracaena frag	0	0
38	Luseno	Ficusespe	0	0
39	Lusiola	Markhamia lute	20	380
40	Luvinu	Sennadidy	3	6
41	Lweyi	Indioferahomb	0	0
42	Mukavaka	Ficusverr	0	0
43	Mukhonzuli	Albizia gram	3	6
44	Mukoloho	Cassipourearuwe	0	0
45	Mukuhakuha	Macarangakili	0	0
46	Mukumari	Cordia afri	2	2
47	Mukumasia	Uvariopsis	0	0
48	Mukuyu	Ficussur	0	0
49	Mulundu	Antiaristoxi	6	30
50	Munyama	Trichiliaemet	0	0
51	Musutsu	Croton macr	22	462
52	Mutere	Maesopsisemin	0	0
53	Olunani	Caesalpiniadeca	0	0
54	Omushirinya	Pseudospondiasmicr	0	0
55	Mudondo	Mussaendaarcu	0	0
56	Muhutu	Vilexfisc	0	0
57	Lipera	Gardenia tome	55	2970
58	Musine	Croton mega	37	1332
59	Kitate	Tecleanobilis	9	72
60	Musengeli	Albizia gummifera	3	6
61	Shikuma	clerodendrum	2	2
62	Shiloka	Plecanthrusbabatus	2	2
63	Livona	Castor oil	3	6
	Total		232	5732
			N = 232	∑n(n-1) = 5732

Source: Field observation data (2019).

$$D = 1 - \frac{\sum n\,(n-1)}{N\,(N-1)}$$

$$D = 1 - \frac{(5732)}{(53592)}$$

D = 1 –0.1069562621 = 0.893043737

D = 0.9

The plant species diversity index is 0.9. Therefore 0.9 is close to 1 hence the region has a high species diversity but low species richness and evenness.

Table 7: Plant species diversity in Jepkoyai Division

No.	Species Name		Number of individuals (n)	n(n-1)
	Luhya	English / Botanical		
1	Amuuta	Pavetta tern	0	0
2	Apacha	WarburgiaUgan	0	0
3	Bukarambi	Flacourtiaindi	0	0
4	Embano	Dracaena frag	0	0
5	Enguu	Microglossapyri	0	0
6	Eshimwani	Garciniabuch	0	0
7	Ikhomo	Chaetacmearis	0	0
8	Ikoyi	Artabotrysliki	0	0
9	Indulandula	Solanuminca	10	90
10	Isambakhulu	Boehmeriamacr	0	0
11	Itikwa	Rutideaorie	0	0
12	Kegoyogoyo	Indigofera trit	0	0
13	Kisagula	Premna ango	0	0
14	Kisasari	Flueggaciaviro	0	0
15	Kumototo	Ficusnata	3	6
16	Kumuchanjasi	Eucleadiri	0	0
17	Kumufungu	Kigelia afri	0	0
18	Kumufwora	Annonasene	0	0
19	Kmugumu	Lanneaschi	0	0
20	Kumuimbi	Hymenodyctionflor	0	0
21	Kumukhomeli	Garciniabuch	0	0
22	Kumukhondo	Acacia macr	0	0
23	Kumukhuyu	Ficus Sur	0	0
24	Kumukomosi	Vangueriaapic	0	0
25	Kumulinda	Parinaricura	0	0
26	Kumulondang'ombe	Brideliamicr	0	0
27	Kumunyenya	Acacia laha	3	6
28	Kumuperi	Albizia Cori	2	2
29	Kumurembe	Erythrinaabys	2	2
30	Kumusemwa	Syzygiumguin	3	6
31	Kumusilamosi	Senna sing	0	0
32	Lihori	Critalarialach	0	0
33	Likhomolo	Chaetacmearis	0	0
34	Lirakalu	Acanthus pube	9	72
35	Lisala	Clerodendrum john	0	0
36	Lisebesebe	Maesaian	0	0
37	Lukhuba	Dracaena frag	0	0
38	Luseno	Ficusespe	0	0
39	Lusiola	Markhamia lute	30	870
40	Luvinu	Sennadidy	3	6

41	Lweyi	Indioferahomb	0	0
42	Mukavaka	Ficusverr	3	6
43	Mukhonzuli	Albizia gram	2	2
44	Mukoloho	Cassipourearuwe	0	0
45	Mukuhakuha	Macarangakili	0	0
46	Mukumari	Cordia afri	0	0
47	Mukumasia	Uvariopsis	0	0
48	Mukuyu	Ficussur	0	0
49	Mulundu	Antiaristoxi	0	0
50	Munyama	Trichiliaemet	2	2
51	Musutsu	Croton macr	10	90
52	Mutere	Maesopsisemin	0	0
53	Olunani	Caesalpiniadeca	20	380
54	Omushirinya	Pseudospondiasmicr	0	0
55	Mudondo	Mussaendaarcu	2	2
56	Muhutu	Vilexfisc	0	0
57	Lipera	Gardenia tome	16	240
58	Musine	Croton mega	0	0
59	Kitate	Tecleanobilis	4	12
60	Musengeli	Albizia gummifera	3	6
61	Shikuma	Shikuma	0	0
62	Shiloka	Plecanthrusbabatus	20	380
63	Livona	Castro oil	5	20
64	Mnamsai	Madagascaharungana	50	2450
	Total		199	4644
			N = 199	∑n(n-1) = 4644

Source: Field observation data (2019).

$$D = 1 - \frac{\sum n\,(n-1)}{N\,(N-1)}$$

$$D = 1 - \frac{(4644)}{(39402)}$$

D = 1 – 0.1178620374 = 0.8821379626

D = 0.9

The plant species diversity index is 0.9. Therefore 0.9 is close to 1 hence the region has a high species diversity but low species richness and evenness.

Species richness is the measure of individual species abundance per specific area. While evenness is the measure of the distribution of individual species expected to form a plant cover. Therefore, from the two sets of field data above, that is, Table 6 and Table 7 the frequency (n) of most individual species is low depicting low richness and evenness hence a high rate of decline. Low richness implied that existing species were very few in their numbers within specified areas contrary to how it was before the increase in farming, human settlement and infrastructure development as noted by questionnaire responses, FGD and key informants. These species also had the tendency of existing in pure strands characteristic of low diversity as opposed to existing in mixed strands which is an indicator of high diversity. Consequently, low species evenness implied that the plant cover had reduced to a great extent. The existing species were irregular in the formation of plant cover leaving some places bare. These bare places are the ones that had the greatest effect on anthropogenic activities, that is, farming, human settlement and infrastructure development as observed during the study.

From these two sets of field observation data, it was evident that most of the indigenous plant species were extinct in both Shaviringa and Jepkoyai Divisions. This information was in agreement with the findings of the interviews. In both cases the extinct plant species were like; Amuuta (Pavetta tern), Bukarambi (Flacourtiaindi), Embano (Dracaena frag), Eshimwani (Garciniabuch), Kumukhondo (Acacia macr), Kumukhuyu (Ficus Sur), Mukumasia (Uvariopsis). From the questionnaires and interview schedules the respondents confirmed that these species existed in the region in the 1980s but today one can rarely come across them. On the other hand, plant species like Mudondo (Mussaendaarcu), Mukavaka (Ficusverr), mukhonzuli (Albizia gram), Kumuimbi (Hymenodyctionflor) among others existed only to a small extent. Whereas few plant species namely: Indulandula (Solanuminca), Lusiola (Markhamia lute), Musutsu (Croton macr), Lipera (Guava), Olunani (Caesalpiniadeca), shiloka (Plecanthrusbabatus) and Mnamsai (Madagascaharungana) are the only ones that existed to a large extend. These findings were still in line with Beentje (1994) who gave an account of the extinction of plants like *Indigofera trit* and *Acacia laha* among others. According to him, these plants existed in the 1980s and 1990s; the very sentiments that were echoed by household respondents, members of focus groups and key informants. Some of their sentiments are captured below:

> "*The most common plant species are: Indulandula (Solanuminca), Lusiola (Markhamia lute), Musutsu (Croton macr), Lipera (Gardenia tome), Olunani (Caesalpiniadeca), shiloka (Shiloka) and Mnamsai (Madagascaharungana). But others like Amuuta (Pavetta tern), Ikhomo (Chaetacmearis), Mutoto (Ficusnata) are completely extinct in the sub county.*" CBO leader (18th October 2019).

> "*Murembe (Erythrinaabys), Munyama (Trichilia emet), Munyenya (Acacia laha), Muperi (Albizia Cori) are among the plants that existed in pure strands of which today one can rarely come across them.*" Head of KWS (24th October 2019)

From photography, this was captured:

Figure 1: Erythrinaabys plant species

Source: Researcher s' photography, 2019.

Figure 2: Trichilia emet plant species

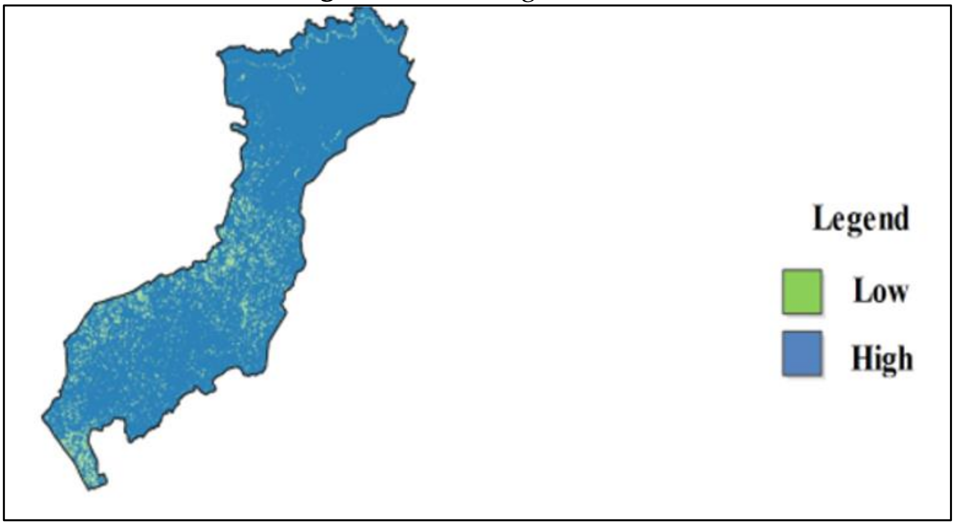
Source: Researcher's photography, 2019.

The photo in Figures 1 and 2 displayed some of the indigenous plant species that are now rare in Sub County. The plant species in figure 1 is called Mutembe locally and the scientific name is Erythrinaabys (with red flowers); the plant species in figure 2 is called Munyama locally and the scientific name is Trichilia emet.

4.2 GIS plates

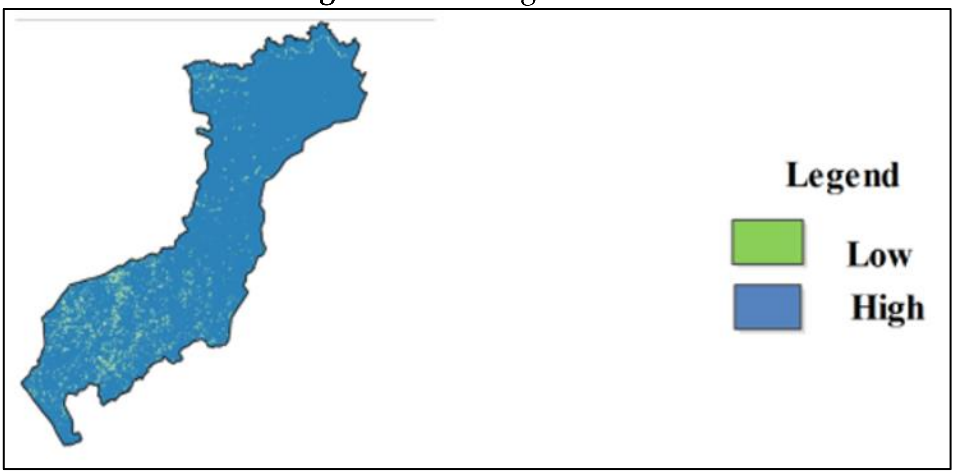
ArcGIS tools for desktop were also employed to help visualize the status of indigenous plant cover within the sub-county. Figures 3, 4, 5 and 6 showed the changes in the indigenous plant species for purposively selected years and months from 1984-2020. The years and months were January 1984, January 1995, December 2003 and December 2015. This was informed by the fact that the season of the year would determine the status of plant cover due to activities like farming. Therefore, January and December being relatively dry months would minimize the number of perennial crops occupying the land.

Figure 3: GIS image for 1984



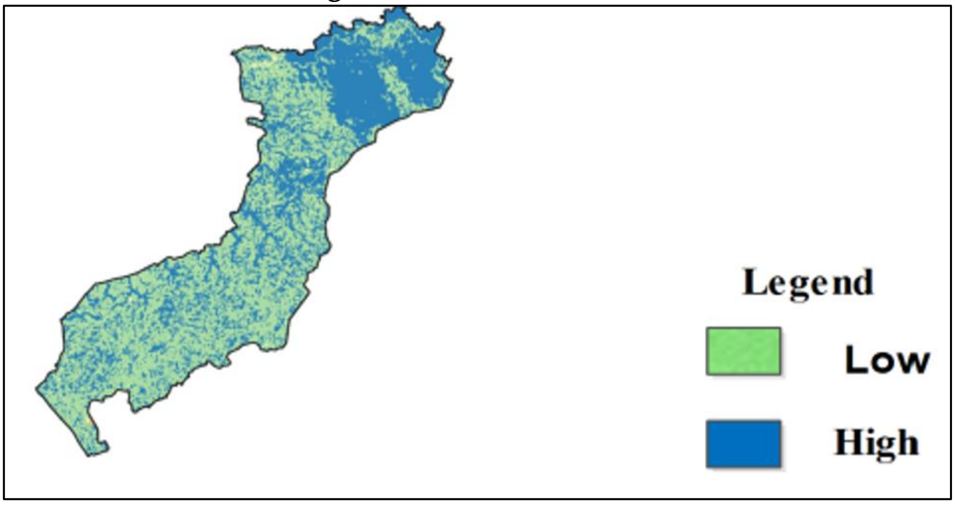
Source: Researcher s' ArcGIS Desktop tools.

Figure 4: GIS image for 1994



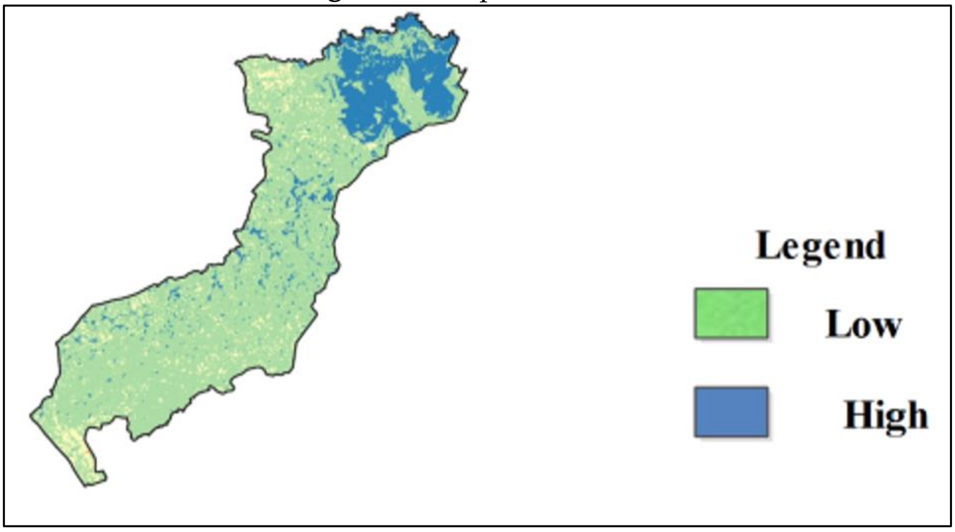
Source: Researcher s' ArcGIS Desktop tools.

Figure 5: GIS Plate for 2004



Source: Researcher s' ArcGIS Desktop tools.

Figure 6: GIS plate for 2015



Source: Researcher s' ArcGIS Desktop tools.

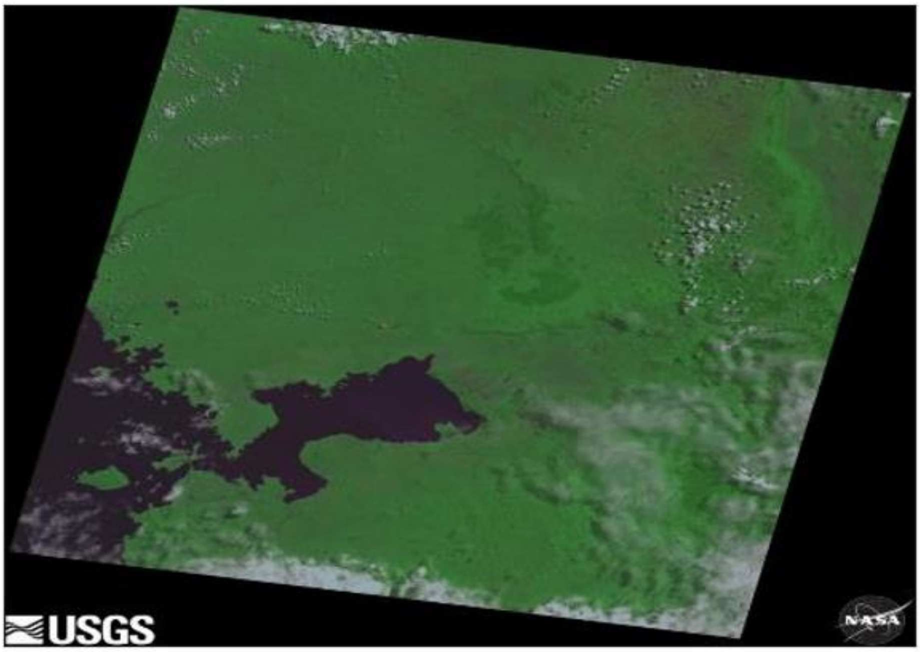
From the GIS plates, the study findings revealed that there was plant species diversity loss from 1984-2015. Figure 3 indicates a rich plant species cover especially within Jepkoyai and Shaviringa divisions. Figure 4 indicates minimum change, while Figures 5 and 6 show moderate and sharp decline respectively. According to the researcher, Figures 3 and 4 show the plant cover status during a time when there was no dense human population. This means the demand for land was still low; farming, settlement and infrastructural development were not extensive. Therefore, the plant cover was still rich consisting of the indigenous species in line with FGD' views and questionnaire responses. However, as shown in Figures 5 and 6 there was increased demand for land use like farming, settlement and infrastructure development to cater for the increasing population leading to both moderate and sharp decline in species diversity. The researcher further observed that the moderate species decline as per Figure

4.6 could be attributed to planted species rather than indigenous hence low species diversity as it was directly observed during the study.

4.3 Satellite images

Apart from GIS plates, satellite images were also captured to help visualize real-time change within the sub-county. Figures 7, 8, 9 and 10 show the changes in the plant cover from 1975-2015.

Figure 7: Satellite image for April 1985



Source: USGS Earth Explorer (2020).

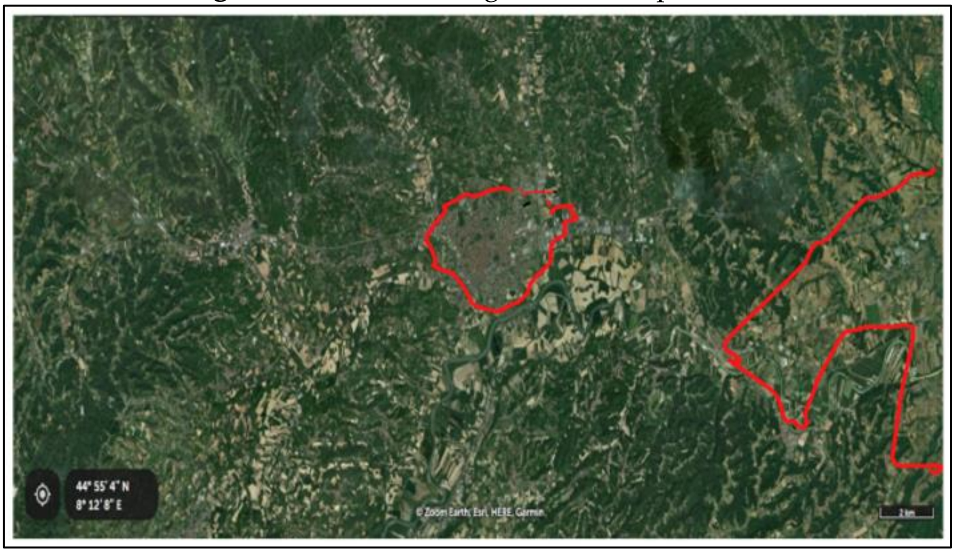
Figure 8: Satellite image for December 2000

Source: Zoom Earth Explorer (2019).

Figure 9: Satellite image taken in December 2010

Source: Zoom Earth Explorer (2019).

Figure 10: Satellite image taken in April 2015



Source: Zoom Earth Explorer (2019)

From the satellite images, the study findings revealed that there were changes in the plant cover density from 1975-2015. Figure 7 revealed that there was dense plant cover on the land in Hamisi Sub County as portrayed by the deep green shade, Figure 8 showed a decline in the plant cover between 1999 and 2004 as indicated by reduced green and increased brown shade demarcated with red, Figure 9 showed a slight increase in the plant cover while in Figure 4.10, there was a big improvement in the plant cover within the region.

According to the researcher, Figure 7 showed the plant cover status during a time when the human population was still small and there was not much demand for land use like farming, settlement and infrastructural development. Therefore, the clearing of plants was minimal and the plant cover was still extensive consisting of the indigenous species. However, as shown in Figure 8, the human population was increasing and there was increased demand for land use like farming, settlement and developing infrastructure to cater for that population. Therefore, clearance of lands that had the indigenous plant species took place in order to create space for farming, settlement and infrastructural development, hence the reduced plant cover as evident from Figure 8 especially in areas demarcated red. Figure 9 portrayed an increase in the plant cover which evidently from the direct observation during the study is made up of main crops grown in the region such as tea plantations, maize, Napier grass as well as exotic trees among them eucalyptus, cypress, Gruveria that were planted rather than self-sown. This is because the indigenous species had been cleared to create space for settlement, farming and infrastructural development.

To support this, the following photographs show how the land is densely covered by plants but which are exotic like eucalyptus, cypress and the cash crops like tea and maize with just a small population of the indigenous species as revealed in Figure 12 of *Trichilia emet* besides a maize plantation and Figure 11 of tea amidst eucalyptus and cypress trees.

Figure 11: Tea plantation with eucalyptus and cypress trees

Source: Researcher s' photography, 2019

Figure 12: Maize plantation with Trichila emet beside the farm

Source: Researcher s' photography 2019.

The study findings also revealed that by 2015, as shown in Figure 10, the plant cover in Hamisi Sub County had increased even more than it was in 2010. In the same way, the researcher attributed this to the exotic plants as well as cash crops like tea and maize which are the main crops grown in the region. This is supported by what transpired from the data in the questionnaires in Table 7 where respondents said that indigenous species had become extinct due to anthropogenic activities like farming.

These study findings were in line with the report of GOK (2010) where it was discovered that on average, 5000 hectares of forest cover were lost every year through direct human interference. Similarly, in a study by Mutiso, et al. (2015) on the Mau Forest where the focus was to evaluate the floristic composition affinities and plant formation, they acknowledged that the wide range of disturbances was majorly anthropogenic in nature. And to the sources from Kenya Forest Department and National Museums of Kenya, plants like *Indigofera trit, Premna ango, Acacia laha, Albizia cori, Cordia afri* among others existed in the 1980s and 1990s (Beentje, 1994). But as of now, one can rarely come across such plants. According to MDP (2013) and to the report by Hamisi Sub-county Agriculture Office (2015), the pieces of land that were initially rich in such plant species are currently occupied by maize and tea plantations; an implication that these plant species have either declined immensely in their population or worse off become extinct.

5. Conclusions

The terrestrial plant species available in Hamisi Sub-county had either declined to a large extent or had become extinct whereby most of them had been replaced with exotic species like cypress and eucalyptus and crops like maize and tea.

5.1 Recommendations

In order to reverse the trend of terrestrial plant species decline and subsequent extinction as per the findings of the first objective. The researcher recommended a species upgrade approach. This is where most of the species that had adversely reduced or become extinct will be upgraded from self-sown species to cultivated species and be re-introduced in their respective regions instead of propagating exotic plants which may be invasive in nature. This will require studying individual species' ecological needs to improve tendering skills of native people. Consequently, there will be a need to expose the native people to more knowledge on both exploitation and the general importance of indigenous plants. This will attach great value to specific plant species and act as a motivating factor for the natives to nurture them hence increasing terrestrial plants species diversity

Likewise, more indigenous plants woodlots and patches are to be established on farmlands. The woodlots and patches are to comprise specific species that will be carefully selected and their economic value established. Such will create a reservoir for many terrestrial plant species that are on the decline while others becoming extinct.

Conflict of Interest Statement

The authors declare no conflicts of interest.

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References

Althof, J. A. (2005). *Human Impact on Flora and Vegetation of Kakamega Forest, Kenya; Structure, Distribution and Disturbances of Plant Communities in an East African Rainforest.* Bochum: Arnchild Johanna Althof.

Bendall, R. (1996). *Biodiversity; The Follow-up to Rio.* Washington DC: Cambridge University Press.

Convention on Biological Diversity. (2006). *Global Biodiversity Outlook 2 Assessment Report.* Montreal: The Secretariat of the Convention on Biological Diversity.

Convention on Biological Diversity. (2006b). *Biodiversity in Development; Biodiversity Brief 8.* Montreal: The Secretariat of the Convention on Biological Diversity.

Convention on Biological Diversity. (2009). *Biodiversity, Development and Poverty Alleviation; Recognizing the Role of Biodiversity for Human Well-being.* Montreal: The Secretariat of the Convention on Biological Diversity.

Convention on Biological Diversity. (2010). *Biodiversity and Sustainable Development.* Montreal Quebec: Secretariat of the Convention on Biological Diversity.

Convention on Biological Diversity. (2010). *Biodiversity is Our Life; Gicana 7 Report.* Montreal: The Secretariat of the Convention on Biological Diversity.

Creswell, J. W., and Plano Clark, V. L. (2011). *Designing and Conducting Mixed Methods Research* (2ndEd.,). Thousand Oaks, CA: Sage

Food and Agricultural Organization of the United Nations. (2009). *Forest and the Global Economy.* United Nations; Rome: FAO.

Food and Agricultural Organization of the United Nations. (2010). *Global Forest Resources Assessment 2010; FAO Forestry Pp. 163.* Rome Italy: FAO.

Food and Agricultural Organization of the United Nations. (2015). *Global Forest Assessment 2015. How are the Worlds' Forest Changing? 1990-2015; Twenty-five years in review.* Rome: FAO UN Press.

Food and Agricultural Organization of the United Nations. (2005). *Global Forest Resources Assessment Update 2OO5, Terms and Definitions; Working Pp.83.* Rome, Italy: FAO

Government of Kenya. (2010). *National Environment Action Plan (NEAP) 2009-2013; Ministry of Environment and Mineral Resources.* Nairobi: Government Printers.

Hamisi Sub-county Agriculture Office Report. (2015). *Hamisi Sub-county Profile and Progress Report.* Hamisi: Hamisi Sub-county.

Hawthorne, W. D., Marshall, C. A. M., Abu, M. and Agyeman, V. K. (2011). *The impact of Logging Damage on Tropical Rainforest, their Recovery and Regeneration.* Oxford, South Park Road: Oxford Forestry Institute.

Hayashi Jr., P., Abib, G., and Hoppen, N. (2019). *Validity in Qualitative Research: Approcessual Approach.* The Qualitative Report. Vol. 24 pp. 98 - 112

Heywood, V. H. and Watson R. T. (2003). *Global Biodiversity Assessment.* New York: Cambridge University Press.

Hungarian State of the Art Report. (2000). *The Effects of Linear Infrastructure on Habitat Fragmentation; Hungarian State of the Art Report.* Hungary: Budapest.

Isaac & Michael (1995). *A Handbook in Research and Evaluation.* San Diego: C.A. Educational and Industrial Testing Services.

International Union for Conservation of Nature. (2006). *2006 IUCN Red List of Threatened Species.* Gland, Switzerland: The World Conservation Union.

International Union for Conservation of Nature. (2010). *Plants Under Pressure; A Global Assessment. The First Report of the IUCN Sampled Red List Index for Plants.* Royal Botanic Gardens London: The World Conservation Union.

Kirk, J., and Miller, M. L. (1986). *Reliability and Validity in Qualitative Research*. Beverly Hills, CA: Sage.

Kothari C. R. (2004). *Research Methodology; Methods and Techniques, 2nd Revised edition.* New Delhi: New Age International Publishers.

Kuper, W., Sommer, J. H. and Lovett, J. C. (2004). Africa s' Hotspots of Biodiversity Redefined. *Annals of the Missouri Botanical Garden 91 (4)*, 525-535.

Lowman, D. M. and Moffett, M. (1993). *Tropical Rainforest Canopy Development.* Sarasota: Botanica Gardens.

Mahiri, I. and Howorth, C. (2001). Twenty Years of Resolving the Irresolvable; Approaches to the Fuel Wood Problem in Kenya. *Land Degradation and Development (12)*, 205-215.

Ministry of Devolution and Planning. (2013). *Vihiga County Development Profile.* Nairobi: Government Printers.

Ministry of Devolution and Planning. (2014). *First Vihiga County Integrated Development Plan.* Nairobi: Government Printers.

Millennium Ecosystem Assessment Board. (2005a). *Ecosystem and Human Well-being; Biodiversity Synthesis Report.* Washington DC: World Resource Institute.

Millennium Ecosystem Assessment Board. (2005b). *Ecosystem and Human Well-being; Wetlands and Water Synthesis. Millennium Ecosystem Assessment.* Washington, D.C.: World Resource Institute Island Press.

Ministry of Forestry and Wildlife. (2013). *Analysis of Drivers and Underlying Causes of Forest Cover Change in the Various Forest Types of Kenya; Ministry of Forestry and Wildlife.* Nairobi; Kenya: Government Printers.

Morris, R. J. (2010). *Review of Anthropogenic Impact on Tropical Forest Biodiversity; A Network Structure and Ecosystem Functioning Perspective.* Oxford: University of Oxford Press.

Mutavi, I. N. (2012). *Assessment of the Effects of Anthropogenic Activity on Terrestrial Biodiversity Conservation in Matayos Division Busia County; Kenya.* Maseno: Maseno University.

Mutiso, F., Hitiman, J., Kiyapi, J. and Eboh, E. (2013). Recovery of Kakamega Tropical Rainforest from Anthropogenic Disturbances. *Tropical Forest Science 25 (4)*, 566-576.

Mutiso, F. M., Mugo, M. J., Cheboiwo, J., Sang, F. and Tarus, G. K. (2015). Floristic Composition, Affinities and Plant Formation in Tropical Forest; A Case Study of Mau Forest in Kenya. *International of Agriculture and Forestry 2015(2)*, 79-91.

Ozturk, M., Celik, A., Yarci, C., Aksoy, A. and Feoli, E. (2002). An Overview of Plant Diversity Landuse and Degradation in the Mediterranean Region of Turkey. *Environmental Management and Health Vol. 13 No. 5.*, 442-449.

Rodney & Keenan. (2015). Dynamics of Global Forest Area. *Forest Ecology and Management; Science to Sustain the Worlds' Forest; Changes in Global Forest Resources from 1990-2015 Vol. 352*, 9-20.

Tschakert, P., Zimmerer, K., King, B., Baum, S. and Chongming, W. (2014). *A Case Study of Amazon Rainforest.* Pennsylvania: Pennsylvania State University Press.

United Nations Environmental Programme. (2009a). *Kenya; Atlas of Our Changing Environment.* Nairobi: UNEP.

United Nations Environmental Programme. (1995). *Global Biodiversity Assessment Report; Press Release.* Washington DC: World Resource Institute.

United Nations Environmental Programme. (2007). *Global Biodiversity Assessment Report.* Washington DC: Cambridge University Press.

United Nations Environmental Programme. (2011). *Emerging Perspective on Forest Diversity.* Washington DC: World Resource Institute.

Wawire, M. E. (2007). *The Impact of Anthropogenic Activities on Plant Species in Kakamega Forest, Shinyulu Division Kenya.* Maseno University: Maseno.

Yamane, Taro. (1967): *Statistics: An Introductory Analysis, 2nd Ed.*, New York: Harper and Row.