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Species Diversity and Utilization of Non-Timber Forest Products (NTFPs) by Households Adjacent to South Nandi Forest, Kenya

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Abstract
The importance of non-timber forest products is recognized due to its support to the bulk of rural households in developing countries and a huge proportion of urban households in terms of their energy, nutritional, health, house construction or other needs. In recognition of their importance a study was undertaken to determine the types of NTFPs extracted by forest adjacent households for subsistence or income generation in South Nandi Forest. 431 household heads from 9 villages were interviewed using proportional random sampling and 3 focused group discussion held to document their uses in May to August 2016. The findings revealed that the key informants had relatively homogenous knowledge on the names and uses of the plants. A total of 128 plant species belonging to 105 genera and 55 families were mentioned for various NTFP uses. The used included herbal medicine that accounted for 51.6% of all the plant species, making small implements (46.9%), lighting fire (42.2%), firewood (40.6%) and charcoal production (29.7%). There was gender differentiation in the division of labor/roles on extraction of NTFPs except for herbal medicine and cultivation in forest which was done equally by both men and women. The relationship between gender and NTFP extraction showed a significant difference ($\chi 2$ (20,380) = 209.115, $p<0.0001$). The most common NTFPs utilized in South Nandi Forest were firewood, fodder and herbal medicine and families of plants mentioned as NTFP yielding were Euphorbiaceae, Asteraceae, Rubiaceae, Acanthaceae, Celastraceae, Meliaceae and Solanaceae. The study showed that NTFPs were important to local households for both income and subsistence purposes. Majority of the households used NTFPs mainly for subsistence purposes and there was a significant difference between NTFPs for domestic and commercial use ($\chi 2$ (8,431) = 160.586, $p<0.0001$). The NTFP Stock condition was perceived by the households to have reduced compared to ten years ago. The reasons for stock degradation were mainly due to increased human population and overexploitation of NTFPs (74%) and lack of NTFP domestication initiatives (11%). The study recommends that NTFPs should be managed based on the principles of sustainable forest management and NTFPs that enhance food security, health and basic households products need special consideration in the planning of forest conservation activities general.
Keywords: NTFPs utilization, species, households, sustainable, South Nandi Forest

1. Introduction

The families living adjacent forests depend on Non-Timber Forest Products (NTFPs) for numerous tangible and intangible benefits; NTFPs are known to contribute significantly to the economies of these communities (FAO, 1997; Stanley et al., 2012; Melaku et al., 2014; Sharma et al., 2015). The NTFPs in this paper are defined as all tangible forest products other than industrial wood which can be collected from forests for subsistence as well as for trade (Ros-Tonen et al., 1995). Importance on the use of NTFPs has grown in the last three decades as their extraction is considered low impact forest use compatible to conservation compared to other forms of forest extraction activities such as logging, mining, and plantation agriculture. NTFPs collected include wild fruits, leaves, bark, resin and roots that don't affect much the structure and function of forests (Arnold and Ruiz Perez, 2001; Stanley et al., 2012). However, with the growing NTFPs market and increase in human population, it is worthwhile to understand which types of NTFPs and in what quantities they are extracted so that the risk of overexploitation are checked (de Beer & McDermott, 1989; Ros-Tonen 1999; Varghese & Ticktin, 2008; Sumukwo et al., 2013).

Various studies have shown a wide diversity of plants used as NTFPs, for instance, a survey in Ri-Bhoi District, Meghalaya, India recorded 92 plant species used for ethnobotanical use, fuelwood, animal fodder, construction materials and edible forest products (Sharma et al., 2016); and a total of 480 plant species (25% of recorded flora) from 117 families and 334 genera used as NTFPs by the local people were encountered in China (Ghorbani et al., 2012). Similarly, in Malaysia, Kodoh et al. (2009) showed that 109 species of NTFPs were locally traded in an open market comprising of 35 species of wild edible plants, 32 species of medicinal plants, 8 species of orchids, 4 species of bamboos, 6 species of rattans, 8 species of fish, 8 species of wild fruits among others. A study in Bilaspur Forest Division of Chhattisgarh in India found that knowledge on NTFPs use and their refinement was location specific and therefore value addition to enhance the livelihood of the communities in the forest villages should not be generalized for all sites (Tiwari and Itoo, 2014). Omkar et al. (2012) reported that forests in India that were once known for their valuable timber had changed roles to the provision of NTFPs with 183 species having shifted emphasis to the provision of NTFPs. Those harvested for NTFPs belonged to

149 genera representing 64 families: Dicots/Magnoliopsida (164) and Monocots/Liliopsida (19) whereas the growth forms were dominated by trees (111), Shrubs (29), Herbs (21), Climbers (19) and Lianas (3) indicating that the floral elements are primarily woody forest trees. The shift to NTFPs could have been due to the degradation of the forest that changed the structure from predominantly timber species to shrubs and climbers.

More studies have reported the diversity of plants used as NTFPs, for instance, Foster & Duke (1990) catalogued identification and use of about 500 medicinal plants of eastern and central North America, many of which are forest grown; Zhaohua (2001) found out that China was very rich in NTFPs, particularly edible fungi (659 types), with 132 genus and 41 families; more than 5000 species of medicinal plants; 460 kinds of wild fibre and 140 species of woody forage among other NTFPs. These NTFPs included edible fungi, woody grain and oil plants, fibre plants, nectar plants, forest insects, forage, edible wild herbs, woody plants for drinks, rattan, bamboo, resin and gums, essential oils, vegetable among others. Overall, NTFPs provide many uses as they contribute to food and other basic needs; thus a better understanding of the extent and nature of the role of NTFPs is necessary to make a decision about forest management that adequately meets the society's demand upon the forest resource (Adepoju & Salau, 2007). The challenges to the availability of NTFPs are linked to anthropogenic pressures mainly caused by increased human population, heavy extraction levels, and grazing livestock. Therefore for sustainable harvesting and management strategies should take into consideration these factors to ensure there is a balance between growth and extraction to prevent overexploitation of the specific species (Ghorbani et al., 2012; Adepoju & Salau, 2007; Parren and de Graaf, 1995). Sustainable forest management will remain elusive until knowledge concerning NWFPs/NTFPs is developed where it can support management decisions (Agustino et al., 2011). It is against this background that this study was done to determine the types of NTFPs extracted by forest adjacent households for subsistence or income generation in South Nandi Forest.

2. Methodology

2.1 Study site description

The South Nandi forest (Figure 1) is the eastern-most remnant of the Guineo–Congolian rainforest, which in the past millennium stretched across the entire expanse of West and Central Africa to the East African highlands (Young, 1984; KIFCON, 1994). It is one of the last remnants of pristine sub-humid tropical rainforests that is located in a densely populated and intensely cultivated region. Geographically, the unique jug-shaped structure of Nandi County is bound by the Equator to the south and extends northwards to latitude $0^0$34'N. The Western boundary extends to Longitude $34^0$45'E, while the Eastern boundary reaches Longitude $35^0$25'E.

South Nandi forest consists of 13,000 ha of closed-canopy forest; 1,400 ha of exotic trees plantations, 340 ha planted with tea and 3,260 ha of scrub, grassland or under some form of cultivation (Birdlife, 2007). The forest elevation is between 1700 to 2000 meters above sea level. It receives average annual rainfall between 1600 and 1900 millimeters, which makes it classified as a 'moist forest' (under the Forest and Agricultural Organization of the United Nations (FAO) guidelines (Brown, 1997). Currently, it is classified as a transitional forest between the lowland forests of West and Central Africa and the montane forests of Rift Valley and Central Kenya (KIFCON, 1994). The soils in the southern Nandi forest are composed of well-drained, extremely deep dark to reddish brown with friable clay and thick humic top layer principally developed on biotite-gneisses parent material and is heavily leached with pH < 5.5. (Kagezi et al., 2011).

South Nandi forest reserve is drained by Kimondi and Sirwa rivers which merge within the forest to form the Yala River that subsequently flows through Kakamega forest and empties into Lake Victoria. Other rivers include Mokong, Orobo and Kundos. The rivers are perennial and provide water for domestic and industrial use and have waterfalls which can be harnessed for hydroelectric power and ecotourism (GoK, 2008).

The primary economic activity in the region is tea, maize, sugarcane and horticultural farming. South Nandi Forest Reserve is jointly managed by the Kenya Forest Service (KFS) and the forest adjacent communities through the Community Forest Association. The forest adjacent community uses the forest for their livelihoods by obtaining wood, non-wood forest products and environmental services (Muchiri and Mbuvi, 2010). The main reasons for managing the forest reserve are mainly conservation for water and biodiversity purposes with minimal controlled extraction for subsistence livelihood uses and ecotourism are permitted. Environmental degradation threatens the South Nandi forest reserve like many other indigenous forests in the country due to pressure from surrounding population. Sustainable management of South Nandi Forest Reserve is important considering that South Nandi Sub-County where the forest is located includes Kobujoi and Kaptumo locations that have high population density.

2.2 Sampling technique

Seven out of 16 villages adjacent to South Nandi forest were selected using a simple random method. The villages selected were Kiptenden, Sebetetwo, Burende, Kamobo, Koimwe, Kaptebengwo and Chemumul (Figure 2); other villages (Kemeloi and Ndurio) were purposively selected as controls because they were far (more than

5km from the forest) to enable comparison in dependence on South Nandi forest. The sampling frame in this study was the household. An existing household list per village was used to select households' heads to be interviewed randomly (Mbuvi et al., 2010). The formula by (Yamane, 1967; Singh & Masuku, 2014) was used to determine a representative sample size of household heads per village identified for the study (Table 1) following a proportional sampling method. The formula for sample size determination:

$n = N / [1 + N (e)^2]$ …….. (1)

where n is the sample size, N is the population size, and e is the level of precision. A 95% confidence level and P = 0.5 are assumed. P=0.5 i.e. assumes maximum variability.

2.3 Household survey

The minimum sample size required according to equation (1) was 397; however, a total of 431 households were interviewed. A household was defined as a group of people who eat from a common pot, sharing the same dwelling and may cultivate the same land (Katani, 1999). The key respondent during the household survey was the household head as they are the decision makers for the households in the use of NTFPs (Kajembe, 1994). However, in his/her absence; a responsible person over 18 years familiar with the household setting was interviewed. If there was none, the next household in the list was chosen. The household survey was conducted between May and August 2016. The household information was collected through a face to face interview using a semi-structured questionnaire. Pretesting of ten questionnaires was done in each of the three villages, that is, Kamobo, Burende and Koimwe, to ascertain instrument effectiveness and necessary adjustments done where ambiguity was noted (Mettrick, 1993; Reynolds et al., 1993). The questionnaire captured data on household characteristics of the forest adjacent communities, NTFP status, and utilization among other attributes of NTFPs.

2.4 Focused group discussion

Focused group discussion (FGD) based on the procedure by Krueger & Casey (2009) was done.

First, 6-9 people to participate in each of the three FGDs were identified in consultation with KFS, the local community leaders and field assistants on people meeting the criteria as follows: 1) knowledge of forest plants in the local language (Nandi) and well versed with their uses and 2) be living adjacent to the South Nandi Forest. The people were purposively selected from different sites adjacent to the forest to ensure diversity of the groups i.e. Koimwe, Kaptebengwo, and Kabungu. Each group was handled on a different date at the sites selected. Second, an existing checklist of plants of South Nandi Forest was used during the exercise to ensure that all known plants in the forest were covered. For each plant species, all its known uses were mentioned and consensus reached among members of the group before recording them. Additional species mentioned but not in the checklist were also recorded. Focused group discussions per site were done separately in different locations in September 2016.

2.5 Data analysis

The data collected through questionnaires was entered into the SPSS (Statistical Package for Social Science) version 23.0 computer software and coding done as necessary. The different variables entered were analyzed to obtain descriptive statistics in the form of frequency tables, cross-tabulation tables, the ranking of species and figures.

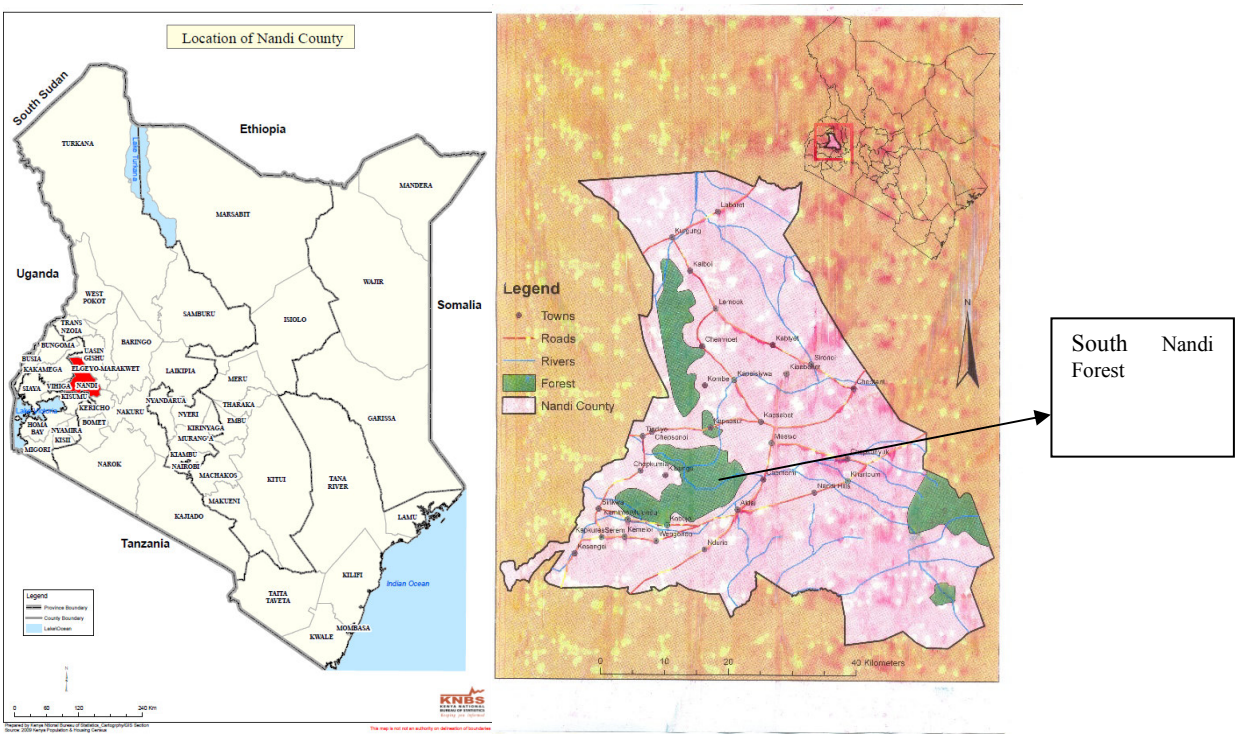

Figure 1: Location of the study area in Kenya and in Nandi County. (Source: Kenya National Bureau of Statistics, 2013).

Figure 1: Location of the study area in Kenya and Nandi County. (Source: Kenya National Bureau of Statistics, 2013).

Table 1: List of sampled villages and households around South Nandi Forest.

Village	Population	Total No. households	Household sample	Actual number done
Kamobo	7209	1414	61	67
Kiptenden	10771	2112	92	92
Burende	8886	1742	76	88
Koimwe	1790	703	31	42
Kimeloi	2840	1144	50	36
Sebetetwo	1558	305	13	21
Chemamul	1746	342	15	20
Ndurio	3799	745	32	38
Kaptebengwo	3188	625	27	27
	39,004	**9132**	**397**	**431**

Source: Based on Kenya National Bureau of Statistics, Kapsabet office

Figure 2: Villages surrounding South Nandi forest identified for the household interviews

3. Results

3.1 Characteristics of NTFPs

3.1.1 Species used as NTFPs

A total of 128 plant species belonging to 105 genera and 55 families were reported during the FGD (Appendix 1). The were no significant differences in responses among the 3 groups of community members versed with plant uses from study sites (Control, Koimwe, Kaptebengwo and Kabungu) adjacent to the forest was not significant ($F_{(3,89)}$ = 2.06, p-value=0.115), while the difference between the NTFP uses was significant ($F_{(22,89)}$ = 6.41,$p<0.001$). Tukey HSD test showed the significant differences between the specific uses (Table 2). The most common families of plants mentioned were Euphorbiaceae (10 species), Asteraceae (8 species), Rubiaceae (7 species), Acanthaceae (6 species). Celastraceae, Meliaceae and Solanaceae families had 5 species each, the other families are shown in Appendix 1. The growth habits of the above species were trees (26.56%), herbs (25.00%), shrubs (22.66%) and climbers (21.09%); additionally plants with growth habits of both trees/shrubs and herbs/climbers as well as ferns comprised 1.56% each.

3.1.2 Multiple uses of plant species as NTFPs

Appendix 1 shows all the species cited during FGD by informants with their family name, local name, growth habit and their uses. Plants with a single use were 16 (12.50%); over two uses were 101 out of 128 (78.90%); and those whose use was unknown to the informants were 11 (8.6%) plant species. Most of the plants had multiple uses with over 44 (34.38%) plant species mentioned having over 5 uses as NTFPs. The highest number of uses from a single plant was 14; these were Syzygium guineense and *Allophylus abyssinic*a. Twenty-two types of Non-timber Forest products were cited during the focused group discussions by the informants (Table 3).

Table 2: Tukey HSD test for different tree/plant uses mentioned by forest adjacent communities during focused group discussions in South Nandi Forest

Uses	Mean	SE of mean	Confidence interval
Smoking milk calabash	0.462 a	0.4621	0.462±0.4621
Banana ripening	0.576 a	0.3814	0.576±0.3814
Dye making	0.621 a	0.2281	0.621±0.2281
Boundary fencing	0.693 ab	0.4002	0.693±0.4002
Water storage	0.909 ab	0.6977	0.909±0.6977
Rafters	1.108 ab	0.4627	1.108±0.4627
Spears/arrows	1.197 abc	0.4744	1.197±0.4744
Traps	1.242 abc	0.2318	1.242±0.2318
String	1.746 abcd	0.3507	1.746±0.3507
Ceremonial	1.951 abcd	0.1415	1.951±0.1415
Fruit	2.004 abcd	0.1645	2.004±0.1645
Fodder	2.17 abcd	0.5702	2.17±0.5702
Construction	2.181 abcd	0.2086	2.181±0.2086
Food/spices	2.283 abcd	0.2404	2.283±0.2404
Beehive	2.301 abcd	0.2649	2.301±0.2649
Posts/poles	2.306 abcd	0.3206	2.306±0.3206
Fencing	2.51 abcd	0.3479	2.51±0.3479
Fire lighting	2.606 bcd	0.67	2.606±0.67
Timber	2.635 bcd	0.1651	2.635±0.1651
Charcoal`making	2.685 bcd	0.3212	2.685±0.3212
Small implements	3.088 cd	0.3579	3.088±0.3579
Firewood	3.226 d	0.1407	3.226±0.1407
Medicinal	3.658 d	0.1255	3.658±0.1255
Lsd = 1.049			

Table 3: Summary of uses of plants per species cited during FGDs by the informants

No.	Uses of plants	Total number of species per use	Percent of species per use (%)
1	Medicinal	66	51.56
2	Making small implements	60	46.88
3	Fire lighting	54	42.19
4	Firewood	52	40.63
5	Charcoal	38	29.69
6	Timber	36	28.13
7	Making beehive	28	21.88
8	Posts/poles	28	21.88
9	Fencing	28	21.88
10	Construction	27	21.09
11	Rafters	21	16.41
12	Food/spices	20	15.63
13	Ceremonial	15	11.72
14	Fodder	15	11.72
15	Strings	15	11.72
16	Fruits	11	8.59
17	Making traps	10	7.81
18	Banana ripening	10	7.81
19	Spears/arrows	6	4.69
20	Smoke calabashes	6	4.69
21	Water storage	4	3.13
22	Boundary fencing	4	3.13
23	Dye making	2	1.56

The above NTFP uses were regrouped into four categories according to Modi & Trivedi (2013):

Firstly, NTFPs for food security which includes species useful for honey, mushroom, edible fruits and nuts, foliage and rhizomes: - there were 20 species used as food or spices and 11 species used as fruits;

Secondly, NTFPs for wood and biomass included species for fuel, furniture, thatching, forage and manure: - 60 species (small implements), 54 species (fire lighting), 53 species (firewood), 38 species (charcoal), 28 species

(making beehives), 28 species (posts/poles), 28 species (fencing), 27 species (construction), 21 species (rafters), 15 species (making strings), 15 species (fodder), 10 species (making traps), 10 species (banana ripening), 6 species (smoking calabashes), 5 species (spear/arrow making), 4 species (boundary live fence), and 3 species (water storage);

Thirdly, NTFPs for medicine and plant protection included herbal medicine for human beings, animals and for control of pests and diseases in crops: there were 66 plant species used for herbal medicine and 15 species for ceremonial uses; and

Fourthly, NTFP for aromatics, dyes, and oilseeds for medicinal and industrial uses: 2 species (dye making).

Overall, most NTFP uses in this study were found in the second category on wood and biomass and are linked to domestic uses. Table 4 shows some of the NTFPs collected from the forest; there was a significant difference between NTFPs for domestic and commercial use ($\chi2_{(8,431)} = 160.586$, $p<0.0001$).

3.1.3 Utilization of NTFPs by gender

Collection of firewood was done mostly by women while grazing, beekeeping, posts, and harvesting of sand was done mostly by men. Herbal medicine and cultivation in the forest are done equally by both male and female (Table 5).The relationship between gender and NTFP extraction showed a significant difference ($\chi2_{(20,380)} = 209.115$, $p<0.0001$).

Table 4: The purpose of collecting NTFPs in South Nandi Forest

Type of NTFP	Purpose of the NTFPs (%)			N
	commercial	domestic	Both domestic and commercial	
Grazing	1	96	3	224
Firewood	0	47	53	196
Herbs	14	86	0	7
water	0	100	0	3
Charcoal	0	100	0	1
	1	74	25	431
Test statistic: Pearson Chi-square $\chi^2_{(8, 431)} = 160.586$, p-value<0.0001				

Table 5: The relationship between gender and the type of NTFP collected in SNF

Gender of person collecting NTFP	Type of NTFPs											
	Graz-ing	Fire-wood	Herbs	Fruits	Water	Char-coal	Honey /Beehive	Cultiv-ation	Vege-tables	Sand	Posts	Total
Mostly Female	26	141	3	0	1	0	0	0	1	0	0	172
Mostly male	112	15	1	1	0	0	1	0	0	1	1	132
Male and Female equally	58	11	4	0	1	1	0	1	0	0	0	76
Total	196	167	8	1	2	1	1	1	1	1	1	380
Test statistic: Pearson Chi-square $\chi2_{(20, 380)} = 209.115$, p-value<0.0001												

3.1.4 Part of plants used as NTFPs and stock degradation

The most common NTFPs utilized in South Nandi Forest were firewood, fodder and medicinal plants (herbs). The main parts used for firewood were branches (76.3%), followed by stems (15.1%) and deadwood (7.4%). Roots were also used by 0.6% of the respondents suggesting that the whole tree was used for firewood, particularly where there were scarcities of the firewood. Grass was also used as fuel but mainly for lighting purposes. For grazing in the forest, grass (94.6%), leaves (3.8%) and shrubs (1.6%) were the main parts eaten by livestock, particularly cattle and sheep which are the only livestock type allowed in the forest by KFS. Roots and/or bark (76.8%), leaves (20.8%), grass (3.4%), branches (0.6%) and seeds (0.6%) were the plant parts used for medicinal purposes. The relationship between the type of NTFP sourced and the specific part collected (Table 6) was strongly associated ($\chi2_{(30,284)} = 777.497$, $p<0.001$). The NTFP Stock condition was perceived by the households to have reduced compared to ten years ago (Figure 3). The reasons for stock degradation were mainly due to increased human population and overexploitation of NTFPs (74%) and lack of NTFP domestication initiatives (11%); the other reasons are shown in Figure 4.

Table 6: Types of NTFP sourced and part of the NTFP utilized

Type of NTFP	Part of the NTFPs							
	Leaves	Grass	Branches	Roots and/or Bark	Dead wood	Stem	Sand	Total
Grazing	6	123	0	0	0	0	0	129
Firewood	0	1	115	2	9	17	0	144
Herbs	2	0	0	6	0	0	0	8
Vegetables	1	0	0	0	0	0	0	1
Sand	0	0	0	0	0	0	1	1
Posts	0	0	0	0	0	1	0	1
Total	9	124	115	8	9	18	1	284

Test statistic : Pearson Chi-Square $\chi 2_{(30, 284)} = 777.497$, $p<0.0001$

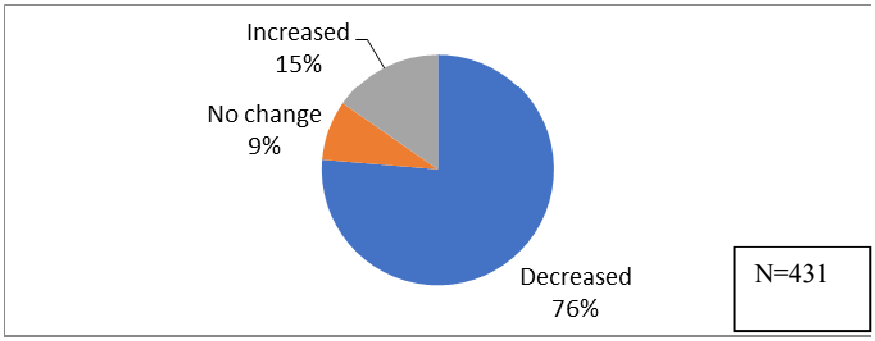

Figure 3: Perception of the households on the NTFP stock condition now compared to ten years ago.

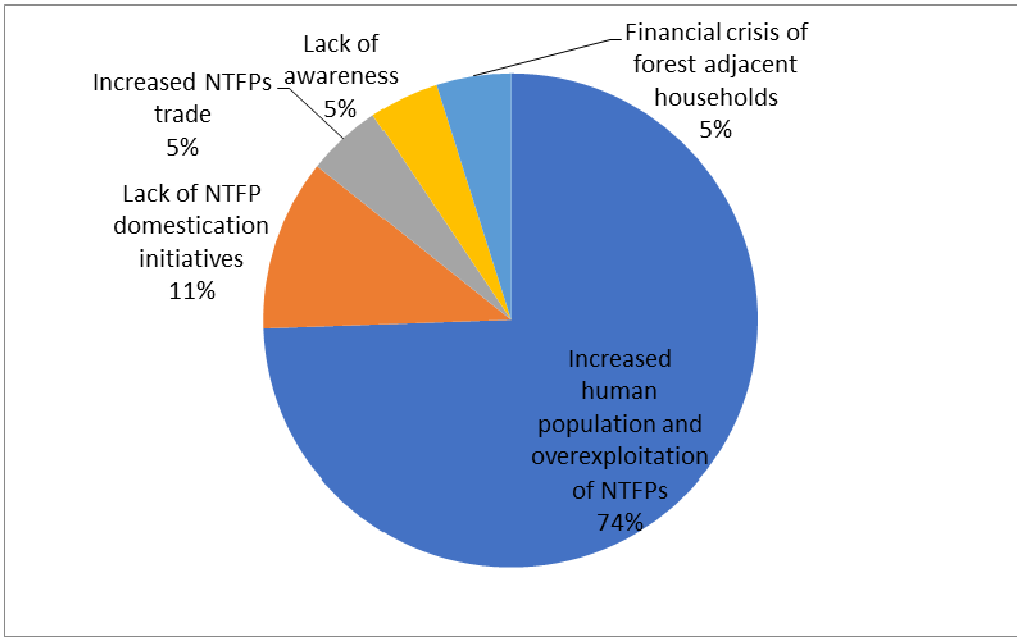

Figure 4: Reasons for degradation of NTFP stock condition in the last ten years

4.0 Discussion

4.1 Knowledge of and use of NTFPs

There was no significant difference between the three groups of FGD informants suggesting that they had relatively homogenous knowledge on the names and uses of the plants. A study on traditional ecological knowledge of a riverine forest in Turkana, Kenya also stated that the local Turkana informants had relatively similar ethno-botanical knowledge (Stave et al., 2007) suggesting that the information generated was reliable. Local knowledge has been recommended as a tool for rapid assessment of plant resources (Dalle & Potvin, 2004) as one collects data on a large number of species including less abundant ones using less labor-intensive methods. This study confirmed that it is possible to obtain a lot of data through the local informants. However, some

studies have reported heterogeneous local knowledge on plant uses which was unevenly distributed among informants (Bruschi et al., 2014) suggesting that caution is required when using local knowledge. It is therefore suggested that at least six to ten informants be used (Krueger & Casey, 2009) and consensus among them be reached before recording the local names of plant and their uses.

4.2 Diversity of NTFPs

The number of NTFPs used by the forest adjacent households are comparable to those found in other studies; for instance, a survey in Ri-Bhoi District, Meghalaya, India recorded 92 plant species used for ethnobotanical use, fuelwood, animal fodder, construction materials and edible forest products (Sharma et al., 2016); in Malaysia, Kodoh et al. (2009) showed that 109 species of NTFPs were locally traded in an open market comprising of 35 species of wild edible plants, 32 species of medicinal plants, 8 species of orchids, 4 species of bamboos, 6 species of rattans, 8 species of fish, 8 species of wild fruits among others. Lynser and Tiwari (2016) also reported that people in rural Meghalaya, North-East India used 172 NTFPs belonging to 139 plant species, 117 genera and 70 families mainly for food, medicine and fuelwood which are comparable to main uses of NTFP in South Nandi Forest. However, there was a difference in the families of the dominant NTFP yielding families. The dominant families in South Nandi were were Euphorbiaceae, Asteraceae, Rubiaceae and Acanthaceae whereas they were Rosaceae, Poaceae and Fagaceae in the case of study in India (Lynser and Tiwari, 2016). Omkar et al. (2012) reported that plants in harvested in India for NTFPs belonged to 149 genera representing 64 families with growth forms dominated by trees (111), Shrubs (29), Herbs (21), Climbers (19) and Lianas (3) indicating that the floral elements are primarily woody forest trees. The growth habits in the South Nandi forest were led by Trees (26.56%), followed by Herbs (25.00%), Shrubs (22.66%) and Climbers (21.09%) showed a similar trend in terms of woody forest plants.

According to the categorization of NTFPs by Modi & Trivedi (2013); most of the NTFPs in the study were found in the category (b) which includes NTFPs used for wood and biomass as well as species for fuel, furniture, thatching, forage, and manure. These NTFPs are used to meet the basic needs and survival of the households in South Nandi Forest. Modi & Trivedi (2013) reported the similar findings; however, in their case category (a) which deals with food security was also included as very important to the survival of households. Another study, Uprety et al. (2016), reported that a total of 739 species of NTFPs were used by the local people of Kangchenjunga landscape (a trans-boundary landscape shared by Bhutan, India, and Nepal) for 24 different purposes; medicinal and edible plants were the most frequently used NTFP categories in the landscape. A similar trend was also reported by Saha & Sundruyal (2012) which revealed that the tribal communities used 163 out of 343 NTFPs recorded for medicinal purpose in Arunachal Pradesh state that forms a major part of humid tropics in the eastern Himalayan region of India. In this study 51.56% of all the species were used for medicinal purposes. The above observations indicate that NTFPs that affect food security, health and basic products used by the households need special consideration when planning activities affecting the conservation of forest in general, however, locality-specific surveys must be done to take care of varying characteristics and cultures of different regions.

4.3 Multiple uses of NTFPs

In this study, firewood was obtained from plant species in thirty families with Euphorbiaceae and Rutaceae as the most preferred families for firewood use. The dominant fodder family was Acanthaceae and Asteraceae whereas, for medicinal use, the families were dominated by Asteraceae, Euphorbiaceae, and Lamiaceae. Most of the plant species had multiple uses with over 78% having more than one use suggesting that South Nandi forest played an important role in the household's subsistence and income contribution. Plants with multiple uses especially more than five uses are considered as versatile species, for instance, *Syzigium guineense* and *Allophyllus abyssinica* had 14 uses each: fire lighting, water storage, food/spices, medicinal, timber, firewood, making beehives, posts/poles, fencing, construction, rafters, fruits (*S. guineense*), making traps (*A. abyssinica*) and making small implements. Most multipurpose species are targeted by the forest adjacent households for the various uses mentioned. They should be protected or managed in a sustainable way to reduce chances of overexploitation or even local extinction of the species. The results in this study show that almost every plant in South Nandi Forest is used by the households adjacent to the forest, mainly as NTFPs. The findings are in agreement with other studies that state NTFPs support the bulk of rural households in developing countries and a considerable proportion of urban households in terms of their energy, nutritional, health, house construction or other needs (Alcorn, 1995; Bodeker et al., 1997; Modi & Trivedi, 2013; Shackleton et al., 2015; Pandey et al., 2016; Tewari et al., 2017).

4.4 Plant parts used

The plant parts used as NTFPs is determined by the intended use, for instance, firewood mainly utilizes branches of trees and deadwood. The other parts such as roots system of trees are used when scarcity prevails otherwise

where abundant firewood supply exists; nobody would be willing to expend the energy required to uproot stumps left after cutting trees. Where livestock graze in the forest, the target NTFP is mainly grass followed by fodder plants such as those in the families' Acanthaceae and Asteraceae in this study. For medicinal herbs, the ailments treated by the 66 medicinal plants fell in the following categories: stomach/digestive-related; skin-related; respiratory-related and procreation-related such as aphrodisiacs, venereal diseases, and gynecological ones. Others were stress-related ailments such as headaches, hypertension, heart, nervous and pain producing sicknesses. The plant parts used were mainly roots and/or bark (76.8%), leaves (20.8%), grass (3.4%), branches (0.6%) and seeds (0.6%). Harvesting methods which involve complete removal of plants or ring barking should be discouraged (Turner, 2001), especially if the target plants are rare in the forest. It is suggested that management strategies that reduce damage to the whole plant be developed in SNF to ensure sustainable exploitation of the forest. This is especially necessary where the active ingredients to be derived from the roots are also available in other parts of the plant such as the leaves, bark, seeds, and buds.

4.5 Utilization of NTFPs and division of labor by gender

In this study, there was gender bias in the division of labor/roles on NTFPs except for herbal medicine and cultivation in the forest which was done equally by both men and women. Several studies have confirmed that both men and women play different roles and their interests in NTFPs were relatively different as women play greater roles as primary harvesters, processors and marketers of NTFPs (Hecht et al. 1988; Falconer 1990; Malhotra et al. 1993; Terry and Cunningham 1993 and Ghatak 1995). Therefore an examination of gender roles in NTFPs extraction and utilization is critical in understanding the impacts of NTFP commercialization on society's social justice, equity, and welfare. Other studies have shown the existence of gender division of labor and income control can vary spatially, by species, by the level of technology, and by the type of task in the chain of activities from harvesting to marketing (Neumann and Hirsch, 2000). Similarly, studies have confirmed that women's social, political and economic status can be helped or harmed through NTFP commercialization efforts. The most negative impacts occur under two conditions when men have control over the income derived from NTFP collection and sale hence women were not likely to directly benefit from commercialization. Secondly, when mechanization and centralization of processing is part of the commercialization process that ends in displacing women processors from the market value chain. The most positive situations for women are those that include an institutional or organizational component specifically designed to increase women's political power that enables women to defend their economic interests in NTFPs. In the absence of specific mechanisms to redress existing gender inequities, NTFP commercialization efforts can and do result in adverse economic and social consequences for women. Thus, important issues and concerns relating to gender needs to be addressed whenever planning and implementing projects that promotes commercialization of NTFPs (Neumann and Hirsch, 2000).

4.6 Domestic versus commercial use of NTFPs

Majority of the households used NTFPs mainly for subsistence purposes; other studies that have found similar findings include Lynser and Tiwari (2016) in Meghalaya, North-East India; Sharma et al., (2015) in Arunachal Pradesh, India; and Mbuvi and Boon (2009) in Makueni District, Kenya. Within the households adjacent to the South Nandi forests, almost all NTFPs such as firewood, water, grazing (fodder), herbs were used mainly for subsistence. It is only firewood that nearly half the households used for both domestic and commercial purposes; however, there was a reluctance to admit that they sold firewood or any other NTFP for income generation. Herbal medicine was the only NTFP openly traded commercially by a small portion of the households.

4.7 NTFP Stock condition

The NTFP Stock condition was perceived by the households to have reduced compared to ten years ago. The reasons for stock degradation were stated as increased human population and overexploitation of NTFPs, lack of NTFP domestication initiatives, lack of awareness, and increased trade in NTFP and financial crisis in households adjacent to the forest hence over-relying on the forest resources. This finding may be an indicator that South Nandi Forest is being managed in an unsustainable manner. It is therefore recommended that an inventory of NTFPs be done to enable the forest managers to know the capacity of the forest, after that embrace the use a sustainable harvesting schedule through the development of a participatory forest management plan together with Community Forest Association. This plan will give management strategies that contribute to the conservation of the forest at the same time encourage agroforestry, private forestry and growing of NTFPs outside the gazetted forests.

4.8 Sustainable use of NTFPs

Even though, the above species in South Nandi Forest currently do not fall in the red list, i.e., according to the IUCN criteria of threatened species (IUCN, 2017); the NTFPs need to be managed based on the principles of

sustainable forest management. Sustainable forest management is built on the principle that forest management will meet current societal needs without prejudice to future generations or the forests' abilities to rejuvenate and maintain existing stature (Chamberlain et al., 2002). The concept considers three fundamental standards: 1) forest management is socially acceptable and equitable, 2) the impact is ecological benign and 3) the economic impact to the local communities is positive. The Montreal Process, an international agreement for sustainable management of temperate forests, provides national-level criteria and indicators for assessing efforts to fulfill these three principles (Chamberlain et al., 2002). Detailed principles of sustainable harvesting of NTFPs are discussed in a report by Turner (2001); she points out five areas which should be considered and are summarized as: general factors, ecological and biological factors, harvesting factors, cultural and social factors and also marketing and economic factors. These factors should be considered by forest managers to ensure that NTFPs in South Nandi Forest and elsewhere are utilized in a sustainable manner for the benefit of present and future generations.

4.9 Conclusions

A total of 128 plant species belonging to 105 genera and 55 families were cited from South Nandi Forest. The forest adjacent households utilized twenty-two types of NTFPs that were collected from the forest. However, the most common NTFPs were identified as firewood, grazing and herbal medicine.

The roles on extraction of NTFPs was differentiated by gender with collection of firewood being done by the female, grazing, beekeeping, harvesting of posts and sand done by male but collection of herbal medicine and cultivation in the forest were done equally by both male and female.

The study found out that there was a significant difference between NTFPs used for domestic and commercial purposes as most of the households used NTFPs mainly for subsistence purposes. The NTFP stock condition was perceived by most households to have reduced compared to ten years ago.

In general, NTFPs had some bearing on household food security, health and primary products hence need some special consideration in the development of forest conservation and management plans.

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Appendix 1: Species listed during FGD by informants with their family name, local name, growth habit and their uses

No.	Species	Family name	Local name (Nandi)	GH	Uses	TU
1	Syzigium guineense	Myrtaceae	Lamaiywet	T	1,3,6,7,8,9,10,12,13,14,16,19,21,22	14
2	Allophylus abyssinica	Sapindaceae	Sakamwet	T	1,3,5,7,8,9,10,12,13,14,16,17,19,22	14
3	Tabernaemontana stapfiana	Apocynaceae	Mobondet	T	1,7,8,9,10,12,13,14,16,17,19,22	12
4	Cordia abyssinica	Boraginaceae	Tepesuet	T	1,4,7,8,9,10,12,13,14,16,17,22	12
5	Olea capensis	Oleaceae	Murkuiywet	T	1,3,7,8,9,10,12,13,14,16,19,22	12
6	Albizia gummifera	Mimosaceae	Seet	T	1,7,8,9,10,11,12,13,16,22,23	11
7	Strombosia scheffleri	Olacaceae	Chepkorkoriet	T	1,8,9,10,12,13,14,15,16,19,22	11
8	Chionanthus mildbraedii	Oleaceae	Kwomurguiwet	T	1,2,7,9,10,13,14,16,18,19,22	11
9	Cassipourea malosana	Rhizophoraceae	Martit	T	1,9,10,13,14,15,16,17,19,21,22	11
10	Prunus Africana	Rosaceae	Tenduet	T	1,7,8,9,10,12,13,14,16,19,22	11
11	Fagaropsis angolensis	Rutaceae	Noiwet	T	1,7,8,9,10,12,13,14,16,19,22	11
12	Zanthoxylum gillettii	Rutaceae	Sagawaitet	T	1,7,8,9,10,12,13,14,16,19,22	11
13	Celtis mildbraedii	Ulmaceae	Sertet	T	1,8,9,10,12,13,14,16,17,21,22	11
14	Maytenus heterophylla	Celastaceae	Kukerwet	T	1,8,9,10,12,13,14,16,19,22	10
15	Diospyros abbysinica	Ebenaceae	Kendoiywet	T	1,4,8,9,10,13,15,16,19,22	10
16	Drypetes gerrardii	Euphorbiaceae	Mekunyet	T	1,8,9,10,12,13,16,17,19,22	10
17	Lepidotrichilia volkensii	Meliaceae	Sakamwet	T	1,8,9,10,12,13,14,16,19,22	10
18	Trilepsium madagascariense	Moraceae	Mbaraka	T	1,6,8,9,10,12,16,19,21,22	10
19	Craibia brownie	Papilionaceae	Mekunyet	T	1,7,8,9,10,13,14,16,17,22	10
20	Vangueria madagascariensis	Rubiaceae	Kimolwet/kipmowet	T	1,6,7,9,10,13,14,17,21,22	10
21	Teclea nobilis	Rutaceae	Kuriot	T/S	1,8,9,10,12,13,14,16,19,22	10
22	Croton megalocarpus	Euphorbiaceae	Masinaidet	T	1,4,8,9,10,12,16,19,22	9
23	Dovyalis macrocalyx	Flacourtiaceae	Kapchopinyat	S	1,6,7,8,9,10,14,21,22	9
24	Ekebergia capensis	Meliaceae	Teldet	T	1,7,8,9,10,13,14,16,22	9
25	Croton macrostachyus	Euphorbiaceae	Tebesuet	T	1,4,7,9,10,16,19,22	8
26	Macaranga kilimandscharica	Euphorbiaceae	Sebesebet	T	1,8,9,10,13,14,16,22	8
27	Nuxia congesta	Loganiaceae	Choruwet	S	1,4,9,10,11,13,14,22	8
28	Trichilia emetica	Meliaceae	Noiywet	T	1,8,9,13,14,15,17,23	8
29	Ficus sur	Moraceae	Mukoiyot	T	1,6,8,9,10,11,21,22	8
30	Dovyalis abyssinica	Flacourtiaceae	Nukiat	S	1,6,7,9,10,21,22	7
31	Bersama abyssinica	Melianthaceae	Kipumetiet	T	1,4,7,9,10,17,22	7
32	Coffea eugenioides	Rubiaceae	Noruyot Noriot	S	1,8,9,10,12,13,22	7
33	Heinsenia diervilleoides	Rubiaceae	Sekerbanga	T	1,3,8,13,14,16,19	7
34	Dombeya burgessiae	Sterculiaceae	Silipchet	T	1,9,10,11,19,20,22	7
35	Ensete ventricosa	Musaceae	Sasusuwet	S	4,6,16,18,21,22	6
36	Maesa lanceolata	Myrsinaceae	Kipapusitanyet	T	1,2,7,9,10,22	6
37	Triumfetta ruwenzoriensis	Tiliaceae	Miswot	H	7,8,12,20,22,23	6
38	Caesalpinia volkensii	Caesalpiniaceae	Chepkomon	S	1,5,7,9,14	5
39	Erythrococa bongensis	Euphorbiaceae	Sekelipagang or Chesicheiyot	S	1,7,9,19,22	5
40	Ricinus communis	Euphorbiaceae	Imaniat	S	1,4,7,9,22	5
41	Ocimum suave	Lamiaceae	Mwokiot	H	7,8,9,11,12	5
42	Rubus apetalus	Rosaceae	Momonyet	S	1,7,9,15,21	5
43	Solanum mauritianum	Solanaceae	Cheptomotwo	S	1,9,13,14,22	5
44	Solanum sp.	Solanaceae	Mororuwet	S	1,4,7,9,22	5

45	Brillantaisia madagascariense	Acanthaceae	Kipongiat	S	1,11,13,14,	4
46	Brillantaisia nitens	Acanthaceae	Sietet	H	11,12,22,23	4
47	Hippocratea graciliflora	Celastraceae	Kipcheiyot	C	1,7,20,22	4
48	Hippocratea sp.	Celastraceae	Chepseleitet	C	8,9,10,11	4
49	Hippoctratea africana	Celastraceae	Ng'ngichet	C	6,14,18,20	4
50	Solenecio sp.	Asteraceae	Chepkurbet	S	1,7,9,22	4
51	Dracaena laxissima	Dracaenaceae	Chepkitonget	S	1,10,20,22	4
52	Acalypha sp	Euphorbiaceae	Sambachet or chesumeiyot	H	6,7,11,22	4
53	Neoboutonia macrocalyx	Euphorbiaceae	Kipsebwet	T	1,9,10,22	4
54	Stephania abyssinica	Menispermaceae	Tapariet	C	6,20,22,23	4
55	Tiliacora keniensis	Menispermaceae	Mborosiet	C	6,7,18,20	4
56	Pavetta sp.	Rubiaceae	Sekerbanga	S	1,9,16,19	4
57	Toddalia asiatica	Rutaceae	Kipkoskosit	C	1,7,9,22	4
58	Solanum aculeastrum	Solanaceae	Sikowet	S	1,5,7,9	4
59	Trema orientalis	Ulmaceae	Kipsartet	T	1,9,10,22	4
60	Acanthus eminens	Acanthaceae	Indakariat	S	1,7,9,	3
61	Achyranthes aspera	Amarathaceae	Chesirmit	H	12,18,22	3
62	Momordica sp	Cucurbitaceae	Cheptenderet	C	4,7,20	3
63	Dracaena steudneri	Dracaenaceae	Lepekwet	T	7,18,22	3
64	Achyrospermum schimperi	Lamiaceae	Inyonyoitat	S	6,7,8	3
65	Leonotis nepetifolia	Lamiaceae	Sisiyat	S	1,7,9	3
66	Hibiscus calyphyllus	Malvaceae	Motosheiet	S	1,7,9	3
67	Adenia sp.	Passifloraceae	Chemyalelder	C	7,8,20	3
68	Gouania longispicata	Rhamnaceae	Riksoit	C	3,14,23	3
69	Chlorophytum galabatense	Liliaceae	Sikotiet	H	7,15	2
70	Macrorungia pubinervia	Acanthaceae	Kipongiet	H	9,11	2
71	Pseuderanthemum	Acanthaceae	Chesumeiyot	S	11,12	2
72	Landolphia sp.	Apocynaceae	Ngingichet	C	20,22	2
73	Landolphia buchananii	Apocynaceae	Ngigiye/Ngingichet	C	21,22	2
74	Rauvolfia sp.	Apocynaceae	Kipcheiyot	C	7,20	2
75	Asplenium sandersonii	Aspleniaceae	Kataputiet	F	6,22	2
76	Asplenium theciferum	Aspleniaceae	Kataputiet	F	6,22	2
77	Commelina latifolia	Commelinaceae	Lepulopitiet	H	6,7	2
78	Bidens sp.	Asteraceae	Chepketel	H	7,11	2
79	Galinsoga parviflora	Asteraceae	Kipkoleitet	H	7,11	2
80	Vernonia sp	Asteraceae	Kipsabuni	S	7,12	2
81	Kalanchoe densiflora	Crassulceae	Kuserwet	H	7,23	2
82	Phyllanthus odontadenius	Euphorbiaceae	Mengeiwet	H	8,12	2
83	Tragia brevidens	Euphorbiaceae	Sambachet	H/C	4,7	2
84	Ocimum kilimandscharicum	Lamiaceae		S	7,12	2
85	Gloriosa superba	Liliaceae		H	7,23	2
86	Lobelia gibberoa	Lobeliaceae	Sereguet	H	7,22	2
87	Turraea sp	Meliaceae	Kosositiet	S	7,22	2
88	Ficus sp.	Moraceae	Kipchimdet	C	7,20	2
89	Calpumea sp.	Papilionaceae	Senendet	S	4,7	2
90	Desmodium repandum	Papilionaceae	Chemigoiyot	H	6,7	2
91	Passiflora edulis	Passifloraceae	Kerenderiat or Chemagururiet	C	6,20	2
92	Plantago palmate	Plantaginaceae	Yakariet	H	7,11	2
93	Helimus mystacinus	Rhamnaceae	Sesiat	C	7,22	2

94	Scutia myrtina	Rhamnaceae	Sumbeiywet	S/C	1,9	2
95	Psychotria sp.	Rubiaceae	Rogoret or chelelkatiat	C	4,22	2
96	Physalis peruviana	Solanaceae	Mbomiat	H	5,21	2
97	Solanum nigrum	Solanaceae	Sojo or isochot	H	6,7	2
98	Urtica sp.	Urticaceae	Sabajet	H	4,7	2
99	Laportea alatipes	Urticaceae	Sambachet	H	11,12	2
100	Cyphostemma orondo	Vitaceae	Simet	C	7,22	2
101	Aframomum keniense	Zingiberaceae	Chemagururiet	S	6,7	2
102	Lactuca capensis	Asteraceae	Cheparaa	H	7	1
103	Lactuca glandulifera	Asteraceae	Cheparaa	H	7	1
104	Eulophia horsfalli	Orchidaceae	Sigotiet	C	23	1
105	Culcasia scandens	Araceae	Kataputiet	C	8	1
106	Mondia sp.	Asclepiadaceae	Chemangururiet	C	7	1
107	Blumea crispate	Asteraceae	Taptiet	H	23	1
108	Commelina benghalensis	Commelinaceae	Sochet	H	6	1
109	Sonchus sp.	Asteraceae	Cheparaa	H	7	1
110	Ipomoea wightii	Convolvulaceae	Kimoiyat	C	11	1
111	Neonotonia wightii	Fabaceae	Ng'wang'wanyet	H	12	1
112	Sida cuneifolia	Malraceae	Kerundut	H	8	1
113	Phytolacca dodecandra	Phytolaccaceae	Patakwet	C	7	1
114	Piper capense	Piperaceae	Kiptutung'it	H	7	1
115	Rumex usambarensis	Polygonaceae	Chemideleliet	H	8	1
116	Pentas lanceolata	Rubiaceae	Cheruriet	H	8	1
117	Rutidea orientalis	Rubiaceae	Tinguet	C	20	1
118	Mimulopsis solmsii	Acanthaceae	Sietet	H		0
119	Meyna tetraphylla	Celastraceae	Chebikonyat	S		0
120	Momordica foetida	Cucurbitaceae	Sisiyet	C		0
121	Momordica friesiorum	Cucurbitaceae	Ng'wang'wanyet	C		0
122	Dumasia villosa	Fabaceae	Ng'wang'wanyet	C		0
123	Vigna sp	Fabaceae	Ngw'angw'anyet	C		0
124	Turraea holstii	Meliaceae	Chemuriat	T		0
125	Olea sp.	Oleaceae	Itaat	T/S		0
126	Calpumea aurea	Papilionaceae	Ipembetiet	S		0
127	Thalictrum rhynchocarpum	Ranunculaceae	Chesumeiyot	H		0
128	Allophylus rubifolia	Sapindaceae	Chemoriat	S		0

SUMMARY

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USES*	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Total no. of species/use	54	2	4	15	4	20	66	36	52	38	15	28	28	28	6	27	10	6	21	15	11	60	10

KEY:

*1= fire lighting; 2= dye making; 3= water storage; 4= ceremonial; 5= boundary fencing; 6= Food/spices; 7= Medicinal; 8= Timber; 9= Firewood; 10= Charcoal; 11= Fodder; 12= Making beehive; 13= Posts/poles; 14= Fencing; 15= Spears/arrows; 16= construction; 17=Making traps; 18= smoking milk calabash; 19= Rafters; 20= Strings; 21=Fruits; 22= Making small implements; 23= Banana ripening

GH =Growth habit; T=Tree, S=Shrub, H=Herb, C=Climber; F=Ferns, TU=Total number of uses per species.