Post harvesting regeneration and establishment of permanent forest regeneration plots

Transforming Tanzania's Charcoal Sector (TTCS) project, Kilosa District, Tanzania

By

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Executive summary

This report presents the findings of post harvesting regeneration and establishment of permanent forest regeneration plots studies in the Sustainable Charcoal Project sites in Kilosa District, Tanzania. The major aim of these two studies was to assess regeneration level in previously harvested areas and establish permanent plots in areas that will, but have not yet been harvested. The project plans to arrange for the permanent plots to be tracked over the long term so that long term growth rates can be estimated and the accumulating biomass can be compared with the starting biomass.

Data were collected in eight project villages of Kilosa District in September to October 2015 whereby a total of 69 regeneration plots harvested between 2013 and 2014 and 50 permanent plots were established. Under regeneration plots, about 50% of the measured stumps were found to develop coppices that averaged six (6) individuals per stump and with overall mean height of 102.30 ± 3.47 cm. Moreover, about 37% of the stumps were observed to develop new root sprouts/suckers with average of five (5) individuals per stump and with overall mean height of 87.53 ± 3.33 cm. About 48.4% of the total stumps were developing both coppices and root sprouts on the same plant. The most frequently harvested tree species for charcoal making were *Brachystegia boehmii* (Myombo) and *Brachystegia spiciformis* (Mhani/Mtondoro). These species comprised of 36.3% and 20.8% of the total measured tree stumps respectively. In terms of seedlings, there was low species diversity that averaged 1.7/5.0 of the Shannon-Wiener index compared to 1.9/5.0 of original species in the area in which the most dominant seedlings where those of *B. spiciformis* and *B. boehmii.* The average seedling height was 37±3.6 cm and no seedlings of invasive tree species were observed. No regeneration in terms of seedling establishment and root sprouts were recorded in kiln scars. Fire was found to have both positive and negative effects on regeneration in which light fires were enhancing regeneration whilst intense fires were weakening or completely killing the new coppices, root sprouts and seedlings. Light grazing was found not to have an effect on regeneration as most herbivores were grazing on herbaceous species and not on young trees. Seedlings were more frequent in open areas with minimal vegetation cover, often burnt areas or where big trees have been felled. The above ground biomass of the tree was found to be 66.7 t/ha equivalent to 16.7 tons per 50 m* 50 m block in areas that charcoal has not yet being harvested.

We conclude that regeneration in the charcoal harvested areas is occurring; fire has both direct beneficial and deleterious effects on tree regeneration depending on its intensity and timing. We recommend that further monitoring of the kilns is required in order to determine their effects on regeneration. Further research on age effect on coppicing efficiency of the harvested trees is required. Nevertheless, initiatives for controlling wildfires through training of the villagers on forest fire fighting and use of prescribed burning techniques are worth undertaking.

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1.0 INTRODUCTION

This report presents findings of post harvesting regeneration and establishment of permanent forest regeneration plots in the Sustainable Charcoal Project sites in Kilosa District, Tanzania. These findings were obtained as a result of a consultancy work aimed to examine the project's post charcoal harvesting regeneration and charcoal yield. Ecological data were collected in eight project villages of Kilosa District where a total of 69 regeneration plots and 50 permanent plots were sampled.

2.0 MATERIAL AND METHODS

2.1 Study area

The study was carried out in eight out of 10 project villages in Kilosa District. These villages are located in either side of the Kilosa-Mikumi road. At least eight villages have started harvesting charcoal in a sustainable manner in average of 300 m x 300 m blocks for harvesting since 2013. Regeneration plots were established in these blocks and biomass plots for monitoring were established in un-harvested blocks with harvesting plans for the year 2015 and onwards where harvesting blocks have been reduced to 50 m * 50 m blocks (Figure 1).

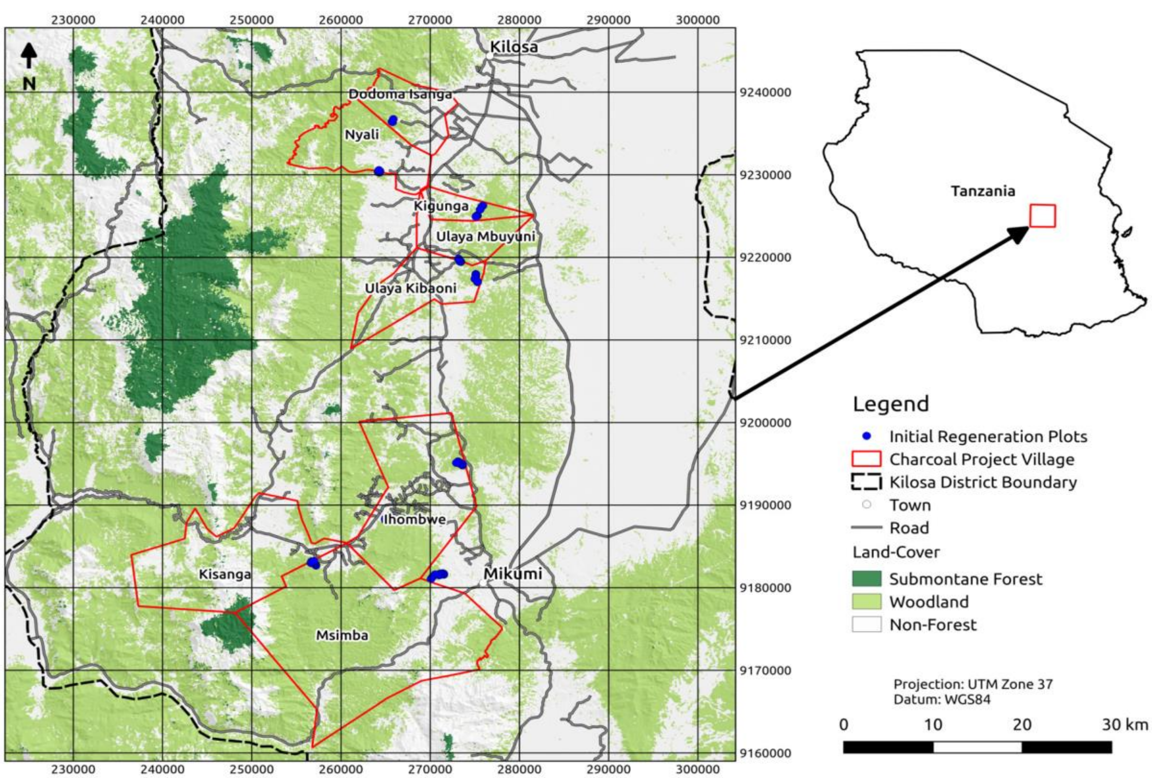

Figure 1a: Map of the study site showing location of regeneration plots

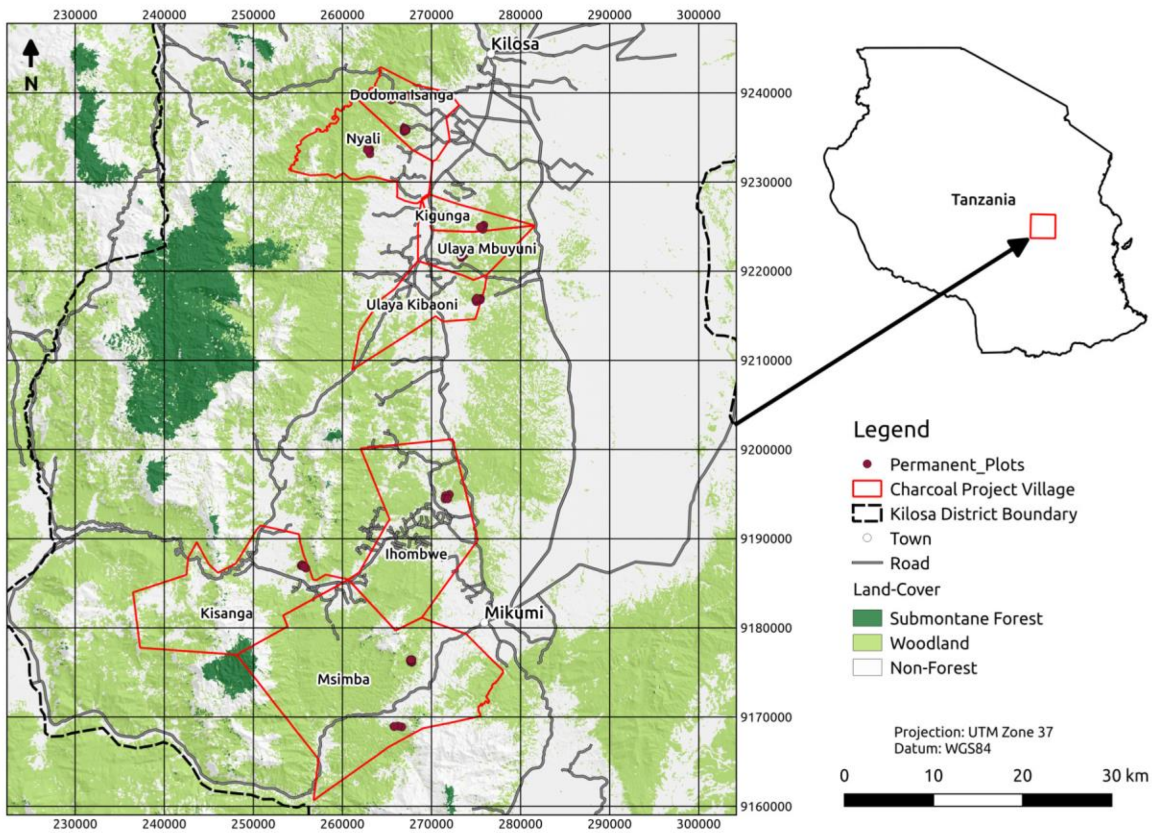

Figure 1b: Map of the study site showing location of permanent plots

Regeneration and biomass plots are shown in Table 1.

Table 1: Distribution and type of plots in each project village, Kilosa Tanzania

Sno.	Village Name	Regeneration plots	Permanent plots
1	Ulaya Mbuyuni	06	05
2	Ulaya Kibaoni	07	06
3	Dodoma Isanga	07	11
4	Ihombwe	14	04
5	Kigunga	07	04
6	Kisanga	10	05
7	Msimba	11	10
8	Nyali	07	05
	Total	**69**	**50**

2.2 Study materials

Two studies (amount of regeneration and biomass estimation) were carried out simultaneously in eight project villages. In both studies the following tools and equipments were used; Diameter tape for measuring Diameter at Breast Height (DBH) and Basal Diameter (BD) of trees and stumps respectively, height pole for measuring height of coppices, tape measures for measuring distance and height of seedlings, GPS for recording coordinates (location), Sunto hypsometer for tree heights, Clinometer for slope angle, colour spray and short piece of rebar for marking the plot centers, NARFOMA botanical guide for tree species identification, Field forms for data recording, Camera for photos and other stationeries for record management.

2.3 Study team and data collection

Study team comprised of consultant and his assistant, project staff, plot identifier (secretary of VNRC) local botanist, driver, village leader (VEO or chair person) and other few VNRC members of a particular village under study. Methods used in data collection were as proposed in the methodological manual (Annex 1).

2.4 Study limitations

During implementation of the study, the following limitations were encountered;

- Maps showing harvesting plans for two villages (Mhenda and Kitunduweta) could not be obtained during data collection. It was informed that the responsible person was not in office to accomplish mapping for these villages.
- In some villages (e.g. some parts of Dodoma Isanga, Nyali and Ihombwe) miombo woodlands were burnt out by wildfire, something that minimized chances of estimating regeneration as most seedlings, root suckers and coppices were completely burnt by fire.
- Several permanent plots which were recorded as un-harvested in maps were actually found harvested on ground or there were established new farms. Serious problems were found in Kisanga and Msimba villages. This phenomenon caused unnecessary delays in field since other blocks had to be identified to cover the gap.

3.0 KEY FINDINGS

3.1 Study I- Regeneration plots

3.1.1 Effects of charcoal kiln scar and placement on tree/forest regeneration

In every harvested block there was at least one kiln placement which left a scar on the ground. In some few cases depending on topography and easiness to dig soil for a kiln placement, the kiln was placed outside the harvested block. Visual observation in most kilns of 2013 and 2014, no regeneration of tree species is observed yet inside the kiln areas. Only 10% of 2013 kilns were observed to have herb species such as wild amaranths but 100% of the 2014 kilns were completely devoid of vegetation. However, it should not be taken as a conclusion that Miombo tree species do not regenerate on kiln scars because, most of Miombo tree seeds have prolonged seed dormancy which may take a longer time to regenerate. A conclusion with regard to regeneration on kiln scars needs more data through monitoring studies. Figure 2 shows the status of regeneration on kilns after two years of harvesting.

Figure 2: Kiln scar of 2013 with no regeneration in harvested area of Ulaya Mbuyuni village

3.1.2 Amount of regeneration in areas harvested in the last two years

In this study, 903 sample stumps that were left following tree harvesting for charcoal making between 2013 and 2014 years were measured, this corresponded to about 185 stumps/ha. The overall stump diameter and stump height were 22.34 ± 0.43 cm and 53.64 ± 0.76 cm respectively. It was observed that 67.7% of all stumps had either coppices or sprouts. There were no plots without at least one stump that was sprouting and/or coppicing. Stump vegetative regeneration at the plot level ranged from 17 to 100% with an average of 64.4%. Furthermore, about 50% of the measured stumps were found to develop coppices with an average of six (6) individuals per stump and with overall mean height of 102.30 ± 3.47 cm. Also, about 37% of the stumps were observed to develop new stems from the roots (root sprouts/suckers) that averaged five (5) individuals per stump and with overall mean height of 87.53 ± 3.33 cm. The overall mean coppice number/ha was 88±4 whilst the mean root sprout/sucker number/ha was 66±5. In addition, the sampled 903 tree stumps belonged to 40 different tree species in which 85% and 60% of the species were found to develop coppices and root sprouts respectively. Moreover, 57.5% of the tree species harvested for charcoal were observed to develop both coppices and root sprouts on the same plant as a means for vegetative propagation.

The most frequently harvested tree species for charcoal making were *Brachystegia boehmii (*myombo) and *Brachystegia spiciformis* (mhani/mtondoro), these species comprised 36.3% and 20.8% of the total measured tree stumps respectively. Others included *Diplorynchus condylocarpon* (mtogo) 6.8%, *Pseudolachnostylis maprouneifolia* (msolo) 6.6%, *Combretum molle* (mlama mweupe) 4.4%, *Combretum zeyhen* (mlama mweusi) 4.3%, *Combretum/Terminalia spp* (Mgung'u) 3.7% and *Brachystegia microphylla* (mgelegele/mtelela) 2.5%. The proportional of harvesting was corresponding to availability of particular tree species. This can be justified by tree species frequency in the permanent plots (un-harvested areas) in which 670 trees were randomly sampled for above ground biomass estimation and of these included 26.1% of B. *boehmii, 19.6% B.*

microphylla, 10.6% D. condylocarpon, 9.1% B. spiciformis and *4.5% combretum spp*. that were also found to be highly harvested.

However, some valuable timber tree species in particular *Pterocarpus angolensis*, and tree species of high conservation importance such as *Dalbergia melanoxylon* were also occasionally felled for charcoal at a proportion of 1.8% and 0.2% of the total stumps. However, informal discussions with members of village environmental committees and charcoal producers revealed that at the beginning of the project there was a provision to harvest timber trees that are naturally deformed and badly damaged e.g. by fire. It was further revealed that, in accordance with the present guidelines, harvesting of timber trees is strictly prohibited and none was observed to be felled in the newly harvested areas. See Table 4 for detailed stump and regeneration characteristics of the most commonly harvested tree species.

Despite the fact that the stumps of *B. boehmii* and *B. spiciformis* were observed to exhibit both coppicing and root sprouting, *B. boehmii* was relatively robust in coppicing and especially the stumps with less than 30cm diameter were observed to develop thicker and taller coppices than old tree stumps (>30cm diameter). *B. spiciformis* was observed to do best through root sprouting and most stumps did not have coppices and with advance of dry season and upon exposure to fire most immature coppices (<30cm height) were found either wilted or dead. Moreover, *B. microphylla, D. condylocarpon, Combretum* and *Acacia spp* were observed to regrow robustly in terms of both coppices and root suckers. In some instances, the coppices of these species were found to achieve a height of up to 3m within a year.

In general, trees of large size basal diameter classes were not showing much vegetative regeneration at the time of this study (Table 2). Thus, more monitoring is needed in order to know after how long they will start to coppice/sprout or die.

Table 2: Percentage of regeneration by stump basal diameter classes

Diameter category (cm)	Stump number	Number of regenerating stumps	Percent of regenerating stumps (%)
0 - 5	15	15	100.00
5-15	291	255	87.63
15-25	275	216	78.55
25-35	168	78	46.43
35-45	98	34	34.69
45-55	41	15	36.59
55-65	8	0	0.00
65-75	7	2	28.57

3.1.3 Plant species diversity in the areas under regeneration

Results showed that on average, diversity of regenerating tree species was slightly lower compared to that of un-harvested tree species. Mean diversity index value of regenerating species was 1.7 while that of un-harvested tree was 1.9 out of possible 5.0 in all the 8 forests/villages (Table 3). The low diversity of regeneration through seedlings can be caused by several factors including fire, grass cover and seed dormancy.

Table 3: Diversity of seedlings and original standing tree species using Shannon Wiener index

Sno	Village Forest Area	Number of regenerating species	Number of standing tree species	Index (*H′*) for Regeneration	Index (*H′*) for standing tree species
1	Ulaya Mbuyuni	9	18	1.3	2.6
2	Kigunga	7	11	1.6	1.6
3	Nyali	7	9	1.7	1.9
4	Dodoma Isanga	12	14	2.2	1.9
5	Ihombwe	10	14	1.6	2.3
6	Ulaya Kibaoni	13	8	2.4	1.5
7	Msimba	5	13	1.6	1.8
8	Kisanga	3	9	1	1.4
	Mean	**8**	**12**	**1.7**	**1.9**

Further, results showed that there was no regeneration of invasive tree species in the study sites. A total of 27 common tree species were found regenerating in all the eight study villages. The overall mean height of tree seedlings was 37±3.6 cm and the seedling density was 57±2/ha. The dominant tree species of regenerating trees included *B. spiciformis* (34%), *B. boehmii* (13%), *D. cinerea* (8%) and *F. virosa* (6%). Others were *D. condylocarpon*, *B. microphylla* and 'Mtutum*a'* (all 4%).

Table 4: Regeneration measurements from stumps of harvested trees for charcoal production in the 8 village forests in Kilosa, Tanzania

	Tree species		Stump diameter		Stump height			Coppice No.		Coppice height			Root sprout No.		Root sprout height	
S/N	Botanical name	Local name	Mean (cm)	SD (cm)	Mean (cm)	SD (cm)	N	Mean	SD	Mean (cm)	SD (cm)	N	Mean	SD	Mean (cm)	SD (cm)
1	*Brachystegia boehmii*	Myombo	22.92	0.71	54.37	5.97	328	4	0	70.09	4.41	162	3	0	74.63	4.61
2	*Brachystegia spiciformis*	Mhani/Mtondoro	28.20	0.99	60.91	13.44	188	5	1	80.69	6.11	48	5	1	68.72	5.21
3	*Diplorynchus condylocarpon*	Mtogo	12.17	0.76	47.20	3.37	61	7	1	115.16	10.81	45	5	1	105.09	11.60
4	*Pseudolachnostylis maprouneifolia*	Msolo	20.18	1.06	50.59	24.50	60	12	2	92.75	11.55	32	16	7	118.75	23.03
5	*Combretum molle*	Mlama mweupe	14.12	1.09	42.77	10.04	40	7	1	142.53	14.90	30	7	1	113.40	20.46
6	*Combretum zeyhen*	Mlama mweusi	14.52	1.15	51.41	.	39	8	1	145.61	15.76	28	2	0	117.50	16.93
7	*Combretum/Terminalia spp*	Mgung'u	19.52	1.42	53.36	3.20	33	9	1	164.54	14.65	26	6	3	184.20	19.57
8	*Brachystegia bussei/microphylla*	Mgelegele/Mtelela	33.70	2.57	55.57	.	23	5	3	105.00	26.39	7	8	3	121.17	22.31
9	*Acacia senegal*	Mzasa/Kikwata	14.78	1.57	43.36	0.76	15	4	1	153.87	18.70	15	8	3	27.00	3.00
10	*Dichrostachys cinerea*	Mkulagembe	8.97	1.58	42.67	5.16	3	10	1	78.50	1.50	2				
11	*Pericopsis spp*	Mmanga	42.07	4.98	63.67	4.48	11	11	5	73.00	2.52	3	3		85.00	.
12	*Combretum/Terminalia spp*	Mkombeziko	14.13	1.92	58.79	4.36	14	11	2	100.25	14.79	12	4	1	90.50	30.93
13	*Xeroderris stuhlmannii*	Mnyenye	20.75	6.09	52.00	.	4	4	0	89.00	11.00	2	2	.	136.00	.
14	*Zanthoxylum gillettii*	Mhanga	20.08	10.48	45.00	4.72	4	2	1	114.00	56.00	2	4	.	61.00	.
15	*Buckea africana*	Mkalati	26.67	2.59	49.36	1.46	11	7	1	198.67	75.52	3				
16	*Acacia nigrescens*	Mkambaa	24.15	7.93	51.20	7.52	5						1	0	89.33	39.94
17	*Faidherbia albida*	Mkungugu	22.61	5.82	46.40	11.47	5	2	1	83.33	24.92	3	6	3	125.50	21.96
18	*Acacia macrothyrsa*	Mkongoe	22.73	6.24	60.67	3.67	3	2	.	273.00	.	1				
19	*Flueggea virosa*	Mkwambekwambe	8.60	.	47.00	18.10	1	1	.	180.00	.	1	1		200.00	.
20	*Markhamia spp*	Mtalawanda	19.51	7.54	38.00	8.19	3	3	1	161.33	6.33	3				
21	*Combretum/Terminalia spp*	Mzaza	15.38	4.50	27.67		6	5	0	78.50	58.50	2				
22	*Annona spp*	Mtopetope pori	9.55		41.00	3.38	1	8	.	75.00	.	1				
23	*Sclerocarya birrea*	Mng'ong'o	39.00	.	56.00	.	1	10	.	230.00	.	1				
24	*Pterocarpus angolensis*	Mninga	21.06	3.37	44.44	8.80	16	9	2	117.27	20.17	11	5	2	127.25	21.48
25	*Dalbergia melanoxylon*	Mpingo	16.88	0.96	46.50	.	2	1	.	200.00	.	1		.		

3.1.4 Effects of residual canopy, grass cover and fire on regeneration

About 49% of the established regeneration plots were burnt in various intensities depending on fuel (grass and litter) density. Results on average regeneration suggest that less fire is generally better, but the pattern is very clear for higher intensities of fire (perhaps due to low sample sizes) (Table 5).

Table 5: Influence of fire on regeneration of coppices and sprouts

Fire intensity	Average regeneration (%)	N
No fire	74.61	32
Low	49.07	8
Moderate	62.63	16
High	46.41	10

Fire was found to have both advantages and disadvantages in the surveyed areas in which it was found to trigger root sprouting in many tree species including *B. boehmii* and *B. spiciformis* in which areas burnt between July and August 2015 were observed to have immature root sprouts in late September, 2015 (Figure 3). However, in many cases intense fire was found to kill most seedlings with soft barks especially in areas with taller grasses and in steep slopes. For example, less regeneration was recorded in Nyali, and most surveyed areas of Ihombwe and Dodoma Isanga due to intense wildfires (see Figure 4)

Figure 3: Showing recently burnt area (LHS) with no regeneration and a site where *B. spiciformis* seedlings are establishing themselves about two months post fire (RHS).

Average tree canopy cover was estimated to be 6.34% in all regeneration plots implying that most harvested areas were open. Despite the fact that there was insignificant relationship between residual canopy cover and vegetative regeneration, most seedlings and root sprouts were visually observed to prefer open areas. The seedlings that were observed to be dense in open areas included those of *B. boehmii, B. spiciformis, P. angolensis* and *D. melanoxylon.*

Figure 4: Seedlings of *B. spiciformis* occupying an open area at Ihombwe village (LHS) and a cover of *T. triandra* and *H. rufa* grasses (RHS) at Dodoma Isanga village

However, regeneration in terms of seedlings was observed to be poor in areas dominated by tall grass species (over 1.5m height) that were too dense. Dominant grass species were *Themeda triandra* (red grass) and *Hyparrhenia rufa* (thatch grass) that were very dominant in high altitudes (650 -850 asl) and along steep slopes, for example in Msimba and Dodoma Isanga villages. The aforementioned grass species were also the major sources of wildfires due to their ability to accumulate higher biomass, thus affecting regeneration negatively. Table 6 shows intensity of burn in project villages.

Table 6: Fire intensity in the plots under harvested areas in 8 villages, Kilosa district

Fire intensity	Frequency	Percentage
No fire	34	49.3
Low	8	11.6
Moderate	16	23.2
High	11	15.9
Total	**69**	**100.0**

3.1.5 Effects of grazing on initial regeneration of Miombo under charcoal harvesting

Grazing of livestock (cattle, goats and sheep) and wildlife (antelopes) was noticed in the harvested areas (56.5% of the total plots) in the form of animal droppings and leaf defoliation (Table 7). Results showed no statistical relationship between grazing intensity and vegetative regeneration. There was neither relationship between vegetative regeneration and grass cover nor grass height. However, the effect of grazing on initial regeneration was minimal as the grazing intensity was low in most sites and the herbivores were noted to consume grasses while no signs of seedling consumption were noted.

Table 7: Grazing intensity in the plots under harvested areas in 8 villages, Kilosa district

Grazing intensity	Frequency	Percentage
No grazing	30	43.5
Low	18	26.1
Moderate	17	24.6
High	04	5.8
Total	**69**	**100**

Also, no signs of heavy vegetation trampling or soil damage were observed. Occasionally, new coppices of *P. maprouneifolia* were observed to be browsed and locals revealed that it is preferred by some wildlife species in particular small and medium antelopes such as Dikdik and Impala.

Grazing incidences were higher in Ihombwe and Msimba villages whilst in Nyali and Dodoma Isanga no grazing incidence was observed perhaps because most areas were recently burnt (Figure 5). It was also observed that light grazing is beneficial to regeneration as it reduces grass cover (fuel load) that is responsible for wildfires, a good example of light grazing was observed in Ulaya Kibaoni, Ulaya Mbuyuni and Kigunga villages where there was no fire and relatively flat terrain was observed in these villages (Figure 5).

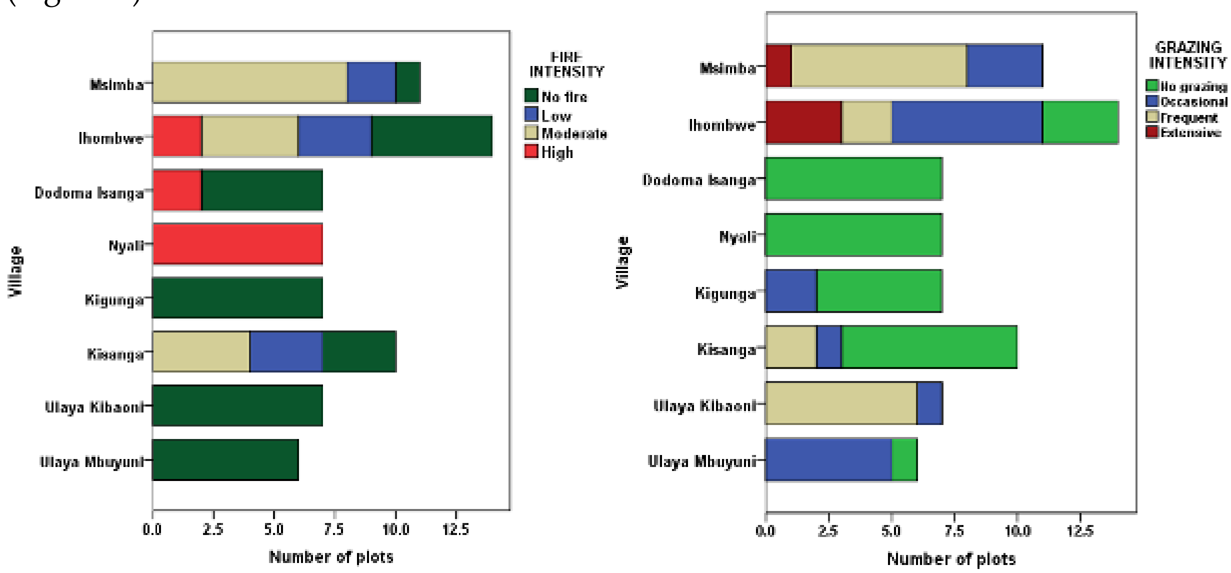

Figure 5: Fire and grazing intensities in 8 study villages in Kilosa district.

3.2 Study II-Biomass plots

3.2.1 Estimation of starting biomass for each plot

The current biomass for each plot was estimated using existing allometric equations developed for Miombo by Mugasha et al., 2012. The equation used was *Biomass* (Kg) = *exp[a+b.In(dbh),* where a=-1.6557 and b=2.3427. This was found appropriate to use due to climatic factors of Miombo ecosystem found in Kilosa District. All the study sites received more than 1000 mm of rainfall per year and the kind of dominant tree species found also support the use of the equation. Therefore, mean biomass was found to be 66.7 tons per hectare in the study sites. This was equivalent to 16.7 tons per 50 m* 50 m harvesting block. Furthermore, the mean biomass obtained was equivalent to 4.6 tons per plot of 15 m radius. In comparison with other miombo ecosystem in the tropics, this amount of biomass is reasonably good since most dominant tree species qualify for charcoal in the harvesting blocks.

3.2.2 Effect of tree harvesting for charcoal making on fire incidences and grass cover

There was no significant difference in fire incidences between the un-harvested plots and regeneration plots (P= 0.18, F=5.7, T-test). The mean proportion of fire incidences (0=no fire and 1=burnt) was 0.64 ± 0.07 and 0.51 ± 0.061 in the un-harvested and harvesting regenerating plots respectively. This implied that tree harvesting for charcoal making does not influence fire occurrence in Miombo woodlands. Moreover, there was no significant difference in grass cover between un-harvested plots (N=50) and the regeneration plots (N=69), (P= 0.057, F=3.7, T-test). The mean grass cover was 33.4 ± 3.28 and 32.04 ± 3.54% in the un-harvested and harvested regenerating areas respectively. This observation might be attributed to the fact that the surveyed Miombo woodlands were also having open canopy covers, in which the mean canopy cover in the un-harvested areas was 28.66±1.85%, and it ranged between 5-60%. Thus, allowing grasses to thrive well contrary to dense forests where grass cover is known to be low due to limited sunshine.

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

Findings of these studies conclude the following;

i Generally, there is a robust regeneration of the harvested Miombo tree species through coppicing and root suckers across all harvested areas/villages since 2013 and 2014. However, regeneration through seedlings and its associated diversity was relatively low as compared to that of original standing tree species. There were also no invasive species found to colonize the harvested areas.

ii Dominant tree species such as *B. spiciformis* and *B. boehmii* were found to perform differently in regeneration, with the *B. boehmii* performing better in coppicing and *B. spiciformis* in root sprouting.

iii Wood biomass in the areas set for harvesting was very attractive, suggesting that villagers engaging in charcoal business are in a position to generate good income due to good available biomass in their forests. An average of 16.7 tons per 50 m* 50 m equivalent to 66.7 tons per ha was found.

iv Wild fire was found to have both negative and positive affects with regard to initial regeneration of Miombo tree species. High intensity fire was found to damage most growing seedlings, root suckers and coppices especially in areas with heavy fuel load (grass) and steep slopes. Less intensive fire also resulted in initiating development of new root suckers during very dry season.

v For the first two years of regeneration, there are no tree species found regenerating in the kiln placement areas. These areas are still bare grounds with no vegetation cover on them.

4.2 Recommendations

Based on the above findings and conclusions, the following recommendations are made:

i There is a need for a continuous monitoring in the harvested blocks for the next two years to assess the status of regeneration in the kiln scars. A specific ecological study can then be done to investigate the status of regeneration in kiln scars if regeneration does not happen. Action steps such as enrichment planting of indigenous tree species can then be done to reduce risks associated with bare grounds especially in slopes.

ii Prevention of intensive wild fires is required. Efforts to reduce fuel load in the forest is a must for a better survival of immature seedlings, coppices and root suckers/sprouts. Fuel can be managed by early burning using prescribed fire or controlled grazing.

iii There is a need to enforce rules and regulations set for harvesting. Boundary trees and regular tree species that are listed as "not for charcoal" should not be harvested.

iv Further detailed study to investigate the effect of age of a tree to regeneration is required. This is because, the dominant tree species has shown a decrease in number of coppices and root suckers as diameter of tree stump increased.

Annex 1. Methodological Manual
Annex 2. Field data sheets (Excel sheet)