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Effects of selective cutting of Gum Arabic tree (*Acacia senegal* L.) on Farmland based on Respondent's Perceptions in *Wad Banda* area, West Kordofan, Sudan

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Abstract: **This research was conducted in *Wad Banda* locality, West Kordofan state- Sudan during 2018/2019. It aimed to identify the current status of Gum Arabic tree (*Hashab*) under practice of selective cutting and to find out effects of selective cutting of Hashab trees on farmland, crop yield, wind speed and rainfall based on farmer's perceptions. It also aimed to investigate the causes of farm land degradation in the area. Primary data was collected through social survey where in-depth interview was conducted. Fifty eight farmers who practice selective cutting were interviewed. Secondary information was collected from relevant references, annual reports and scientific publications. The data were descriptively analyzed where averages, percentages were calculated in Statistical Packages for social Sciences (version 16.00) and Microsoft Excel (2008) Programs. The results found that more than 50% of respondents indicated that Hashab tree increased last ten years. The total area targeted to be cut by all (85) farmers was 355 feddan (149.1 ha) with an average of 4.2 feddan (1.8 ha) per farmer. The proportion of felling in 2018 was 12.9%. There were 87.1% of respondents stated that selective cutting of Hashab trees does not have much effect on the farmland and 92.9% of respondents said it does not negatively affect crops yield but it increases the wind speed according to 98.8%. The main reasons caused farmland degradation were overcutting and overgrazing. Pearson Correlation analysis revealed that there was positive correlation (P≤0.08) between respondent's perception and importance of selective cutting however, it is weak. The majority (84.7%) of respondent assured role of the Forest National Corporation in protection and encouraging people toward plantation. The study recommended declining the selective logging to the minimum level (≤5%) and organizing it. It also recommends activating forest laws and controlling grazing system.**

Keywords: **Selective logging, Acacia Senegal, farmland, Gum Arabic tree, soil erosion.**

1. INTRODUCTION

There are many studies carried out on selective logging. It was found that selective logging in Atlantic forest altered canopy structure and increased the relative abundance of some early-secondary species and decreased the litter input and stock of nutrients (Villela *et al*., 2006). Selective logging has a minor effect on tree species composition, at least in a single felling cycle (Villela *et al*., 2006). In many Sub-Saharan African countries, dry woodlands have been exploited for charcoal production (Arnold *et al*., 2006; Ahrends *et al*., 2010; Chidumayo and Gumbo, 2010, 2013) mostly through selective logging of hardwood species which are preferred for their dense charcoal and high caloric value (Butz, 2013). Well-planned selective logging, especially of large canopy trees, improves light penetration to the understory vegetation, thus stimulating natural regeneration processes (Zida *et al*., 2007). However, selective logging targeting specific species

has the potential to materially alter the composition and physiognomy of the woodlands and may lead to undesirable ecological consequences (Ahrends *et al*., 2010). Reduced impact logging (RIL) practices comprise harvest planning, infrastructure development and operational techniques that aim to reduce the damaging impacts of logging and improving the production efficiency of logging operations. RIL techniques and guidelines are not fixed prescriptions, but adapt the best harvesting techniques to existing biophysical and economic conditions. Throughout the tropics, RIL has proven more ecologically benign than conventional logging activities. Quantifying canopy effects of RIL and conventional logging is useful for understanding effects of these practices on forest fauna, micro-climate, and regeneration. Understanding canopy damage and recovery is needed for the interpretation and detection of logging using remote sensing. Few studies have quantified effects of selective logging on tropical forest canopies. Previous studies used quantified canopy damage using ground mapping and spherical densitometers (Verissimo *et al*., 1995 and Johns *et al*., 1996). Canopy loss for RIL blocks was generally lower than for paired conventionally logged blocks. Johns *et al.,* (1996) found that conventional logging led to canopy loss of 21.8% versus only 10% for RIL treatments in their study. The harvest consisted almost entirely of *Chlorocardium rodii* (green heart) which grows in dense stands. The conventional practice focused on dense clumps of this species. The strong relationship between canopy opening and harvest volume for conventionally logged blocks is surprising given the large differences in forest type, logging practices, and measurement techniques. Different measurement approaches may lead to compensating errors. Mapping of canopy gaps from the ground will tend to overestimate the gap fraction within the gap, while neglecting damage far from the gap. Understanding of canopy structural changes resulting from different logging intensities is critical to the prospect of logging damage estimation using current and future remote sensing observations. Selective logging is known to have highly variable effects on tropical forest canopies in the Amazon (Uhl 1997, and Pereira *et al*., 2002). Conventional logging (CL) consistently resulted in greater canopy damage than did reduced-impact logging (RIL), independent of the number of trees harvested per hectare. Initial canopy gap fractions were lower in RIL than in CL immediately following timber extraction. However, the rate of canopy closure in CL blocks was equal to or greater than that of RIL treatments (Gregory *et al*., 2004). This research investigates the effect of cutting down of trees and shrubs on farmland, productivity, and wind speed from farmer's point of view and tresses the role of Forest National Corporation in this case.

2. MATERIALS AND METHODS

2.1 Study area:

2.1.1 *Wad Banda* locality

Wad Banda located in West Kordofan State between 13°15'N and 27°12'E. The area is 13,039 square kilometers. The population is 184,790 people according to the national census for the year 2017. Local inhabitants of *Wad Banda* are engaged in both agriculture and little trade, in addition to the recent mining in the northern part of the locality, with regions producing high proportions of vegetables and fruits, such as Um Bwiru, Administrative *Wad Banda*, *Suqe Aljamal, Zurnakh, Dardouk and Armal* which is where there are gold mining. The forest of *Wad Banda are all reserved.* They are *Banda belt, Eldam Jamad belt, Forest Wad Rabah, Umm Dibiba Forest, Wad Salman Forest, Shakro Aljilda forest and Hamimid forest. Hammer tribe* is the dominant with its various branches such as *Almuslamat, Taradat, BaniBadr, Gkhisat, Mananieuh, Awlad Zubair, Awlad Sahayeh, Alwaylih, Sobha, Ghanimiyah, and Nawajat.* Other tribes also are *Kaja, Mima, Midub, Zaghawa, Alberti, Bargo, Alhalab, Alqemir, Aljame* and *Alqurean*. All of them have equal rights and duties. The only problems are overlapping in farmland, grazing, agriculture and small thefts, and these do not come out of being ordinary and are solved by the traditional sheikhs, the shepherds, the rural courts and the judiciary. In the local *Wad Banda* there are five Local administrations are: *Chertoia Wad Banda, Chertoia Eldam Jamad* and *Zurnakh, Chertoia Suqe Aljamal, Chertoia Armal and Chertoia Alkutra* (overlapping with the Elnuhud). The most important agricultural activities are crop cultivation such as Peanuts, millet, hibiscus, Sesame, corn and Watermelon together and within Gum Arabic gardens (*Wad Banda* locality, (2019) and FNC, (2019).

2.1.2 The Climate

The climate includes poor savannah on the northern and central part and rich savannah on the south parts of the localities, characterized by the variability in rainfall, temperature and relative humidity. Rainfall is concentrated during a few summer months (high seasonality) and to relatively few occasions (high intensity). The rainy season is from March to November with the highest precipitation generally occurring in August. The amount of rainfall is estimated from 352.3 to

1114.9 mm/year. The length of the rainy season depends on the degree of latitude. It decreases steadily towards the north. The mean annual temperature 31 varies between 24.4 °C to 39.3°C. The coldest months are December and January with mean temperatures of 24.4°C, and the hottest months are April, May and June with an average mean temperature exceeding 31°C. The average minimum relative humidity is about 32%, relative humidity to the maximum annual average of 40.5% and the year average is about 36.2%, while the highest humidity season occurs from March to November (Babanusa Metrological Station, 2016).

2.2 Data Collection

Primary data was collected during 2018/2019 from 85 respondents whom were purposively selected because they practice selective cutting. The selected respondents were interviewed using structures questionnaire. The questionnaire was designed with open and closed questions. Both quantitative and qualitative data were collected. The variables which studied were total area of farmland, area subjected to cutting, number and age of hashab trees subjected to cutting, purposes and season of cutting and rotation of farmland. In the same study effect of cutting trees on soil erosion, crop yield, wind speed and rainfall in addition to the dynamic of hashab trees in the area were also studied. Secondary data was collected from references, FNC reports and published related papers. The data collection was through review and screening the FNC law specifically the law of the year 2002 which considered the fundamental the most comprehensive law. The information was included the most relevant ones to the selective logging, conventional logging and reduced impact logging.

2.3 Data Analysis:

Data was analyzed in Microsoft Excel and also in Statistical Packages for Social Sciences (SPSS 16.00) where descriptive analysis was applied. Means, maximum, minimum and percentages were calculated. Correlation was also used where Pearson correlation was used to determine respondent's perception and importance of selective cutting.

3. RESULTS AND DISCUSSION

3.1 General Characteristics of Respondents

The results showed that males constituted 91.8% while females constituted 8.2% of the farmers. With regards to age gradation of respondents, those at age of 20 years, 21-30, 31-40, 41-50 and over 50 represented 3.5%, 34.1%, 18.8%, 10.6% and 32.9% respectively. Concerning education level, the uneducated people, at primary level, secondary level, and graduates were 34.1%, 36.5%, 27.1% and 2.4 % respectively. The source of income is generated from farming, wood felling by percentage of 98.8% and 1.2% respectively. The annual income ranged from 1000-20000 mentioned by 98.8% of respondents while from 21000-30000 SGD mentioned by 1.2% of respondents (Table 3.1).

Table 3.1: General characteristics of respondents in *Wad Banda* locality

Characteristics		Frequency	Percent (%)
Gender	Male	78	91.8
	Female	7	8.2
Age	20 years	3	3.5
	21-30 years old	29	34.1
	31-40 years old	16	18.8
	41-50 years old	9	10.6
	Over 50 years old	28	32.9
Education	Illiterate	29	34.1
	Primary	31	36.5
	Secondary	23	27.1
	Graduate	2	2.4
Source of income	Farming	84	98.8
	Wood cutting	1	1.2

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Table 3.2: Total area of farmland in *Wad Banda* locality

Area/ha	Frequency	Percent (%)
≤10	12	14.1
10-20	29	34.1
21-30	9	10.6
31-40	13	15.3
41-50	2	2.4
51-60	8	9.4
61-70	7	8.2
71-80	4	4.7
≥100	1	1.2
Total	85	100.0

3.2 Area Subjected to Cutting in 2018

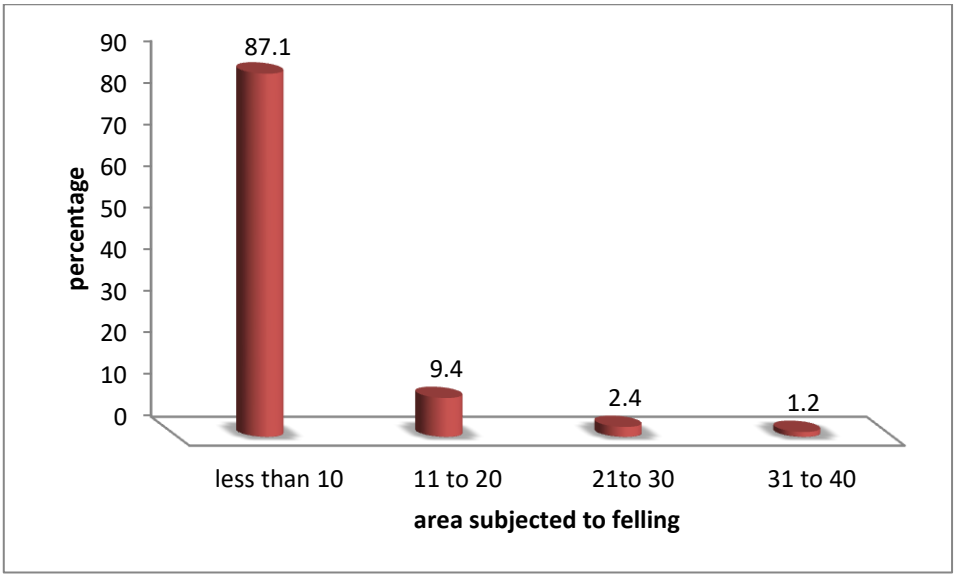

Figure 3.1: Total area subjected to cutting 2018 in *Wad Banda* locality

3.3 Number and age of Hashab Trees Subjected to Cutting in 2018

The results showed the number of Hashab trees subjected to be felled in 2018. There is 81.1% of respondents indicated cutting of areas less than 50 trees (Table 3.3). The age gradation of respondents , those at age of 5years, 6-10 years, 11-15 years, 16-20 years, 21-25 years, respondents 2.4%, 8.2%, 8.2%, 24.7%, 56.5%, respectively. On the same line all (100%) of respondents indicated that they use axe for cutting the trees (Table 3.4).

Table 3.3: Number of Hashab trees subjected to cutting in 2018

Classes	**Frequency**	Percent (%)
≥50 trees	69	81.2
51-100 trees	8	9.4
101-150 trees	3	3.5
151-200 trees	1	1.2
201-250 trees	2	2.4
251-300 trees	2	2.4
Total	85	100.0

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Table 3.4: Age of trees subjected to the cutting.

Age of trees	Frequency	Percent (%)
5 years	2	2.4
6-10 years	7	8.2
11-15 years	7	8.2
16-20 years	21	24.7
21-25 years	48	56.5
Total	85	100.0

3.4 Purposes of Tree Cutting and Season of Cutting

The purposes of tree cutting were for farming and building materials as indicated by 98.8% and 1.2 % of respondent respectively (Figure 3.2). The results showed the time of cutting the trees. There were 98.8% of respondent fell trees shortly before rainfall, and only 1.2 % of respondents fell trees in winter (Table 3.5).

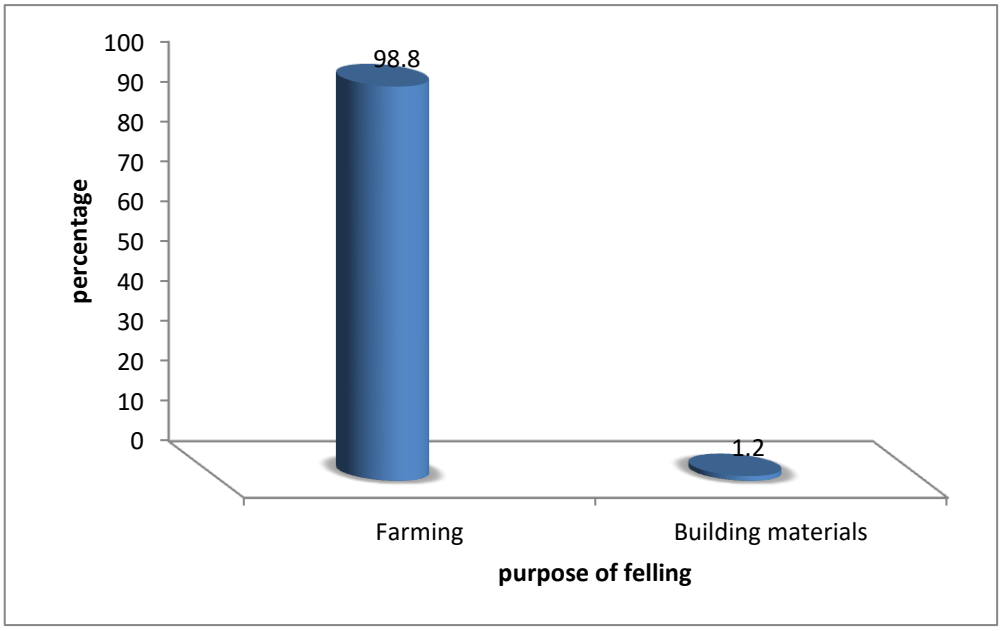

Figure 3.2 Purpose of tree cutting in *Wad Banda* locality

Table 3.5: Season of cutting trees

The season	Frequency	Percent (%)
Before rainfall	84	98.8
During winter	1	1.2
Total	85	100.0

3.5 Rotation of Clearing the Land:

The results showed the rotation of clearing the land. There was 90.6, 8.2% and 1.2% of respondents follow rotation of 5 years, 10 years, and 15 years respectively (Figure 3.3).

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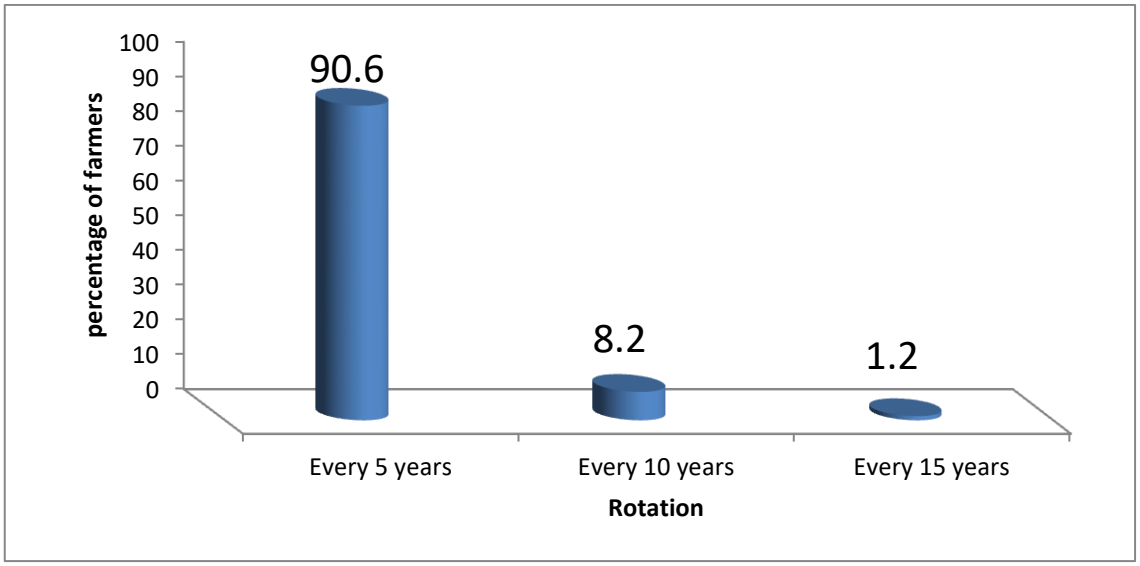

Figure 3.3 Rotation of clearing the land for agricultural purpose

3.6: Permission from FNC for Cutting

The results showed that 71.8% of respondents asked for permission while 28.2% of respondents do not ask for permission when they clear their land by cutting trees (Table 3.6)

Table 3.6: Permission from FNC for cutting

Permission status	Frequency	Percent (%)
Applied for permission	61	71.8
Did not apply for permission	24	28.2
Total	85	100.0

3.7: Effect of Cutting Hashab Trees on Soil erosion, Crop yield, Wind Speed and Rainfall

The results showed the perception of respondents regarding effect of cutting Hashab trees on soil erosion where 12.9% said cutting cause erosion while 87.1% said not. Concerning corps yield, 7.1% said cutting reduced the yield of crops while 92.9% of the farmers said no effect. The effect of wind speed was also pointed out by respondents where 98.8% of respondents said cutting increased wind speed while 1.2% of respondents said cutting decreased wind speed. Concerning rainfall, only 2,4% claimed that cutting increase rainfall however, 96.5% claimed that cutting decreased rainfall (Table 3.7).

Table 3.7: Respondents perception regarding effect of cutting Hashab trees on soil erosion, crop yield, wind speed and rainfall

variable	The status	Frequency	Percent (%)
Erosion	Cause erosion	11	12.9
	Not cause erosion	74	87.1
Yield	Reduces yield	6	7.1
	No effect	79	92.9
Wind speed	Increases wind speed	84	98.8
	Decreases wind speed	1	1.2
Rainfall	Increases rainfall	2	2.4
	Decreases rainfall	82	96.5
	No effect	1	1.2

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3.8 Respondents Perception on effect of Cutting trees on the Environment

Regarding the overall effect of cutting on the environment, 43.5%, 40%, 14.1%, 2.4% of respondents said that cutting results in decrease rainfall, cause soil deterioration, cause desertification and reduce crops yield respectively (Table 3.8). However, all (100%) respondents indicated that cutting has negative effect on environment.

Table 3.8: Overall effect of cutting trees regarding on environment

Effects	Frequency	Percent (%)
Decrease rainfall amount	37	43.5
Cause soil deterioration	34	40.0
Cause desertification	12	14.1
Reduce crop yield	2	2.4
Total	85	100.0

3.9: Current status of Hashab trees in the most Areas of *Wad Banda*

There was 57.6%, 5.9%, 22.4% and 14.1% of respondents indicated that the situation of hashab trees was intensively increased, relatively increased, deteriorated and stable respectively (Table 3.9).

Table 3.9: Current status of Hashab trees in *Wad Banda* area

The status	Percent (%)	Causes	Percent (%)
Intensively increased	57.6	Rainfall and Plantation	45
Relatively increased	5.9		55
Deteriorated	22.4	Hashab cutting	16.5
		Overgrazing	3.5
		Overcutting	8.2
Stable	14.1	-	71.8
Total	100	Total	

3. 10: Status and dynamic of Hashab trees in other Areas of *Wad Banda*

There was 27.1% of respondents said that hashab trees were disappeared in some areas e.g. (*Aldam jamad and Armel*) but 72.9% stated that there is no disappearance of hashab trees (Figure 3.4).

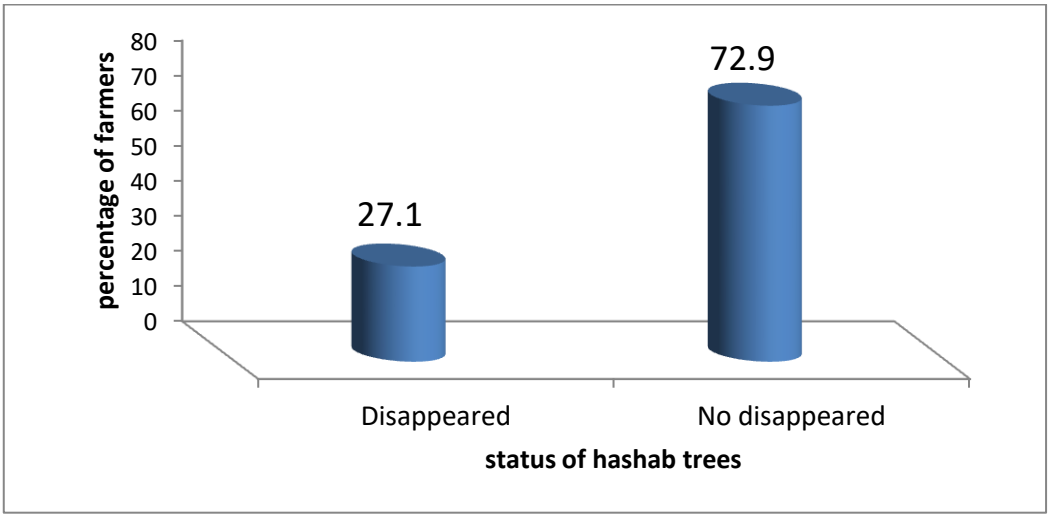

Figure 3.4 Status of Hashab trees in some areas

3. 11: Appearance of new species in *Wad Banda*

About 48.2% said other species were appeared while 51.8% said no species appeared in their farmland. The causes of appearance of other species than Hashab were increase of rainfall as said by 15.3% and planting by people as said by 25.9% (Table 3.10).

Table 3.10: Appearance of new species

	Frequency	Percent (%)	Causes	Percent (%)
Appeared	41	48.2	Increase of rainfall	15.3
			Planting by people	25.9
			Other factors	58.8
Not appeared	44	51.8	-	-
Total	85	100	-	-

3.12: The Efficiency of FNC role regarding Hashab trees Conservation

The results showed that FNC played great role toward Hashab plantation and conservation. The efficiency of FNC represented in encouraging people for planting and protection as indicated by 84.7% and protection as indicated by 15.3% (Table 3.11).

Table 3.11: The efficiency of FNC regarding Hashab trees conservation

	Frequency	Percent (%)
Protection	13	15.3
Encouraging planting and providing protection	72	84.7
Total	85	100.0

3.13 Correlation Analysis

Table 3.12 Correlations between education level and status of getting permission for cutting Hashab trees

The results of table 3.12 showed that correlation analysis revealed positive correlation between education level of respondents and the status of getting permission for cutting the trees. The correlation (0.08) was found weak.

		Education level	Permission from FNC
Education level	Pearson Correlation	1	**0.080**
	Sig. (1-tailed)		0.234
	N	85	85
Permission from FNC	Pearson Correlation	**0.080**	1
	Sig. (1-tailed)	0.234	
	N	85	85

4. DISCUSSION

4.1 General Characteristics Respondents

It was found that the most frequent farmers to the Forest National corporation offices were males who represent more than 90% who also represent more than third of the interviewees. It is also important to indicate that more than third of the interviewees finished their secondary level. This indicates that the education began to be the priority for the people in the area. Most of the interviewees depend on farming as the main source of income where the annual income of 98.8% of respondents ranged from 1000-20000 SDG however; little percentage (1.2%) of the interviewees gained income 21000-30000 SGD. This also means that agriculture could be reliable source of income for the people beside livestock, trade and other sources.

4.2 Farmland, Tree Cutting, Seasons and Purpose of Cutting

It was found that the total area of all (85) respondents was 2740 feddan. The average land for a farmer was 32.22 feddan. The total area targeted to be felled by all (85) farmers was 355 feddan with an average of 4.2 feddan for a farmer. The total number of trees occupied the area was 3593 however; the average number of trees per farmer targeted to cutting was 43 trees. Most of the interviewees (87.1%) cut 10 ha at least during 2018. There were more than 81.1% cut 50 trees per year for farming. The proportion of cutting in 2018 was 12.9%. This percentage is considered not high but since they practice agriculture, Gum Arabic production, and they also considered the natural regeneration under integrated production system so it is accepted. On the other hand due to high population and the land is limited so they are admitted by low to clear their land. According to (FNC, 2002), keeping 10% of the trees under rain-fed agriculture is must. Since 34.1% of respondents having between10-20 ha, this indicates that more than third of the community own small pieces of land where the practice small scale farming. More than half of respondent (56.5%) stated that the trees are cut at age of (21-25), concerning this age there will be no objection to cut Hashab trees at this age because tree will be averaged and less productive in term of Gum Arabic production. However, for the environment there might be an effect. It worth to mentioned that the majority of the community fell trees for farming and building materials, this because trees are the most available source of material there. On the same line more than 71.8% asked for permission, this means that the awareness about forest regulation is high.

4.3 Seasons and Rotations of Cutting

Since the majorities (98.8%) of respondents fall their trees shortly before rainfall, it means that the main reason of cutting trees is for farmland not for commercial use. It is worth mentioning that more than (90.6%) of respondents followed the rotation of 5 years. This helps for tree conservation and allows the trees to reach the optimum production age and it also allows re-growth by coppicing.

4.4 Effect of Cutting Hashab Trees on Soil erosion, Crop yield, Wind speed and Rainfall

The respondents stated that cutting Hashab tree affect the soil, crops yield and amount of rainfall but there was differences in their effects. Only (13%) of respondents observed that cutting trees cause erosion. This might be due to the cutting of small area in average (12%). Regarding the yield also only (7.1%) observed that cutting reduced the yield. This might be attributed to that cutting is not son intensive. The percentage of cutting in the whole area by farmers was 27%. However, the percentage of cutting per farmer in his own farm was 25.6%. It was found that if a farmer own 43 trees in his farm he fell only 11 trees from them in a year. It is worth mentioning that, in some cases trees and farm land are deliberated that is why a number of three (3) trees was found as an average over all land. In the same line most of the respondents (98.8%) believe that of selective cutting increased wind speed. This is widely known because Hashab trees were dominant tree there and play great role as shelter belt. Rain fall decrease was observed by majority of respondents (96.5%) of respondent as a result of cutting trees. Regarding the overall effect of cutting on the environment, all (100%) of respondent stated occurrence of negative impact on environment. the most frequent impacts were drought (43.5%), soil deterioration (40%), desertification (14.1%) and reduction in crop yield (2.4%).

4.5 Current status of Hashab trees in the Area

From the result it was found that more 50% of respondents observed that Hashab tree were increased however, 27% stated that there is disappearance of Hashab trees in some areas such in south west directions. This could be attributed to the expansion of agriculture. However, 73% mentioned that Hashab in their areas is not disappeared but in contrast it is in increase. This was in the west east direction.

4.6 The efficiency of FNC regarding Hashab trees Conservation

The majority (84.7%) of respondent acknowledge the Forest National Corporation role. This might be attributed to the cooperation between the forest sector and the people particular in protection and conservation. FNC allow farming within Hashab trees without exposing the trees to danger. On same line FNC provide extension packages through the media.

4.7 Correlation Analysis

The correlation analysis between respondent's perception and importance of selective cutting was positive but weak. That means that some of the respondents are aware with the importance of permission from FNC. The interpretation the

relationship as weak means they do not always apply for permission and not all of them do that. The situation in this case necessitate intervention by FNC to make people aware about importance of permission and the risk of non-asking for permission.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This study concluded to the following: males constituted most of the farmers who annually apply to get permission for land clearance for the purpose of agricultural land extension. Their education level is mainly the primary levels. Their main source of income is from agriculture and Non Timber Forest Products. There is a big variation in their annual income as well as high variation in piece of land owned. Axe still is the most common and only one tool used for cutting. Regarding the Hashab tree status, more than half of respondents indicated that it was increased last ten years. The total area targeted to be cut by all (85) farmers was 355 feddan (149.1 ha) with an average of 4.2 feddan (1.8 ha) per farmer. The proportion of tree cutting in 2018 was 12.9%. Most of respondents stated that selective cutting of Hashab trees does not have much effect on the farmland and does not negatively effect of crops yield but it increases the wind speed. However, the main reasons caused farmland degradation were overcutting and overgrazing. The role of Forest National Corporation was obvious to the respondents through protection and supporting people for plantation.

5.2 Recommendations

1. Declining tree cutting to the minimum level (≤5%) and organizing it based on rotation, tree age and area of cutting
2. Activation of forest law and controlling the current grazing system
3. Encouraging people to understand and to adopt the idea of ideal selective cutting of trees to minimize soil erosion and to decrease wind speed.

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