Environmental and Medicinal value analysis of Moringa (*Moringa oleifera*) tree species in Sanja, North Gondar, Ethiopia.

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ABSTRACT

This study was conducted in Sanja district that aimed on the, Environmental and Medicinal value analysis of Moringa (Moringa oleifera) tree species. The study aimed to assess the roles of Moringa (Moringa oleifera) tree species for environmental, economic and its medicinal values. Step by step procedures were designed to take soil samples from the field. Simple random sampling method was used to take samples. Sample plots were laid to takesample from the soil and DBH of trees were measured. The soil samples were taken from Moringa land and areas with no Morinaga trees grown for organic carbon determination and soil fertility estimation of the soil for comparative analysis. Based on the study 98.742 ton/ha and 4.894 ton/ha the maximum and minimum carbon stocks observed in the above ground biomass, respectively. On the other hand, the carbon content in the soil carbon pool was 587.21118 ton/ha and 101.3601 ton/ha maximum and minimum values per plot of the study site respectively on the Moringa site. But, the maximum and minimum carbon content in areas with no Moringa tree was 485.57 ton/ha and 29.71 ton/ha respectively. The data were analyzed using Statistical Package for Social Science (SPSS) software version 20.

Keywords: *Carbon stocks, Economic, Medicinal value, Moringa ,Sanja*

1. INTRODUCTION

1.1. Background

The Moringa tree can play an important role in mitigating climate change and increasing the incomes of poor farmers in Africa, but its development needs to be carefully implemented. There is an urgent need to implement climate-smart policies that can build more resilient food systems and combat climate change. There is great potential for the moringa tree to not only store carbon, if it is grown on a much larger scale, but to improve the livelihoods of many farmers in sub-Saharan Africa.

The World Health Organization (WHO) and other international humanitarian relief organizations have used Moringa to combat malnutrition in many parts of the world. The many medicinal, nutritional, industrial, and agricultural uses of Moringa are well documented. Fahey (2005) said that "the nutritional properties of Moringa are now so well known that there seems to be little doubt of the substantial health benefit to be realized by consumption of Moringa leaf powder in situations where starvation is imminent." The interest generated from the second international conference held in 2006 in Ghana on the uses of the Moringa tree has been so great that several national Moringa associations have already been formed in African countries. Moringa is well adapted to most of sub-Saharan Africa, where the world's worst rates of malnutrition are found (Kennedy, 2011).

The Moringa tree offers new opportunities to small scale farmers and contributes to the development of natural resources but will need strong policies, research and market development strategies in order to realize its full potential. The integration into food systems should be both lateral within Africa and vertical as product development, coupled with market development and penetration efforts, to facilitate the entry of Moringa products into both the developed countries and emerging economy markets. All of this should be carried out in a way that serves the fundamental interests of all stakeholders, with the most important consideration given to the vulnerable, poor, rural communities wherein primary production occur. A dynamic new suite of bio-products can be produced from agro-forestry systems that will at the same time contribute to the restoration of badly degraded ecosystems and agricultural site productivity.

One practical step to compensate for the several unpreventable carbon dioxide emissions is to plant trees. This is because trees take carbon dioxide out of the atmosphere and they release oxygen in return. The type of trees planted will have a great influence on the environmental outcome. According to Japanese study (Villafuerte, and Villafurte-Abonal, 2009) the rate of absorption or assimilation of carbon dioxide by the Moringa tree is twenty times higher than that of general vegetation. The Moringa tree therefore will be a useful tool in the prevention of global warming. The seeds and seed cake of Moringa oleifera are recognized as effective primary coagulant in water treatment as they have the capacity to remove up to 99% of bacteria from water (Foidl, *et al.*, 2001, Villafuerte, and Villafurte-Abonal 2009). Fresh Moringa leaves can be cooked and eaten as vegetables or processed into tea, powder and other pharmaceutical preparations. Moringa leaves, shoots and seeds can be used as green teas, animal feed with tremendous results. A juice can be extracted from the fresh leaves which can be used as a growth hormone that can increase yields of crop by 25-35% (Foidl, *et al*., 2001).

Moringa is thus a multipurpose plant that is difficult to overlook in today's battle with the climate. It is fast growing and well adapted to growing in adverse conditions where many plants would not be able to requiring at least 400mm of rain per annum. It presents itself as an easy plant for agri-business, poverty mitigation and a climate smart choice of plant to be developed for the benefit of present and future generations.

1.2. Statement of the Problems

The extent to which GHGs especially CO_2 absorbed by “sinks” such as forests have been the focus of international negotiations. Thus, it is widely recognized that large scale reductions in CO_2 emissions are required to fairly strict limits on how much carbon absorbed so as to mitigate the climate change. According to Perschel *et al.* (2007), fossil fuel combustion, industrial processes, and unprecedented land use conversion have led to rising levels of CO_2 and other GHGs in the atmosphere. This in turn has created “the greenhouse effect,” which if unabated will continue to warm the earth resulting in devastating ecological, social, and economic consequences.

Researches were not done on the multipurpose benefits of Moringa trees in Ethiopia. It has many advantages from environmental, economic and cultural perspectives.

The environmental impacts caused by human industry are compromising the sustainability of current economic activities, and degrading the natural life support systems, on which we and all other species depend. Climate change is expected to trigger severe consequences to smallholder poor farmers who dominate the agriculture sector in Africa.

The presence of long taproot makes Moringa resistant to periods of drought. For hundreds of millions of people the threat of famine is connected to the change of the climate. The effects of climate change are making droughts more of a norm than an exception. This is a pattern that places some of the most vulnerable communities in an increasingly precarious position when it comes to meeting basic food needs. By the time shortages and hunger reach "emergency" levels and warrant aid; families, communities, agricultural practices and lands will have suffered greatly. Importing vitamin pills or nutrition bars is not a long term solution for chronic food shortages or climate change mitigation. To know which aid is really durable to combat food shortages and efficient for climate change mitigation, it is good to look at the potential that is already available in developing and third world countries. Moringa is a very simple and readily available solution.

1.3. Objective of the study

1.3.1. General objective

The overall objective of this study was to assess the roles of Moringa (*Moringa oleifera*) tree species for environmental, economic and its medicinal values.

1.3.2. Specific objectivities

- To estimate the carbon that is sequestered in soils of *Moringa oleifera* tree
- To estimate the carbon that is sequestered in above ground biomass
- To estimate the carbon that is sequestered in below ground biomass
- To assess the comparative advantage of *Moringa oleifera*
- To recommend the farmers to plant the trees

2. MATERIALS AND METHODS

2.1. Description of the study area

The study area is located in North Gondar, Ethiopia. Tach Armachiho, Sanja is one of the 105 woredas in the Amhara region of Ethiopia. The rainfall pattern was unimodal, stretching from May to September with the maximum rain from June to August. Annual rainfall ranges between 800 and 1800mm. The annual temperature ranges from 25 ^{o}C to 42^{o}C.

2.2. Sampling Techniques

Simple random sampling method was used to take samples. Sample plots were laid along line transects and soil and DBH were taken based on age variation of species. The diameter was measured at breast height (DBH, 1.3 m height from the ground) to estimate biomass. The top part of the soil will not be taken when we take soil samples to avoid ambiguity of carbon stocks due to litter fall. And also soil samples from other bare areas other than Moringa land were taken for comparison of carbon content. Twenty samples from each land use types were taken for analysis.

2.3. Sampling procedures

2. 3.1. Estimation of carbon stocks

The methodology and procedures used to estimate carbon stocks are simple step-by-step procedures using standard carbon inventory principles and techniques. Procedures were based on data collection and analysis of carbon accumulating in the above-ground biomass; below-ground biomass, leaf litter, and soil carbon using verifiable modern methods. As indicated in Pearson *et al.* (2005 and 2007), the followings were the steps followed in carbon measurement during the field data collection.

2. 3.1.1. Field Measurements

Ground inventory data of tree parameters i.e., DBH of the trees were collected.

2. 3.1.2. Field Carbon Stock Measurement

The major activities of carbon measurement during the field data collection were above-ground tree biomass, below-ground biomass, leaf litter and soil organic carbon measurements. Detailed methods are explained under the following sub-headings.

a. Above Ground Tree Biomass (AGB)

The DBH (at 1.3m) and height of individual trees greater than or equal to 5cm DBH were measured in each sampling plots using Clinometer and diameter tape. Quadrates with a size of 1 m × 1 m were established to sample litters. In each sample plots a total of five small quadrates were laid to minimize heterogeneity. The litter sample was taken in sub-quadrate of 1 m × 1 m along diagonal from one corner to the other.

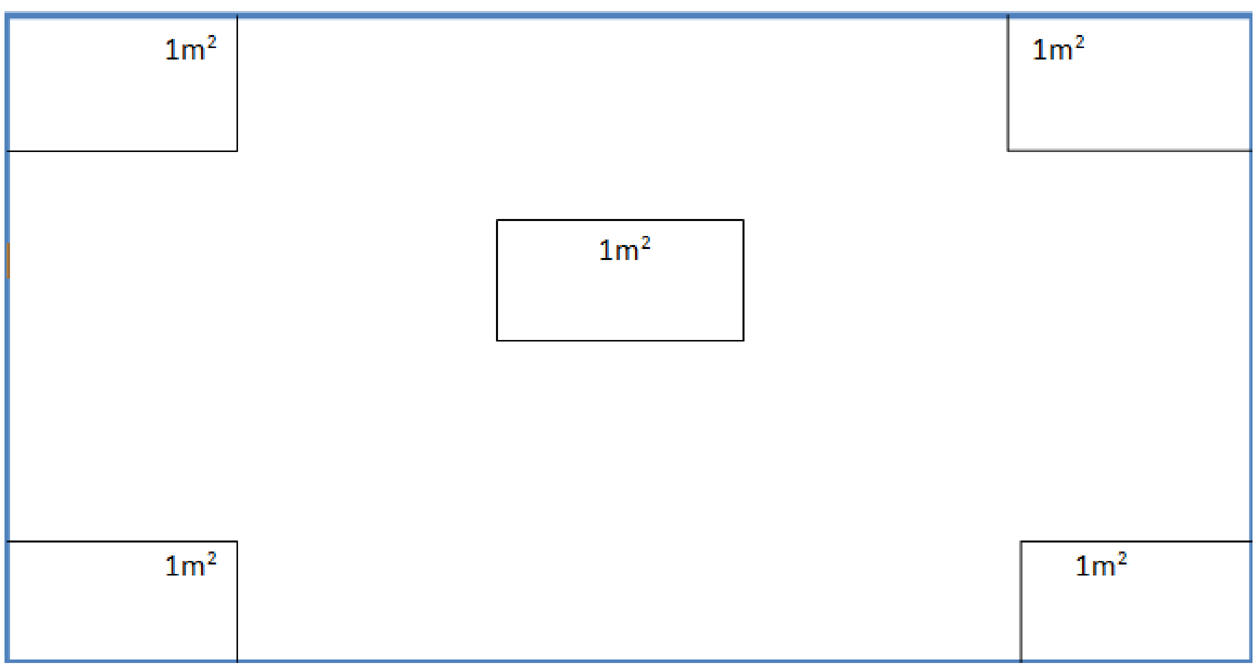

Figure 1: Size of sub sample plots in which litters were collected

b. Soil Organic Carbon (SOC)

In order to obtain an accurate inventory of organic carbon stocks in mineral or organic soil, three types of variables must be measured: (1) soil depth, (2) bulk density and (3) the concentrations of organic carbon within the sample (Pearson *et al.*, 2005). For convenience and cost-efficiency, it is recommended to take samples to a constant depth, maintaining a constant sample volume rather than mass. Composite samples were collected from one plot from three depths (0-10 cm, 10-20 cm, and 20-30 cm) by digging the soil with the help of standardized soil sampling corer. The soil samples collected from plot were brought to the laboratory placing in a sample paper bags to determine the bulk density and amounts of soil organic matter.

2. 3.1. 3. Estimation of Above Ground Tree Biomass (AGTB)

Bhishma *et al.* (2010) defined allometric equation as a statistical relationship between key characteristic dimension(s) of trees that are fairly easy to measure, such as DBH or height, and other properties that are more difficult to assess, such as above-ground biomass.

The equation used to calculate the above ground biomass is given below:

$$AGB = 34.4703 - 8.0671(DBH) + 0.6589(DBH^2) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \text{(equ.2)}$$

Where, AGB is above ground biomass, DBH is diameter at breast height.

2. 3.1.4 Estimation of Below Ground Biomass (BGB)

Below ground biomass estimation is much more difficult and time consuming than estimating aboveground biomass (Geider *et al.,* 2001). Roots play an important role in the carbon cycle as they transfer considerable amounts of Carbon to the ground, where it may be stored for a relatively long period of time. The plant uses part of the Carbon in the roots to increase the total tree biomass through photosynthesis, although Carbon is also lost through the respiration, exudation and decomposition of the roots. Some roots can extend to great depths, but the greatest proportion of the total root mass was within the first 30 cm of the soil surface. Carbon loss or accumulation in the ground was intense in the top layer of soil profiles (0-20 cm.). Sampling was concentrated on this section of the soil profile.

According to MacDicken (1997), standard method for estimation of below ground biomass can be obtained as 20% of above ground tree biomass i.e., root-to-shoot ratio value of 1:5 was used. The equation is given below:

$$BGB = AGB \times 0.2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \text{(equ.3)}$$

Where, BGB is below ground biomass, AGB is above ground biomass, 0.2 is conversion factor (or 20% of AGB).

2.3.1.5. Estimation of Carbon Stocks in the Leaf Litter Biomass

According to Pearson *et al.* (2005), estimation of the amount of biomass in the leaf litter can be calculated by:

$$\boldsymbol{LBM} = \frac{\boldsymbol{Wfield}}{\boldsymbol{A}} * \frac{\boldsymbol{Wsub\ sample(dry)}}{\boldsymbol{Wsub\ sample(fresh)}} * \frac{\mathbf{1}}{\mathbf{10{,}000}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(equ.4)}$$

Where: LBM = Litter (biomass of litter ha^{-1})

W_{field} = weight of wet field sample of litter sampled within an area of size 1 m^2 (g);

A = size of the area in which litter were collected (ha);

W sub-sample, dry = weight of the oven-dry sub-sample of litter taken to the laboratory to determine moisture content (g), and

W sub-sample, fresh = weight of the fresh sub-sample of litter taken to the laboratory to determine moisture content (g).

2. 3.1.6. Carbon stocks in dead litter biomass

$$C_L = LBM \times \%C \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. \text{(equ.5)}$$

Where, C_L is total carbon stocks in the dead litter in t ha^{-1}, % C is carbon fraction determined in the laboratory (**Pearson** *et al.,* 2005).

2.3.1.7. Estimation of Soil Organic Carbon

The carbon stock density of soil organic carbon can be calculated as recommended by Pearson *et al.* (2005) from the volume and bulk density of the soil.

$$V = h \times \pi r^2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. \text{(equ.9)}$$

Where, V is volume of the soil in the core sampler augur in cm^3, h is the height of core sampler augur in cm, and r is the radius of core sampler augur in cm (**Pearson** *et al.*, 2005). More over the bulk density of a soil sample can be calculated as follows:

$$BD = \frac{W_{av,\ dry}}{V}$$ …………………………………… (equ.10)

Where, BD is bulk density of the soil sample per, $W_{av,\ dry}$ is average air dry weight of soil sample per the quadrant, V is volume of the soil sample in the core sampler auger in cm^3 (**Pearson** *et al.*, 2005).

$$SOC = BD * D * \% C$$ ………………………………... *(equ.11)*

Where, SOC= soil organic carbon stock per unit area (t ha^{-1}),

BD = soil bulk density (g cm^{-3}),

D = the total depth at which the sample was taken (30 cm), and

%C = Carbon concentration (%)

2.3.1.8 .Total Carbon Stock Density

The carbon stock density is calculated by summing the carbon stock densities of the individual carbon pools of the stratum using the Pearson *et al.* (2005) formula.

Carbon stock density of a study area:

$$C_{density} = C_{AGB} + C_{BGB} + C_{Lit} + C_{DWS} + SOC$$ ……………………….. *(equ.12)*

Where:

$C_{density}$ = Carbon stock density for all pools [ton ha^{-1}], C_{AGTB} = Carbon in above -ground tree biomass [t C ha^{-1}], CBGB = Carbon in below-ground biomass [t C ha^{-1}], C_{Lit} = Carbon in dead litter [t C ha^{-1}], C_{DWS} = Carbon in dead wood and stumps, SOC = Soil organic carbon. The total carbon stock is then converted to tons of CO_2 equivalent by multiplying it by 44/12, or 3.67 (Pearson *et al.*, 2007).

3. RESULTS AND DISCUSION

3.1 Results

3.1.1. Estimation of Biomass and carbon stocks in different pools

3.1.1.1. Above ground biomass **(AGB***)*

The result indicated that the maximum biomass per plot per hectare was 197.485 in plot six and the minimum was 9.788 ton/ha in plot eleven.

3.1.1.2. Estimation of carbon stocks in AGB

A generic conversion factor of 50% has been widely used to estimate the Carbon stocks in plant biomass as indicated by (Clark *et al*., 2001, Chave *et al*., 2008). The result of this study showed that 98.742 ton/ha and 4.894 ton/ha the maximum and minimum carbon stocks was observed in the above ground biomass, respectively. The results are more or less similar to the previous researches of bove round biomass of afromontane forest which were 403 ton/ ha, 754.5 ton/ ha, and 567.2 ton/ ha as indicated by (Getachewesfaye,2007).

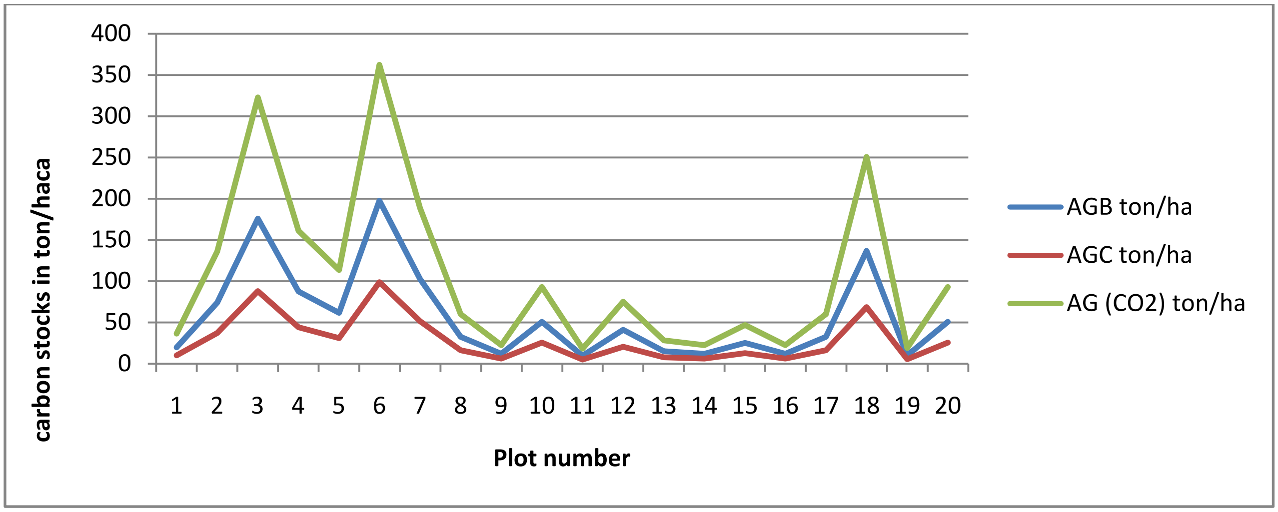

Figure 2: Above ground biomass and carbon with respect to plot number

3.1.1.3. Estimation of carbon stocks in BGB

The result of this study showed that 39.497 ton/ha and 1.957 ton/ha were the minimum and the maximum values of BGB respectively.

3.1.1.4. Estimation of carbon stocks in BGC

The result of this study showed that 19.749 ton/ha and 0.979 ton/ha were the minimum and the maximum below ground carbon stocks respectively. Like that of above ground carbon dioxide, the carbon dioxide sequestered by below ground biomass was also increased with an increasing of below ground biomass and carbon stocks. In this study, the differences in biomass and carbon accumulation among plots could be largely due to differences in the growth rates of plants as indicated by (Redondo, 2007). This is graphically shown below:

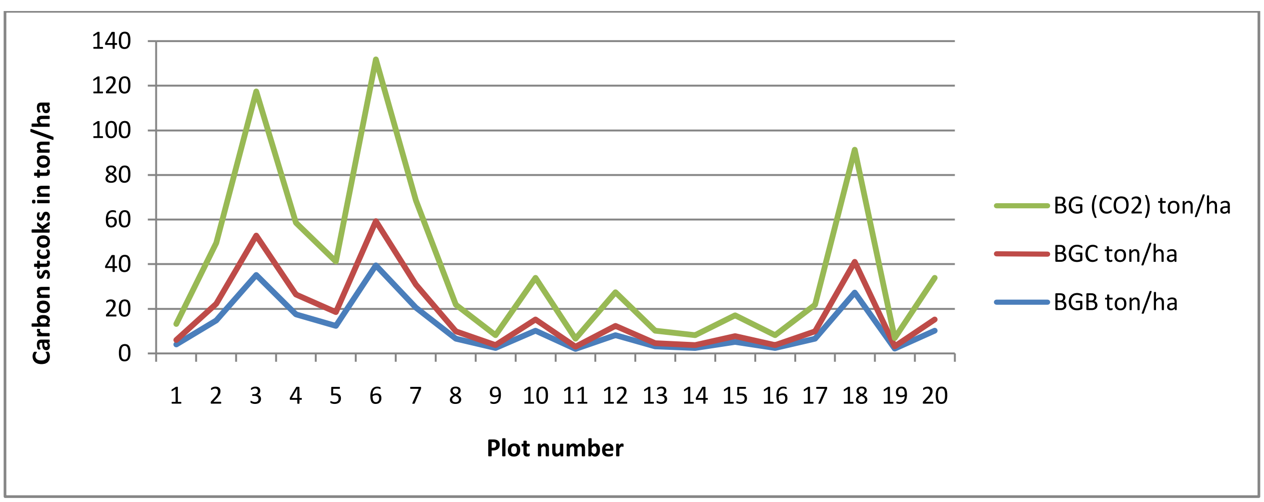

Figure 3: Below ground biomass and carbon with respect to plot number

3.1.1.5. Estimation of carbon stocks in litter biomass

The analysis of concentration of litter carbon per sample plot in the laboratory was found to be a minimum of 2.978% and maximum of 8.86%. This shows a high variation among plots. Based on the result obtained, the minimum biomass value recorded was 0.00093 ton/ ha in plot nine and the maximum value was 0.0028 ton/ ha in plot eight. The maximum and minimum carbon stocks in litter biomass were 0.021 ton/ ha and 0.0024 ton/ ha, respectively. The relatively low quantities of Carbon stored in litter carbon stock in the studied area may be due to the high decomposition rate and sweeping as reported in a 10-year study by Tang *et al. (*2010).

3.1.1.6. Estimation of carbon stocks in SOC

3.1.1.6.1. Bulk density

The bulk density was computed on the soil profile. The bulk density of the soil found was 0.159 g/cm^3 minimum value in plot two and 0.522 g/cm^3 maximum value in plot nine.

3.1.1.6.2. Soil organic carbon

The laboratory results for the organic carbon of the sample soils are shown in (appendix 3). The result showed that, the highest percentage of organic carbon was 28.71% where as 6.47% is the lowest value and the average percentage value of organic carbon in this pool as a whole was found to be 14.25%. On the other hand, the carbon content of the soil carbon pool was 587.21118 ton/ha in plot fifteen and 101.3601 ton/ha in plot eleven maximum and minimum values per plot of the study site respectively. As indicated in Morisada *et al*. (2004), Leifeld *et al*. (2004), the bulk density of soil depends on several factors such as compaction, consolidation and amount of soil organic carbon present in the soil but it is highly correlated to the organic carbon content. This indicates that, there was high content of soil organic matter in the mineral soils. The soil organic carbon in forest soil depends upon the forest type, climate, moisture, temperature, aspect, altitude, slope gradient and types of soil. The soil is the most important carbon pool in this study forest as indicated in (Russell *et al*., 2007; Schedlbauer and Kavanagh, 2008; Solis and Moya, 2004; Tschakert *et al*., 2007) but, changes in carbon stocks within this pool are not easy to assess a low enhancement of soil carbon as a result of forest tree plantations.

3.1.2. Soil carbon sequestration

The mean value of the sum of soil carbon sequestration in all plots along the soil profile is shown in Appendix 3. Based on the result that obtained, 371.994 ton/ha and 2155.067 ton/ha was the minimum and maximum CO_2 values that is sequestered in the study area respectively.

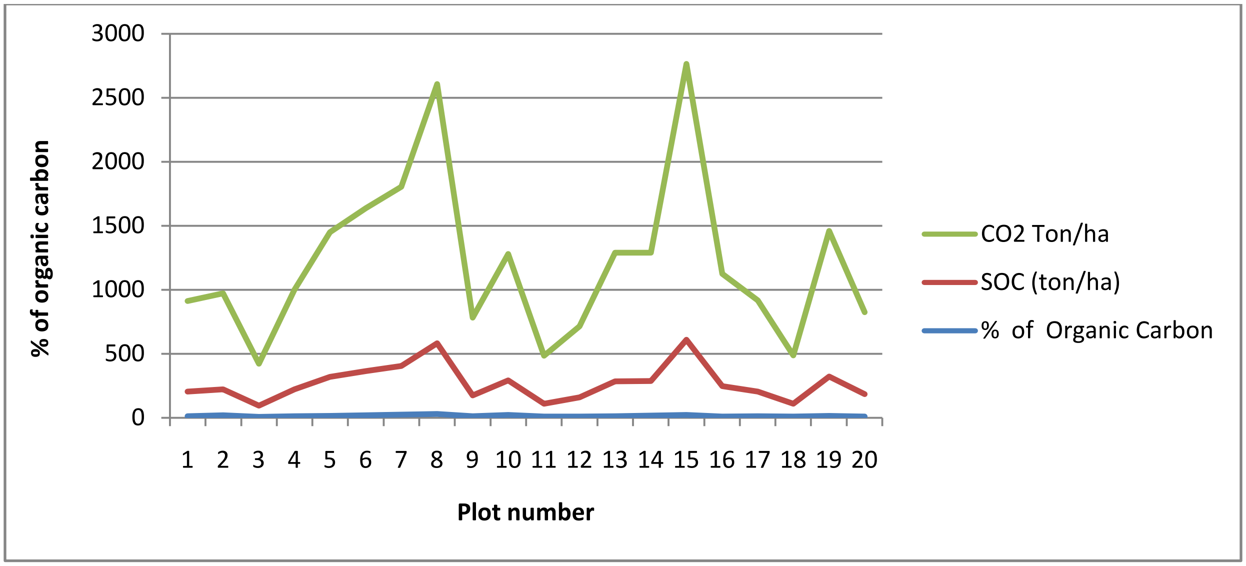

Figure 4: Percentage of organic carbon with respect to plot number

3.1.1.7. Estimation of carbon stocks in bare soil with no Moringa tree

The following table shows the maximum and the minimum values of carbon in each sampled plots. Based on the result, 485.57 ton/ha and 29.71ton/ha were the maximum and the minimum values of carbon respectively. The low values of carbon in each sampled plots may be due to the absence of Moringa trees in that area; this in turn makes the soil low in organic carbon content.

In all carbon pools there was a significance difference in carbon stocks of the sampled soils in both land with Moringa tree and the bare lands at 95% confidence interval (α=0.05).

Table 1: Carbon stocks in bare soil (areas with no Moringa tree)

Plot No	Volume	Soil depth (cm)	bulk density (g/cm^3)	% of Organic Carbon	Oven dry weight (g)	SOC (ton/ha)	CO_2 Ton/ha
1	98.125	30	0.215032	22.17	21.1	143.01	524.87
2	98.125	30	0.158981	6.23	15.6	29.71	109.05
3	98.125	30	0.252739	32.75	24.8	248.32	911.32
4	98.125	30	0.296561	17.67	29.1	157.21	576.95
5	98.125	30	0.401529	21.12	39.4	254.41	933.68
6	98.125	30	0.314904	19.32	30.9	182.52	669.84
7	98.125	30	0.343439	17.43	33.7	179.58	659.07
8	98.125	30	0.335287	30.56	32.9	307.39	1128.13
9	98.125	30	0.521783	31.02	51.2	485.57	1782.05
10	98.125	30	0.19465	32.54	19.1	190.02	697.36
11	98.125	30	0.405605	23.74	39.8	288.87	1060.16
12	98.125	30	0.322038	18.79	31.6	181.53	666.23

13	98.125	30	0.316943	25.78	31.1	245.12	899.60
14	98.125	30	0.277197	28.57	27.2	237.59	871.94
15	98.125	30	0.167134	37.72	16.4	189.13	694.10
16	98.125	30	0.206879	41.07	20.3	254.89	935.47
17	98.125	30	0.21707	31.61	21.3	205.85	755.46
18	98.125	30	0.36586	19.05	35.9	209.09	767.36
19	98.125	30	0.256815	26.97	25.2	207.79	762.59
20	98.125	30	0.289427	27.08	28.4	235.13	862.93

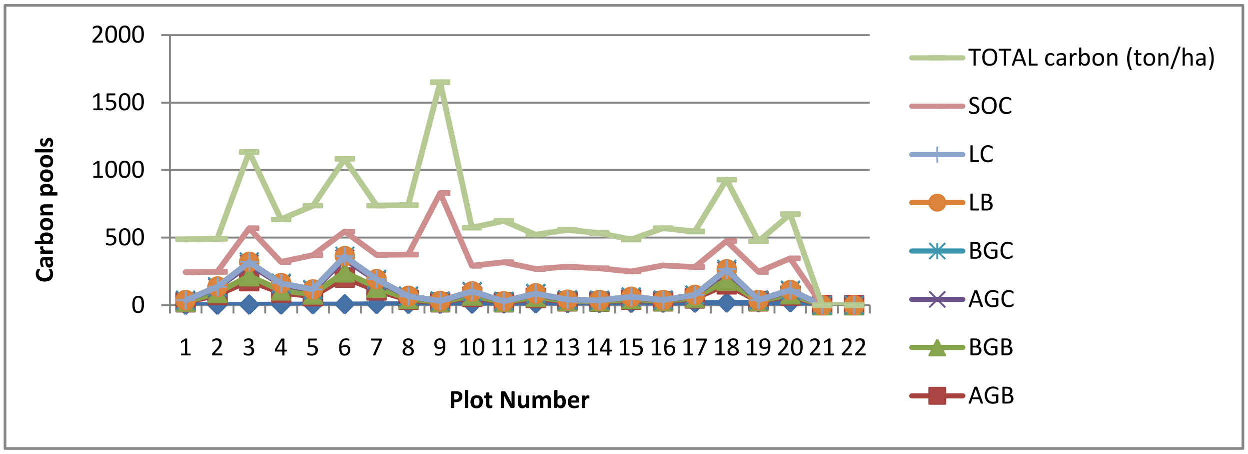

Figure 5: Total carbon stocks in different pools with respect to plot number

3.2. Medicinal values of Moringa Oleifera

From the interviewed sample respondents, 98% said that, Moringa Oleifera is a nutrient plant that can help to maintain normal blood sugar levels. Moringa Oleifera holds so much promise for those who suffer from diabetes. This is primarily because of its many amazing, natural benefits. Moringa Oleifera has been shown to naturally boost the immune system, which usually becomes compromised in those who suffer from type 1 and type 2 diabetes. Moringa Oleifera has also been shown to possess many key anti-inflammatory benefits; diabetes often causes circulatory problems which can be managed through anti-inflammatory supplements.

There are no negative side effects associated with Moringa Oleifera use, meaning that it is a safe, natural way for people to manage their blood sugar and care for their diabetes symptoms. It's just one more option for the many people who have to cope with this serious condition. (Admin, 2010). Unexpected benefits of Moringa include an apparent cure for tapeworms and help in controlling diabetes and high blood pressure. (Fuglie, 2001).

Several studies have shown Moringa's health benefits.

- It is a strong antioxidant effective against prostate and skin cancers, an anti-tumor and an anti-aging substance.
- It modulates anemia, high blood pressure, diabetes, high serum or blood cholesterol, thyroid, liver, and kidney problems.
- It has strong anti-inflammatory properties ameliorating rheumatism, joint pain, arthritis, edema, and Lupus.

- It is effective against digestive disorders including colitis, diarrhea, flatulence (gas), ulcer or gastritis.
- As an anti-bacterial, anti-microbial, and anti-viral agent, it is affective against urinary tract infection, typhoid, syphilis, dental caries and toothaches, fungus, thrush, common cold, Epstein-Barr Virus, Herpes- Simplex, HIV AIDS, warts, parasites, worms, schistosomes, and trypanosomes.
- As a detoxifying agent, it is effective against snake and scorpion bites.
- It is effective against nervous disorders including headaches, migraines, hysteria, and epilepsy. (Richardson, 2009)

3.3. Moringa Helps Plants to Grow & Nourishes Soil

Moringa also contain plant hormones (including Zeatin) that plants and crops to produce greater yields. Respondent farmers told us that, the plant also improve soil fertility. Researchers have found evidence, that Moringa can be used as a foliar spray to increase plant growth and as a green manure to improve soil fertility. Juices from fresh Moringa leaves can be used to produce an effective (spray containing) plant growth hormone, increasing yields by 25-30% for nearly any crop. One of the active substances is Zeatin: a plant hormone from the cytokinins group (Price, 1985).

3.4. Moringa as water purification

The local people used Moringa powder for polluted water purification. In the same talken, in the Sudan, dry *Moringa oleifera* seeds are used in place of alum by rural women to treat highly turbid Nile water (Jahn, 1986). In Northern Nigeria, the fresh leaves are used as a vegetable, roots for medicinal purposes and branches for demarcation of property boundaries and fencing. Studies by Eilert *et al.* (1981) identified the presence of an active antimicrobial agent in *Moringa*

oleifera seeds. The active agent isolated was found to be 4a Lrhamnosyloxy- benzyl isothiocyanate, at present the only known glycosidic mustard oil. Madsen *et al.* (1987) carried out coagulation and bacterial reduction studies on turbid Nile water in the Sudan using *Moringa oleifera* seeds and observed turbidity reduction of 80-99.5% paralleled by a bacterial reduction of 1-4 log units (90-99.9%) within the first one to two hours of treatment, the bacteria being concentrated in the coagulated sediment.

4. CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

This study has tried to investigate the economical, Environmental and Medicinal values of Moringa Oleifera Sanja District. Moringa is a multipurpose plant that is difficult to overlook in today's battle with the climate. It is fast growing and well adapted to growing in adverse conditions where many plants would not be able to requiring at least 400mm of rain per annum. It presents itself as an easy plant for agri-business, poverty mitigation and a climate smart choice of plant to be developed for the benefit of present and future generations.

The environmental impacts caused by human industry are compromising the sustainability of current economic activities, and degrading the natural life support systems, on which we and all other species depend. Therefore, Moringa Oleifra offers new opportunities to small scale farmers and contributes to the development of natural resources but will need strong policies, research and market development strategies in order to realize its full potential.

Valuation of economical, environmental and medicinal values has a great importance in the decision making process of developmental and environmental planning which is missed for the long time in the ecosystem management decision making process like rehabilitation, conservation and restoration of ecosystem services for long time for particular area in Ethiopia.

It has also a great potential for prevention of different diseases like nutrient deficiency, cancer, anemia as well as for dirty water purification. Moringa powder contains sufficient amount of vitamins, nutrients and chemicals in it. This makes the tree a medicine for many different diseases.

Moringa Oleifera also sequesters more Carbon with its parts. Researchers indicated that, the carbon sink potentials of the Moringa tree is twenty times greater than that of general vegetation. Therefore, planting of this tree in different parts of the country will mitigate the impacts of climate change or sustainable life.

4.2 Recommendations

Based on the findings of this study, the following recommendations were forwarded:

- The government should initiate the people to plant this plants for multiple purpose
- Promote planting of this species around the residence home for private use
- Raising awareness about the merits of Moringa Oleifera to the people
- Promote planting of this species on degraded areas to restore the site and micro climate amelioration

APPENDICES

Appendix 1: Mean above and below ground biomass and carbon stocks of taken samples

Plot Number	Average DBH(cm)	AGB ton/ha	BGB ton/ha	AGC ton/ha	AG (CO_2) ton/ha	BGC ton/ha	BG (CO_2) ton/ha
1	10	19.6893	3.93786	9.84465	36.12987	1.96893	7.225973
2	16	74.0751	14.81502	37.03755	135.9278	7.40751	27.18556
3	22	175.9017	35.18034	87.95085	322.7796	17.59017	64.55592
4	17	87.7517	17.55034	43.87585	161.0244	8.77517	32.20487
5	15	61.7163	12.34326	30.85815	113.2494	6.17163	22.64988
6	23	197.4851	39.49702	98.74255	362.3852	19.74851	72.47703
7	18	102.7461	20.54922	51.37305	188.5391	10.27461	37.70782
8	12	32.5467	6.50934	16.27335	59.72319	3.25467	11.94464
9	8	12.1031	2.42062	6.05155	22.20919	1.21031	4.441838
10	14	50.6753	10.13506	25.33765	92.98918	5.06753	18.59784
11	6	9.7881	1.95762	4.89405	17.96116	0.97881	3.592233
12	13	40.9521	8.19042	20.47605	75.1471	4.09521	15.02942
13	9	15.2373	3.04746	7.61865	27.96045	1.52373	5.592089
14	8	12.1031	2.42062	6.05155	22.20919	1.21031	4.441838

15	11	25.4591	5.09182	12.72955	46.71745	2.54591	9.34349
16	8	12.1031	2.42062	6.05155	22.20919	1.21031	4.441838
17	12	32.5467	6.50934	16.27335	59.72319	3.25467	11.94464
18	20	136.6883	27.33766	68.34415	250.823	13.66883	50.16461
19	7	10.2867	2.05734	5.14335	18.87609	1.02867	3.775219
20	14	50.6753	10.13506	25.33765	92.98918	5.06753	18.59784

Appendix 2: Litter carbon stock estimation data

Plot No	**Field code**	**wet wt(g)**	**fresh wt (g)**	**oven dry wt(g)**	**% O.C ton/ha**	**LB**	**LC**	**CO_2 ton/ha**
1	MD/2014/15	50	50	17.12	8.56	0.001712	0.014655	0.053783
2	MD/2014/15	90	50	8.25	4.125	0.001485	0.006126	0.022481
3	MD/2014/15	70	50	15.53	7.765	0.002174	0.016883	0.061959
4	MD/2014/15	90	50	13.32	6.66	0.002398	0.015968	0.058603
5	MD/2014/15	100	50	11.45	5.725	0.00229	0.01311	0.048115
6	MD/2014/15	60	50	10.13	5.065	0.001216	0.006157	0.022596
7	MD/2014/15	70	50	11.14	5.57	0.00156	0.008687	0.031881
8	MD/2014/15	100	50	14.41	7.205	0.002882	0.020765	0.076207
9	MD/2014/15	70	50	5.95	2.975	0.000833	0.002478	0.009095
10	MD/2014/15	65	50	15.55	7.775	0.002022	0.015717	0.057682
11	MD/2014/15	85	50	7.10	3.55	0.001207	0.004285	0.015725
12	MD/2014/15	65	50	13.17	6.585	0.001712	0.011274	0.041376
13	MD/2014/15	75	50	9.85	4.925	0.001478	0.007277	0.026705
14	MD/2014/15	80	50	5.97	2.985	0.000955	0.002851	0.010464
15	MD/2014/15	75	50	9.35	4.675	0.001403	0.006557	0.024063
16	MD/2014/15	65	50	8.00	4	0.00104	0.00416	0.015267
17	MD/2014/15	55	50	9.12	4.56	0.001003	0.004575	0.016789
18	MD/2014/15	60	50	10.56	5.28	0.001267	0.006691	0.024555
19	MD/2014/15	70	50	7.87	3.935	0.001102	0.004336	0.015912
20	MD/2014/15	80	50	8.00	4	0.00128	0.00512	0.01879

Appendix 3: Carbon stock estimation in soil pool

Plot No	Volume	Soil depth (cm)	bulk density (g/cm^3)	% of Organic Carbon	Oven dry weight (g)	SOC (ton/ha)	CO_2 Ton/ha
1	98.125	30	0.520764	12.32	51.1	192.4745	706.381403
2	98.125	30	0.362803	18.73	35.6	203.8588	748.161618
3	98.125	30	0.456561	6.47	44.8	88.61839	325.229509
4	98.125	30	0.602293	11.69	59.1	211.2242	775.192641
5	98.125	30	0.809172	12.66	79.4	307.3235	1127.8773
6	98.125	30	0.620637	18.60	60.9	346.3154	1270.97757
7	98.125	30	0.547261	23.21	53.7	381.0579	1398.48263
8	98.125	30	0.641019	28.71	62.9	552.1098	2026.24281
9	98.125	30	0.521783	10.52	51.2	164.6749	604.356712
10	98.125	30	0.398471	22.51	39.1	269.0877	987.551838
11	98.125	30	0.405605	8.33	39.8	101.3607	371.993818
12	98.125	30	0.52586	9.54	51.6	150.5011	552.339021
13	98.125	30	0.724586	12.58	71.1	273.4588	1003.59362
14	98.125	30	0.58293	15.59	57.2	272.6363	1000.57534
15	98.125	30	0.88051	22.23	86.4	587.2118	2155.06739
16	98.125	30	0.818344	9.72	80.3	238.6291	875.768781
17	98.125	30	0.624713	10.33	61.3	193.5987	710.507138
18	98.125	30	0.36586	9.28	35.9	101.8554	373.809276
19	98.125	30	0.766369	13.45	75.2	309.2301	1134.87433
20	98.125	30	0.595159	9.76	58.4	174.2626	639.543831

Appendix 4: Summary of mean biomass and carbon stock in each carbon pools

Plot No	AGB	BGB	AGC	BGC	LB	LC	SOC	TOTAL carbon (ton/ha)
1	19.6893	3.93786	9.84465	1.96893	0.001712	0.014655	207.5272	242.9843
2	74.0751	14.81502	37.03755	7.40751	0.001485	0.006126	110.7938	244.1366
3	175.9017	35.18034	87.95085	17.59017	0.002174	0.016883	248.3159	564.958
4	87.7517	17.55034	43.87585	8.77517	0.002398	0.015968	157.2067	315.1781
5	61.7163	12.34326	30.85815	6.17163	0.00229	0.01311	254.4086	365.5133
6	197.4851	39.49702	98.74255	19.74851	0.001216	0.006157	182.5186	537.9992
7	102.7461	20.54922	51.37305	10.27461	0.00156	0.008687	179.5845	364.5377
8	32.5467	6.50934	16.27335	3.25467	0.002882	0.020765	307.3908	365.9985
9	12.1031	2.42062	6.05155	1.21031	0.000833	0.002478	798.6417	820.4306
10	50.6753	10.13506	25.33765	5.06753	0.002022	0.015717	190.017	281.2503
11	9.7881	1.95762	4.89405	0.97881	0.001207	0.004285	288.8719	306.496
12	40.9521	8.19042	20.47605	4.09521	0.001712	0.011274	181.5329	255.2597
13	15.2373	3.04746	7.61865	1.52373	0.001478	0.007277	245.1235	272.5594
14	12.1031	2.42062	6.05155	1.21031	0.000955	0.002851	237.5859	259.3753
15	25.4591	5.09182	12.72955	2.54591	0.001403	0.006557	189.1286	234.9629
16	12.1031	2.42062	6.05155	1.21031	0.00104	0.00416	254.8956	276.6864
17	32.5467	6.50934	16.27335	3.25467	0.001003	0.004575	205.8475	264.4371
18	136.6883	27.33766	68.34415	13.66883	0.001267	0.006691	209.0889	455.1358
19	10.2867	2.05734	5.14335	1.02867	0.001102	0.004336	207.7892	226.3107
20	50.6753	10.13506	25.33765	5.06753	0.00128	0.00512	235.1303	326.3522

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