Carbon Stock Assessment of Vegetation in Domiara Valley, Ziarat, Balochistan.

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Carbon Stock Assessment of Vegetation in Domiara Valley, Ziarat, Balochistan.

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In

Environmental Science

By

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I hereby declare that the work present in the following thesis is my own effort, except where acknowledged. No part of the thesis has been previously presented elsewhere for any other degree

Date __________

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ABSTRACT

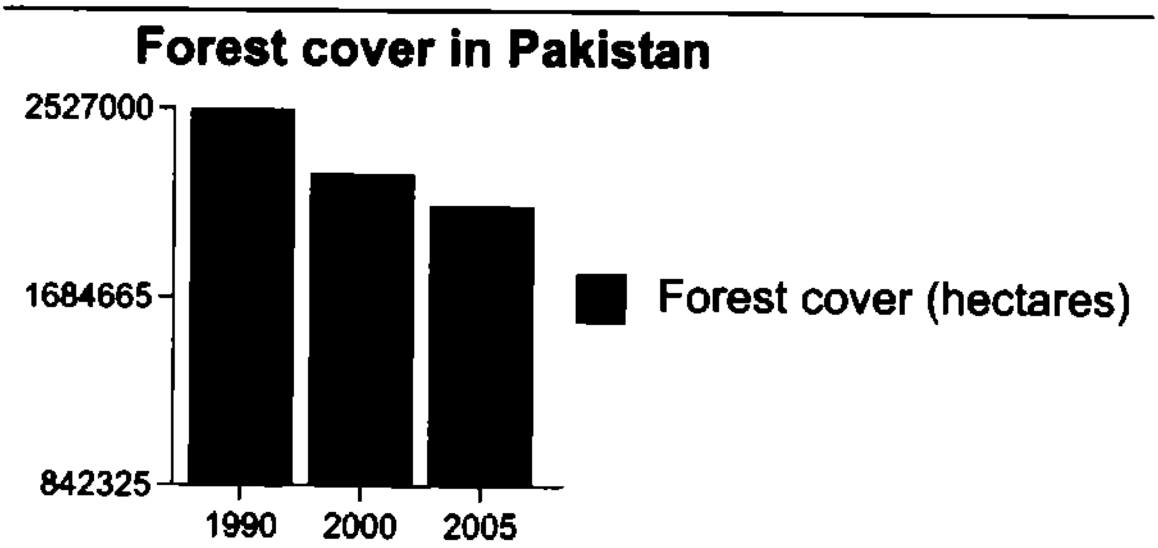
In the present investigation below and above ground carbon sequestration potential of *Olea ferruginea* in Domiara Valley, Ziarat is estimated Vegetation and trees were sampled using 16 samples and 4 density zones in Domiara covering an area of 6,623 acres with each plot of 1 acre In each plot tree height and diameter at breast height was measured Total carbon stocks in tree biomass were calculated using appropriate wood density and biomass expansion factor The results show that Carbon stocks calculated in ecosystem of Domiara valley are 33,144 tons of carbon

Keywords: biomass, carbon, sequestration, Ziarat, carbon stock

1. INTRODUCTION

Pakistan has the potential to earn $400 million to $4 billion each year from the carbon stored in its forests These figures are enormously huge as compared to what we earn from textile industry By implementing the REDD+ strategy we can reap additional benefits by empowering the forest communities and can also control soil erosion and poverty while contributing to the conservation of wild life REDD+ is mechanism which helps in conservation of forest ecosystem by economic incentives But due to lack of knowledge among researchers and officials of Pakistan forest department we are unable to generate finance by forest conservation In order the reap the benefits arising from carbon stored in forests Pakistan needs to emphasize on making of policy and quantifying the amount of carbon which is stored in its forests In order to address the problems such as deforestation and degradation of forests Pakistan needs to develop a common understanding among professionals, policy makes and politicians which will be helpful in the making of an appropriate public policy to address the problems of forests of Pakistan (The Express Tribune, 2013)

Pakistan has a wide range of forest ranging from the mangrove mangals located along coastline of Sindh and Balochistan to moist temperate forest in North to ancient forest of juniper in Balochistan Depending on the official statements of government of Pakistan or WWF-Pakistan the forest cover in Pakistan ranges from 5 2-2 2 percent Pakistan also has the highest forest degradation rate in the region and losing about 42,000 per year which is 1 66 percent of total forest cover of Pakistan KPK & Balochistan however are regulating strict policies to protect the forest cover in their provinces The ambitious "Billion Trees Tsunami" is a massive afforestation project for planting and saving forest cover of Pakistan Government of Balochistan is also taking immediate steps to save the massive and ancient juniper forest, a world heritage site Forests in Balochistan, Murree and Gilgit-Baltistan have the potential to contribute in economy of Pakistan via international mechanism that financially rewards countries for using their forest cover to reduce global warming (Khan, 2016)



Source: Forest Resource Assessment and the State of the World's Forests, FAO

Fig 1.1 Forest cover in Pakistan

Carbon stock assessment is a complex process used to find the amount of carbon stored in a reservoir A reservoir may refer to forest, soil or water (Kayranli*et al*., 2010) Carbon appears to become an international traded commodity for that we need to build up consensus for correct estimation of carbon stocked in various pools of the country Monitoring of carbon stocks has become a necessity nowadays considering the economic benefits that can be cashed just by assessing the number of carbon stored in various inventories in forests

Forests can act in both ways as a carbon storing facility and carbon capturing factory. A rapidly growing young forest had the ability to sequester large amount of atmospheric carbon roughly proportional to its biomass while an old forest act as a massive reservoir and holding large volumes of carbon even if the net growth of forest is stopped. Thus an old forest continues to hold large volume of carbon while the young forest continues to sequester the carbon as the biomass of forests expand it indirectly expands the carbon storage inventories (Sedjo, 2001). The Intergovernmental Panel on Climate Change (IPCC) estimates that with the correct use of forestry, forest management and policy the carbon stocks can be 100 GTS more if compared to forests without a policy and management (IPCC 2001).

In order to correctly estimate the stocks of carbon in a forest compartment following four carbon pools should be measured accurately -

1. Above Ground Biomass
2. Below Ground Biomass
3. Soil Carbon
4. Standing Litter Crop

Above ground biomass includes trees and shrubs. It is of greater importance as it will emit carbon when the forest is removed. In some cases more carbon is released back into environment when a forest is converted into agricultural land. The Intergovernmental Panel on Climate Change (IPCC) 2006 guidelines provides default values for above ground biomass estimations. According to this panel the tree category has the diameter of at least 10cm at breast height (DBH). The shrub/small tree category has the diameter less than 10cm at breast height (Arino, 2009). Estimation of carbon stocks in above ground biomass is mostly time consuming especially in hilly areas where the land is usually not uniform and the topographical features changes more abruptly as compared to flat areas Thus the use of Google maps and imaginary satellites can also prove fruitful in deploying sample plots across the area A simple random sampling is not a solution in hilly areas as the deployed plots may not be the true representation of geographical area With the help of Google maps and assessing the crown cover of forest equal number of sampling plots should be deployed in whole area to have the true representation The use of GPS in marking and locating the sampling area is efficient and correct way of sampling the plots especially in areas with fewer roads (MacDicken, 1997) Due to the massive industrialization and fossil fuel burning which directly triggers the increase of atmospheric carbon, lot of effort and hope is put into mitigations measures and research as to understand the true potential of trees, soil, oceans and other plants to temporarily sink the carbon The Kyoto Protocol which is the main instrument for combating the global warming and sea level rise suggests that the reduction of carbon emission is just as important as reduction of atmospheric carbon by trees and soil (Roger *et al.*, 1998) The carbon tends to absorb more readily in ocean as compared to land Due to rise of temperature of sea surface, the stored carbon in oceans is making its way back to our atmosphere this contributing more in global warming As cold water has much higher tendency to hold dissolved gases as compared to warm water This action is also known as "Carbon Pump" Before the massive industrialization we had a basic 280 parts per million (ppm) of atmospheric carbon Now we are rising above 394 ppm to reach 400ppm by 2016 More carbon is produced each year which accumulates into the environment resulting in Global Warming, Sea level rise and depletion of ozone The permanent solution is to use the ability of trees to absorb the carbon and storing it permanently The ability of soil and oceans to absorb carbon is also considered but it is temporary solution (IPCC, 2007)

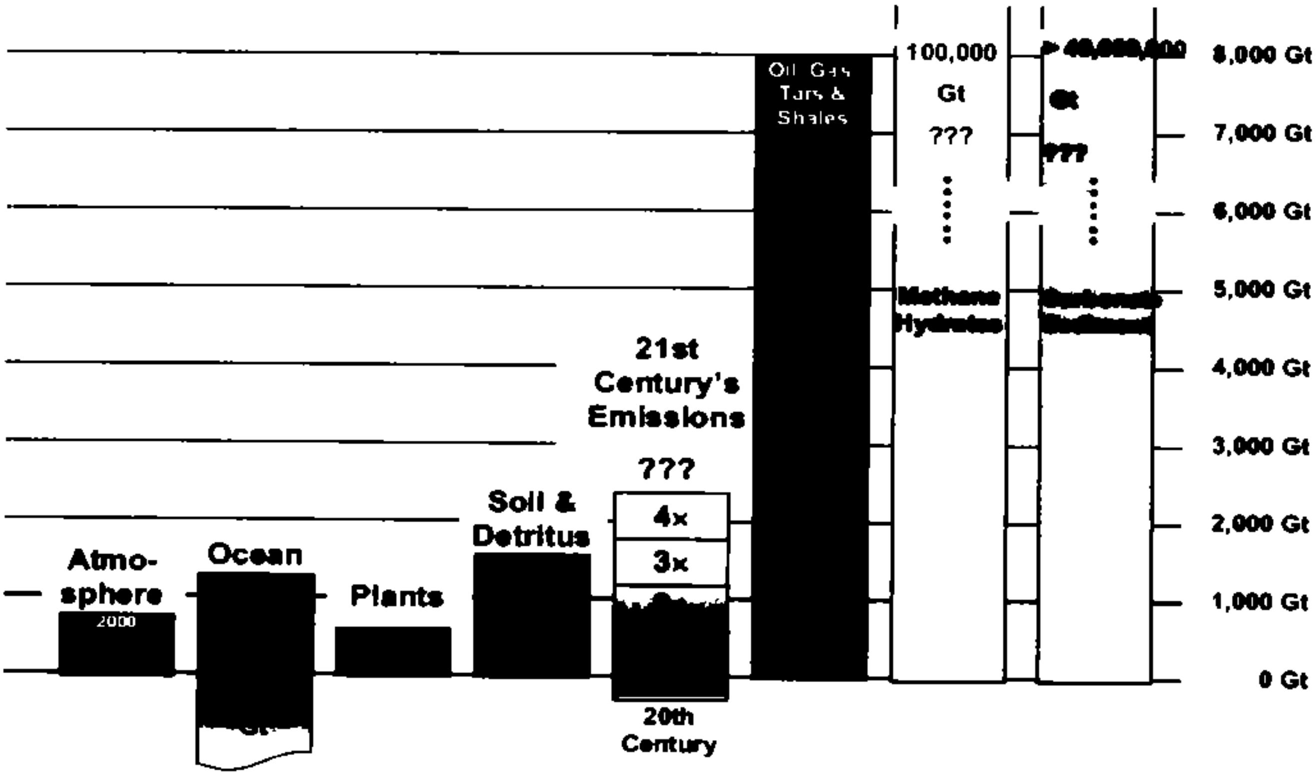


Fig 1.2 Sources of Carbon in atmosphere

Watershed:A watershed areas are fairly common in hilly areas they act as a basin or water catchment They funnel the water accumulated via rainfall or snow into a common outlet normally a river or water channel **Precipitation** Precipitation is the major controlling factor contributing to stream flow, the precipitation is controlled the amount of snow or rainfall in watershed area **Infiltration** A common characteristic of water shedding areas When the rain falls on dry ground, some of the water is absorbed into the soil which eventually seeps down the hill into the water channel Some water penetrates deep into the soil and recharging the main aquifers **Soil Saturation** When the rain falls on a wet ground it doesn't gets absorbed into the soil The surface acts as a runoff and all the water quickly accumulates into the main water channel **Slope of the Land**: Slope of the land plays an important role in the time required for water from rain to reach the common outflow. Rain falling over steep land will consume less time in comparison to rain over a flat land. **Water use by People**: Water shedding areas play an important role especially in areas where annual rainfall is scarce. The use may range from drinking water to water for irrigation, industries and mining.

In developing countries both government development agencies and non-governmental organizations have implemented watershed management projects with the aim of reducing poverty and increasing agricultural productivity especially on hillsides and rural areas (P. Carlos, 2003). Vegetation is of extreme importance in water shed areas as its loss will directly trigger the loss of top layer of fertile soil which indirectly increases the loss of sediment due to stream flow. The accumulation of sediment lost from ridges will accumulate in water basin this reducing the water storing capacity. (GOP *et al.*, 1992, NCS, 1991, Shah, 1989, Shah, 1991, Ali, 1990, Minissale, 1991). Watersheds are far below their reproductive potential and in depleted conditions. This is because of lack of management, unchecked grazing, continued misused through deforestation and lack of facilities for cultivation of steep slopes.

As a result watersheds are severely damaged and their reproductive potential is decreased. The loss of sediment due to mismanagement of watersheds will result in accumulation of sediment in water storage dams thus decreasing their storage capacity (WASID, 1967). Together watershed and range lands make up about 65 to 70% of country's area (Ashraf, 1987).

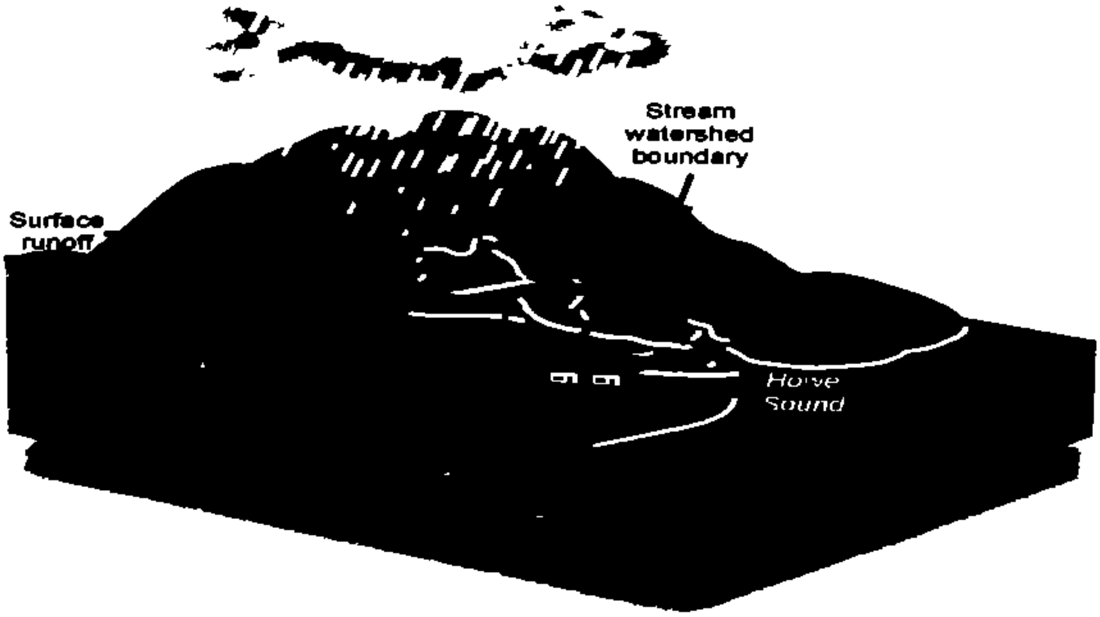


Fig 1.3 Watershed Management

From the whether perspective, Pakistan is basically a dry country except for the sub-tropical terrain in Punjab and wet zones on the southern slopes of Karakoram and Himalayan range while majority of Balochistan is arid and dry More than three-fourth of country receives an annual rainfall of 250mm And thus less than 25% of area is important when it comes to watersheds (NCS, 1991)

The carbon stock assessment will be done on Domiara district Ziarat which is a water shed area of Ziarat, Balochistan The area is abundant in vegetation of "*Olea ferruginea*" and comprises of many small water streams merging into a big water channel Ziarat is located at East of Quetta at the distance of 120 km's and 8,850 feet above sea level The ecological value of Ziarat is inestimable The biosphere reserve house the largest juniper forest of Pakistan expanding to an area of 110,000 hectares Ziarat and the surrounding areas also provide very good opportunity for hiking and trekking and is a major tourist attraction especially in winter. Ziarat is regarded as national treasure not only because it hosts one of the most ancient juniper forests of world but the founding father of Pakistan Muhammad Ali Jinnah spent last days of his life at Ziarat. The area is a major tourist attraction in Ziarat due picturesque landscape, various gorges, Quaid-e-Azam residency and presence of holy shrines. Domiara serves as a passage way for local people to travel quickly into surrounding regions of Harnai and Kohlu. The area is usually inhibited by Nomads. Domiara also hosts the highest peak of district Ziarat named "Khalifat" while it also hosts the second highest peak of Ziarat region known as "Malikat". This region is unique as its not only the water shed area but this small area has no forest of *Juniperus macropoda*. This is the first time that any study pertaining to estimations of carbon stocks is carried out in Balochistan province.

Olea ferruginea is found in dry temperate, sub-tropical and moist regions of Pakistan from 500 to 2000m. It was recorded from Western hills of Balochistan, Afghan Border, Chitral, Dir, Azad Kashmir, Salt Range, Waziristan, Murree and Swat hills (Baquar, 1969, Sheikh, 1993). This drought and frost resistant specie is also known as Indian Olive and Kahi. It shows great diversity and adaptation to harsh environments. It can survive 250mm to 1000mm per year precipitation and temperature ranging from -10 C to 40 C, therefore it can be easily planted on semi-arid, arid and dry temperate regions with minimum input. This specie help in improving of microclimatic, water shed, edaphic and environmental condition of the area through plantation. Further benefits can be reaped through its fruit, leave and wood which can be utilized to make fodder, fuel, oil and construction (Baquar, 1969). This tree is native to subcontinent including India, Pakistan and Afghanistan. Indian olive is evergreen tree reaching about 9 to 12m tall and

0.3 to 0.6m in diameter. Leaves of Indian olive are long measuring about 3 to 10cm. It produces white flower which are arranged in bunches. The fruit is 8mm long drupe which matures between May and December. The flowers of Indian Olive bloom between March and September. Indian Olive is a tolerant tree and has the ability to grow in various soil textures such as calcareous, loamy, gravel and sandy soils. This specie has no known disease or insect problem and is frost and drought resistant. This tree is good for reforestation in semi-arid to arid regions. Its fruit, oil and wood can also provide economic benefits. The wood is commonly used as a fuel and for furniture making as its hard and heavy. The tree is significantly known for its protection of watershed areas (Shiekh, 1993).

1.1 Problem Statement

Pakistan is basically an agricultural land with wide range of dense and thick forest spread in to the country. Leaning towards Kyoto Protocol, Pakistan can use the thick forest spread across the country as a source of income thus playing its vital role in Carbon reduction as well reaping the economic benefits (Khan , 2016). Atmospheric carbon is of major concern as its percentage continues to rise in environment. The idea behind carbon trading is quite similar to the trading of commodities in a market. Carbon would be given an economic value, allowing people, companies or nations to trade it (IPCC, 2007).

The major problem of the world is the excessive use of fossil fuels for the generation of energy required for modem life operations and the amount of Carbon Dioxide produced as a result of burning wood, coal, gas and petroleum. Due to increase of Carbon Dioxide in atmosphere the world temperature is increasing with each year also known as Global Warming. Global warming is responsible for melting of glaciers in Southern and Northern hemisphere and

Sea Level Rise This problem arising due to atmospheric carbon needs to addressed and thus the use of forestry and forest management is proving to be beneficial The role of forestry management and forestry is now a recognized remedy and mitigation measure for controlling Carbon and other Green House Gases build up in the atmosphere The protection of forests and building forests specifically for Carbon Sequestration will not reduce harmful gases in our environment but can also prove economical by the production of wood (Sedjo, 2001)

The Indian Olive forest in Ziarat especially the concentrated and uniform juniper forest can't be ignored due to its bio-diversity and thus an immediate consensus needs to be developed for measuring Carbon sequestration and ultimately its potential No study has been carried out in Balochistan for assessing the carbon stocks of forest cover This is the first time a study is carried out in Ziarat district to assess the carbon stocks of Domiara

1.2 Aim and Objective

This study was designed

- To map and calculate total area of Domiara. Ziarat
- To identify the forest cover and habitat
- To document the carbon stocks of Domiara, Ziarat
- To analyze soil, tree, shrub and litter samples

1.3 Significance of the study

The benefits of the study pertaining to assessment of carbon stocks will help in policy making and estimation of carbon stocks which help in assessing future threats or damages related to removing of forest cover (Bolin 1998) Photosynthesis transfers carbon dioxide from the atmosphere to wood and other plant tissues in the form of carbon (Dillinger *et al.* 2006) many efforts are being made for reduction in atmospheric carbon dioxide levels (Hairiah, 2009) In global carbon cycle biomass is an important building block and is used to help quantify carbon pools and changes of Green House Gases from the terrestrial biosphere to the atmosphere associated with land cover changes land-use (Cairns *et al.*, 2003, IPCC, 2001) Biomass production in different forms plays important role in carbon sequestration in trees These carbon pools are composed of dead and love below and above ground biomass Above-ground biomass, below-ground biomass, dead wood, litter is the major carbon pools in any ecosystem (FAO, 2005, IPCC, 2003, IPCC, 2006) The increasing carbon emission is of major concerns for entire world and it is addressed in Kyoto protocol (Chavan, and Rasal, 2010, Ravindranath, *et al.*, 1997)

There is no previous record of carbon stock from the area and the habitat status and specie values are still not identified There is a possibility of discovery of some new inventories in the documentation of indigenous knowledge The study will help in documentation of total area of Domiara valley in Ziarat and assessing its forest cover The study will also help in identification of tree species located in Domiara as this is the first time such study is being carried out in Domiara, Ziarat

2. REVIEW OF LITERATURE

REDD+ is recent phenomenon which measures the Carbon storing capacity and capability of forests of the world Work on Carbon Stock reservoirs has started recently in Pakistan So far very less work has been carried out in Pakistan to assess the Carbon Stock of national forests

Recent studies have been carried out on GhoraGali forest and Margalla forest. Result shows that the assessment of stock with defined methodology is completely feasible and bears fruitful results. The amount of carbon stored in plant biomass exceeds that of atmospheric carbon dioxide. This shows the importance of forest ecosystems in the carbon cycle globally and the necessity to accurately calculate the amount of carbon stored in forest ecosystems (Morison *et al.*, 2006).

A study was conducted to analyze the potential of watershed. The widespread deterioration of watersheds around the world is a threat to agricultural and livestock production, livelihoods and ecosystem health, strengthened by climate variability and change. Large scale restoration of degraded watersheds may require 10 to 20 years for full benefits to be realized. In this perspective watershed management and sustainable land and water management are key development areas which present a multiple win potential synergy between food security, climate adaptation and climate mitigation. Global surface temperatures have increased by 0.8oC since the late 19th Century with an average rate of increase of 0.15oC per decade since 1975. The Earth's mean temperature is projected to increase by 1.5oC– 5.8oC during the 21st Century. Watershed and land degradation are compromising the capacity of ecosystems to provide, maintain, and regulate critical functions and services, including resilience to climate variability and natural hazards, e.g. regulating floods and preventing droughts. Upstream land degradation reduces the capacity of ecosystems to retain water and regulate water flows, thus preventing excessive runoff during the rainy season. Carbon trading offers opportunities for the rehabilitation of degraded lands and watersheds through different practices. Tree planting on degraded lands that cannot support crop production can contribute to carbon sequestration and have local benefits in the form of reduced erosion and water use efficiency, and off-site benefits such as water quality improvements It demonstrates the synergistic relationship of watershed, land and water management that should be consciously promoted in climate change and carbon market negotiations and cooperation Payment for Ecosystem Services in the form of carbon sequestration could also be integrated into trans boundary basin cooperation efforts (Bernoux*et al* 2011)

It is extremely hard to predict the magnitude of future carbon dioxide induced global warming because of ambiguities in the role played by ecosystems and oceans with the sourcing and sinking of carbon dioxide As Siberia is known for extensive areas (1 * 106 km2) of deep (up to 90 m) deposits of organic-rich frozen loess (wind-blown silt) that piled up during the Pleistocene, still it has not been considered in most global carbon (C) inventories Same deposits are present but in far less quantity in Alaska Due to global warming at high altitudes permafrost (permanently frozen ground) to melt and raising questions about the role of carbon in thawing permafrost (Zimov*et al*, 2006) It was shown in the research that Siberian loss permafrost contains a large organic carbon pool (~ 450 GT—far more than the quantity of carbon present in our atmosphere) The organic carbon pool decomposes quickly when thawed and normally act as a positive feedback to climate/global warming The researchers provide the first quantitative estimate of carbon stocks in Siberian loess permafrost and show that the pool is so large (~ 450 GT carbon—more than half the quantity in the current atmosphere) that it can warrant changes in global carbon inventories In this research, observations are made thus providing prediction into the processes by which carbon accumulates in or disappears from Siberian loess permafrost Furthermore, the hurdles of changes in permafrost carbon for the global carbon cycle are discussed (Zimov*et al*, 2006)

Another research study aboutcarbon sequestration potential of swamps and lakes in China Wetlands are considered as one of the most important ecosystems of land Investigation showed that there are major differencesin the carbon sequestration potential of various lakes Swamps had a carbon sequestration potential of 4 90 Tg carbon which is significantly higher than lakes in China Coastal marsh and mangroves have the highest carbon sediment rate in swamps Carbon sequestration potential of returning farms to lakes and swamps was 30 26 and 0 22 $GgCa^{-1}$, respectively The carbon sequestration potential of wetland restoration was 6 57 $GgCa^{-1}$(Baiwenet *al*, 2007)

Carbon sink possesses importance, as it controls the atmosphere directly and indirectly To understand and find driving factors behind this process attains a recent question in biogeochemistry This paper investigates approaches related to different research studies as oxygen exposure time and preservation by dissolving from organic matter to minerals and recalcitrant organic matter Lakes possess a high rate of carbon sink but they were usually ignored due to their small functions and size This study is mostly done in marine sediments and results adapted to lake sites The lakes carbon burial can be best compared with deltaic sediment systems as terrestrial organic matter in the terrestrial catchment connected river systems and terrestrial catchment area usually plays a vital role in the much higher carbon burial rates of lakes (Lal*et al* 2005)

It has been found that the industrial emission of carbon (C) in China in 2000 was about 1 Pg yr^{-1} It is expected that it may exceed that of the United States (1c84 Pg C) by 2020 China has a large land area which is similar in size to that of the United States It comprises of 124 Mha of cropland, 400 Mha of grazing land and 134 Mha of forestland Terrestrial C pool of China comprises about 35–60 Pg in the forest and 120–186 Pg in soils Soil degradation is a major issue which affects 145 Mha by different degradative processes Out of those, 126 Mha are susceptible to increased soil erosion Total annual loss by erosion is estimated at 5e5 Pg of soil and 15e9 Tg of soil organic carbon (SOC) Erosion-induced emission of C into the atmosphere may be 32–64 Tg yr^{-1} The SOC pool progressively declined from the 1930s to 1980s in soils of northern China On the other hand, it slightly increased in those of southern China because of change in land use A number of management practices lead to depletion of the SOC stock which include cultivation of upland soils, negative nutrient balance in cropland, residue removal, and soil degradation by accelerated soil erosion and salinization Agricultural practices that augment the SOC stock include conversion of upland to rice paddies, integrated nutrient management based on liberal use of bio solids and compost, crop rotations that return large quantities of biomass, and conservation-effective systems Moreover, soil restoration has a potential to sequester SOC Total potential of soil C sequestration in China is 105–198 Tg C yr^{-1} of SOC and 7–138 Tg C yr^{-1} for soil inorganic carbon (SIC) The accumulative potential of soil C sequestration of 11 Pg at an average rate of 224 Tg yr^{-1} may be realized by 2050 Soil C sequestration potential can make up for about 20 per cent of the annual industrial emissions in China (Abdul*et al*., 2008)

It is a well-known fact that scientific advancements in understanding of processes which regulate carbon (C) balance in terrestrial semi-aquatic ecosystems are crucial However, empirical evidence in favor of assessing the roles and potentials of wetlands and semi-aquatic ecosystems in C sequestration is scarce The stability of organic matter and assessment of roles of biotic abiotic factors may help in improving the understanding of fundamental biogeochemical and eco-physical processes as well as in the reduction of anthropogenic CO2 in the atmosphere with long-term equivalence (Wang *et al*., 2007)

3. RESEARCH METHODOLOGY

The current study was carried out in Department of Environmental Science, Faculty of Basic and Applied Sciences, International Islamic University Islamabad during January 2016 to July 2016.

3.1 Study Area:

The carbon stock assessment will be done on Domiara district Ziarat which is a water shed area of Ziarat, Balochistan The area is abundant in vegetation of *Olea ferruginea* and comprises of many small water streams merging into a big water channel Ziarat is located at East of Quetta at the distance of 120 km's and 8,850 feet above sea level The ecological value of Ziarat is inestimable The biosphere reserve house the largest juniper forest of Pakistan expanding to an area of 110,000 hectares

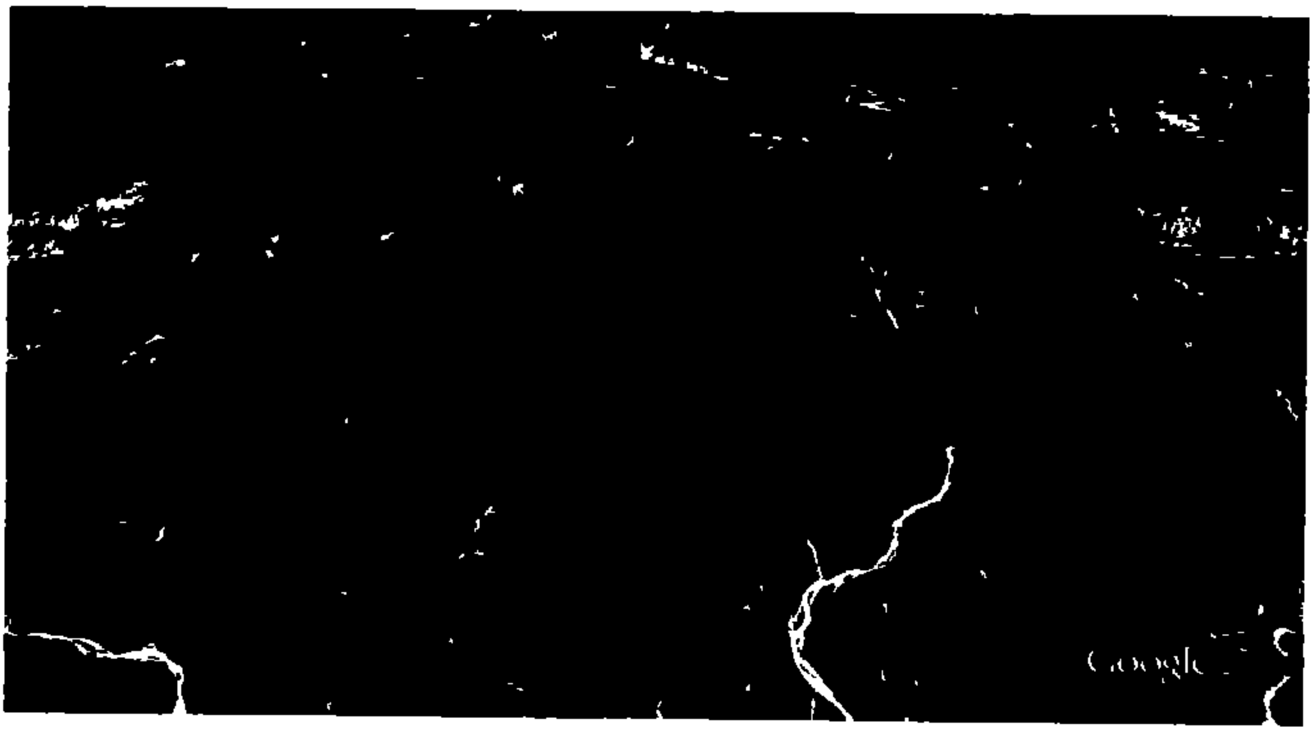


Fig 3.1Area map of Domiara Valley

Configuration of the ground: The tract is rugged and hilly The gradient ranges from precipitous to moderately steep The hill tops are mostly rounded and form plateaus The upper slopes are precipitous and rocky The lower slopes are moderate steep to steep The narrow valleys located between hills are gently slope The elevation varies from 5000 to 11,755 ft

Geology (Rock and Soil): The main rocks are sand stone, Jurassic, Siwalik Conglomerate, Pabi, Ghazij, Shales and Kirth The soil is poorly developed due to steep slope and inadequate rainfall The properties of soil are governed by texture, depth, water infiltration, gravel content, topography, drainage and moisture holding capacity rather than chemical makeup

Climate: The climate of Ziarat is extremely cold in winter Snow falls from December to March and frosts are frequent Strong winds are common in Ziarat and they blow throughout the year in TorShor and Zarghun and over the rest of the area in winter

Water Supply: The central Zarghun, North Zarghun and Maza state forests drain towards Quetta rest of the area of Ziarat drains into Nari River Kach, Sur Kanr, Kowas, Wani and Khwara are the main nullas of Ziarat

State of Boundaries: This is the first time the Domiara Valley is given a separate entity in any research The area is excluded in Working Plan for the Juniper Forest of Quetta Civil Division due to non-availability of Juniper trees Domiara is abundant in *Olea ferruginea* crop and this is the only locality in Ziarat forest where no such crop is found It is a watershed zone which opens into Domiara Nulla Nulla in center of Domiara valley which takes all the freshwater to Harnai

The total area of Domiara which is calculated for the first time with the help of map sheet no 34 N, 11 and 34 N, 15 from Geological Survey of Pakistan and Google Maps is 6,623 acres The total area was then divided into 4 categories as per crop density after a survey with the help of Google maps and frequent visits The green area shows the maximum crop density which is 51-60%, the orange area shows the crop density ranging from 31-50%, the yellow marked zone shows the crop density of 11-30% while the black area denotes the crop density of 0-10% Hence it can be seen that Domiara valley's massive area is not under cultivation and the vegetation is not uniform The maximum tree/vegetation density was found along the Domiara Nulla which extend and splits in two ways

The demarcation of density zones is as follows

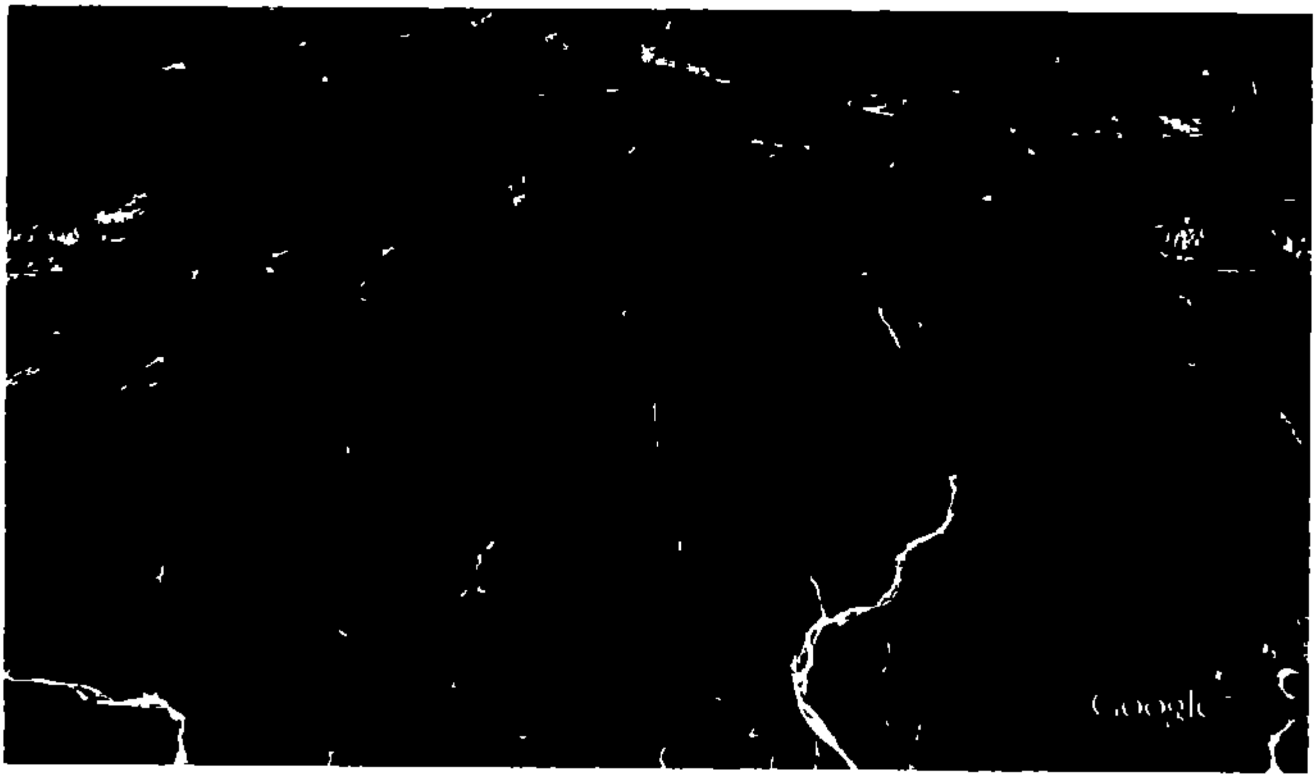


Fig 3.2 Different density zones of Domiara Valley

Fig 3.3 showing the abundance *of Olea ferruginea* in study area

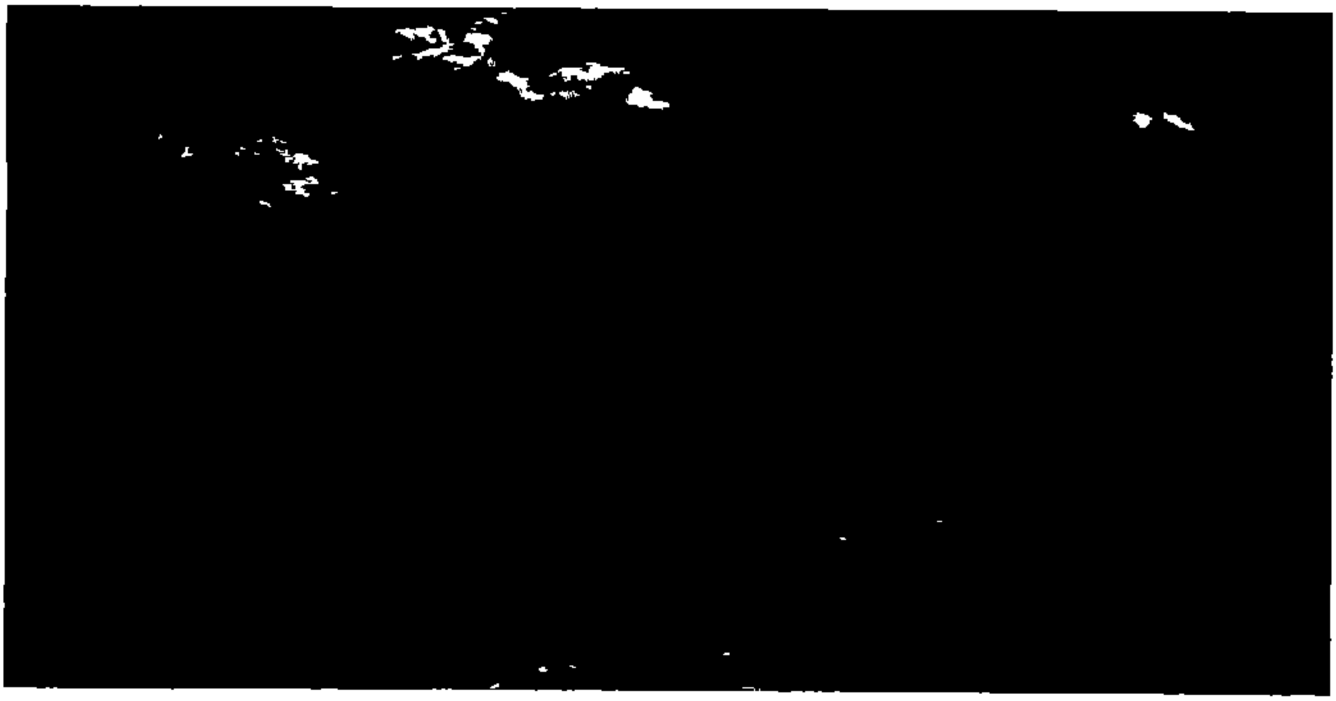


Fig 3.4 showing the entrance of Domiara Valley

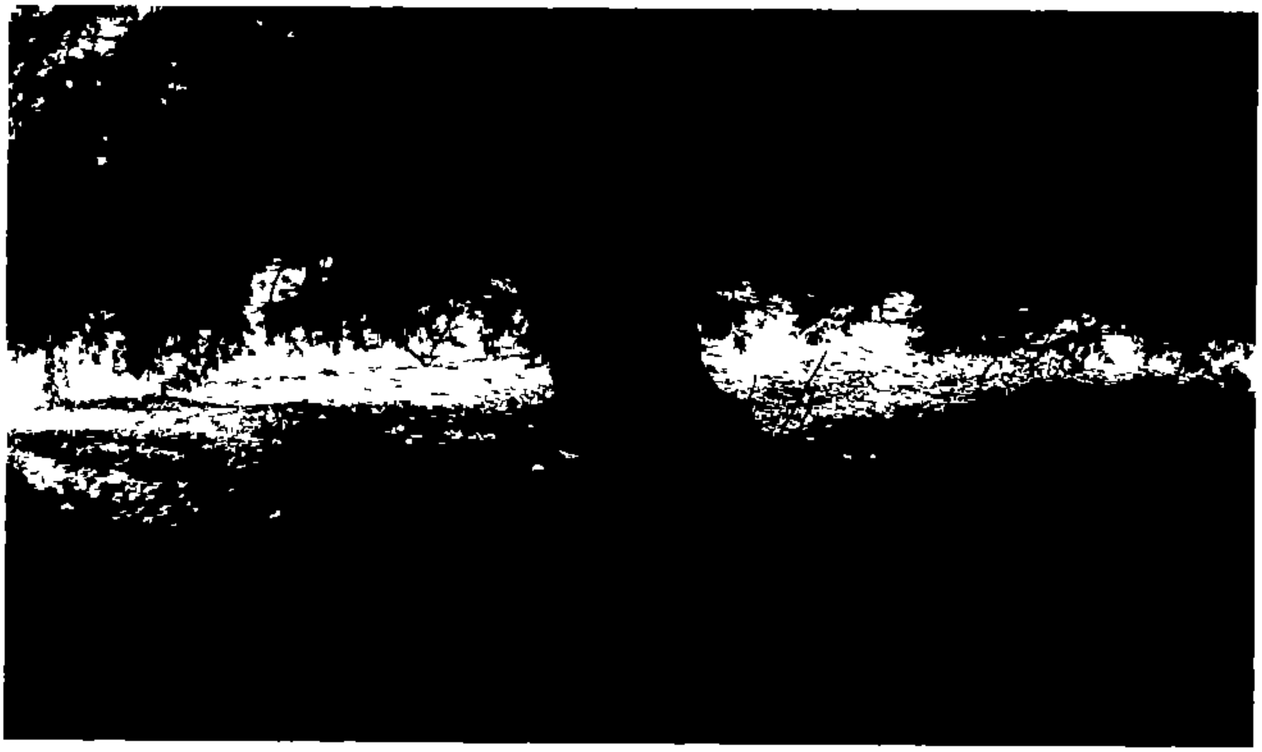


Fig 3.5 Showing the form and structure of *Olea ferruginea*

3.2 Materials

3.2.1 Type of Sampling

Tree Sampling

Tree samples were measured at breast height using girth tape and its height via bamboo All the data was recorded on a pre-made table at site There was no dead wood and herbs/shrubs to be recorded

3.2.2 Chemicals

There were no chemicals used for sampling or preservation of vegetation and trees.

3.2.3 Equipment's and Instruments

The instruments used were Girth tapes, volume tables, handheld GPS, measuring tape, wood markers, shovel, spray paint, 6ft bamboo stick, rope and polyethylene bags

3.3 Methods

3.3.1 Sample Collection

The study area was first divided into 4 density zones after survey Assessing the crop density the area of Domiara was classified into 51 to 60% crop density, 31 to 50% crop density, 11 to 30% density and 0 to 10% crop density Each density zone was then sampled by deploying 4 random 1 acre plots so it represents the whole area of particular density GPS co-ordinates were recorded for each plot using handheld GPS Measuring tape was used to mark area of198x220ft

The area was marked at corners using a red spray paint After the area is marked trees were counted and total number of trees per plot was recorded for statistical analysis Measurement of each tree in plot sample was then taken at breast height using girth tape and similarly its height was recorded using a 6ft bamboo stick as a guide Same procedure was repeated for 16 sample plots deployed throughout the study area Data collected from the field was recorded in pre made tables along with all the necessary stats of area The plots were picked randomly in each density class

3.3.2 Analysis

FORMULA AND DEFAULT VALUES USED FOR ESTIMATION OF Vegetation CARBON IN STUDY AREA

Step- 1

a. Stem Volume

Volume (m^3/Ac) of tree species for all the sampling sites was calculated using following formula (Philips, 1994)

$$\textbf{Volume of tree } (m^3) = (\pi/4) \times d^2 \times h \times f$$

Where

"π" is 3 1416

"d" is diameter at breast height

"h" is height of tree up to first branch

"f" is form factor

*Form factor used for *Olea ferruginea* is 0 50 (Altrell*et al*, 2012)

b. Stem Biomass

Stem Biomass (t) = Volume (m^3) x Wood Density (t/m^3)

*Wood density used for *Olea ferruginea* 1 125 (Sheikh 1983)

c. Above Ground Biomass

Above Ground Biomass = Stem Biomass x Biomass Expansion Factor

*Biomass expansion factor used for *Olea ferruginea*

= 1.91

(IPCC Table 3A.1.10, Rawat and Tandon 1993, Rana and Singh, 1990)

d. Root Biomass

Root Biomass = Above Ground Biomass x Root Shoot Ratio

*0.56 root shoot ratio was used for *Olea ferruginea* (VCS MODULE VMD0001, 2013)

e. Total Tree Biomass

Total Tree Biomass = Above Ground Biomass + Root Biomass

Step-2

Carbon Stock in Trees

Carbon Stock in Trees = Total Tree Biomass x .50 (Carbon ratio)

4. RESULTS AND DISCUSSIONS

Global carbon dioxide emission has increased by 18% and is fatal for environment by reaching its highest level after 1750. It is contributing to climate change and global warming which was also discussed in earth summit held at Rio De-Janerio in 1992, Kyoto protocol at Japan in 1997, Copenhagen conference in 2009 held at Denmark (D.M., 2011).

The aboveground biomass of the selected study area was calculated using taking diameter of a selected tree species at breast height, height of tree and wood density. The sequestration potential of other parts of tree are rarely measured but generally assumed to be 50% of the dry weight (Los*et al.*, 2003, Jana *et al.* 2009). The carbon content in any woody mass of a forest is 50% of dry matter (Paladinic *et al.* 2009).Temperate forest which occur in mid-latitudes normally about 50 North and South of equator contains less stored carbon as compared to tropical forests. Around one-third of the carbon is stored in tree vegetation while a small portion is stored in soil. As more photosynthesis is carried out by terrestrial green plants more carbon is stored in tree biomass by conversion of carbondioxide (Gorte 2009, IPCC, 2003) which results in growth of different parts of tree (Chavan and Rasal. 2010).

For more authentic estimations the study area was divided into four class densities after survey. The *Olea ferruginea* in its maximum density was present along the skirts of Domiara Nulla. Hence 4 density categories were established with maximum crop density of 60 percent and minimum of 0 percent. The interval was divided into 51-60%, 31-50%, 11-30%, 0-10%. The average diameter of class densities were 12.26 inches, 9.4 inches, 8.2 inches and 12.36 inches respectively.

Similarly average height recorded per class density was 18.9 ft, 28.2 ft, 26ft and 29.6 ft. The total dry biomass, carbon dioxide and biomass in 16 plots of 1 acre can be seen in table 4.1

Density Class	Total Dry Biomass (t)	Total Carbon Dioxide (t)	Total Biomass (t)
51-60% Density	33.23 tons	131.27 tons	71.53 tons
31-50% Density	29.98 tons	118.47 tons	64.55 tons
11-30% Density	15.69 tons	61.99 tons	33.79 tons
0-10% Density	13.91 tons	54.94 tons	29.94 tons

Table 4.1 Showing total dry biomass, carbon dioxide and biomass in four density zones

Quantifying the biomass will help in building statistics for different carbon pools which indirectly will benefit in economic gains and policy making against emission of Green House Gases, Sea Level Rise and Global Warming (Cairns *et al*, 2003, IPCC, 2001). Estimations of changes in carbon stocks and carbon stocks above and below ground is important and necessary for reporting to Kyoto Protocol and United Nation Framework Convention on Climate Change(UNFCC) (Green *et al*, 2007). Trees are considered as most important means of reducing carbon content in atmosphere, not only they are significant element of diversity and landscape but it help greatly reduce the effect of carbon in an environment thus trees are the only long term solution as 50 percent of their standing biomass is carbon itself (Ravindranath *et al*, 1997)

The carbon stocks of *Olea ferruginea* in Domara Valley which is a water shed zone of Ziarat Valley were calculated using 16 samples of 1 acre deployed via random selection. Watersheds are far below their reproductive potential and in depleted conditions. This is because of lack of management, unchecked grazing, continued misused through deforestation and lack of facilities for cultivation of steep slopes. As a result watersheds are severely damaged and their reproductive potential is decreased. The loss of sediment due to mismanagement of watersheds will result in accumulation of sediment in water storage dams thus decreasing their storage capacity (WASID, 1967). Together watershed and range lands make up about 65 to 70% of country's area (Ashraf, 1987).

Overall 123 trees were sampled in density class 51-60%, 103 trees in density class 31-50%, 66 trees in density class 11-30% and 30 trees in density 0-10%. Every tree was measured using girth tape at breast height and the height of the tree was measured using 6ft bamboo stick as a guide. The data collected after sampling 322 trees in 16 sample plots can be seen in table 4.2.

Tree Species: *Olea ferruginea*			
Density Class	**Tree density**	**Average Volume (m)**	**CS Area (m2)**
51-60% density	123 trees	0.245	0.0825
31-50% density	103 trees	0.255	0.0525
11-30% density	66 trees	0.215	0.0462
0-11% density	30 trees	0.45	0.0842

Table 4.2: Showing tree density, average volume and Carbon stock area

4.1 Carbon stocks of *Olea ferruginea* in crop density 51-60%

Total carbon stocks calculated in this crop density were5507 tons in 616 acres The details of the crop/tree density along with it Diameter, Height, Dry Biomass, Biomass Expansion Factor, Root shoot ratio, total biomass in each tree, carbon and carbon dioxide is shown in table below

Diameter (inches)	Height (ft)	Dry Bio mass(t)	D.biomass* Exp.Factor (t)	Root shoot ratio	Total Biomass (t)	Carbon (t)	CO2 (t)
12 4	27 5	0 3673	0 506874	0 2838	0 7907	0 3954	1 4511
17 2	17 4	0 4472	0 617136	0 3456	0 9627	0 4814	1 7667
6 2	21	0 0701	0 096738	0 0542	0 1509	0 0755	0 2771
16 5	23 9	0 5653	0 780114	0 4369	1 217	0 6085	2 2332
7 6	15 4	0 0773	0 106674	0 0597	0 1664	0 0832	0 3053
9 3	25 7	0 1931	0 266478	0 1492	0 4157	0 2079	0 763
15 4	15 7	0 3235	0 44643	0 25	0 6964	0 3482	1 2779
14 3	12 9	0 2292	0 316296	0 1771	0 4934	0 2467	0 9054
14 9	10 5	0 2025	0 27945	0 1565	0 436	0 218	0 8001
12 3	18 1	0 2379	0 328302	0 1838	0 5121	0 2561	0 9399
12 3	6	0 0789	0 108882	0 061	0 1699	0 085	0 312
11 9	7 5	0 0923	0 127374	0 0713	0 1987	0 0994	0 3648
17 3	11 1	0 2886	0 398268	0 223	0 6213	0 3107	1 1403
10 3	27 9	0 2571	0 354798	0 1987	0 5535	0 2768	1 0159
12 4	25 3	0 338	0 46644	0 2612	0 7276	0 3638	1 3351
16 2	12	0 2736	0 377568	0 2114	0 589	0 2945	1 0808
4 6	11 5	0 0211	0 029118	0 0163	0 0454	0 0227	0 0833
14 1	16 5	0 285	0 3933	0 2202	0 6135	0 3068	1 126
11 3	16 7	0 1853	0 255714	0 1432	0 3989	0 1995	0 7322
16 1	21 3	0 4797	0 661986	0 3707	1 0327	0 5164	1 8952
17 1	22 4	0 569	0 78522	0 4397	1 2249	0 6125	2 2479
14 4	13 5	0 2432	0 335616	0 1879	0 5235	0 2618	0 9608
6 8	14 1	0 0566	0 078108	0 0437	0 1218	0 0609	0 2235
15 3	17 4	0 3539	0 488382	0 2735	0 7619	0 381	1 3983
14 5	25 7	0 4694	0 647772	0 3628	1 0106	0 5053	1 8545
11 1	26 4	0 2826	0 389988	0 2184	0 6084	0 3042	1 1164
12 3	27 5	0 3614	0 498732	0 2793	0 778	0 389	1 4276
13 4	29 1	0 4539	0 626382	0 3508	0 9772	0 4886	1 7932
6 6	15 7	0 0594	0 081972	0 0459	0 1279	0 064	0 2349
10 5	12 1	0 1159	0 159942	0 0896	0 2495	0 1248	0 458
8 7	22 4	0 1473	0 203274	0 1138	0 3171	0 1586	0 5821

Diameter (inches)	Height (ft)	Dry Bio mass(t)	D.biomass* Exp.Factor (t)	Root shoot ratio	Total Biomass (t)	Carbon (t)	CO2 (t)
12 4	23	0 3072	0 423936	0 2374	0 6613	0 3307	1 2137
5 6	13 4	0 0365	0 05037	0 0282	0 0786	0 0393	0 1442
14 6	13 7	0 2537	0 350106	0 1961	0 5462	0 2731	1 0023
6 9	16 1	0 0666	0 091908	0 0515	0 1434	0 0717	0 2631
15 3	8 9	0 181	0 24978	0 1399	0 3897	0 1949	0 7153
4 5	12 3	0 0216	0 029808	0 0167	0 0465	0 0233	0 0855
17 8	17 1	0 4707	0 649566	0 3638	1 0134	0 5067	1 8596
19 3	21 4	0 6925	0 95565	0 5352	1 4909	0 7455	2 736
13 4	21 7	0 3385	0 46713	0 2616	0 7287	0 3644	1 3373
16 5	20 4	0 4825	0 66585	0 3729	1 0388	0 5194	1 9062
11 4	27 9	0 315	0 4347	0 2434	0 6781	0 3391	1 2445
13 4	12 4	0 1934	0 266892	0 1495	0 4164	0 2082	0 7641
3 7	9 1	0 0108	0 014904	0 0083	0 0232	0 0116	0 0426
5 6	13 4	0 0365	0 05037	0 0282	0 0786	0 0393	0 1442
8 3	17 4	0 1041	0 143658	0 0804	0 2241	0 1121	0 4114
12 4	31 5	0 4208	0 580704	0 3252	0 9059	0 453	1 6625
6 3	33 7	0 1162	0 160356	0 0898	0 2502	0 1251	0 4591
14 6	12 3	0 2278	0 314364	0 176	0 4904	0 2452	0 8999
6 7	17 3	0 0675	0 09315	0 0522	0 1454	0 0727	0 2668
15 3	14 4	0 2929	0 404202	0 2264	0 6306	0 3153	1 1572
7 3	9 1	0 0421	0 058098	0 0325	0 0906	0 0453	0 1663
12 3	6 4	0 0841	0 116058	0 065	0 1811	0 0906	0 3325
2 4	6 5	0 0033	0 004554	0 0026	0 0072	0 0036	0 0132
16 8	18 2	0 4463	0 615894	0 3449	0 9608	0 4804	1 7631
11 3	17 4	0 193	0 26634	0 1492	0 4155	0 2078	0 7626
8 9	21 2	0 1459	0 201342	0 1128	0 3141	0 1571	0 5766
13 5	23 4	0 3705	0 51129	0 2863	0 7976	0 3988	1 4636
4 2	25 4	0 0389	0 053682	0 0301	0 0838	0 0419	0 1538
13 4	9 2	0 1435	0 19803	0 1109	0 3089	0 1545	0 567
3 2	7 9	0 007	0 00966	0 0054	0 0151	0 0076	0 0279
13 2	6 8	0 1029	0 142002	0 0795	0 2215	0 1108	0 4066
15 3	13 2	0 2684	0 370392	0 2074	0 5778	0 2889	1 0603
6 2	16 4	0 0548	0 075624	0 0423	0 1179	0 059	0 2165
11 1	23 1	0 2473	0 341274	0 1911	0 5324	0 2662	0 977
9 3	6 7	0 0503	0 069414	0 0389	0 1083	0 0542	0 1989
14 5	17 2	0 3142	0 433596	0 2428	0 6764	0 3382	1 2412
11 3	15 3	0 1697	0 234186	0 1311	0 3653	0 1827	0 6705
14 7	18 1	0 3398	0 468924	0 2626	0 7315	0 3658	1 3425
11 1	21 2	0 2269	0 313122	0 1753	0 4884	0 2442	0 8962
14 3	19 4	0 3446	0 475548	0 2663	0 7418	0 3709	1 3612
12 3	23 5	0 3089	0 426282	0 2387	0 665	0 3325	1 2203
9 11	24 3	0 1752	0 241776	0 1354	0 3772	0 1886	0 6922

Diameter (inches)	Height (ft)	Dry Bio mass(t)	D.biomass* Exp.Factor (t)	Root shoot ratio	Total Biomass (t)	Carbon (t)	CO2 (t)
11 1	23 4	0 2505	0 34569	0 1936	0 5393	0 2697	0 9898
12 3	22 5	0 2957	0 408066	0 2285	0 6366	0 3183	1 1682
13 4	29 3	0 4571	0 630798	0 3532	0 984	0 492	1 8056
14 5	30 4	0 5553	0 766314	0 4291	1 1954	0 5977	2 1936
15 7	33 7	0 7217	0 995946	0 5577	1 5536	0 7768	2 8509
12 3	12 3	0 1617	0 223146	0 125	0 3481	0 1741	0 6389
14 4	17 6	0 3171	0 437598	0 2451	0 6827	0 3414	1 2529
11 2	19 2	0 2092	0 288696	0 1617	0 4504	0 2252	0 8265
13 3	9 3	0 1429	0 197202	0 1104	0 3076	0 1538	0 5644
13 5	15 4	0 2438	0 336444	0 1884	0 5248	0 2624	0 963
7 9	19 7	0 1068	0 147384	0 0825	0 2299	0 115	0 4221
9 8	20 1	0 1677	0 231426	0 1296	0 361	0 1805	0 6624
11 2	19 4	0 2114	0 291732	0 1634	0 4551	0 2276	0 8353
7 7	17 7	0 0912	0 125856	0 0705	0 1964	0 0982	0 3604
12 1	16 6	0 2111	0 291318	0 1631	0 4544	0 2272	0 8338
17 1	16 4	0 4166	0 574908	0 3219	0 8968	0 4484	1 6456
2 4	6 2	0 0031	0 004278	0 0024	0 0067	0 0034	0 0125
18 2	11 4	0 3281	0 452778	0 2536	0 7064	0 3532	1 2962
7 3	17 4	0 0806	0 111228	0 0623	0 1735	0 0868	0 3186
19 3	11 2	0 3624	0 500112	0 2801	0 7802	0 3901	1 4317
13 4	22 3	0 3479	0 480102	0 2689	0 749	0 3745	1 3744
17 3	27 8	0 7228	0 997464	0 5586	1 5561	0 7781	2 8556
14 5	29 4	0 537	0 74106	0 415	1 1561	0 5781	2 1216
13 4	34 5	0 5382	0 742716	0 4159	1 1586	0 5793	2 126
15 6	35 6	0 7527	1 038726	0 5817	1 6204	0 8102	2 9734
11 1	23 2	0 2483	0 342654	0 1919	0 5346	0 2673	0 981
12 9	6 1	0 0882	0 121716	0 0682	0 1899	0 095	0 3487
14 5	10 8	0 1973	0 272274	0 1525	0 4248	0 2124	0 7795
13 4	16 5	0 2574	0 355212	0 1989	0 5541	0 2771	1 017
12 3	21 3	0 28	0 3864	0 2164	0 6028	0 3014	1 1061
15 3	22 4	0 4555	0 62859	0 352	0 9806	0 4903	1 7994
11 2	22 5	0 2452	0 338376	0 1895	0 5279	0 264	0 9689
12 3	9 3	0 1222	0 168636	0 0944	0 263	0 1315	0 4826
16 1	11 2	0 2522	0 348036	0 1949	0 5429	0 2715	0 9964
15 8	23 1	0 501	0 69138	0 3872	1 0786	0 5393	1 9792
13 5	27 3	0 4322	0 596436	0 334	0 9304	0 4652	1 7073
3 4	29 1	0 0292	0 040296	0 0226	0 0629	0 0315	0 1156
15 1	33 1	0 6557	0 904866	0 5067	1 4116	0 7058	2 5903
16 4	22 4	0 5234	0 722292	0 4045	1 1268	0 5634	2 0677
16 4	26 7	0 6239	0 860982	0 4821	1 3431	0 6716	2 4648
11 3	15 6	0 1731	0 238878	0 1338	0 3727	0 1864	0 6841
17 1	15 3	0 3887	0 536406	0 3004	0 8368	0 4184	1 5355

Diameter (inches)	Height (ft)	Dry Bio mass(t)	D.biomass* Exp.Factor (t)	Root shoot ratio	Total Biomass (t)	Carbon (t)	CO2 (t)
16 4	22 4	0 5234	0 722292	0 4045	1 1268	0 5634	2 0677
7 5	24 1	0 1178	0 162564	0 091	0 2536	0 1268	0 4654
10 4	23 1	0 2171	0 299598	0 1678	0 4674	0 2337	0 8577
14 5	25 1	0 4585	0 63273	0 3543	0 987	0 4935	1 8111
13 2	27 1	0 4102	0 566076	0 317	0 8831	0 4416	1 6207
15 3	15 3	0 3112	0 429456	0 2405	0 67	0 335	1 2295
15 3	16 4	0 3335	0 46023	0 2577	0 7179	0 359	1 3175
14 2	17 7	0 3101	0 427938	0 2396	0 6675	0 3338	1 225

Table 4.1.1Showing carbon stock in crop density 51-60%

4.2 Carbon stocks of *Olea ferruginea* in crop density 31-50%

Total carbon stocks calculated in this crop density were9304 tons in 1153 acres The details of the crop/tree density along with it Diameter, Height, Dry Biomass, Biomass Expansion Factor Root shoot ratio, total biomass in each tree, carbon and carbon dioxide is shown in table below

Diameter (inches)	Height (ft)	Dry Bio mass(t)	D.biomass* Exp.Factor (t)	Root shoot ratio	Total Biomass (t)	Carbon (t)	CO2 (t)
2 6	27 5	0 0162	0 022356	0 0125	0 0349	0 0175	0 0642
11 4	29 5	0 3331	0 459678	0 2574	0 7171	0 3586	1 3161
12 3	31 4	0 4127	0 569526	0 3189	0 8884	0 4442	1 6302
4 5	15 7	0 0276	0 038088	0 0213	0 0594	0 0297	0 109
6 7	22 4	0 0874	0 120612	0 0675	0 1881	0 0941	0 3453
8 9	29 5	0 203	0 28014	0 1569	0 437	0 2185	0 8019
9 8	33 4	0 2787	0 384606	0 2154	0 6	0 3	1 101
9 9	31 4	0 2674	0 369012	0 2066	0 5756	0 2878	1 0562
8 8	29 4	0 1978	0 272964	0 1529	0 4259	0 213	0 7817
7 8	26 7	0 1411	0 194718	0 109	0 3037	0 1519	0 5575
9 5	29 1	0 2282	0 314916	0 1764	0 4913	0 2457	0 9017
6 7	24 5	0 0955	0 13179	0 0738	0 2056	0 1028	0 3773
3 1	32 4	0 0271	0 037398	0 0209	0 0583	0 0292	0 1072

Diameter (inches)	Height (ft)	Dry Bio mass(t)	D.biomass* Exp.Factor (t)	Root shoot ratio	Total Biomass (t)	Carbon (t)	CO2 (t)
13 4	33 5	0 5226	0 721188	0 4039	1 1251	0 5626	2 0647
2 3	32 3	0 0148	0 020424	0 0114	0 0318	0 0159	0 0584
7 4	35 3	0 1679	0 231702	0 1298	0 3615	0 1808	0 6635
13 3	31 2	0 4795	0 66171	0 3706	1 0323	0 5162	1 8945
4 4	35 5	0 0597	0 082386	0 0461	0 1285	0 0643	0 236
4 3	30 2	0 0485	0 06693	0 0375	0 1044	0 0522	0 1916
7 8	35 5	0 1876	0 258888	0 145	0 4039	0 202	0 7413
6 1	36 5	0 118	0 16284	0 0912	0 254	0 127	0 4661
2 3	33 4	0 0153	0 021114	0 0118	0 0329	0 0165	0 0606
3 2	34 5	0 0307	0 042366	0 0237	0 0661	0 0331	0 1215
4 1	34 4	0 0502	0 069276	0 0388	0 1081	0 0541	0 1985
4 5	16 4	0 0289	0 039882	0 0223	0 0622	0 0311	0 1141
6 7	23 4	0 0913	0 125994	0 0706	0 1966	0 0983	0 3608
8 4	29 1	0 1784	0 246192	0 1379	0 3841	0 1921	0 705
11 9	32	0 3937	0 543306	0 3043	0 8476	0 4238	1 5553
12 3	32 1	0 4219	0 582222	0 326	0 9082	0 4541	1 6665
14 5	33 1	0 6046	0 834348	0 4672	1 3015	0 6508	2 3884
6 7	24 5	0 0955	0 13179	0 0738	0 2056	0 1028	0 3773
8 9	29 3	0 2016	0 278208	0 1558	0 434	0 217	0 7964
9 4	29 1	0 2234	0 308292	0 1726	0 4809	0 2405	0 8826
9 6	30 1	0 241	0 33258	0 1862	0 5188	0 2594	0 952
7 8	27 5	0 1454	0 200652	0 1124	0 3131	0 1566	0 5747
9 4	29 7	0 228	0 31464	0 1762	0 4908	0 2454	0 9006
5 6	20 1	0 0548	0 075624	0 0423	0 1179	0 059	0 2165
3 4	12 4	0 0125	0 01725	0 0097	0 027	0 0135	0 0495
5 6	21 3	0 058	0 08004	0 0448	0 1248	0 0624	0 229
6 7	24 4	0 0952	0 131376	0 0736	0 205	0 1025	0 3762
8 3	27 9	0 167	0 23046	0 1291	0 3596	0 1798	0 6599
12 4	29 1	0 3887	0 536406	0 3004	0 8368	0 4184	1 5355
13 5	31 2	0 494	0 68172	0 3818	1 0635	0 5318	1 9517
16 7	32 3	0 7826	1 079988	0 6048	1 6848	0 8424	3 0916
8 9	29 9	0 2058	0 284004	0 159	0 443	0 2215	0 8129
13 5	33 3	0 5272	0 727536	0 4074	1 1349	0 5675	2 0827
15 6	35 4	0 7484	1 032792	0 5784	1 6112	0 8056	2 9566
19 4	36 1	1 1804	1 628952	0 9122	2 5412	1 2706	4 6631
12 9	29	0 4193	0 578634	0 324	0 9026	0 4513	1 6563
12 3	32 4	0 4259	0 587742	0 3291	0 9168	0 4584	1 6823
12 7	31 2	0 4372	0 603336	0 3379	0 9412	0 4706	1 7271
8 8	29 1	0 1958	0 270204	0 1513	0 4215	0 2108	0 7736
9 7	27 6	0 2256	0 311328	0 1743	0 4856	0 2428	0 8911
6 5	24 4	0 0896	0 123648	0 0692	0 1928	0 0964	0 3538
5 8	21 2	0 062	0 08556	0 0479	0 1335	0 0668	0 2452

Diameter (inches)	Height (ft)	Dry Bio mass(t)	D.biomass* Exp.Factor (t)	Root shoot ratio	Total Biomass (t)	Carbon (t)	CO2 (t)
8 4	28 9	0 1772	0 244536	0 1369	0 3814	0 1907	0 6999
12 3	32 1	0 4219	0 582222	0 326	0 9082	0 4541	1 6665
13 5	33 1	0 5241	0 723258	0 405	1 1283	0 5642	2 0706
14 6	32 1	0 5944	0 820272	0 4594	1 2797	0 6399	2 3484
15 5	34 1	0 7117	0 982146	0 55	1 5321	0 7661	2 8116
17 7	33 4	0 9091	1 254558	0 7026	1 9572	0 9786	3 5915
14 5	34 1	0 6229	0 859602	0 4814	1 341	0 6705	2 4607
15 6	32 1	0 6787	0 936606	0 5245	1 4611	0 7306	2 6813
16 7	33 4	0 8092	1 116696	0 6253	1 742	0 871	3 1966
17 8	32 3	0 8891	1 226958	0 6871	1 9141	0 9571	3 5126
9 6	27 2	0 2178	0 300564	0 1683	0 4689	0 2345	0 8606
23 4	31 2	1 4842	2 048196	1 147	3 1952	1 5976	5 8632
19 4	33 4	1 0921	1 507098	0 844	2 3511	1 1756	4 3145
14 5	34 5	0 6302	0 869676	0 487	1 3567	0 6784	2 4897
4 4	16 5	0 0278	0 038364	0 0215	0 0599	0 03	0 1101
4 5	16 7	0 0294	0 040572	0 0227	0 0633	0 0317	0 1163
3 4	9 3	0 0093	0 012834	0 0072	0 02	0 01	0 0367
3 3	11 2	0 0106	0 014628	0 0082	0 0228	0 0114	0 0418
2 7	8 7	0 0055	0 00759	0 0043	0 0119	0 006	0 022
7 5	27 6	0 1349	0 186162	0 1043	0 2905	0 1453	0 5333
6 7	24 5	0 0955	0 13179	0 0738	0 2056	0 1028	0 3773
7 7	28 7	0 1478	0 203964	0 1142	0 3182	0 1591	0 5839
7 1	26 5	0 1161	0 160218	0 0897	0 2499	0 125	0 4588
7 2	24 5	0 1103	0 152214	0 0852	0 2374	0 1187	0 4356
7 2	26 8	0 1207	0 166566	0 0933	0 2599	0 13	0 4771
7 4	27 9	0 1327	0 183126	0 1026	0 2857	0 1429	0 5244
5 5	20 1	0 0528	0 072864	0 0408	0 1137	0 0569	0 2088
5 6	19 4	0 0529	0 073002	0 0409	0 1139	0 057	0 2092
13 4	32	0 4992	0 688896	0 3858	1 0747	0 5374	1 9723
12 4	32 1	0 4288	0 591744	0 3314	0 9231	0 4616	1 6941
14 5	33 1	0 6046	0 834348	0 4672	1 3015	0 6508	2 3884
16 6	34 2	0 8187	1 129806	0 6327	1 7625	0 8813	3 2344
13 5	31 2	0 494	0 68172	0 3818	1 0635	0 5318	1 9517
13 3	30 5	0 4687	0 646806	0 3622	1 009	0 5045	1 8515
4 3	16 4	0 0263	0 036294	0 0203	0 0566	0 0283	0 1039
4 5	16 7	0 0294	0 040572	0 0227	0 0633	0 0317	0 1163
6 6	24 5	0 0927	0 127926	0 0716	0 1995	0 0998	0 3663
7 7	24 3	0 1252	0 172776	0 0968	0 2696	0 1348	0 4947
8 8	29 8	0 2005	0 27669	0 1549	0 4316	0 2158	0 792
9 8	30 5	0 2545	0 35121	0 1967	0 5479	0 274	1 0056
7 7	29 3	0 1509	0 208242	0 1166	0 3248	0 1624	0 596
7 6	27 4	0 1375	0 18975	0 1063	0 2961	0 1481	0 5435

Diameter (inches)	Height (ft)	Dry Bio mass(t)	D.biomass* Exp.Factor (t)	Root shoot ratio	Total Biomass (t)	Carbon (t)	CO_2 (t)
5 6	20 1	0 0548	0 075624	0 0423	0 1179	0 059	0 2165
6 6	24 5	0 0927	0 127926	0 0716	0 1995	0 0998	0 3663
12 3	32 1	0 4219	0 582222	0 326	0 9082	0 4541	1 6665
11 2	30 1	0 328	0 45264	0 2535	0 7061	0 3531	1 2959
10 2	32 1	0 2901	0 400338	0 2242	0 6245	0 3123	1 1461
9 4	29 3	0 2249	0 310362	0 1738	0 4842	0 2421	0 8885

Table 4.2.1Showing carbon stock in crop density 31-50%

4.3 Carbon stocks of *Olea ferruginea* in crop density 11-30%

Total carbon stocks calculated in this crop density were1 177 tons in 279 acres The details of the crop tree density along with it Diameter, Height, Dry Biomass, Biomass Expansion Factor, Root shoot ratio, total biomass in each tree, carbon and carbon dioxide is shown in table below

Diameter (inches)	Height (ft)	Dry Bio mass(t)	D.biomass* Exp.Factor (t)	Root shoot ratio	Total Biomass (t)	Carbon (t)	CO_2 (t)
9 4	27	0 1769	0 244122	0 1367	0 3808	0 1904	0 6988
12 6	34 1	0 4013	0 553794	0 3101	0 8639	0 432	1 5854
7 8	28 8	0 1299	0 179262	0 1004	0 2797	0 1399	0 5134
9 7	28 9	0 2016	0 278208	0 1558	0 434	0 217	0 7964
8 5	29 1	0 1559	0 215142	0 1205	0 3356	0 1678	0 6158
6 7	24 5	0 0815	0 11247	0 063	0 1755	0 0878	0 3222
13 4	32 1	0 4273	0 589674	0 3302	0 9199	0 46	1 6882
15 6	34 1	0 6152	0 848976	0 4754	1 3244	0 6622	2 4303
16 7	33 1	0 6844	0 944472	0 5289	1 4734	0 7367	2 7037
4 5	14 2	0 0213	0 029394	0 0165	0 0459	0 023	0 0844
5 6	19 1	0 0444	0 061272	0 0343	0 0956	0 0478	0 1754
6 5	24 6	0 0771	0 106398	0 0596	0 166	0 083	0 3046
6 6	24 7	0 0798	0 110124	0 0617	0 1718	0 0859	0 3153
7 8	27 9	0 1258	0 173604	0 0972	0 2708	0 1354	0 4969
8 8	29 6	0 1699	0 234462	0 1313	0 3658	0 1829	0 6712
9 6	30 1	0 2057	0 283866	0 159	0 4429	0 2215	0 8129
6 7	25 6	0 0852	0 117576	0 0658	0 1834	0 0917	0 3365
12 3	32 1	0 4219	0 582222	0 326	0 9082	0 4541	1 6665

Diameter (inches)	Height (ft)	Dry Bio mass(t)	D.biomass* Exp.Factor (t)	Root shoot ratio	Total Biomass (t)	Carbon (t)	CO2 (t)
4.3	15.4	0.0247	0.034086	0.0191	0.0532	0.0266	0.0976
5.4	20.3	0.0514	0.070932	0.0397	0.1106	0.0553	0.203
3.4	12.3	0.0124	0.017112	0.0096	0.0267	0.0134	0.0492
16.6	32.1	0.7685	1.06053	0.5939	1.6544	0.8272	3.0358
17.8	33.5	0.9221	1.272498	0.7126	1.9851	0.9926	3.6428
8.3	28.8	0.1724	0.237912	0.1332	0.3711	0.1856	0.6812
4.5	16.4	0.0289	0.039882	0.0223	0.0622	0.0311	0.1141
3.4	11.2	0.0112	0.015456	0.0087	0.0242	0.0121	0.0444
4.6	16.4	0.0301	0.041538	0.0233	0.0648	0.0324	0.1189
5.5	20.1	0.0528	0.072864	0.0408	0.1137	0.0569	0.2088
4.3	16.3	0.0262	0.036156	0.0202	0.0564	0.0282	0.1035
4.4	15.4	0.0259	0.035742	0.02	0.0557	0.0279	0.1024
3.3	9.3	0.0088	0.012144	0.0068	0.0189	0.0095	0.0349
3.3	11.2	0.0106	0.014628	0.0082	0.0228	0.0114	0.0418
20.4	33.1	1.1967	1.651446	0.9248	2.5762	1.2881	4.7273
12.4	31.2	0.4168	0.575184	0.3221	0.8973	0.4487	1.6467
13.5	34.8	0.551	0.76038	0.4258	1.1862	0.5931	2.1767
6.7	24.5	0.0955	0.13179	0.0738	0.2056	0.1028	0.3773
7.7	26.7	0.1375	0.18975	0.1063	0.2961	0.1481	0.5435
6.6	25.3	0.0957	0.132066	0.074	0.2061	0.1031	0.3784
8.4	29.1	0.1784	0.246192	0.1379	0.3841	0.1921	0.705
5.4	18.5	0.0469	0.064722	0.0362	0.1009	0.0505	0.1853
9.5	29.2	0.2289	0.315882	0.1769	0.4928	0.2464	0.9043
4.4	17.6	0.0296	0.040848	0.0229	0.0637	0.0319	0.1171
5.5	21.2	0.0557	0.076866	0.043	0.1199	0.06	0.2202
6.4	24.5	0.0872	0.120336	0.0674	0.1877	0.0939	0.3446
3.5	9.4	0.01	0.0138	0.0077	0.0215	0.0108	0.0396
13.4	32.1	0.5007	0.690966	0.3869	1.0779	0.539	1.9781
2.3	31.3	0.0144	0.019872	0.0111	0.031	0.0155	0.0569
4.2	34.5	0.0529	0.073002	0.0409	0.1139	0.057	0.2092
6.3	35.6	0.1228	0.169464	0.0949	0.2644	0.1322	0.4852
21.3	34.5	1.3598	1.876524	1.0509	2.9274	1.4637	5.3718
7.1	33.2	0.1454	0.200652	0.1124	0.3131	0.1566	0.5747
3.1	34.6	0.0289	0.039882	0.0223	0.0622	0.0311	0.1141
13.6	33.1	0.5319	0.734022	0.4111	1.1451	0.5726	2.1014
14.7	31.3	0.5876	0.810888	0.4541	1.265	0.6325	2.3213
4.3	32.5	0.0522	0.072036	0.0403	0.1123	0.0562	0.2063
18.9	33.5	1.0396	1.434648	0.8034	2.238	1.119	4.1067
8.4	27.9	0.171	0.23598	0.1321	0.3681	0.1841	0.6756
3.2	36.1	0.0321	0.044298	0.0248	0.0691	0.0346	0.127
9.7	30.1	0.246	0.33948	0.1901	0.5296	0.2648	0.9718
8.4	28.9	0.1772	0.244536	0.1369	0.3814	0.1907	0.6999

Diameter (inches)	Height (ft)	Dry Bio mass(t)	D.biomass* Exp.Factor (t)	Root shoot ratio	Total Biomass (t)	Carbon (t)	CO2 (t)
6 3	23 1	0 0797	0 109986	0 0616	0 1716	0 0858	0 3149
3 1	32 5	0 0271	0 037398	0 0209	0 0583	0 0292	0 1072
11 3	31 2	0 3461	0 477618	0 2675	0 7451	0 3726	1 3674
12 3	34 1	0 4482	0 618516	0 3464	0 9649	0 4825	1 7708
2 3	32 1	0 0148	0 020424	0 0114	0 0318	0 0159	0 0584
11 3	30	0 3328	0 459264	0 2572	0 7165	0 3583	1 315

Table 4.3.1 Showing carbon stock in crop density 11-30%

4.4 Carbon stocks of *Olea ferruginea* in crop density 0-10%

Total carbon stocks calculated in this crop density were17156 tons in 4575 acres The details of the crop tree density along with it Diameter, Height, Dry Biomass, Biomass Expansion Factor, Root shoot ratio total biomass in each tree carbon and carbon dioxide is shown in table below

Diameter (inches)	Height (ft)	Dry Bio mass(t)	D.biomass* Exp.Factor (t)	Root shoot ratio	Total Biomass (t)	Carbon (t)	CO2 (t)
4 6	15 4	0 0283	0 039054	0 0219	0 061	0 0305	0 1119
8 6	23 5	0 151	0 20838	0 1167	0 3251	0 1626	0 5967
12 5	31 3	0 4249	0 586362	0 3284	0 9148	0 4574	1 6787
17 4	31 5	0 8285	1 14333	0 6403	1 7836	0 8918	3 2729
15 7	33 3	0 7131	0 984078	0 5511	1 5352	0 7676	2 8171
16 2	34 6	0 7889	1 088682	0 6097	1 6984	0 8492	3 1166
3 6	9 1	0 0102	0 014076	0 0079	0 022	0 011	0 0404
7 6	27 4	0 1375	0 18975	0 1063	0 2961	0 1481	0 5435
8 4	29 4	0 1802	0 248676	0 1393	0 388	0 194	0 712
5 8	20 3	0 0593	0 081834	0 0458	0 1276	0 0638	0 2341
9 1	29 9	0 2151	0 296838	0 1662	0 463	0 2315	0 8496
13 5	33 3	0 5272	0 727536	0 4074	1 1349	0 5675	2 0827
15 6	35 4	0 7484	1 032792	0 5784	1 6112	0 8056	2 9566
19 4	36 1	1 1804	1 628952	0 9122	2 5412	1 2706	4 6631
21 6	34 4	1 3943	1 924134	1 0775	3 0016	1 5008	5 5079

Diameter (inches)	Height (ft)	Dry Bio mass(t)	D.biomass* Exp.Factor (t)	Root shoot ratio	Total Biomass (t)	Carbon (t)	CO2 (t)
12 5	31 2	0 4235	0 58443	0 3273	0 9117	0 4559	1 6732
16 7	34 2	0 8286	1 143468	0 6403	1 7838	0 8919	3 2733
17 4	31 2	0 8206	1 132428	0 6342	1 7666	0 8833	3.2417
5 4	18 9	0 0479	0 066102	0 037	0 1031	0 0516	0 1894
23 1	34	1 5762	2 175156	1 2181	3 3933	1 6967	6 2269
12 7	31 2	0 4372	0 603336	0 3379	0 9412	0 4706	1 7271
14 7	36 1	0 6777	0 935226	0 5237	1 4589	0 7295	2 6773
9 7	30 1	0 246	0 33948	0 1901	0 5296	0 2648	0 9718
8.4	28 9	0 1772	0 244536	0 1369	0 3814	0 1907	0 6999
6 3	23 1	0 0797	0 109986	0 0616	0 1716	0 0858	0 3149
12 4	32 5	0 4341	0 599058	0 3355	0 9346	0 4673	1 715
11 3	31 2	0 3461	0 477618	0 2675	0 7451	0 3726	1 3674
4 5	34 1	0 06	0.0828	0 0464	0 1292	0 0646	0 2371
3 4	32 1	0 0322	0 044436	0 0249	0 0693	0 0347	0 1273
11 3	30	0 3328	0 459264	0 2572	0 7165	0 3583	1 315

Table 4.4.1 Showing carbon stock in crop density 0-10%

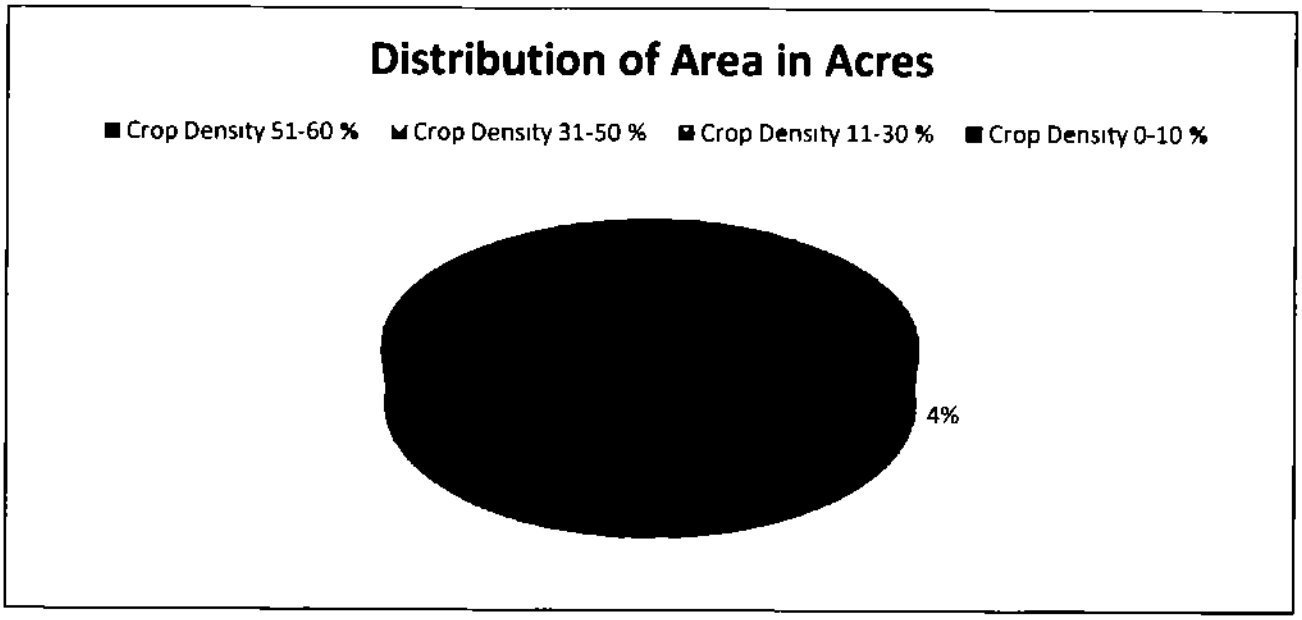


Fig 4.1 Distribution of study area in Acres and their percentage

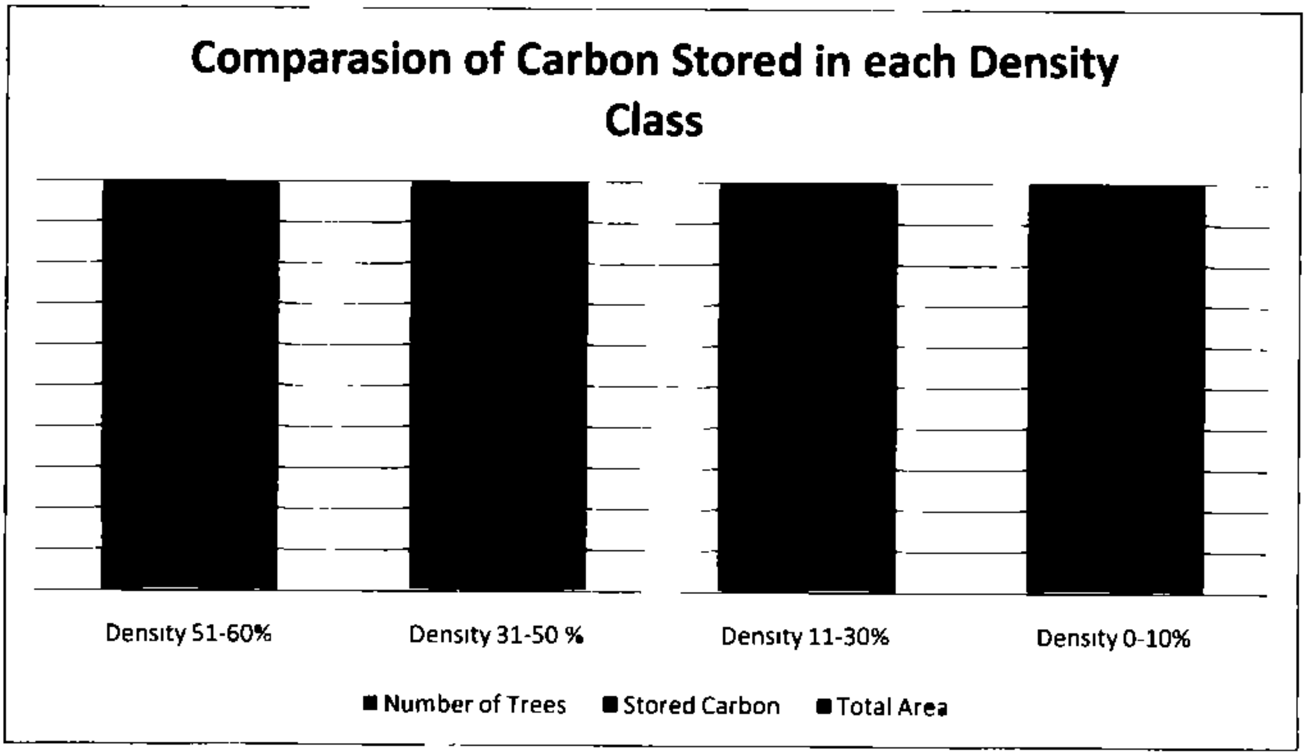


Fig 4.2 Comparison of Tree, Stored Carbon against area in each density class

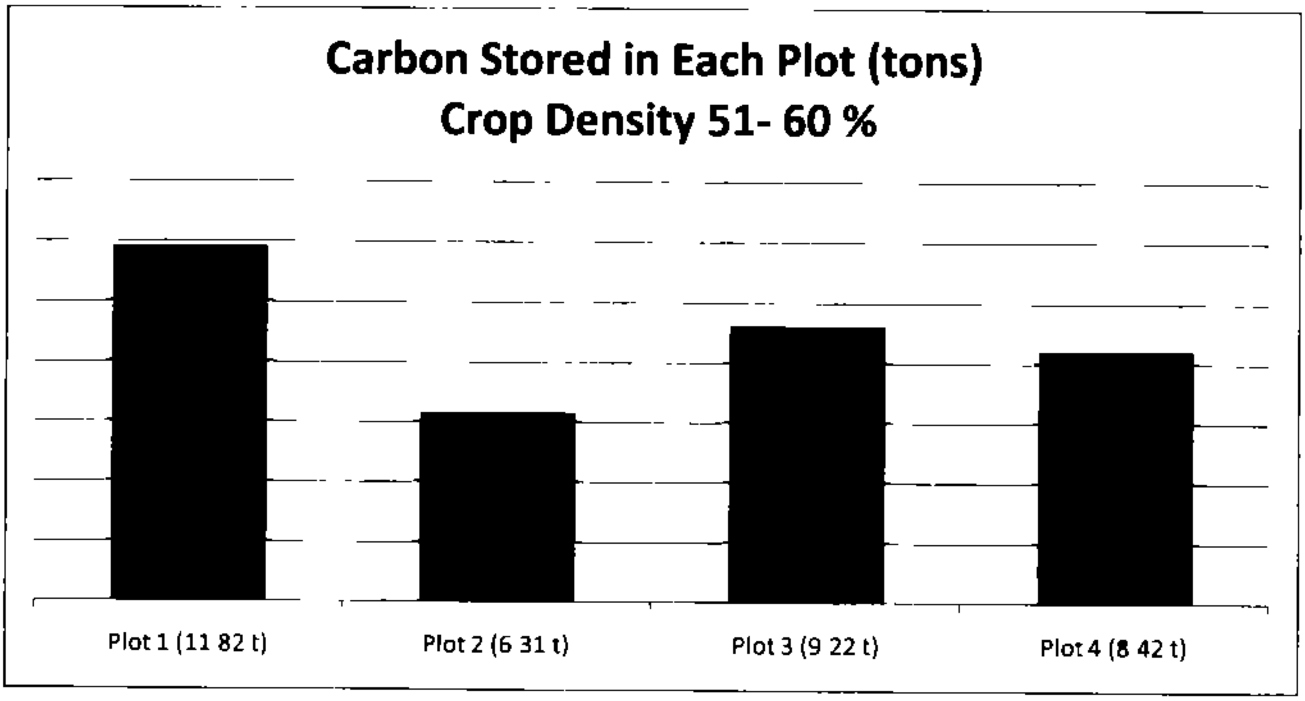


Fig 4.3 Carbon Stocks in each plot of crop density 51-60%

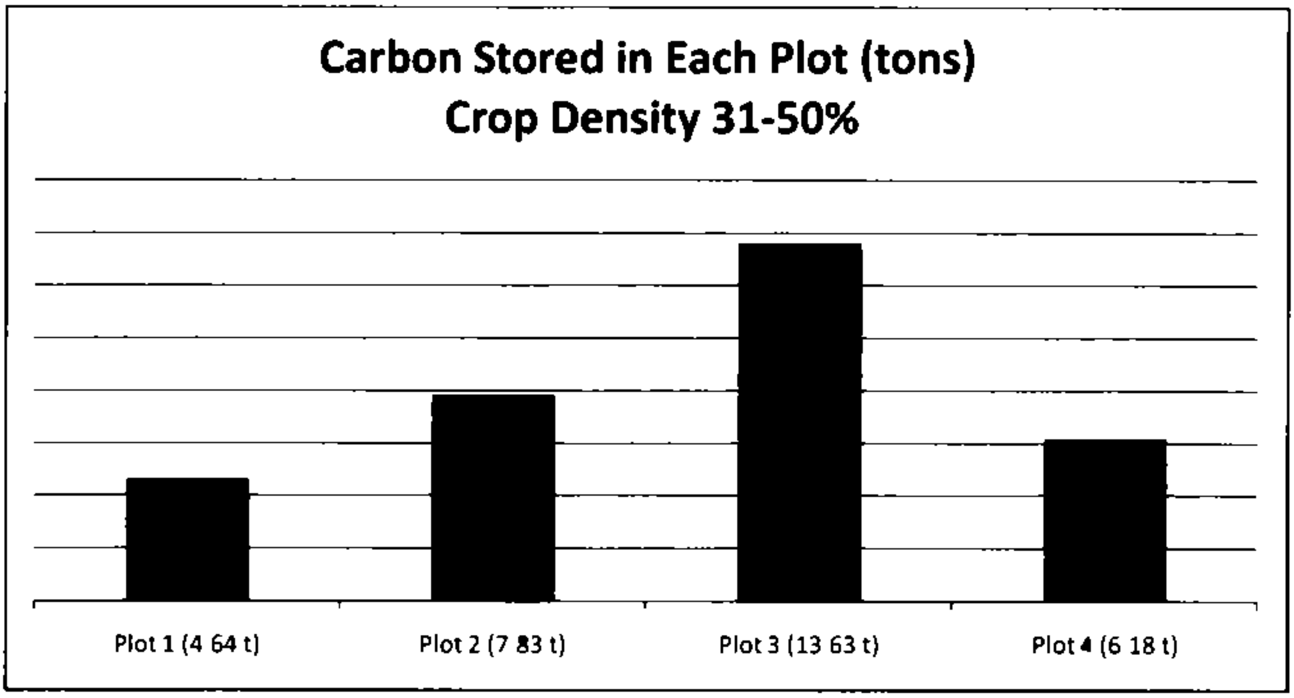


Fig 4.4 Carbon Stocks in each plot of crop density 31-50%

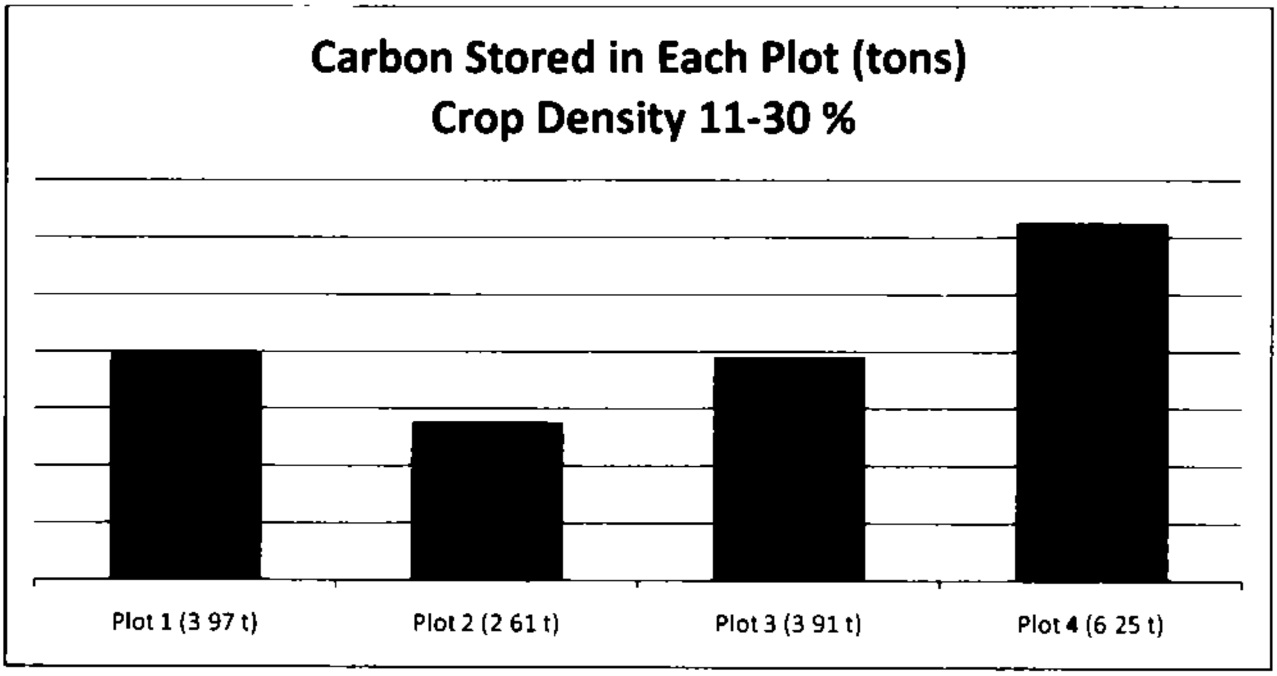


Fig 4.5 Carbon Stocks in each plot of crop density 11-30%

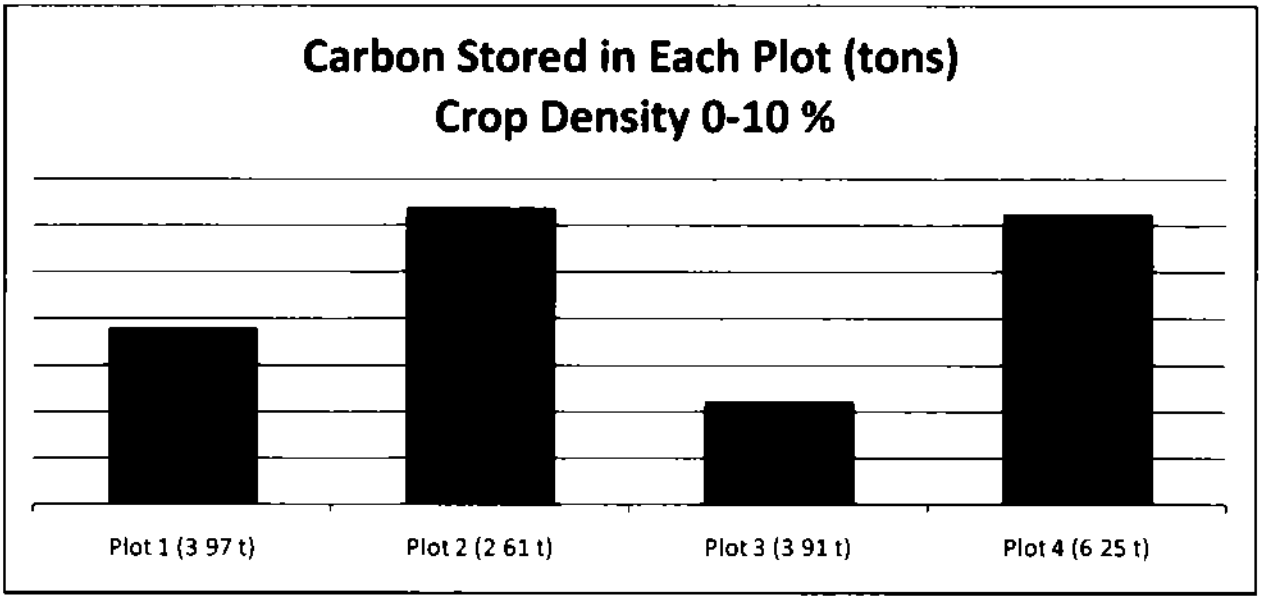


Fig 4.6 Carbon Stocks in each plot of crop density 0-10%

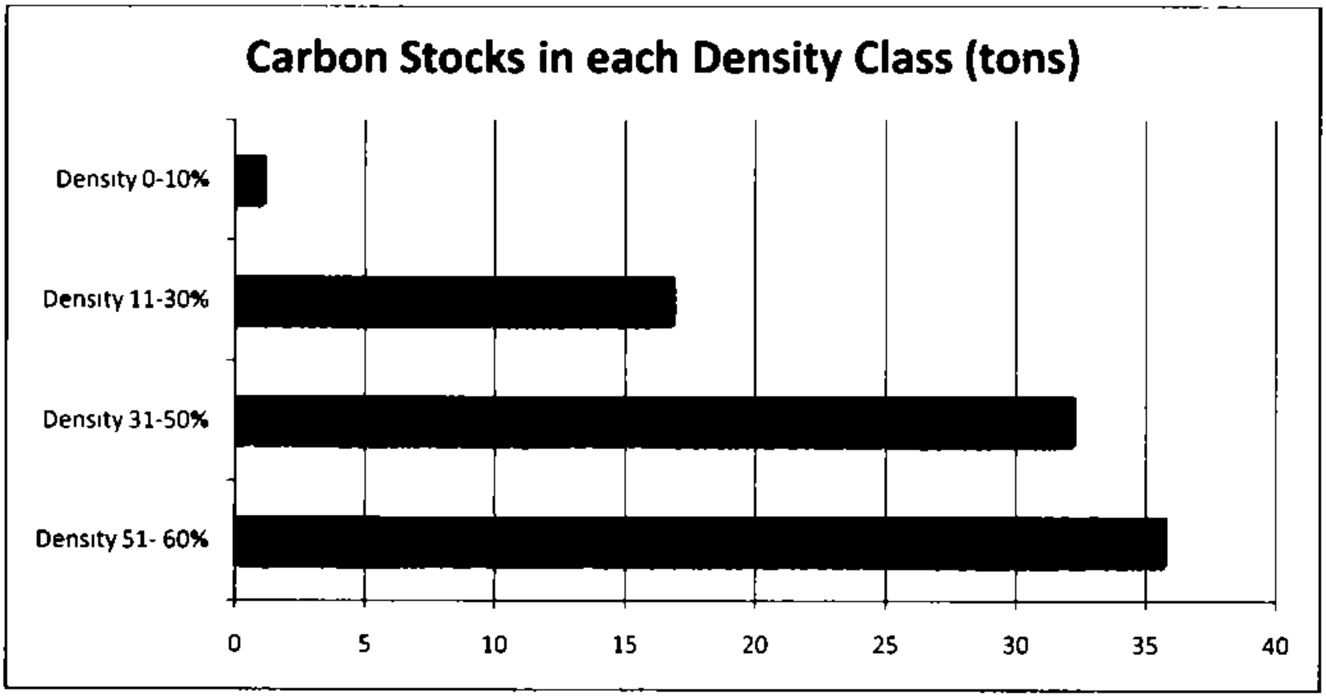


Fig 4.7 Overall carbon stocks of each class density in study area

5. CONCLUSION AND RECOMMENDATIONS

The concerned departments of the four provinces are carrying out the watershed management programs/projects in collaboration with the Water and Power Development Authority (WAPDA) In last two decades many agencies emerged which are at now involved in watershed management research and development activities There is a need to have networking of these institutions as no single agency can handle all the issues related to watershed management The area is rich in water resources and hence more cultivation of *Olea ferruginea* can be carried out not only to increase the cultivation area but its fruit "Olive" can reap economic benefits for local community in terms of selling the fruit and using the leaves for livestock Small ponds can be made to increase the economic potential of the area by fish farming The area is dry and temperate and hence the cold water is suitable for the farming of Tuna

This study was designed to calculate carbon stocks of Domara Valley in Ziarat The amount of carbon stored in a single tree was calculated using stem volume, stem biomass, above ground biomass and root biomass Domara valley has an area of 6,623 acres and is currently holding 33,144 tons of carbon which is calculated with the help of 16 sample plots The amount of carbon stocks will be increased with the passage of time as the forest grows old Protected forests are a great source of storing carbon The soil and trees will store carbon as they grow and will act as carbon storage bank

Domara is a watershed area and play a great importance in providing water for agriculture and drinking in nearby areas specially Harnai and Shahrigh Watersheds act as a funnel and all water from storms and rain is collected in a common outlet which is necessary to support animal and plant habitat while providing drinking water for human and wildlife. With the difference of 2600ft between average elevations from highest to lower point Domiara plays an important role in accumulating all the water from Rain and snowfall in the central Domiara Nulla which starts from the center of this valley and empties into Sharigh. It acts as a water catchment area. An area of 4,575 acres which is 69% percent of total area of this valley lacks vegetation and all the water will ultimately seek the lowest point of this valley. This means every stream, tributary or river will ultimately reach large water reservoir. The groundwater that we cannot see will also move towards the lower point of the valley. Due to small water pools and storage of water grazing is a common feature in this region and many shepherds take this route from Ziarat to Harnai for their large herd of sheep.

Cutting of tree is completely banned as Ziarat is a protected area and any activity related to felling of tree is completely banned by Forest Department of Balochistan. The carbon storage potential of Domiara valley can be increased by increasing the forest cover which can be easily achieved by plantation of trees. From total area of Domiara which is 6,623 acres around 69% lacks vegetation due to non-availability of soil and water. Most of the area is barren due to mountainous terrain and lack of soil for growth. Maximum crop density recorded was 60% that was located in the lowest point of Domiara Valley. Domiara Valley has very limited amount of soil and thus cultivation of crop is very limited to specific regions. About 80 person of total area consists of mountains and rocks.

Following recommendations can be fruitful if implemented sincerely by Government of Balochistan and Forest Department of Balochistan -

- Construction of small dams to increase the irrigation area and storage of water for local community
- Construction of a reserve forest in Domiara specifically for *Olea ferruginea* to increase its vegetation and forest cover
- Building economic consensus by Government of Balochistan to know the economic value of Carbon Stocks in Domiara Valley
- Recognizing and developing Domiara as a watershed zone
- Watershed management legislation, policy guidelines or plan in order to manage the mountain ecosystems in Domiara
- Water scarcity in surrounding regions can be reduced by watershed management
- Preservation of Bio-Diversity etc

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