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COMPARATIVE ASSESSMENT OF CARBON STOCK IN CHIR PINE NATURAL FOREST SHINKIARI AND MAN-MADE PLANTATION PARACHINAR, PAKISTAN

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Abstract

The study focuses to assess the natural forest Shinkiari and the Man-made Plantation Parachinar (Khyber Pakhtunkhwa). The purpose is to estimate the Above Ground Biomass, below ground biomass and carbon stock in the forest upper and understory vegetation in both the forest. Total 60 circular plots with an area of 0.1 hectare were systematically laid in both the forest in a circle with a diameter of 17.84m. Aboveground biomass, Diameter at breast height (DBH) and all the trees height in a sample plot were measured in the field. Results shows that the natural forest have 7310 total stems per hectare, 7668.42t/ha the total biomass and 3834.3t/ha the total carbon stock. While the Man-made plantation, the total stem number per hectare 24640, the total biomass 2034.58t/ha while the total carbon stock is 1025.45t/ha. Therefore, these forests may generate carbon stock equal to 4829.48 tons. If the rate of one carbon credit price is US $30, the income may be achieved 1938983.4$ from these carbon credits. Pakistan's high carbon density temperate and subtropical forests have the potential to reduce emission from the forest sector. Therefore, it is necessary to protect forests with large carbon reserves in Khyber Pakhtunkhwa to mitigate climate change.

***Keywords**: Carbon Credits; Carbon Pool; Carbon Sequestration; Carbon Stock; Forest Cover*

Introduction

The forest covers an area of 4 x 10^7km^2 on the surface of the earth, equivalent to 30% of the global ground area. Forests are the significant portion in the worldwide carbon cycle and a large carbon pool that can reduce climate change [1]. Trees swap carbon dioxide with the atmosphere through biological processes, of fixed biomass carbon in the form of carbon stock, becoming the main carbon sink. Therefore, it is necessary to measure the carbon storing of trees in forest systems to understand the potential of forests as carbon sinks. The carbon storage of trees depends on their biomass. The biomass of trees can be evaluate utilizing destructive and non-destructive sampling approaches. Destructive sampling methods for felled trees are mainly used in plantation forests. Non-destructive sampling methods are widely used in natural forests and involve estimation of biomass from forest inventory data by using biomass equation (BE) or biomass expansion factor (BEF), conversion factor (wood density) or biomass conversion and expansion factor (BCEF) Biomass. BE needs tree data, such as diameter or height at breast

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height, age, etc. BEF requires volume data from the forest inventory, and BCEF is a combination of the first two factors [2].

As photosynthesis progresses, more carbon dioxide is converted to biomass, which reduces the carbon in the atmosphere and sequesters it in plant tissues above and below ground [3]. Since the industrial revolution has had a significant impact on the global environment, forest ecosystems have the greatest potential to sequester carbon and increase greenhouse gas emissions.

Due to climate change, carbon balance issues, the main greenhouse gas, people are increasingly concerned about environmental changes, this is very important, so it is necessary to remove carbon and store it in different terrestrial ecosystems to reduce the increase in carbon dioxide levels [4]. However, the ever-increasing population and its continued attempts at deforestation posing serious challenges to the survival of forest ecosystems. Research shows that in the past forest ecosystems have been deforested. Globally, due to industrialization, urbanization and human activities, the main elements of forest ecosystems are decreasing and degrading. Only 7% of the world's region is covered by tropical forests. Tropical forests are the richest home of biodiversity on the earth. They are the main components of our plants, trees, mammals, insects, and birds but they are on a global scale. Play a vital part in the carbon cycle they are the richest home of biodiversity on the earth. They are the main components of our trees, bird's, plants mammal's and insects but they are on a global scale.

Forests are one of the largest reservoirs of long-term atmospheric carbon storing to reduce climate change and global warming [5]. To reduce atmospheric carbon concentration forest landscape and sustainable forest development expansion are one of the fundamental methods. This is a protected, environmentally friendly and worthwhile method for capturing and storing huge quantities of atmospheric carbon. In forest management decisions the simultaneous advancement of marketable carbon credits delivers economic encouragement to look at carbon storing in forest managing decisions [6]. Climate change caused by global warming is partly caused by a large amount of greenhouse gases (GHG) in the atmosphere.

Carbon dioxide is one of the main greenhouse gases. Due to the industrial revolution the increase in carbon dioxide content leads significant a major effect on the climatic condition [7, 8]. At the beginning of industrial revolution, the atmospheric carbon concentration was about 270ppm, which exceeded 400ppm by 2015 [9]. As we all know, growing forests carbon sequestration is a cost-effective option to mitigate global warming and global climate change. In terms of reducing carbon in the atmosphere, through biogeochemical processes trees in urban areas provide the dual benefits of direct carbon storage and care of climatic conditions [10-12]. The purpose of this research was to analyses stand structure, aboveground biomass and below ground biomass, and the carbon Stock of Natural and Man-made Chir Pine forests in KPK, Pakistan. And to explain implications of the policy for the successful implement of 'reducing emissions from deforestation and forest degradation, (REDD+) activities.

Materials and Methods

Study Area

The research focuses on natural forest Shinkiari and man-made Plantation Parachinar in Khyber Pakhtunkhwa Province, located in northwestern Pakistan, latitudes 33°20′ to 34°10′, 60°50′ to 70°50′ east longitude is the province with the most forests in Pakistan (Figure 1). The province over-all area is 7.452 million hectares, which is the 9.36% of the over-all area of Pakistan. The mainland used of the province Range land, forestry and Agriculture, accounting for 20, 26 and 30% of the over-all area. The province's actual forest area is 1.133 million hectares, with a population of 3.052 million [13].

Inventory design and data collection

The systematically distributed sampling units were among the strata. To measure trees, shrubs and litter used the circular plot method. The radius of 17.84m outermost circular plot was established for the measure of trees, shrubs and litter. To measure shrubs and saplings, the 2nd circular plot was used with a radius of 5.64m and a radius of 0.56m the inner most plot was used to measure litter and soil (Fig. 1). Each sample plot the size was 0.1 hectares of one tenth (1/10) of hectare of plot size of a standard inventory was taken for all sample plots. The shape of the plot was circular which occupies one tenth hectare of plot size with a radius of 17.84m. 2.5% was always taken the sampling intensity (Fig. 2). But our study is only for research purposes, that's why the standardize current research, the intensity of the occupied plots taken was 0.5%. While the distance in a specific direction from the plot to the plot was 100x100m in (Fig. 3).

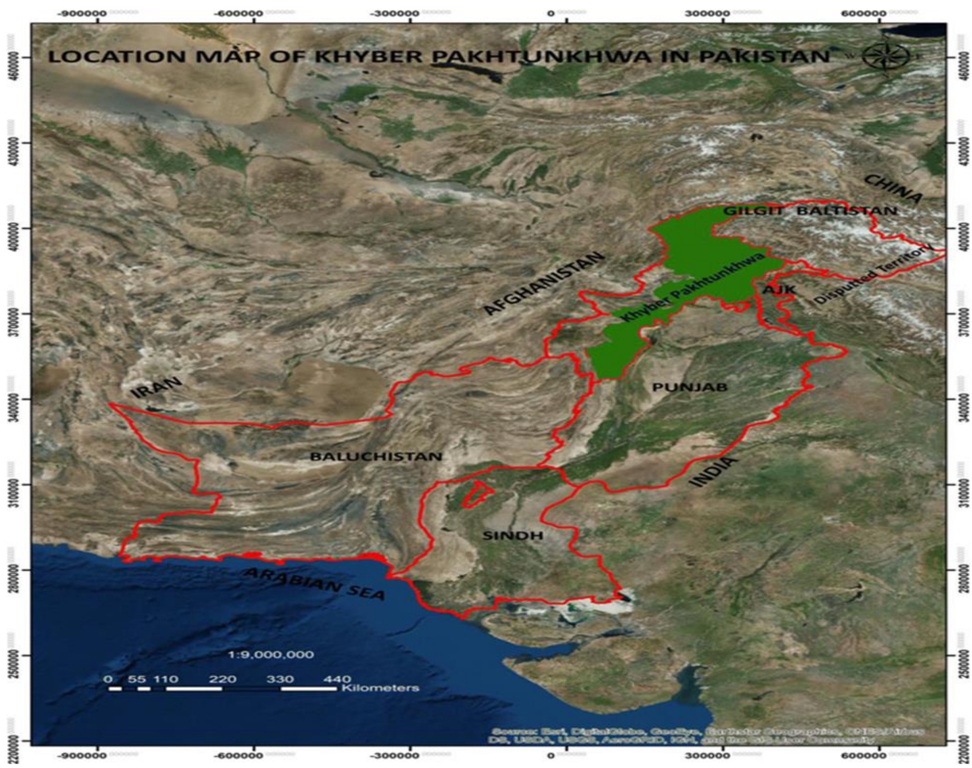

Fig. 1. Map of study areas in Khyber Pakhtunkhwa: the green colored area

For the field inventory nested circular shape plots were preferred because they are easy to build, especially in sloppy terrain, and can reduce the edge effect problems associated with rectangular plots the area was investigated. To determine the tree composition, the general survey was carried out for the distribution of the topographic nature of the area. The Working Plan of Shinkiari and Parachinar were also examined for the verification of land details. After investigation, two main forest natural forest and man-made Chir pine Plantation were elected for research. In individual forest type, 30 sample plots were systematically arranged and total number of 60 plots. Through GPS height and topographical locality of individual plot were measured. Stem density in individual plot, No. of stems/ hectare was also measured. Aluminum calipers and Abney's level were used to measure tree height m and DBH cm. Trees lesser than 6cm in DBH were not enumerated. The local volume table was also used for the data estimation.

For the measurement of understory vegetation, dead wood, litter and cone biomass amount of $2m^2$ plots were laid in individual plot of 0.1ha the plot shape was quadrangular (Sq). Measured all trees with a DBH greater than four 4cm for dendrometric attribute, in each plot such as tree height m and DBH cm at diameter 1.3m. Count the trees in each sample plot and calculate the stem density.

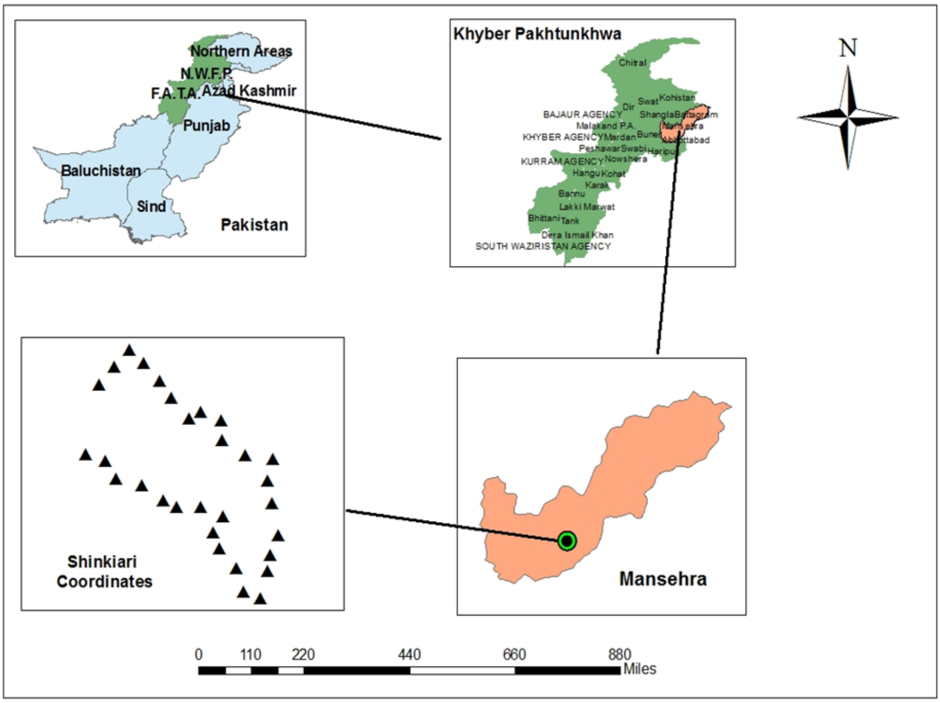

Fig. 2. Map of Study Area: Shinkiari Natural Forest

Growing stock and biomass estimation

The tree volume (m^3) was determined through used the formula (Ahmad & Nizami, 2015). Tree volume (m^3) = [(π/4) x d2 x h x f] (equation 1), where: h = height, d = diameter at breast height (DBH) and f = form Factor. Calculated Stem biomass from the wood density (kg/m^3) of the relevant trees and volume (m^3) by used the coming relation: Biomass [kg] = (BWD) Basic wood density (kg/m^3)×volume (m^3) branches, leaves, roots and twig, involvement in total biomass the tree species was measured by using (BEF) biomass expansion factor. Each species biomass expansion factor (BEF) was present from available literature [14].

Biomass Carbon Estimation

Volume of the stem we calculated (m^3/ha) from Diameter at breast height (DBH) and using the height of Tree [15]. From stem volume (m^3/ha) Stem biomass (t/ha) was measured and wood density (kg/m^3) and then changed into total tree biomass ($t{\cdot}ha^{-1}$) by use the BEF [2, 14]. From each subplot the biomass of understory vegetation measure by accumulating the vegetation destructive. Samples of 1 Kg The fresh mass (kg) was accumulated and were brought to the Pakistan Forest Institute (PFI) laboratory and the dry mass were accumulated for biomass analysis and were dry for 48 hours at 72°C. In each subplot the dead wood, cone, and litter were also accumulated for and from biomass calculation and the dry mass was measured. In each Biomass component, evaluating the content of carbon and we changed the Biomass into carbon consuming a carbon-measurement fraction 0.5 by the various equation 1, [7, 15]. Carbon (t/ha) = Biomass (t/ha) x Carbon (%) [0.5] Carbon (t/ha) = Biomass (t/ha) x Carbon (%) [0.5] [1].

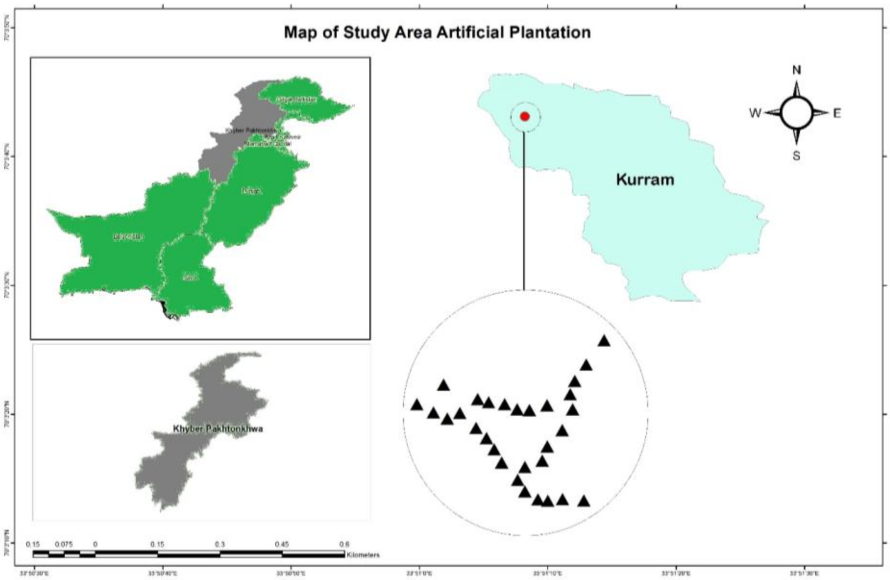

Fig. 3. Map of the studied area of Man-made Plantation Parachinar

Estimation of Carbon

Above ground carbon

Through multiply it with specified gravity, the trees volume of each DBH class can be converted into biomass. Determination of specific gravity using the maximum moisture method [16]. However, according to standard sampling techniques, destructive methods were used to measure the Biomass vegetation, herbs and Shrubs at a quadrat size of 1×1m. Determine the contented of Carbon trees by multiplying biomass with an alteration factors of [0.50] [17] and the biomass of shrub and herbaceous vegetation alteration factors of [0.45] with a Carbon. After its collection within a 50×50cm the carbon of ground litter was resolute Samples were weighed, frame placed centrally within each quadrat sub sampled to a constant weight and oven dried at 65±50°C. Ash corrected dry weight was contain 45% carbon assumed [18].

Below ground carbon

Manually determine belowground carbon (root and soil carbon). After cleaning with water, the fallen Chir pine trees (three) in research area due to landslides weighed were individually for their roots and stems. Then, assuming that the weight ratio of root to stem as Chir pine. Of all tree species is the same, the Biomass of the root of the whole forest is determined based on the weight ratio of root to stem. Then multiply the carbon content of the root biomass with a Carbon (C) conversion factors of 0.45 to determined [18]. The space of 25×25cm structure in for each quadrat to a deepness of 40 (cm) root the sample of vegetation, herbs and shrubs becomes under various land use were calculated. For the further research laboratory study, the root specimen was stored in the cloth bags. Dispersed the sample in the water & cross over a 2mm sieve. Collected the roots from the sieve & cleaned them with water without distinction between alive & dead roots and the roots were dried through oven to constant weight at 65±50°C. Ash corrected dry mass was contain 45% carbon assumed [18].

Total carbon stock Calculation

The estimation of over-all carbon stock in Natural Forest Chir pine and man-made Plantation (t/ha) was estimated by the accumulation of over-all carbon gathered in the uppermost story vegetation, the understory vegetation & the carbon gathered in the soil.

Results and Discussion

Comparative Assessment between Natural and Man-made Plantation

The comparative analysis of total Biomass and the total Carbon stock data have been presented in the Table 1. According to Table 1, for natural forests, the range of biomass, carbon and $CO_{2\,e}$ are 21.45 to 739.33t/ha, 10.72 to 369.66t/ha and 39.25 to 1352.97t/ha respectively. While the range of biomass, carbon and $CO_{2\,e}$ is 21.39 to 41.80t/ha, 10.69 to 20.90t/ha and 39.16 to 76.49t/ha respectively for Man-made plantation. The average values for natural forest for biomass, carbon stock is 257.9 and 124.81t/ha respectively while for Man-made plantation the average values for biomass, carbon stock is 66.80 and 36.61t/ha respectively.

Table 1. Comparative analysis of biomass and carbon for natural and man-made Plantation

	Natural Forest			Man-made Plantation		
Plot N0	**Total Biomass (t/ha)**	**Total Carbon (t/ha)**	**CO_2 e**	**Total Biomass (t/ha)**	**Total Carbon (t/ha)**	**CO_2 e**
1	437.82	218.91	801.22	21.39	10.69	39.16
2	739.33	369.66	1352.97	93.37	46.68	170.87
3	491.15	245.57	898.81	44.16	22.08	80.82
4	680.06	340.03	1244.51	82.78	41.39	151.48
5	491.38	245.69	899.23	46.92	23.46	85.88
6	294.78	147.39	539.45	81.97	40.98	150.01
7	202.84	101.42	371.20	85.78	42.89	156.99
8	161.58	80.79	295.69	102.05	51.02	186.73
9	183.38	91.69	335.59	68.04	34.02	124.51
10	283.18	141.59	518.23	82.63	41.31	151.19
11	193.27	96.63	353.69	61.30	30.65	112.17
12	313.78	156.89	574.22	53.11	26.55	97.17
13	21.45	10.72	39.25	51.20	25.60	93.69
14	67.31	33.65	123.18	42.94	21.47	78.58
15	56.28	28.14	103.00	81.94	49.42	53.08
16	95.52	47.76	174.81	95.96	47.98	175.60
17	50.87	25.43	93.10	104.88	52.44	191.93
18	272.86	136.43	499.34	71.03	35.51	129.96
19	162.04	81.02	296.53	95.10	47.55	174.03
20	308.25	154.12	564.11	61.57	30.78	112.65
21	198.47	99.23	363.20	44.39	22.19	81.21
22	206.36	103.18	377.64	86.72	43.36	158.69
23	181.19	90.59	331.58	84.68	42.34	154.96
24	483.98	241.99	885.69	41.80	20.90	76.49
25	160.86	80.43	294.38	47.14	23.57	86.26
26	161.30	80.65	295.18	51.41	25.70	94.06
27	253.69	126.84	464.26	67.87	33.93	124.18
28	110.13	55.06	201.53	64.64	32.32	118.29
29	201.70	100.85	369.12	66.09	33.04	120.92
30	203.91	101.95	373.16	51.27	25.63	93.80
Total	**7668.72**	**3834.3**	**14033.87**	**2034.14**	**1025.45**	**3625.36**

Stem number, biomass and carbon stock forest wise

The mean stem number per ha, the mean biomass (t/ha) and the mean carbon stock (t/ha) are up scaled to forest area and have been summarized in Table 2. The natural forest has 7290 total stems, 7668.72 tons biomass and 3804.03 carbon stock while in Man-made plantation, the total stem number is 24640, the total biomass 2034.14t/ha and total carbon stock are 1025.45t/ha respectively.

Plot-wise mean DBH, of natural forest mean Height and number of trees have been summarized in Table 3. The mean values for DBH and height were determined by taking an average of the trees DBH and height within the given plot. The highest mean DBH (59.21cm) was found in plot number 12 with 14 total trees, while plot number 14 has the lowest average DBH (18.94cm) with 50 trees.

Table 2. Stem number, biomass and carbon stock forest wise

Forests & Plantation	Area (ha)	Average Mean Stems/ha	Total Stem Number/ha	Average Mean Biomass (t/ha)	Forest Biomass (t/ha)	Average Mean Carbon Stocks (t/ha)	Forest Carbon Stocks (t/ha)
Natural Forests	635	243	154305	255.624	7668.72	126.81	3804.03
Man-made Plantation	107	821	87847	67.80	2034.14	34.18	1025.45
Total	**742**		**242152**		**9702.86**		**4829.48**

Regarding the mean Height of the forest, the highest value of average Height was (31.9 m) in plot number 24 while and the lowest (11.76m) average height was found in plot number 15. Plot-wise mean DBH, of man-made Plantation mean Height and number of trees have been summarized in Table 3. The mean values for DBH and height were determined by taking an average of the trees DBH and height within the given plot. The highest mean DBH (21.75cm) was found in plot number 14 with 32 total trees, while plot number 1 has the lowest average DBH (13.80cm) with 66 trees. Regarding the mean Height of the forest, the highest value of average Height was (11.90m) in plot number 14 while and the lowest (6.92m) average height was found in plot number 1.

Table 3. Mean DBH, Mean Height and Trees/plots for natural and man-made Plantation

	Natural Forest				Man Made Plantation			
Plot N0	**Mean DBH (cm)**	**Mean Height (m)**	**Trees/plots**	**Stems ha^{-1}**	**Mean DBH (cm)**	**Mean Height (m)**	**Trees/plots**	**Stems ha^{-1}**
1	51.86	23.96	30	300	13.80	6.92	66	660
2	49.79	23.18	48	480	16.03	8.92	144	1440
3	48.43	29.18	32	320	14.14	7.79	94	940
4	54.02	29.16	36	360	16.51	9.06	130	1300
5	51.60	28.71	28	280	18.58	9.21	60	600
6	47.85	29	20	200	19.13	9.80	92	920
7	51.33	29.41	12	120	17.83	9.01	118	1180
8	33.12	22.37	24	240	18.38	9.10	133	1330
9	45.71	27.92	14	140	18.52	9.21	85	850
10	50.68	29.37	16	160	19.53	10.12	88	880
11	48.66	28.66	12	120	20.42	10.83	56	560
12	59.21	29	14	140	21.72	11.65	40	400
13	33.33	28.66	3	30	21.23	11.40	42	420
14	18.94	15.64	50	500	21.75	11.90	32	320
15	21.57	11.76	42	420	21.16	11.38	68	680
16	21.32	18.43	46	460	17.71	8.88	136	1360
17	23.92	12.03	27	270	19.77	10.19	108	1080
18	55.58	31.16	12	120	20.33	10.61	68	680
19	26.36	14.95	63	630	19.96	10.32	96	960
20	49.83	28.77	18	180	20.25	10.51	60	600
21	42.25	31.5	16	160	19.07	9.84	52	520
22	42.17	30.47	17	170	19.92	10.42	88	880
23	35.85	29.76	21	210	18.74	9.41	105	1050
24	57.50	31.9	20	200	18.40	9.18	55	550
25	33.31	28.45	22	220	18.32	9.25	62	620
26	37.45	24.8	20	200	19.60	10.09	55	550
27	55.33	31.16	12	120	20.24	10.58	65	650
28	29	17.40	32	320	18.97	9.42	78	780
29	53.8	31.7	10	100	18.41	8.88	90	900
30	47	29.5	14	140	16.61	7.59	98	980
Total			**731**	**7310**			**2464**	**24640**

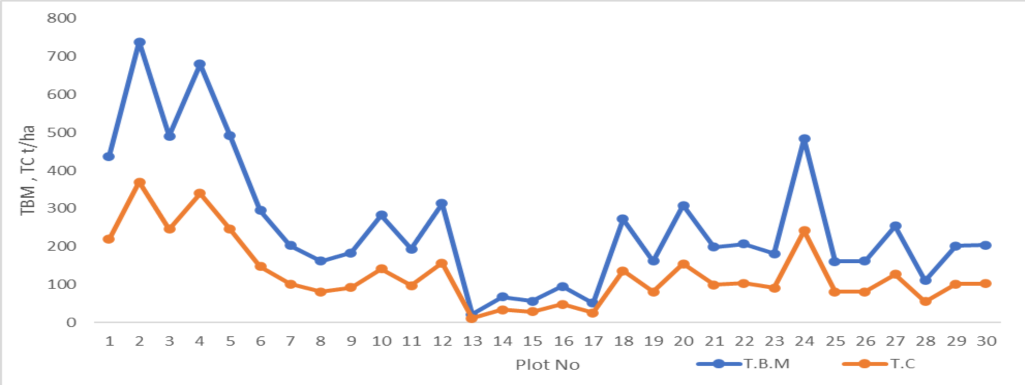

Fig. 5. Over-all Biomass (t/ha) and Over-all Carbon (t/ha) in Natural Forest Shinkiari

Over-all Biomass and Over-all Carbon of Naturel Forest

Estimated over-all biomass (t/ha) and over-all carbon t/ha are summarized in figure 5. The highest over-all biomass, and the over-all carbon (t/ha) was 739.33, and 369.66t/ha respectively in plot 2, whereas the lowest total biomass, and the total carbon 21.45 t/ha, 10.72 t/ha was found in the 13 number of plots in Figure 5. Plot-wise total biomass and total carbon (t/ha).

Total Biomass and the Total Carbon of Man-Plantation

Estimated over-all biomass, and the over-all Carbon (t/ha) are summarized in fig no 6. The highest over-all biomass & over-all carbon (t/ha) was 104.88, and 52.44t/ha, respectively in plot 17, whereas the lowest total biomass and total Carbon 21.39 and 10.69t/ha, was found in the plot number 1 with respectively in figure 6 total biomass and nTotal Carbon.

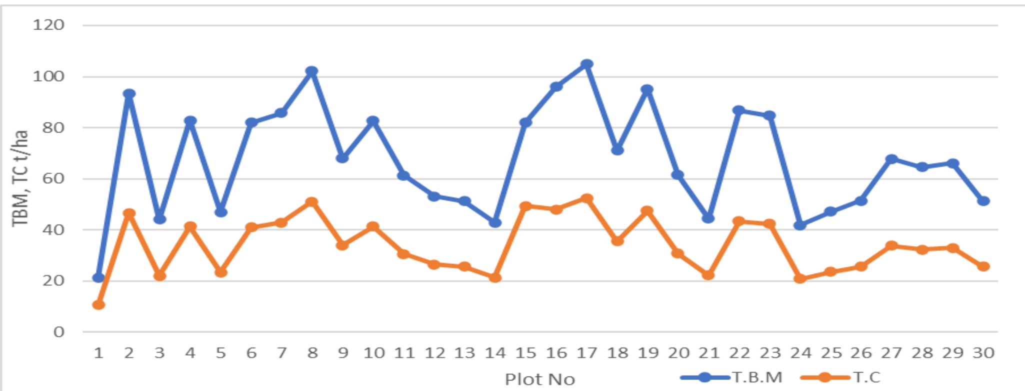

Fig. 6. Over-all Biomass (t/ha) and Over-all Carbon (t/ha) in Man-made Plantation Parachinar

Correlation between Diameter DBH (cm) and Height (m) of Natural Forest

Diameter and height are the significant elements of the part of the carbon pools, have a key role for sequestration of CO_2 just as alleviation of climate change. At the point when the height increments expand the vegetation diameter, these are key elements for preservation and capacity of CO_2 in the forest. At some point, the trees show variety from one another due to quality of site and rivalry among the sunlight and water species. The regression model demonstrates a similar pattern line however at some point they diverge from the line it is a direct result of topmost broken, fire harm or another outside variable influences the development of diameter and height across. R^2 shows reliance on one another. The scatterplot demonstrates that diameter and height are strongly connected to one another and have a coefficient of relationship (R^2) equivalent to 0.6577 in figure 7.

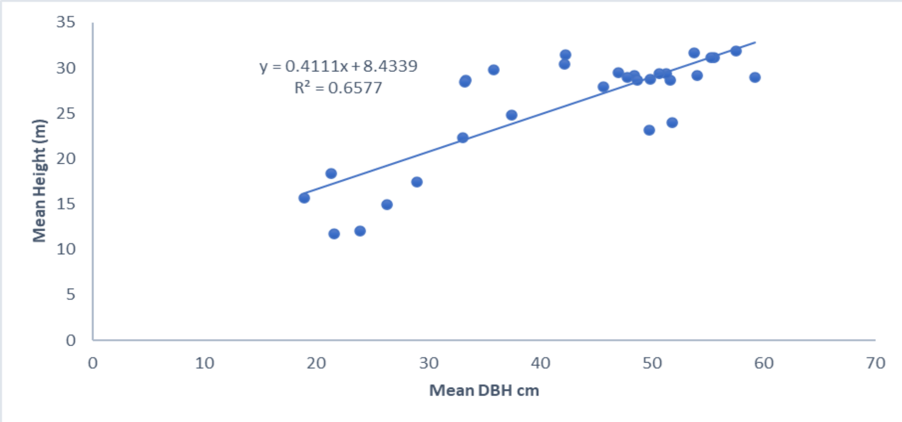

Fig. 7. Correlation between mean Diameter (DBH) and mean Height (h) in Natural Forest Shinkiari.

Correlation between Diameter DBH (cm) and Height (m) of Man-made Plantation

The present data indicated that at some point, the trees show difference from one another due to quality of site rivalry among the water species and sunlight. So, the regression model shows a similar pattern line however at some point they diverge from the line it is a direct result of topmost broken, fire harm or another outside variable influences the development of diameter and height across. R^2 shows reliance on one another. The scatterplot demonstrates that diameter and height are strongly connected to one another and have a coefficient of relationship (R^2) equivalent to 0.8955 in figure 8.

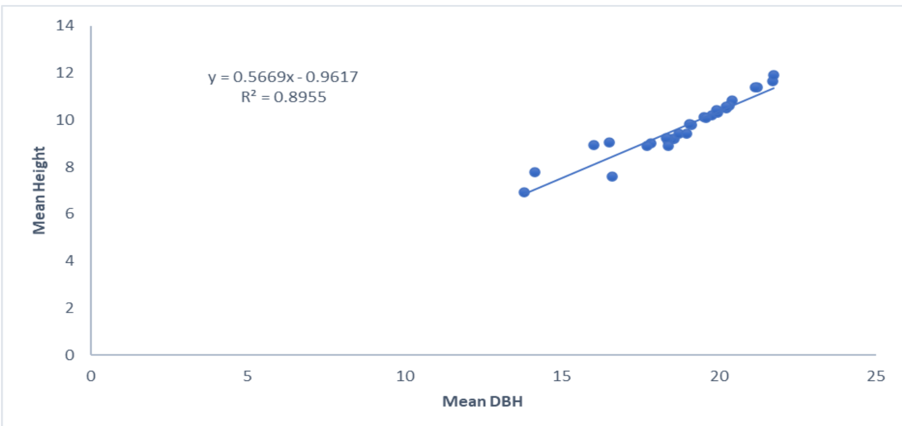

Fig. 8. Correlation between mean Diameter (DBH) and mean Height (h) in Man-made Plantation Parachinar

Correlation between Different Attributes (Natural Forests)

The correlation between different attributes such as Mean DBH, versus Biomass t/ha Mean height versus Biomass were assessed for their statistical interrelationship study. The Table 4. Shows various relations; (1) Mean DBH versus Biomass (t/ha), (2) Mean Height versus Biomass (t/ha), (3) Stems per ha versus Biomass (t/ha), (4) Mean DBH versus Mean Height. According to Table the mean DBH versus mean Height and Mean DBH versus Biomass showed good positive relationships with 0.45 and 0.64 R^2 values respectively, however Mean Height versus Biomass, Stem per ha versus Biomass t/ha the R^2 values are 0.19 and 0.04 respectively and hence are loosely correlated.

Table 4. Summary of regression among different attributes in Natural Forest Shinkiari

Description	Model	Equation	R^2
Mean DBH versus Biomass (t/ha)	Polynomial	$y = 0.0871x^2 + 2.9953x - 41.884$	**$R^2 = 0.45$**
Mean Height versus Biomass (t/ha)	Polynomial	$y = -1.3517x^2 + 71.503x - 640.85$	**$R^2 = 0.1$**
Stems per ha versus Biomass (t/ha)	Power	$y = 45.104x^{0.2785}$	**$R^2 = 0.04$**
Mean DBH versus Mean Height	Linear	$y = 0.4111x + 8.4339$	**$R^2 = 0.65$**

Correlation between Different Attributes Man-made Plantation

The correlation between different attributes such as Mean DBH, versus Biomass t/ha Mean height versus Biomass were assessed for their statistical interrelationship study. The Table 5 Shows various relations; (1) Mean DBH versus Biomass (t/ha), (2) Mean Height versus Biomass (t/ha), (3) Stems per ha versus Biomass (t/ha), (4) Mean DBH versus Mean Height. According to Table the stem per ha versus Biomass and Mean DBH versus mean Height showed good positive relationships with 0.43 and 0.89 R^2 values respectively, however Mean DBH versus Biomass, mean height versus Biomass t/ha the R^2 values are 0.22 and 0.08 respectively are loosely correlated.

Table 5. Summary of regression among different attributes in Man-made Plantation Parachinar

Description	Model	Equation	R^2
Mean DBH versus Biomass (t/ha)	Polynomial	$y = -1.8983x^2 + 69.933x - 568.99$	**$R^2 = 0.22$**
Mean Height versus Biomass (t/ha)	Polynomial	$y = -1.3517x^2 + 71.503x - 640.85$	**$R^2 = 0.08$**
Stems per ha versus Biomass (t/ha)	Power	$y = 1.1257x^{0.6086}$	**$R^2 = 0.43$**
Mean DBH versus Mean Height	Linear	$y = 0.5669x - 0.9617$	**$R^2 = 0.89$**

If the rate of one carbon credit price is US $30, the income may be achieved 1938983.4$ from these carbon credit of both the forest Hence the Natural Forest Shinkiari have more potential and appeared more promising in profit generation as compared to Man-made Plantation at Parachinar. The data of the forest indicated that both Carbon Pools have the potential of income generation from the carbon credits. Although Man-made Plantation exhibited carbon credits to the tune of 13268.82 over an area of 107ha sampled, natural forest appeared more promising with carbon credits 51363.96 and capable of profit generation to the tune of US $1540918.8 in figure 9.

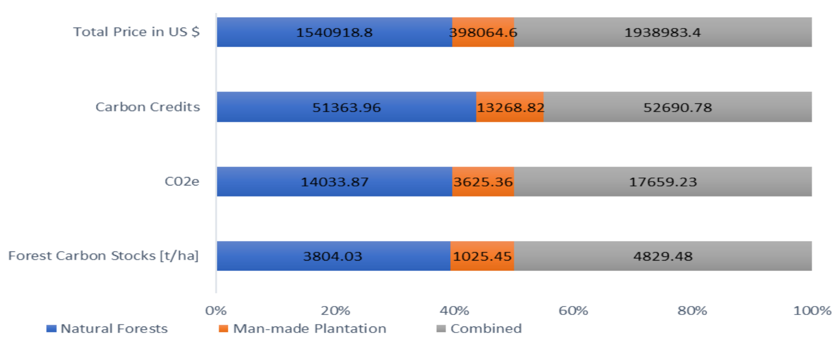

Fig. 9. Comparison of potential of Carbon Credits in Natural Forest Shinkiari and Man-made Plantation Parachinar

Discussion

The Khyber Pakhtunkhwa (KP) forests have experienced brutal forest degradation & deforestation in the ancient because most of the matured trees evacuated in available regions. As a result, C stocks have been reduced in maximum regions. An average storage of carbon in the Khyber Pakhtunkhwa (KP) forests Province was approximated to be 127.72 tons/hectare that is less than the C storage of (Nepal forest) of 153 tons/ hectare [19]. The present study results indicated that average mean carbon stock was recorded 126.81 t/ha in natural and 34.18 t/ha in man-made Planation hence the natural conifers forest have the maximum C density 3804.3t/ha. The average carbon storage of temperate forests in Khyber Pakhtunkhwa Province was 172 (t/ha) that is near to India's Kashmir temperate forests, ranging from 112.5 to 205.7t/ha [20]. The tree height of different forest types is between 3 and 49.85m. The positive co-relation among tree height and tree Diameter (Fig. 3) indicated the height of the tree rises as the tree diameter (DBH) increases. The R^2 values of various tree species sustenance the following assumption: tree elevation is a function of the diameter [21]. In the present study the values of tree elevation in various forest types were in the ranges of 11.76 - 31.9m in Natural Forest and the values of tree elevation in various forest types were in the ranges 6.92 - 11.90m in Man-made Plantation (Table 3) it showed that the elevation of a tree rises the tree diameter also increases. The biomass and carbon stock of the natural forest & man-made Plantation was measured over field inventory.

In the current study it was investigated that mean stem/ha versus Biomass decrease with increases in mean Diameter at breast height (DBH) versus mean Height (h) for all tree species (Table 4). The R^2 value among stem per ha versus Biomass and mean DBH versus mean Height ranges from 0.04 to 0.65 respectively. While in man-made Plantation was assessed through field inventory that mean Height versus Biomass decrease with increase in mean Diameter at breast height (DBH) versus mean height (h) for all tree species (Table 5). The value of R^2 between Height versus Biomass and mean DBH versus mean Height ranges from 0.22 and 0.89 respectively. In the current research study, the natural forest ranges of Biomass, Carbon and CO_{2e} in Table 1 is higher than Man-made plantation because the natural forest tree age was 100 plus, and man-mad Plantation tree age was 32 years. In Table 2 the average stem number of man-made Plantation was greater than natural forest because the man-made Plantation tree planted was 10 by 10 feet and that's why the average stem number was increase in man-made plantation. In Table 3 the highest mean DBH 59.21cm in Plot number 10 in natural forest while in man-made Plantation the highest mean DBH was found 21.75cm the reason is that natural forest has greater mean DBH than man-made Plantation because all the trees were mature and consists of 100 plus age that's why in the natural forest the mean DBH is greater. The highest total Biomass, and total Carbon (t/ha) was 739.33 and 369.66t/ha respectively in plot no 2, whereas the lowest total biomass, and total carbon (21.45 and 10.72t/ha) was found in plot number 13 respectively in natural Forest (Fig. 5)while man-made Plantation the highest total biomass and total carbon (t/ha) was (104.88 and 52.44t/ha), respectively in plot no 17, whereas the lowest total biomass and total Carbon (21.39 and 10.69t/ha), was found in plot no 1 with respectively in figure 6 the reason is the natural Forest have greater total biomass and total carbon because the natural forest tree height and DBH was greater than Man-made Plantation. In figures 7 and 8 correlation between height and diameter of natural forest and man-made Plantation the R^2 equivalent to 0.6577 natural Forest while man-made Plantation R^2 equivalent to 0.8955 its mean that man-made Plantation have strongly connected to one another and have a coefficient of relationship R^2. The Tables 4 and 5 shows various relations; (1) mean DBH versus Biomass (t/ha), (2) mean Height versus Biomass (t/ha), (3) Stems per ha versus Biomass (t/ha), (4) mean DBH versus mean Height.

The regression between different attributes of natural Forest and man-made Plantation According to the Tables 4 and 5 the mean Diameter at breast height (DBH) versus mean Height (h) and mean Diameter at breast height (DBH) versus Biomass Polynomial & Linear Equation showed loosely positive relationships with 0.45 and 0.64 R^2. While man-made Plantation the stem per ha versus Biomass and mean DBH versus mean Height Power and Linear showed good positive relationships with 0.43 and 0.89 R^2. If the rate of one carbon credit price is US **$30,** the income may be achieved **1938983.4$** from these carbon credit of both the forest. Hence the natural forest Shinkiari have more potential and appeared more promising in profit generation as compared to manmade plantation at Parachinar (Fig. 9) hence natural forest appeared more promising with carbon credits 51363.96 and capable of profit generation to the tune of **US $ 1540918.8.**

Conclusions

It is concluded that our research area Natural Forest has high potential of storing and sequestering carbon, and it depicts the importance of *Pinus roxburghii* forest for climate change mitigation. The results will be helpful for decision making, earning carbon credits and implementing REDD+ program great potential of storage & sequestering carbon and it describes the significance of *Pinus roxburghii* forest for climate change reduction. The outcomes results will be helpful for accomplishing, decision earning carbon credits and enforcing REDD+ program. Methods involved in estimating biomass and carbon storage, the latter depends on measurable parameters such as tree height, Diameter at breast height (DBH) perimeter, wood density & volume. This article summarized various estimates of natural forest types and man-made plantations in Pakistan. These estimates are interrelated to Above & Below ground Biomass & Carbon stock, pool & sequester. The estimations can be used to generate an information base that can be used for making-policy especially those correlated to climate change reduction & protection.

Abbreviations

C: Carbon
CP: Carbon Pool
AGB: Aboveground biomass;
BGB: Belowground biomass
CC: Carbon Credits.

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