ASSESSMENT OF *PINUS GERARDIANA* TREE CARBON STOCK IN CHILGOZA FOREST OF SULEIMAN RANGE, PAKISTAN

Pervez Manan[1], Farhat Jabeen[1] and Ahmad Zamir[2]

ABSTRACT

Pinus gerardiana is known for its high value edible seeds (nuts), locally called as “Chilghoza”, rich in carbohydrates and proteins. It is native to the north-western Himalaya and is distributed in eastern Afghanistan, northern Pakistan and north-western India, growing at altitudes ranging between 1800 and 3300 m. It is often associated with the Blue pine (*Pinus wallichiana*) and Deodar (*Cedrus deodara*). In Pakistan these forests are mainly located in the dry temperate zone of the Hindukush-Karakoram-Himalaya region i.e. Sherani Area (Suleiman range) on the border between Baluchistan and Khyber Pakhtunkhwa (KP), South Waziristan, Chitral, Gilgit Baltistan and Azad Jamu & Kashmir (Sherani and Urooj, 2019). As the potential economic benefits of Chilghoza to local livelihoods is worth billions of rupees annually thus economic importance is always given priority and its most important role of the maintenance and protection of vital ecosystem services (e.g. carbon storage and climate change mitigation, soil and flood protection, wildlife habitat, water recharge, watershed conservation and water flow regulation, fodder, etc) are still not accounted properly. Therefore, this study was conducted to ascertain the carbon stock of *Pinus gerardiana* at the landscape level. The study was conducted in Chilghoza Forest of Suleman Range. Systemic sampling approach was adopted. The circular plots with a radius of 17.84 (0.1 Ha area) were used. In each plot, diameters at breast height (DBH) and height of trees with DBH more than 5 cm were measured. Above-ground dry Biomass (AGB) in Kg per 0.1ha was calculated at plot level by using the following equation (Ali, 2015):

$$AGB = 0.0253D^{2.6077} \qquad (1)$$

Where AGB is above-ground dry biomass in Kilogram (Kg) and D is DBH in cm. to obtain per hectare value the plot level AGB was multiplied by 10. While, below-ground biomass (BGB) default values of root-shoot ratio were used (IPCC, 2006). To obtain mean total dry biomass per ha, mean value for AGB and BGB per hectare were added. While mean total dry biomass in Kg per ha was multiplied by 26000 to obtained total dry biomass for the whole study area.

Carbon stock (C) in Kg was calculated by the following equation (IPCC, 2006):

$$C = 0.47M \qquad (2)$$

Where, M is dry biomass.

[1] NFI Expert and RA NFI, National REDD+ Office, Ministry of Climate Change, Islamabad, Pakistan

[2] Assistant Professor of Forestry, Forest Education Division, Pakistan Forest Institute, Peshawar

In both Biomass and Carbon Kg were converted to Tonne (t) by dividing it by 1000.

The study concluded that a total carbon stock of *Pinus gerardiana* in the study area was 239082 tC with an average density of 9.19 tC/ha. In the study area, higher percentage of the trees were in sub-mature and young stages thus having a high potential for REDD+ as generally the growth rate in these stages is fast and they can sequester a large quantity of carbon dioxide. The findings of the study will be helpful in preparation of forest management plans and in developing REDD+ projects.

Keywords: Climate Change, Chilghoza, *Pinus gerardiana*, Biomass, Carbon stock, REED+.

INTRODUCTION

Forests absorb 2.6 billion tons of carbon dioxide each year equivalent to about one-third of that released by burning fossil fuels annually. But this great storage system also means that when forests are cut down, the impact is big. Deforestation contributes about 12% of the global Green House Gasses (GHG) emissions. Similarly, the removal capacity of forests is decreased as forests are lost (Pan *et al.*, 2011). Traditionally forests are always considered in-terms of their economic benefits or timber and fuelwood production ignoring the environmental services it is providing to the humanity and ecosystems, particularly climate change mitigation.

Pinus gerardiana is known for its high value edible seeds (nuts), locally called as “Chilghoza”, rich in carbohydrates and proteins. It is native to the north-western Himalaya and is distributed in eastern Afghanistan, northern Pakistan and north-western India, growing at altitudes ranging between 1800 and 3300 m. It is often associated with the Blue pine (*Pinus wallichiana*) and Deodar (*Cedrus deodara*). In Pakistan these forests are mainly located in the dry temperate zone of the Hindukush-Karakoram-Himalaya region i.e Sherani Area (Suleiman range) on the border between Baluchistan and Khyber Pakhtunkhwa (KP), South Waziristan, Chitral, Gilgit Baltistan and Azad Jamu & Kashmir (Sherani and Urooj, 2019). As the potential economic benefits of Chilghoza to local livelihoods is worth billions of rupees annually thus economic importance is always given priority and its most important role of the maintenance and protection of vital ecosystem services (e.g. carbon storage and climate change mitigation, soil and flood protection, wildlife habitat, water recharge, watershed conservation and water flow regulation, fodder, etc) are still not accounted properly.

Forests play a major role in the carbon cycle globally as they account for a greater part of the carbon exchange between the atmosphere and terrestrial biosphere than any other ecosystem (Lal, 2003). The world’s forests have been estimated to contain up to 80% of all aboveground and 40% of all belowground terrestrial carbon (Dixon et al. 1994). Forest ecosystem biomass estimation is important for assessing the productivity and sustainability of the forest. It also gives us an idea of the potential amount of carbon emissions in the form of carbon dioxide when forests are being cleared or burned (Lu, 2006).

Keeping the importance of forest in view, United Nations Framework Convention on Climate Change introduced the mechanism of REDD+ (Reducing emission from Deforestation, Forest Degradation, Sustainable Forest Management, Conservation of Forest Carbon Stock and Enhancement of Forest Carbon Stock) to incentivize the developing countries for their efforts of reducing carbon emissions from forestry sector by controlling deforestation and forest degradation as well as enhancing the carbon sequestration by conservation, sustainable management of forests, and enhancement activities like reforestation and afforestation, etc. (UNFCCC 2010). REDD+ is considered as one of the viable options for climate change, forestry resources conservation, and alleviating poverty of associated communities (Ngo et al., 2013). It has been identified as one of the most economically feasible mitigation options (Stern, 2007). Pakistan is in the readiness phase of implementing since 2011 (REDD+ Pakistan). For REDD+ initiatives forest carbon stock assessments and monitoring are essential. Therefore, this study has been conducted to ascertain the carbon stock of *Pinus gerardiana* at the landscape level to quantify its climate change mitigation potential in shape of carbon sequestration.

MATERIAL AND METHODS

Description of study area

Suleiman Range contains the world's largest pure stand of Chilghoza (*Pinus gerardiana*) spread over an area of 26,000 Hectares (Urooj, 2019). This pure stand of Chilghoza forests straddles the border of southeastern Balochistan and Khyber Pakhtunkhwa Provinces of Pakistan (31^o – 36' North and from 69^o – 59' East) (Fig.1). With an altitudinal range of 500 - 3,441 meters, the precipitous mountainous terrain of the area with arid climate provides suitable climatic and topographical conditions for the growth of the pure Chilghoza forest. Mean maximum day temperatures range from about 37°C in June to about 13°C in January. Rainfall is scarce (320mm per year), varies with altitude and is highest during the winter season. Chilghoza Forest proprietary rights rest with the Sherani tribe living on both sides of the provincial borders. The Sherani dwelling in Balochistan are called Bargha Sherani whereas those on the KP side are called Largha Sherani. As a tradition, all the tribal people living in the area have equal ownership rights over the available resources. Due to the absence of land settlement in the tribal area, all the ownership record is in the memories of local people (Hussain, 2015).

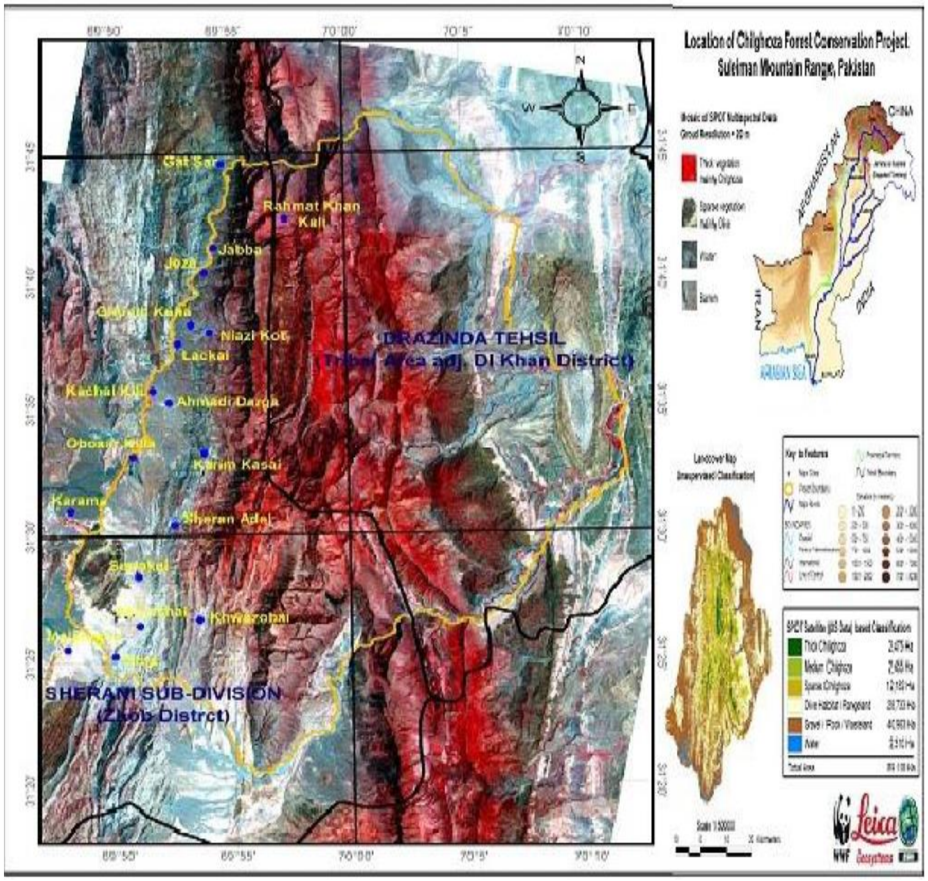

Fig. 1. Map of the study area (Source: WWF- Pakistan)

Data collection and analysis

Systemic sampling approach was adopted, by dividing the total area into 26 equal units on map, and taking sample plots in the center of each unit, thus overall, 26 plots were sampled. Geographic coordinates of the center of each plot from the map were recorded and were used for navigation into the sample plots in the field. The circular plots with a radius of 17.84 (0.1 Ha area) were used. In each plot, diameters at breast height (DBH) and height of trees with DBH more than 5 cm were measured. The DBH were measured with the help of a diameter tape at 1.3 m above the ground level, while heights were measured with the help of Haga altimeter.

Above-ground dry Biomass in Kg per 0.1ha was calculated at plot level by using the following equation (Ali, 2015):

$$AGB = 0.0253D^{2.6077} \quad (1)$$

Where AGB is above-ground dry biomass in Kilogram (Kg) and D is DBH in cm. to obtain per hectare value the plot level AGB was multiplied by 10.

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Carbon stock (C) in Kg was calculated by the following equation (IPCC, 2006):

$$C= 0.47M \quad (2)$$

Where, M is dry biomass.

In both Biomass and Carbon Kg were converted to Tonne (t) by dividing it by 1000.

RESULTS

The study estimated a total of 757,353 numbers of trees in the study area having a density of 29 trees/ Ha. As illustrated in Table-1 the highest percentages of trees were in sub-mature (59%) and Young Stage (34%) whereas only 7% of trees were in mature stage.

Table 1. Development Stages of *Pinus gerardiana*

Development stage (Diameter)	No. of Trees	Percentage (%)
Young (below 30 cm)	255,576	34
Sub-mature (30 to 60 cm)	446,707	59
Mature (above 60 cm)	55,070	7
Total	757,353	100

As shown in Table 2 this study found a total of 508,686 tdm biomass in the study area with a contribution of 363,347 tdm (71%) by AGB whereas 145,339 tdm (29%) by BGB. Similarly, the overall mean biomass density was found as 19.56 tdm/ha whereas mean biomass density in the AGB was found as 13.97 tdm/ha and in BGB as 5.59 tdm/ha.

Table 2. Dry biomass

Mean AGB Density	Total AGB	Mean BGB Density	Total BGB	Total Mean Biomass Density	Total Dry Biomass
tdm/ha	tdm	t/ha	Tdm	tdm/ha	Tdm
13.97	363,347	5.59	145,339	19.56	508,686

Table 3 shows that total carbon stock in the study area was assessed as 239,082 tC with a contribution of 170,773 tC by ABG pool whereas 68309 tC by BGB pool. AGB carbon density was assessed as 6.56 tC/ha and BGB carbon density as 2.62 tC/ha, whereas the total mean carbon density was estimated as 9.19 tC/ha.

Table 3. Carbon stock

Mean Above Ground Carbon Density	Total Above Ground Carbon Stock	Mean Below Ground Carbon Density	Total Below Ground Carbon Stock	Total Average Carbon Stock Density	Total Carbon Stock
tC/ha	tC	tC/ha	tC	tC/ha	tC
6.57	170,773	2.62	68,309	9.19	239,082

DISCUSSION

Hussain (2015) reports 27 trees per hectare for the Chilgoza Forests of Sherani thus very close to our estimate of 29 trees/ha, the slight difference may be due to selection of 4 cm DBH in this study as compared to 16 cm DBH in previous study as well as changes in the stock over the period. The tree stocking density is quite low and there exist scope for enhancement of the carbon stock through assisted natural regeneration activities.

As per findings of this study the highest percentages of trees are in sub-mature and Young Stage thus having a high potential for REDD+ as generally the growth rate in these stages is fast and they can sequester a large quantity of carbon dioxide (Ali, 2020).

MoCC, (2019) reports a mean carbon density of 31 tC/ha for Chilgoza forests which were significantly higher than findings of this study i.e. 9.19 tC/ha. The difference may be due to use of unified national level estimates and inclusion of shrub biomass by the referred study whereas this study was site specific and included only tree biomass.

CONCLUSION

The total carbon stock of *Pinus gerardiana* in the study area has been estimated 239,082 tC with an average density of 9.19 tC/ha with a tree stocking density of 29 tree/ha. The carbon stock as well as tree stocking density is quite low and the carbon stock could be enhanced through assisted natural regeneration activities. In the study area, higher percentage of the trees were in sub-mature and young stages thus having a high potential for REDD+ as generally the growth rate in these stages is fast and they can sequester a large quantity of carbon dioxide.

To the extent of my knowledge, the study was the first attempt for quantifying the carbon stocks of the *Pinus gerardiana* in the Chilgoza forest of Suleiman Range. The data will be helpful in preparation of forest management plans, developing of REDD+ projects, and future studies.

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