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# Performance on Biomass Carbon of Tree Species for Rehabilitation of Deep Chambal Ravines of Madhya Pradesh

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**ABSTRACT: The present study was conceptualized in 2012 under the Morena district of Madhya Pradesh's Niche Area of Excellence of Research Work Plan to control and reclamation of ravines and their management for sustainable livelihood security. To assess the contribution of various plantations after 10 years, the current study, which runs from 2020–2021 to 2021–2022, was done. Several types of native fruit trees and forest trees were assessed on various uneven and flat areas of ravine ground such as *Moringa oleifera, Terminalia arjuna, Azadirachta indica, Gmelina arborea, Millettia pinnata, Albizia lebbeck, Acacia nilotica, Dalbergia sissoo*, and *Justicia adhatoda*. The pooled analysis effect of the carbon content of the tree (pounds/plant) varies within different tree species during 2020–2021 to 2021–2022. The results revealed that the highest carbon weight of the tree was recorded for *Moringa oleifera* (2753.02 pounds/plant), followed by *Albizia lebbeck* (1637.58 pounds/plant), *Azadirachta indica* (768.94 pounds/plant), *Acacia nilotica* (704.23 pounds/plant), *Dalbergia sissoo* (698.84 pounds/plant), *Terminalia arjuna* (356.38 pounds/plant), *Millettia pinnata* (282.65 pounds/plant) and *Gmelina arborea* (147.93 pounds/plant). While the lowest carbon weight of the tree was recorded in *Justicia adhatoda* (4.59 pounds/plant).**

**Keywords:** Biomass carbon, Tree, Rehabilitation, Reclamation and Ravine management.

## INTRODUCTION

The capacity of ravine land to produce biomass and provide other goods and ecosystem services has declined due to natural and anthropogenic factors. It's improbable that these deteriorated places, like ravines land, would be covered with a lush, natural environment. Through various ravine management modules, it is necessary to convert these underutilized biomass land uses into carbon-rich plantations of horticulture, forestry, agroforestry, and medicinal plants. A lot of attention has recently been paid to managing agricultural systems to reduce the impact of climate change through carbon sequestration. Agroforestry offers a lot of potential for preserving and enhancing land-based carbon sinks in degraded areas. Agroforestry may play a significant role in lowering vulnerability, boosting the resilience of farming systems, and protecting families from climate threats by increasing the building of soil organic matter and by producing biomass that can capture more $CO_2$ from the air (Lorenz and Lal 2014). Nowadays, sequestering carbon via a tree-based method is viewed as a lucrative business prospect for carbon trading.

In order to increase the ability of terrestrial ecosystems to store carbon, restoration strategies including rehabilitation, afforestation, reforestation, natural regeneration of native species, and adaptive conservation forestry approaches are more economically and environmentally sound. The IPCC (2007) also said in its special report that the best opportunity to increase carbon stocks and provide other immediate benefits is through the conversion of grassland and wasteland to agroforestry. Restoration of ravine lands using a methodical, scientific approach can boost C-stock in the soil as well as in above- and below-ground biomass. There are several advantages to increasing the terrestrial C-stock of ravines, including better soil quality and health, renewability and purification of water, increased above- and below-ground biodiversity increased net primary production, and general improvement in the environment (Somasundaram *et al.,* 2012; Dagar and Singh 2018). Compared to other landscapes in the same biome that are not degraded, ravine-prone landscapes have lower soil organic carbon reserves. Therefore, via restoration and rehabilitation, degraded and depleted ravine lands offer the significant technical potential for C-stock (Singh *et al.,* 2018). One of the main pathways for C and nutrient cycling in forest ecosystems is litterfall and fine root formation, and their turnover is influenced by a variety of variables, including species, age groups, canopy cover, meteorological conditions, and biotic factors (Lodhiyal *et al.,* 2002; Stewart and Frank 2008). Therefore, the present study was conducted in the ravine-prone area of Chambal to assess the carbon sequestration potential of different forest tree species after 10 years of plantation and their contribution to biomass carbon to enrich the organic carbon of ravine land and identify the best tree species for the rehabilitation ravine lands.

## MATERIALS AND METHOD

**Description of the study area.** The study was conceptualized in 2012 under the Morena district of Madhya Pradesh's Niche Area of Excellence of Research Work Plan to control and reclamation of ravines and their management for sustainable livelihood security. The study region is situated at 26°40'40.84 N latitude and 78°06'29.21 E longitude, 150 to 240 meters above mean sea level. In these studies, a strong focus on the plantation was placed right from the start. Several types of native fruit trees and forest trees were assessed on various uneven and flat areas of ravine ground. To assess the contribution of various plantations after 10 years, the current study, which runs from 2020–2021 to 2021–2022, was done.

**Estimation of Biomass Carbon.** The algorithm is used to calculate the weight of a tree (Clark *et al.,* 1986).

**Biomass carbon in plants per year.** In agroforestry, especially in tropical areas, trees are planted to help store about 50 pounds of $CO_2$ per tree each year. The features of a plant's development, the density of its wood, and the environment in which it is planted are just a few examples of the many factors that can influence how quickly carbon is absorbed by plants. Early ages, between 20 and 50 years, saw the highest levels of carbon sequestration. The yearly biomass carbon sequestration rate was determined by dividing plant age to determine the amount of carbon stored in a given plant. The procedure involved determining:

1. Green weight of the tree
2. Dry weight of the tree
3. Carbon content in the tree

**Green weight of the plant**

W = weight of the plant (pounds), D = Diameter of stem (inches), H = Height of the plant (feet).

If D < 11 then,

$$W = 0.25D^2H \quad (1)$$

If D >11 then,

$$W = 0.15D^2 H \quad (2)$$

The two equations provided could be viewed as the average of all the equations relating to plant species. Depending on the plant species, the coefficient (for example, 0.25), and D2 and H could be raised to exponents just above or below. 20% of the weight of the tree above ground is made up of its root system. Therefore, the above-ground weight of the tree was multiplied by 120 percent to determine the total green weight of the plant.

**Dry weight of the tree.** The plant's weight was multiplied by 72.5% to get the tree's dry weight. All species are considered in the calculation, with an average tree having dry matter (72.5%) and moisture (27.5%).

**Carbon content in the tree.** 50% of the average carbon content is often found in the tree's overall volume. Consequently, 50% of the plant's dry weight is made up of carbon.

## RESULT

The height, diameter and weight of plant above ground of the different tree species is presented in table 1 and depicted in Fig. 1.

**Table 1: Height, diameter and weight of the plant above ground of the different tree species.**

| S. No. | Treatment | Year 2020-21 | | | Year 2021-22 | | | Pooled | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Height (feet) | Diameter (inches) | Weight of the plant above ground (pounds) | Height (feet) | Diameter (inches) | Weight of the plant above ground (pounds) | Height (feet) | Diameter (inches) | Weight of the plant above ground (pounds) |
| $T_1$ | ***Moringa oleifera*** | 27.34 | 38.01 | 6092.82 | 28.43 | 38.71 | 6564.8 | 27.89 | 38.36 | 6328.8 |
| $T_2$ | ***Terminalia arjuna*** | 16.84 | 15.84 | 797.15 | 17.50 | 16.40 | 841.38 | 17.17 | 16.12 | 819.26 |
| $T_3$ | ***Azadirachta indica*** | 19.23 | 24.13 | 1676.29 | 20.18 | 24.80 | 1859.06 | 19.70 | 24.47 | 1767.68 |
| $T_4$ | ***Gmelina arborea*** | 15.47 | 9.70 | 318.02 | 15.97 | 10.24 | 362.12 | 15.72 | 9.97 | 340.07 |
| $T_5$ | ***Millettia pinnata*** | 15.85 | 15.91 | 619.31 | 16.40 | 16.40 | 680.22 | 16.13 | 16.16 | 649.77 |
| $T_6$ | ***Albizia lebbeck*** | 36.71 | 25.56 | 3614.04 | 37.73 | 26.25 | 3915.06 | 37.22 | 25.90 | 3764.55 |
| $T_7$ | ***Acacia nilotica*** | 24.66 | 19.95 | 1542.60 | 25.48 | 20.60 | 1695.24 | 25.07 | 20.28 | 1618.92 |
| $T_8$ | ***Dalbergia sissoo*** | 22.21 | 17.12 | 1541.57 | 22.97 | 17.72 | 1671.48 | 22.59 | 17.42 | 1606.53 |
| $T_9$ | ***Justicia adhatoda*** | 3.76 | 3.03 | 8.83 | 4.16 | 3.41 | 12.29 | 3.96 | 3.22 | 10.56 |
| | **S.Em.±** | **2.56** | **2.56** | **634.37** | **2.56** | **2.56** | **669.83** | **1.81** | **1.81** | **461.28** |
| | **C.D.** | **7.69** | **7.70** | **1901.85** | **7.68** | **7.70** | **2008.16** | **5.22** | **5.23** | **1328.78** |

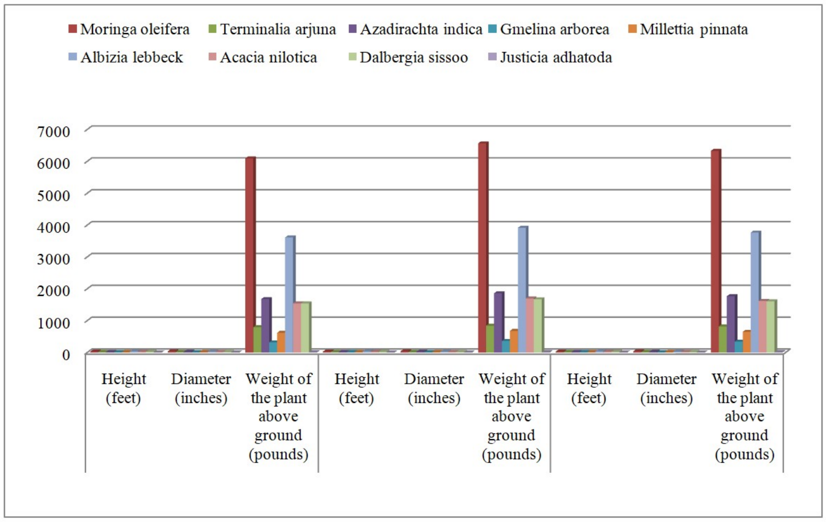


**Fig. 1.** Height, diameter and weight of the plant above ground of the different tree species.

**Carbon content in the tree (biomass carbon).** In the year 2020-21, research findings as per the data presented in Table 2 and depicted in Fig. 2 revealed that the different tree species influenced the carbon content in the tree (pounds/plant). The maximum carbon content of the tree (2650.38 pounds/plant) was demonstrated by the *Moringa oleifera* plantation followed by *Albizia lebbeck* (1572.11 pounds/plant), *Azadirachta indica* (729.19 pounds/plant), *Acacia nilotica* (671.03 pounds/plant), *Dalbergia sissoo* (670.59 pounds/plant), *Terminalia arjuna* (346.76pounds/plant), *Millettia pinnata* (269.40 pounds/plant) and *Gmelina arborea* (138.34 pounds/plant). The minimum carbon content of the tree was found in *Justicia adhatoda*(3.84 pounds/plant).

A perusal of data during the year 2021-22 of the experiment also observed that the carbon content of the tree (pounds/plant) varies significantly within different tree species. Data presented in Table 2 and Fig. 2 revealed that the highest carbon content of the tree of the plant was observed for *Moringa oleifera* followed by with a value of (2855.67 pounds/plant), followed by *Albizia lebbeck* (1703.05 pounds/plant), *Azadirachta indica* (808.69pounds/plant), *Acacia nilotica* (737.43 pounds/plant), *Dalbergia sissoo* (727.09 pounds/plant), *Terminalia arjuna* (366.00 pounds/plant), *Millettia pinnata* (295.90 pounds/plant) *and Gmelina arborea* (157.52 pounds/plant). While the lowest carbon content of the tree was recorded in *Justicia adhatoda* (5.35 pounds/plant).

The pooled analysis effect of the carbon content of the tree (pounds/plant) varies within different tree species. Data presented in Table 2 and Fig. 2 revealed that the highest carbon weight of the tree was recorded for *Moringa oleifera* (2753.02 pounds/plant), followed by *Albizia lebbeck* (1637.58 pounds/plant), *Azadirachta indica* (768.94 pounds/plant), *Acacia nilotica* (704.23 pounds/plant), *Dalbergia sissoo* (698.84 pounds/plant), *Terminalia arjuna* (356.38 pounds/plant), *Millettia pinnata* (282.65 pounds/plant) *and Gmelina arborea* (147.93 pounds/plant). While the lowest carbon weight of the tree was recorded in *Justicia adhatoda* (4.59 pounds/plant).

**Table 2: Green weight, dry weight of the tree and carbon content of the different tree species.**

| S. No. | Treatment | Year 2020-21 | | | Year 2021-22 | | | Pooled | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **Green weight of the plant with roots (pounds)** | **Dry weight of the tree (pounds)** | **Carbon content in the tree (pounds)** | **Green weight of the plant with roots (pounds)** | **Dry weight of the tree (pounds)** | **Carbon content in the tree (pounds)** | **Green weight of the plant with roots (pounds)** | **Dry weight of the tree (pounds)** | **Carbon content in the tree (pounds)** |
| $T_1$ | *Moringa oleifera* | 7311.38 | 5300.8 | 2650.38 | 7877.72 | 5711.3 | 2855.67 | 7594.55 | 5506.05 | 2753.02 |
| $T_2$ | *Terminalia arjuna* | 956.58 | 693.52 | 346.76 | 1009.65 | 732.00 | 366.00 | 983.11 | 712.76 | 356.38 |
| $T_3$ | *Azadirachta indica* | 2011.55 | 1458.37 | 729.19 | 2230.87 | 1617.38 | 808.69 | 2121.21 | 1537.88 | 768.94 |
| $T_4$ | *Gmelina arborea* | 381.62 | 276.67 | 138.34 | 434.55 | 315.05 | 157.52 | 408.08 | 295.86 | 147.93 |
| $T_5$ | *Millettia pinnata* | 743.17 | 538.80 | 269.40 | 816.27 | 591.80 | 295.90 | 779.72 | 565.30 | 282.65 |
| $T_6$ | *Albizia lebbeck* | 4336.85 | 3144.22 | 1572.11 | 4698.07 | 3406.10 | 1703.05 | 4517.46 | 3275.16 | 1637.58 |
| $T_7$ | *Acacia nilotica* | 1851.11 | 1342.06 | 671.03 | 2034.29 | 1474.86 | 737.43 | 1942.70 | 1408.46 | 704.23 |
| $T_8$ | *Dalbergia sissoo* | 1849.89 | 1341.17 | 670.59 | 2005.78 | 1454.19 | 727.09 | 1927.83 | 1397.68 | 698.84 |
| $T_9$ | *Justicia adhatoda* | 10.60 | 7.68 | 3.84 | 14.75 | 10.69 | 5.35 | 12.67 | 9.19 | 4.59 |
| | S.Em.± | **761.25** | **551.91** | **275.95** | **803.80** | **582.75** | **291.38** | **553.53** | **401.31** | **200.66** |
| | C.D. | **2282.22** | **1654.61** | **827.31** | **2409.79** | **1747.10** | **873.55** | **1594.54** | **1156.04** | **578.02** |

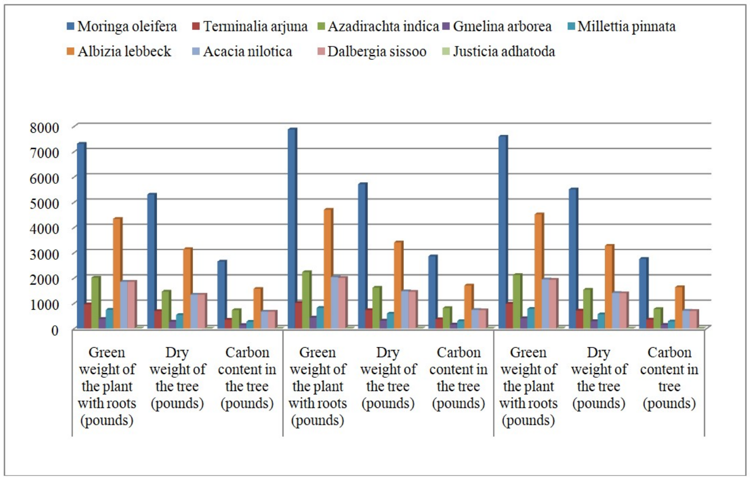


**Fig. 2.** Green weight, dry weight and carbon content of the different tree species.

## DISCUSSION

The highest carbon content of the tree (above ground + below ground**)** in pooled varies significantly and was observed for *Moringa oleifera* (2753.02 pounds/plant), followed by *Albizia lebbeck* (1637.58 pounds/plant), *Azadirachta indica* (768.94 pounds/plant)*,Acacia nilotica* (704.23 pounds/plant)*, Dalbergia sissoo* (698.84 pounds/plant)*, Terminalia arjuna* (356.38 pounds/plant)*, Millettia pinnata* (282.65 pounds/plant) and *Gmelina arborea* (147.93 pounds/plant). While the lowest carbon content of the tree (above ground + below ground**)** was recorded in *Justicia adhatoda* (4.59 pounds/plant). The present study revealed that biomass carbon production levels of different tree species varied with the nature and number of the woody perennial grown. Similar observations for above-ground biomass production (642.32 t $ha^{-1}$) were recorded by Reddy, *et al.* (2014), who reported 635.33 t $ha^{-1}$ as the above-ground biomass production in a hilly zone for teak plantation. Kalita *et al.* (2016) also reported 32.57 t $ha^{-1}$ above-ground biomass in tea plantation which was slightly lower than the present study (41.37 t $ha^{-1}$). The teak plant had a bigger girth and taller height than other plants taken under study. As a result, the teak plantation was found to be maximum in above ground, below ground and total biomass production. Bhardwajand Chandra (2016) also revealed, after 25 years of planting on entisol soil, the biomass and carbon stored in plantations of several tree species were assessed. Compared to the average biomass of all tree species (8.15 q/tree), the highest total biomass was recorded in *A. lebbeck* and *E. globulus*, followed by 16.66 q/tree*. D. indica* and *D. sissoo* had unsatisfactory results because they produced less biomass in entisol soil. A. *lebbeck* had the largest estimated total carbon stocks in the plantation (942.50 t/ha), followed by *E. globulus* (520.62 t/ha), and *T. arjuna* (143.12 t/ha), *A. indica* (106.87 t/ha), etc.

## CONCLUSION

The ravine area has significant effects both on-site and off-site, making it one of the harshest and most sensitive ecosystems. Managing the ravine by planting a variety of tree types will let farmers have more options for a living while also managing the soil's health. In comparison to other species, *Moringa oleifera* may have a good potential for biomass carbon.

## FUTURE SCOPE

Periodic assessment may be conducted of tree species based on biomass carbon and further characterization of tree species at ground level in Chambal ravine will help farmers directly in tree plantation practices and reclaim in gravines.

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**Conflict of Interest.** None.

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