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RESEARCH ARTICLE – ECOLOGY

Estimation of carbon level along the canal bank road-side of some selected tree species from Faiz Ahmad Faiz underpass to Thokar Niaz Baig flyover, Lahore

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Abstract

The climate change effects the world disastrously and the temperature of earth is rising day by day due to accumulation of greenhouse gases. By considering global warming and its effects, the present research work was carried out in order to estimate the carbon stock of some selected tree species along Canal Bank Road Lahore from Faiz Ahmed Faiz Underpass to Thokar Niaz Baig Flyover. The road-side vegetation along Canal Bank Road is distributed into four green belts where abundantly 24 tree species of 12 families were recorded. *Syzygium cumini* L. was dominated by 1224 plants followed by *Dalbergia sissoo* DC. and *Eucalyptus citriodora* Hook. having 671 and 550 trees, respectively. The total estimated carbon stock of trees was 32616.1 kg and 8992.935 kg to roadsides. In terms of an overall carbon sequestration potential, 122367.5 kg was total estimated biomass of all selected trees species present in four green belts of Canal Bank Road and the total carbon stock of all selected species on Canal Bank Road was 61183.74 kg. Moreover, the carbon stock of Family Myrtaceae was 24011.725 kg, followed by Fabaceae (13704.365 kg), Moraceae (9986.49 kg), Malvaceae (4170.64 kg), Bignoniaceae (3164.4 kg), Anacardiaceae (3034.55 kg) and Combretaceae (1419.4 kg). *Dalbergia sissoo* (10159.5 kg), *Eucalyptus citrodora* (9529.1 1 kg) and *Syzygium cumini* (8057. 12 kg) were the richest in number and have greatest potential to sequester carbon dioxide from atmosphere of Canal Bank Road Lahore.

Keywords: Canal bank, Climate change, Carbon biomass, Family Myrtaceae, Flyover, Lahore underpass

Key message: The research was conducted for the estimation of emission of carbon from different sources and sequester ability of plants to reduce the green-house effects and environmental pollution.

1. Introduction

The area selected for the research were green belts avenues of Canal Bank Road, situated in Lahore. It is Pakistan's second largest city, and the capital of the North-eastern Punjab province. Lying between 31°15-31°45' N and 74°01-74°39' E, it is bounded on the north and west by the Sheikhupura District, on the east by Wagah, and on the south by Kas1ur District. The Ravi River flows on the northern side of Lahore. Lahore city covers a total land area of 404 square kilometers. It has a semi-arid climate, not receiving enough rainfall to feature the humid subtropical climate. The hottest month is May where temperatures routinely exceed 42 ℃ (107 °F). The monsoon season starts in late July, and the wettest month is August, with heavy rainfalls and evening thunderstorms with the possibility of cloudbursts and flash floods. The coolest month is January with dense fog. It is widely considered the country's cultural capital and city of gardens. The heart of Lahore is the Walled or Inner City, a very densely populated area of about one square kilometer. Founded in legendary times, and a cultural center for over a thousand years, Lahore has many attractions to keep the tourist busy. The Mughal and Sikh legacy survives in the Lahore Fort, Badshahi Mosque and Gurdwara, the Mall is lined with colonial-gothic buildings from the British Raj, and the suburbs of Gulberg and Defense feature palatial mansions and trendy shopping districts (Ref….). Historically, it has been proven that Lahore is at least 2,000 years old. After Islam came to South Asia, it became a center of learning. It has the largest number of educational institutions in the country. Therefore, its roads are busy with traffic all day and it causes hazardous problems in our environment due to the heavy load of traffic on roads air transparency becomes decrease and cause smog, traffic plays a central role in causing climate change and global warming. To spread the network of roads in whole city and to build the infrastructure, many trees are cut down every year. Reduction of green places in the city causes air pollution.

Lahore Canal begins at the Bambawali-Ravi-Bedian (BRB) Canal that runs through the east of the city of Lahore, Punjab, Pakistan. The 60 kilometers long waterway was initially built by the Mughals. It was then upgraded by the British in 1861. The canal, aside from its importance in irrigation purposes, forms the center of a unique linear park that serves as one of the longest public green belts and popular recreational destination spots. It is an important part of the city's cultural heritage. On local, national and religious festivals, such as Jashn-e-Baharan (the welcoming of spring), Basant, Eid, Pakistan's Independence Day and Pakistan Day the canal is illuminated with lights and different types of decors are laid out into the water relevant to the festival. The average depth of the Canal is 5 feet (1.5 m) and it is bounded by roads on either side called the Canal Bank Road (Rumi, 2008).

Canal Bank Road is a major eight-lane east-west signal-free-road, which extends along the banks of the Canal in Lahore, Punjab, Pakistan. The road serves as a major central artery of Lahore and extends from Multan Road in Thokar Niaz Baig to BRB Canal Road in Khaira, passing through the neighborhoods of Johar Town, Gulberg, Mughalpura and Harbanspura. There are 12 underpasses along the entire route of Canal Bank Road, which allows continuous flow of traffic from Harbunspura to Thokar Niaz Baig.

Research area extends from Faiz Ahmad Faiz underpass to Thokar Niaz Baig flyover. Distance between these two points is almost 14 kilometers. There are four green belts, two on the side banks of the canal and two on the right and left sides of the roads. Roadside vegetation has number of effects that are beneficial for the quality of life in urban areas. They help to reduce the urban heat intensity (Hass et al, 2016) and decrease the need for energy for cooling buildings (Akbari et al, 2001). Roadside vegetation can perform many important functions, including the provision of habitat for rare plants and animals, a source of seeds for adjacent landscapes, a buffer to reduce the penetration of traffic noise and light, carbon sinks and enhanced aesthetics for road users (Walker et al., 2021). They also purify the air through capturing particulate matter, carbon dioxide and other air pollutants originating from traffic and industrial activities (McPherson et al., 1997).

Urban trees act as lungs of the city and reservoirs of "carbon stock." The vegetation patches in and around the urban areas sequester and store large amounts of carbon (Nowak et al., 2008; Strohbach & Haase, 2012). Urban trees also contribute to the mitigation of climate change impacts via carbon sequestration and provide various co-benefits in cities (Nero et al., 2017). Urban trees provide a broad range of ecosystem benefits (Kabisch, 2015) and through application of nature-based solutions the urban vegetation can generate co-benefits by restoring ecological flow in urban areas and strengthen sustainable urbanization with stimulated economic growth as well as improved environment (Nesshöver et al., 2017: Frantzeskaki, 2019; Lafortezza et al., 2018). For example, organic farming in urban vacant patches can allow to sequester carbon from the atmosphere through increased organic matter content in soil (Novara et al., 2019). Further, though the accumulated carbon of these "non-forested" areas are lower as compared to forested areas, they are important to maintain the local and national carbon balances (Jenkins et al., 2003). With increasing urban areas, even the smaller share of carbon sink from the urban vegetation is playing an important role and is also increasing significantly in size. However, in developing countries the urban carbon reservoirs are significantly affected by fast pace urbanization which leads to alteration in land-cover and change in overall vegetation structure (Nowak & Crane, 2002; Nagendra & Gopal, 2010).

Global warming, climate change and weather instability are among the key issues of the modern world. The effects of climate change have been experienced by many countries in the form of increased temperature, severe drought, widespread flooding, devastations of windstorms and destructions of forest fire (Warrick & Barrow, 1991), Deforestation where forests are cut down faster than they are replaced is a major contributor to climate change. This accounts for 20 percent of the world's carbon emissions (more than the entire transport sector produces). Deforestation makes such a huge contribution to carbon emissions because trees absorb CO; as they grow. If there are fewer trees left to absorb CO_2, then CO, will build up in the atmosphere. The agriculture and industry that replace the forests do not only damage the earth's ability to absorb CO, they often cause an additional problem by producing carbon emissions of their own (Ifeanyi-obi et al., 2012). Impacts of climate change divided into two groups i.e., biophysical, and socio-economic impacts. Biophysical impacts include change in physiological process, increase in pesticides challenges, changes in land soil, rise in sea level and water salinity. Socioeconomic impacts comprise over decline in agricultural production, uncertainty in world market price, increased food insecurity and high migration rate (FAO, 2007). Climate change effect on vegetation due to changes in the temperature, rainfall, and climate pattern as a result of which nutrient cycles, microbial activities, as well as physiological activities of plants will vary. Changes in precipitation may change moisture regimes. Soil erosion, salinity, acidity, and other physical and chemical factors may be affected as well. All these factors are closely related to vegetation growth (Ali, 2013). Objectives of the study was to understand the tree diversity of canal bank road avenues from Faiz Ahmad Faiz underpass up to Thokar Niaz Baig interchange Lahore.

2. Materials and Methods

2.1 Plan of work

To carry out research work, a plant inventory of species along the bank of the canal (Figure 1) and along the roadside was prepared. The plant species were profiled into trees. Determined the living biomass (volume) of trees by Diameter at Breast Height (DBH) and tree height. The total carbon stock of selected tree species of different sections of the canal road from Faiz Ahmed Faiz underpasses to Thokar Niaz Baig flyover. For research work, Clinometer, measuring taps, GPS meter, plastic bag, and cutter were used.

Figure 1. View of Canal Bank Road.

2.2 Plant inventory and data collection

An inventory of plants and their profile was prepared after dividing it into trees, shrubs, and herbs (Mullaer-Dombois and Ellenberg, 1974). Data was collected with respect to quadrats on adjacent sides of road. The general size of quadrate was 100m long x 10m wide, while quadrates used along the canal was 100m long × 5m wide. Tree species present in more than fifty numbers were considered for estimating the carbon level. The names of trees were identified by Dr. Zaheer-ud-din Khan, Incharge, Dr. Sultan Ahmed Herbarium, Department of Botany, G.C University Lahore.

2.3 Tree bole diameter at Breast Height (DBH) and tree height

The biomass of each tree of selected species was estimated because of the diameter of the trees trunk at Breast Height (DBH) and the height of the trees (Pandya et al., 2013). The DBH was determined by measuring the circumference of tree stem at breast height directly by using a measuring tape approximately 1.3 meter from the ground. The tree's bole, having a diameter equal to or greater than 300mm, was included in this study. DBH for trees was measured considering multiple stems, and the height was measured by clinometer from eye height, 5.8 feet. With the help of clinometer, the upper (A) angle was measured from a distance (D) of tree. Multiplying D by tangent of "a" gives height above the observer height and multiplying D. By adding both upper reading and eye height gives the total height of the tree (Muller-Dombois and Ellenberg, 1974).

H= (A × D) + 5.8 (eye height)
A tan a, D= distance from tree in feet
Height in meters H/3.281

2.4 Biomass estimation

The aboveground biomass (AGB) was estimated using the non-destructive method, which was developed by Brown 1997. The literature reveals that the non-destructive method is reasonably the most suitable method for the estimation of the biomass of trees (Schroeder, 1992; Brown, 1997; Chavan and Rasal, 2010). The non-destructive method does not require the chopping of trees in order to estimate a tree's biomass but instead relies on the use of equations and formulae. The aboveground biomass of a tree includes the whole shoot, branches, leaves, flowers, and fruits. It is calculated by using the following relation (Hangarge et al., 2012).

AGB (Kg) = Volume of tree (V) × Wood density (Kg/m)
Where V= nPH
V= Volume of tree
R=Radius of tree bole at breast height
H= Height of tree

The Below Ground Biomass (BGB) includes the biomass of live roots excluding fine roots having less than 2mm diameter (Chavan and Rasal, 2011; 2012). Since the below-ground biomass estimation equations are relatively uncommon in the literature, we calculated the below-ground biomass by multiplying aboveground biomass with 0.26 (default value), which was taken as the root to shoot ratio (Cairns et al., 1997; Ravindranath and Ostwald, 2008).

BGB (kg/tree) AGB (kg/tree) × 0.26
Biomass BGB + AGB
Carbon Sequestered - Biomass /2

The biomass of the sampled trees was divided by two to obtain the sequestered carbon in the trees of selected species since the trees contain, on average, 50% carbon in different parts of their biomass (Paladinic et al., 2009; Chavan and Rasal, 2011, 2012).

2.5 Estimation of wood density

The value of wood densities was taken from http:/db.worldagroforestry.org/wd.

2.5.1 The dry weight of trees

This calculation is based on an extension publication from University of Nebraska. A tree has about 72.5% dry weight and 27.5% moisture contents (Dewald et al., 2005). Therefore, for the estimation of the dry weight of tree, the fresh weight was multiplied by 72.59%. Weight of carbon content of trees was estimated by dry weight was multiplied with 0.5 or 50% of the trees total volume (Birdsey, 1992).

2.5.2 Estimation of carbon dioxide sequestered in trees

The molecular weight of CO2 = 43.999, the CO; to Cis 43.999/12.0001 = 3.6663. Therefore, for the estimation of weight of CO: sequestered in a tree, weight of C was multiplied by 3.6663.

2.5.3 Potential of species to sequester carbon

The average carbon stock in quadrat was multiplied to total number of plants of the species present at study. In this way, the total carbon of a single species was estimated.

2.5.4 Statistical Analysis

Statistical analysis was performed by using Minitab 2019 for plotting graph between volume verses carbon stock of trees. Excel 2016 was used for the calculation of standard error and plotting simple graphs.

3. Results

Overall, 6624 trees belonging to 23 species were recorded along Canal Bank Road Lahore (from Faiz Ahmad Faiz underpass to Thokar Niaz Baig flyover). The selected 23 species belonged to 12 families. Tree species present on the adjacent sides of both roads and on the banks of canal were taken into consideration.

3.1 Tree diversity

3.1.1 Adjacent roadside from Faiz Ahmad Faiz underpass to Thokar Niaz Baig flyover

There were 2079 number of trees present on the adjacent side as indicated in Figure 2. The most of trees belonged to family Fabaceae, Myrtaceae, Combretaceae, Meliaceae, Moraceae, Anacardiaceae, Annonaceae, Apocynaceae, Arecaceae, Bignoniaceae, Malvaceae, and Sapotaceae, respectively. The most significant tree species were recorded on study side were *Alstonia scholaris* (162), *Heterophragma adenophyllum* (134), *Dalbergia sissoo* (262), *Morus alba* (100), *Eucalyptus citrodora* (223) and *Conocarpus erectus* (95). *Syzygium cumini* was the most abundant tree species with 531 trees and *Hyophorbe lagenicaulis* with 5 trees were less in numbers.

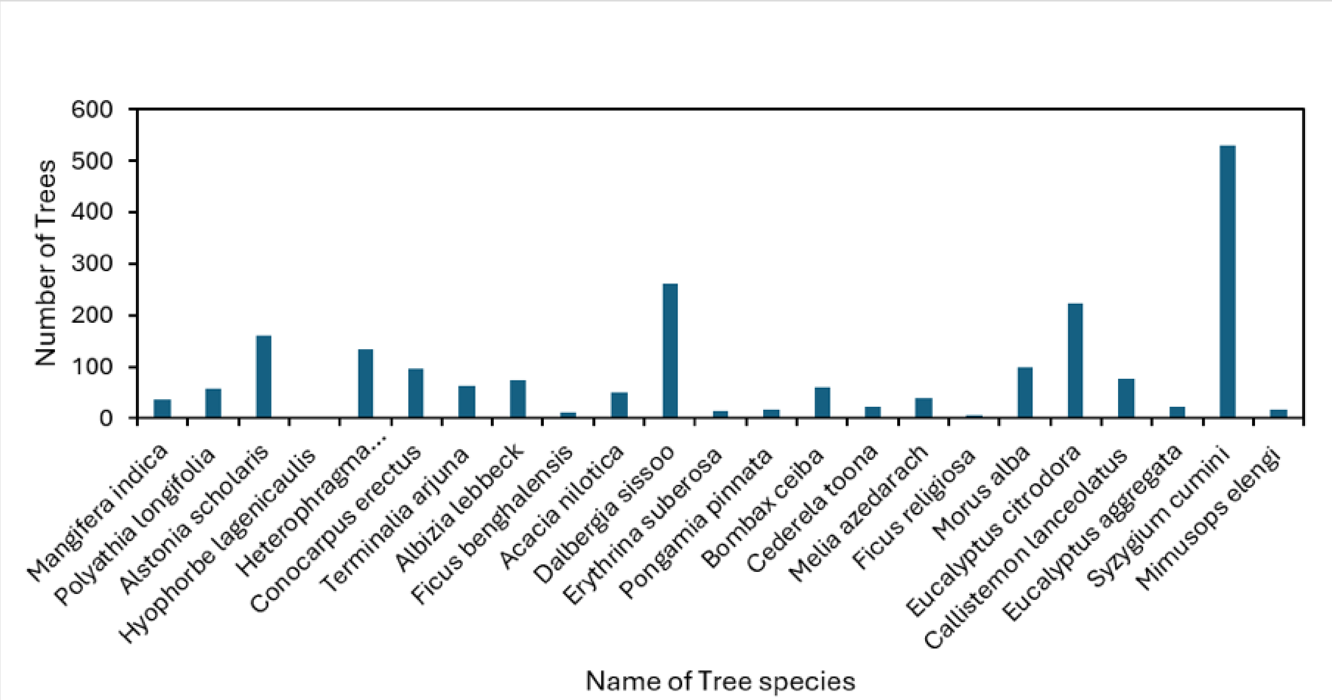

Figure 2. Tree adjacent to roadside from Faiz Ahmad Faiz underpass to Thokar Niaz Baig flyover

3.1.2 Adjacent to roadside from Thokar Niaz Baig flyover to Faiz Ahmed Faiz underpass

There were 2208 trees present on adjacent to roadside as shown in Figure 3. Most of trees were related to family Fabaceae, Myrtaceae, Moraceae, Combretaceae, Anacardiaceae, Annonaceae, Apocynaceae, Arecaceae, Bignoniaceae, Malvaceae, and Sapotaceae, respectively. The tree diversity was high on roadside followed by *Eucalyptus citrodora* (299), *Heterophragma adenophyllum* (226), *Dalbergia sissoo* (199) and *Terminalia arjuna* (81). *Mangifera indica* and *Shyzygium cumini* were most abundant species with 347 and 575 numbers of trees, respectively. *Callistemon lanceolatus* was less in number, with 6 trees.

3.1.3 Bank of canal from Faiz Ahmad Faiz underpass to Thokar Niaz Baig flyover

The recorded tree species on the canal bank were seventeen with low diversity as compared to the adjacent sides of the road. These tree species were related to nine families Fabaceae, Myrtaceae, Meliaceae, Moraceae, Malvaceae, Salicaceae, Anacardiaceae, Arecaceae and Bignoniaceae, respectively. From 1123 trees on the canal bank the most abundant species were *Dalbergia sissoo* (113), *Salix tetrasperma* (112), *Ficus religiosa* (183), *Erythrina suberosa* (172), *Morus alba* (98), *Conocarpus erectus* (95), *Callistemon lanceolatus* (77) and *Eucalyptus aggregata* with 251 highest numbers of trees on Canal banks. *Ficus benghalensis* (4) and *Heterophragma adenophyllum* (1) were fewer in number, as shown in Figure 4.

3.1.4 Bank of canal from Thokar Niaz Baig flyover to Faiz Ahmed Faiz underpass

Tree species studied on canal banks were mostly related to family Fabaceae, Myrtaceae, Moraceae, Malvaceae, Meliaceae, Anacardiaceae, Annonaceae, Apocynaceae, Combretaceae, Salicaceae and Sapotaceae, respectively. Overall, 1214 number of trees on canal banks the most significant were *Ficus religiosa* (172), *Morus alba* (112), *Eucalyptus aggregata* (223), *Dalbergia sisso* (76), *Shyzygium cumini* (72), *Erythrina suberosa* (65), *Callistemon lanceolatus* (50) and *Salix tetrasperma* richest in number with 317 trees. *Albizia lebbeck* (2), *Polyalthia longifolia* (3), *Alstonia scholaris* (3), *Terminalia arjuna* (1), *Ficus benghalensis* (3) and *Mimusops elengi* (1) were poor in species richness on anal banks as indicated in Figure 5.

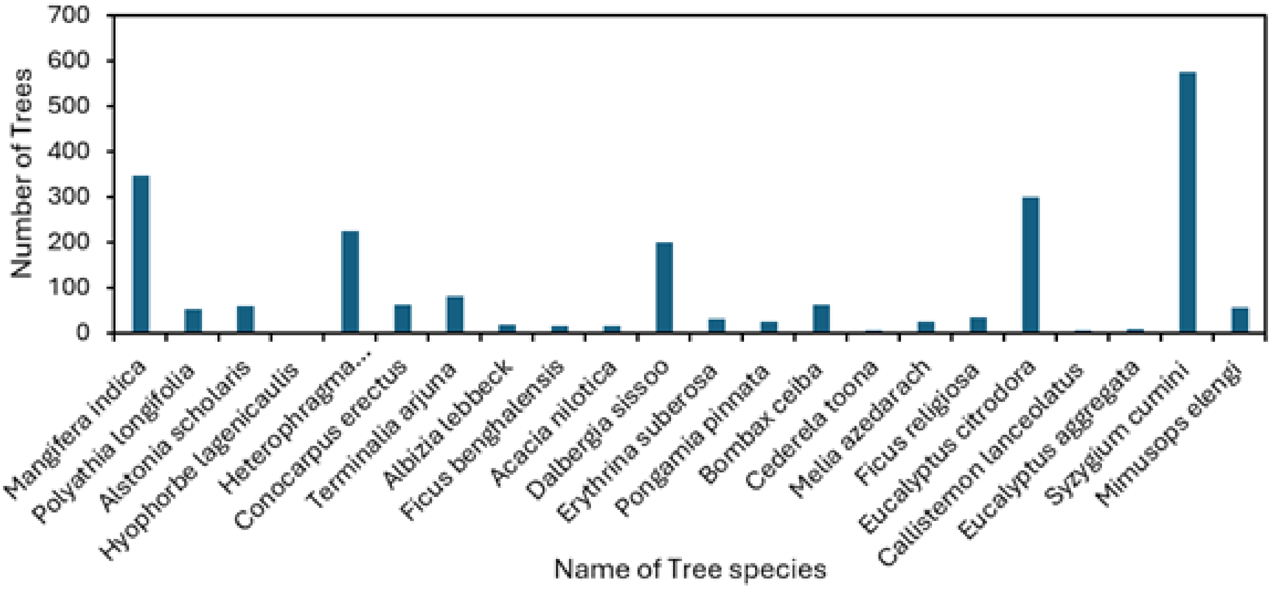

Figure 3. Tree adjacent to roadside from Thokar Niaz Baig flyover to Faiz Ahmed Faiz underpass

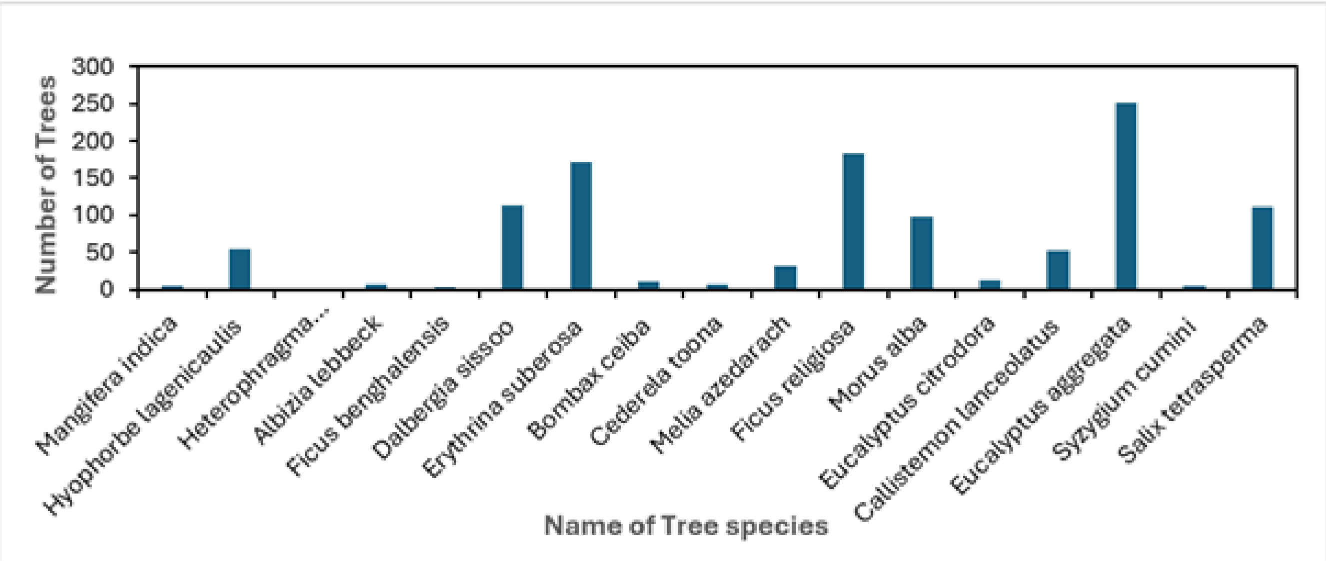

Figure 4. Tree adjacent to Canal from Faiz Ahmad Faiz underpass to Thokar Niaz Baig flyover

3.2 The Biomass and carbon stock

3.2.1 Adjacent to roadside from Faiz Ahmad Faiz underpass to Thokar Niaz Baig flyover

The biomass stored in plant families varied significantly between different tree species as indicated in Figure 6. Abundant trees biomass in *Eucalyptus citrodora* (8547.59 kg), *Dalbergia sissoo* (4558.8 kg), *Morus alba* (3409 kg), *Bombax ceiba* (2778 kg), *Syzygium cumini* (2575.35 kg), *Conocarpus erectus* (1472 kg), *Albizia lebbeck* (1086.32 kg) and *Alstonia scholaris* (907.2 kg), respectively. The carbon stock in *Eucalyptus citrodora* was 4273 kg, the highest level of carbon

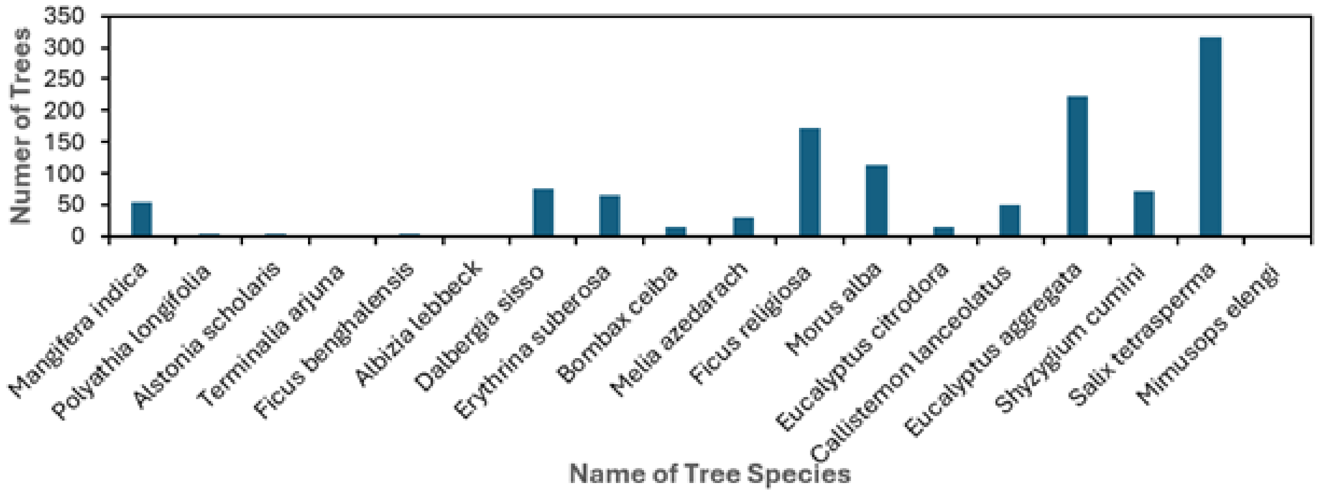

Figure 5. Tree adjacent to Canal from Thokar Niaz Baig flyover to Faiz Ahmed Faiz underpass

recorded on the roadside and *Pongamia pinnata* has 4.63 kg poor in carbon stock. The correlation between carbon stock and volume was very high.

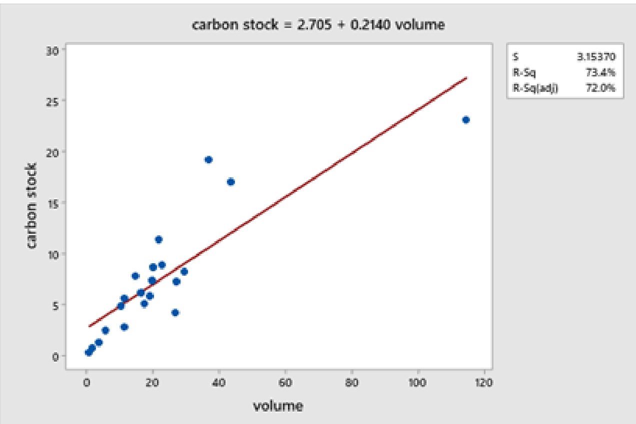

Figure 6. Carbon stock of the roadside from Faiz Ahmad Faiz underpass to Thokar Niaz Baig flyover

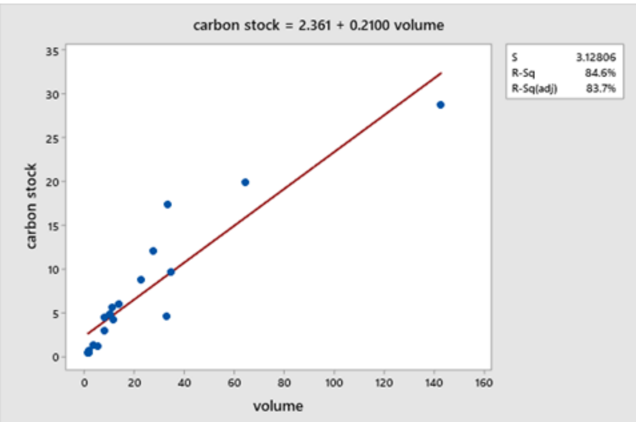

Figure 7. Carbon stock of roadside from Thokar Niaz Baig flyover to Faiz Ahmed Faiz underpass.

3.2.2 Adjacent to roadside from Thokar Niaz Baig fly-over to Faiz Ahmed Faiz underpass

Estimated biomass of different species present on the adjacent side of road is *Eucalyptus citrodora* (10375.3 kg), *Shyzygium cumini* (6831 kg), *Dalbergia sissoo* (4793.91 kg), *Heterophragma adenophyllum* (3948.22 kg), *Mangifera indica* (2935.62 kg), *Terminalia arjuna* (907.2 kg) and *Ficus benghalensis* (636.16 kg), respectively. Highest level of carbon was present in *Eucalyptus citrodora* (5187.65 kg), *Shyzygium cumini* (3415.5 kg), *Dalbergia sissoo* (2396.955 kg), *Heterophragma adenophyllum* (1974.11 kg) and the lowest level of carbon was present in *Callistemon lanceolatus* (4.26 kg), *Melia azedarach* (11 kg) and *Polyathia longifolia* (65.78 kg), respectively as shown in figure 7 and table 8. The correlation between carbon stock and volume was very high.

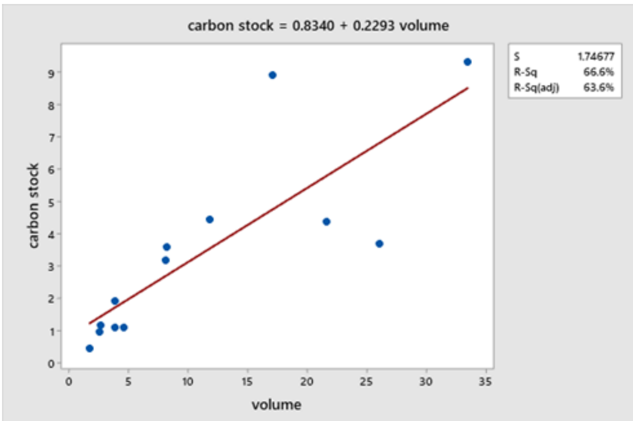

Figure 8. Carbon stock of Canal bank from Faiz Ahmad Faiz underpass to Thokar Niaz Baig flyover

3.2.3 Bank of Canal from Faiz Ahmad Faiz underpass to Thokar Niaz Baig flyover

The biomass stored in plants of selected tree species as in *Eucalyptus aggregata* (4472.82 kg), *Ficus religiosa* (3422.1 kg), *Erythrina suberosa* (1265 kg) and *Dalbergia sissoo* (806.82 kg), respectively. The carbon inventory in *Eucalyptus aggregata* was 2236.41 kg maximum stock of carbon recorded in this facet and *Cederela toona* had 3.09 kg bad in carbon inventory as indicated in Figure 8. The correlation between carbon stock and volume was high.

3.2.4 Bank of Canal from Thokar Niaz Baig flyover to Faiz Ahmed Faiz underpass

The estimated biomass of various species found in this facet was *Ficus religiosa* (2218.8 kg), *Eucalyptus aggregata* (1641.28 kg), *Dalbergia sissoo* (1056.4 kg), *Shyzygium cumini* (588.96 kg), *Salix tetrasperma* (497.69 kg), and *Eucalyptus citrodora* (456.15 kg), respectively. The highest degree of carbon is found in *Ficus religiosa,* 1109.4 kg and the lowest degree of carbon was found in *Melia azedarach* 9.15 kg (Figure 9), with a high correlation present.

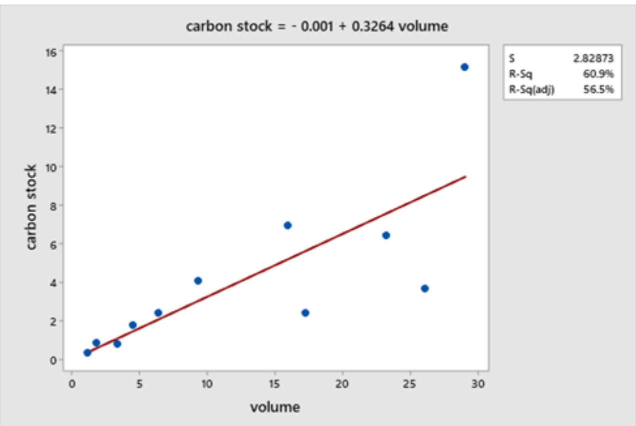

Figure 9. Carbon stock of canal bank from Thokar Niaz Baig flyover to Faiz Ahmed Faiz

3.2.5 Carbon Stock of the adjacent sides of both roads

The total estimated carbon stock of trees adjacent to both roads was 32616.1 kg. Families having major contribution in total carbon stock (kg) were Myrtaceae (14380.84 kg), Fabaceae (6248.255 kg), Malvaceae (3172 kg), Bignoniaceae (3164.4 kg), Anacardiaceae (1977.805 kg), Combretaceae (1419.4 kg), Moraceae (1247.56 kg), Apocynaceae (448.44 kg), Meliaceae (277.335 kg), Sapotaceae (157.62 kg) and Annonaceae (122.44 kg), respectively (Figure 10).

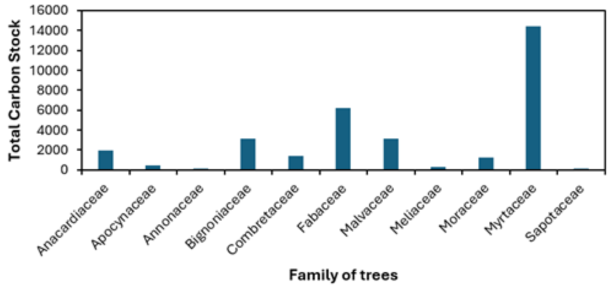

Figure 10. Carbon Stock of adjacent sides of both roads

3.2.6 Carbon Stock of both Banks of Canal

Figure 11 showed the calculated carbon stock of selected tree species of both banks of canal was 8992.935 kg. Tree species related to family Myrtaceae (3329.85 kg), Moraceae (3320.9 kg), Fabaceae (1740.425 kg), Salicaceae (398.97 kg), Anacardiaceae (101.87 kg), Malvaceae (56.68 kg) and Meliaceae (44.24 kg) were contributors for the total reservoir of carbon on both edges of canal.

3.2.7 Total carbon stock of canal bank road

Overall, 122367.5 kg was the total estimated biomass of all selected tree species present in four green belts of canal bank road and the total carbon stock of all selected species on canal bank road was 61183.74 kg. Family Myrtaceae (24011.725 kg), Fabaceae (13704.365 kg), Moraceae (9986.49 kg), Malvaceae (4170.64 kg), Bignoniaceae (3164.4 kg), Anacardiaceae (3034.55 kg) and Combretaceae (1419.4 kg), respectively were the major donor of carbon stock (Figure 12). *Dalbergia sissoo* (10159.5 kg), *Eucalyptus citrodora* (9529.11 kg) and *Syzygium cumini* (8057.12 kg) were richest in number and stored highest level of carbon on Canal Bank Road. *Pongamia pinnata* with 15.84 kg had the lowest stock of carbon.

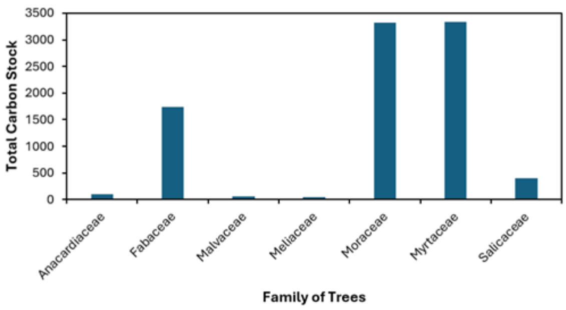

Figure 11. Carbon Stock of both Banks of Canal

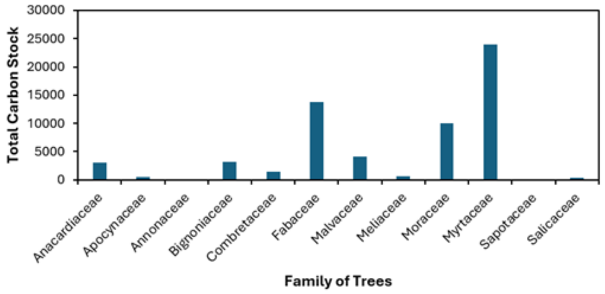

Figure 12. Total Carbon Stock of Canal Bank Road

4. Discussion

Present study enlightened the fact of the green corridor of Lahore city. This green corridor not only provides the esthetic sense to the residents of the city but it also helpful in culminating the pollution pressure generated through the combustion of fossil fuels and industries. Especially the increasing level of carbon dioxide is contributing in the annual increase of average temperature of earth so the scientists can make the importance of the vegetation for their natural ability to sequester the CO; from the atmosphere. In the present study, different plant species were classified into tree, shrub and herbs. Overall, 122.35 tons biomass was estimated along the Canal Bank Road and similar findings were reported by Syafinie and Ainuddin (2015) in Malaysia. Family Myrtaceae (24011.725 kg), Fabaceac (13704.365 kg), Moraceac (9986.49 kg), Malvaceae (4170.64 kg), Bignoniaceae (3 1 64.4 kg), Anacardiaceae (3034.55 kg) and Combretaceae (1419.4 kg), respectively, played a major role to sequester carbon dioxide from the atmosphere that is well aligned with the study of Agbelade et al. (2016). *Dalbergia sissoo* (10159.5 kg), *Eucalyptus* citrodora (9529.11 kg) and *Syzygium cumini* (8057.12 kg) were richest in number (Gibbs et al., 2007; Vashum and Jayakumar, 2012) and store highest level of carbon on Canal Bank Road. *Pongamia pinnata* with 15.84 kg has lowest stock of carbon.

In different section of the roads, different plant species dominated with respect to their potential to sequester CO; as the study of Tak & Kakde (2020) indicated that the *Olea ferruginea, Accacia modesta* and *Azadirachta indica* are the chief component in sequestering the carbon dioxide from the atmosphere in urban areas. Myrtaceae was the dominant family in terms of carbon storage and carbon sequestration rate. The study suggested that *Eucalyptus citriodora* and *Salix babylonica* would be the best species to select for plantation which would yield large impacts on landscape -level carbon stocks and could also mitigate climate change in Kathmandu, Central Nepal (Bhatta et al., 2015).

The CO_2 stocks in roadside trees in Bilaspur, India, were estimated by Anil and Krishna (2020) using a systematic sampling method the 10 tree species that sequestered more than 80% of Bilaspur's CO_2 were, in order of highest to lowest sequestration, *Delonix regia*, *Samanea saman*, *Tamarindus indica*, *Azadirachta indica*, *Ficus religiosa*, *Peltophorum pterocarpum*, *Albizia lebbeck*, *Terminalia catappa*, *Ficus benghalensis* and *Terminalia arjuna*. These tree species were therefore recommended for roadside plantations to sequester large amounts of CO; from the city and contribute to offsetting warming and mitigating the impact of climate change.

Overall, the estimated carbon stock of 61,183.74 kg along Canal Bank Road demonstrates the substantial contribution of urban plantations to climate-change mitigation. Besides carbon sequestration, these trees provide multiple ecosystem services, including mitigation of urban heat islands, reduction of atmospheric pollutants, enhancement of biodiversity and improvement of public well-being (Roy et al., 2012). The results therefore support continued investment in urban forestry, particularly through the conservation of mature trees and the introduction of diverse native species capable of long-term carbon storage. Increasing species diversity while avoiding over-dependence on a limited number of taxa would improve ecosystem resilience against pests, diseases and future climate variability.

Conclusions

The findings provide valuable baseline information for urban forest planning in Lahore. Future plantation programs should prioritize indigenous tree species with high biomass potential, long lifespan and greater resilience to environmental stress. Periodic monitoring of tree growth, health and carbon dynamics would further improve estimates of ecosystem services and support sustainable urban landscape management. Collectively, the study emphasizes that well managed urban green belts can significantly contribute to Pakistan's climate mitigation goals while simultaneously enhancing environmental quality and urban biodiversity.

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formal analysis and investigation, MM; data curation, MM; writing—original draft preparation, MM; writing—review and editing, MM; supervision, MW. All authors have reviewed and approved the manuscript.

Conflict of interest The authors declare no conflict of interest.

Data availability All data supporting the findings of this study are available within the paper. We do not have any research data outside the submitted manuscript file.

Declarations

Consent for publication Not applicable.

Competing interests The authors declare no competing interests.

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