Urbanization and Green Spaces—A Study on Jnana Bharathi Campus, Bangalore University

M. Kumar, N. Nandini, M. Vijay Kumar and M. Raghavendra

Abstract
Global warming is amongst the most alarming problems of the new era. Carbon emission is evidently the strongest fundamental factor for global warming. So increasing carbon emission is one of today's major concerns, which is well addressed in the Kyoto Protocol. Trees are amongst the most significant elements of any landscape, because of both biomass and diversity, and their key role in ecosystem dynamics is well known. Trees absorb the atmospheric carbon dioxide and act as a carbon sink, since 50 % of biomass is carbon itself and the importance of carbon sequestration in forest areas is already accepted, and well documented. With this background, a carbon sequestration potential study was carried out in Jnana Bharathi campus, Bangalore University using the Quadrat method. The total geographical area is about 449.74 ha with a rich vegetation sector and the total amount of both above ground carbon (AGC) and below ground carbon (BGC) was estimated as an average of 54.8 t/ha. The total amount of carbon dioxide assimilated into the vegetation in terms of both above ground and below ground biomass was estimated as an average of 200.9 t/ha. Urbanization and habitat fragmentation seem to be increasing worldwide,

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substantiated by a case study in Bangalore City. The analysis revealed that increase in built-up area at the city level was by about 164.62 km^2, while the vegetation and water bodies decreased by about 285.72 and 7.2 km^2 respectively. However, Bangalore University, Jnana Bharathi campus attains a good vegetation cover and is seen as one of the 'green lungs' of Bangalore city.

Keywords
Urban sprawl · Carbon sequestration · Landscape · Biomass · Bangalore

1 Introduction

Urbanization can be defined as the alteration of rural society into an urban society and is a result of expansion of urban agglomerations and city centres along with changing land use patterns (Roberts and Kanaley 2006). With only 2 % of the world population urbanized in 1,800, global urban population reached the 15 % mark in 1,900 and today almost 180,000 people are added to the world's urban population every day (Pitale 2011) and, worldwide, 65 % of the population are expected to reside in urban areas by 2025 (Schell and Ulijaszek 1999). Rapid and haphazard urbanization has caused many environmental impacts associated with the reduction of green space, making urban settlements a major source of Greenhouse Gas (GHG) emissions and creating additional vulnerabilities to global environmental changes. Green spaces in urban areas are an integral part of the landscape, providing the metropolis and its population with several benefits both tangible and intangible (Gaodi et al. 2010), ecosystem services such as pollutant sequestration and ambient temperature policy, etc. (Nowak et al. 2006; Jim and Chen 2008).

Green spaces act as hot spots in urban biodiversity (Kulkarni et al. 2001), and Bangalore city has major green spaces such as Cubbon Park, Lalbagh, BBMP Parks and Jnana Bharathi campus Bangalore University. Carbon sequestration is a phenomenon for the storage of CO_2 or other forms of carbon to mitigate global warming and is one of the important clauses of the Kyoto Protocol whereby through biological, chemical or physical processes, CO_2 is captured from the atmosphere. Carbon sequestration is a way to mitigate the accumulation of GHG in the atmosphere released by the burning of fossil fuels and other anthropogenic activities. The importance of forested areas in carbon sequestration is already accepted, and well documented (FSI 2009; Tiwari and Singh 1987), although not many attempts have been made to address the potential of trees in carbon sequestration in an urban scenario. Hence, the study of carbon sequestration potential assessment in Jnana Bharathi campus, Bangalore University, is very crucial in conserving green spaces in the city.

2 Materials and Methods

In the present study, the measurement of the quantity of carbon has been carried out and was based on the amount of above ground biomass and below ground biomass of trees in Jnana Bharathi campus, Bangalore University. Among the different methods for estimating above ground biomass, the most commonly used method is the quadrat method wherein 1 % of the total area (4.49 ha) is sampled for the biomass assessment. The quadrat size of 25 m × 25 m was laid and all trees having >1.5 m heights or >5 cm girth at breast height (GBH) were scrutinized individually with their respective measurements of GBH in centimetres and Basal area (square metres). Based on GBH and basal area values, biomass (t/ha) and carbon sequestration rate of trees were calculated using a value of 0.5 of the biomass as carbon content; a default conversion factor of 0.26 was used to convert above ground biomass to below ground biomass (Ravindranath and Ostwald 2008). For the wood density of the tree species, the standard average of 0.45 gm/cm^3 or 450 kg/m^3 was taken. The quantum of carbon was then converted to the quantum of carbon dioxide using the following formulae (Kumar and Singh 2003).

The following formulae were used:

$$\begin{aligned}
\text{Basal area} &= (\text{GBH})^2/4\pi \\
\text{Biovolume} &= \text{Basal area} \times \text{Height} \\
\text{AGB} &= \text{Biovolume} \times \text{Wood density} \\
\text{BGB} &= \text{AGB} \times 0.26 \\
\text{AGC} &= \text{AGB}/2
\end{aligned}$$

where

GBH Girth at Breast Height
AGB Above Ground Biomass
BGB Below Ground Biomass
AGC Above Ground Carbon

$$\text{Quantum of } CO_2 = \frac{\text{Quantum of carbon } \times 44}{12}$$

where

44 molecular weight of CO_2
12 atomic weight of carbon

3 Results and Discussion

3.1 Jnana Bharathi Campus, Bangalore University—A Green Urban Lung Space

Urban green spaces are one of the most significant elements of any urban ecosystem, both because of the ecosystem dynamics and the essential influence in human well-being. Jnana Bharathi campus, Bangalore University is located in southern part of Bangalore, Karnataka, India. The total geographical area of Jnana Bharathi campus is 449.74 ha with a longitude of 77º 30′ 05.604″E and latitude of 12º 56′ 57.608″N of precious land with rich vegetation, next to Cuban park and Lalbagh in Bangalore urban district. The Jnana Bharathi campus has different land use systems, namely evergreen forest, Madhuvana, Charakavana, Sanjeevinivana, bio-energy plants, ecologically conducive plants, natural vegetation, and 98.38 ha is allotted for various organizations such as institutions, buildings, hostels, offices, residential quarters, etc. The trees are present in the form of gardens and avenue trees, in and around the departments. The topography of the area is mostly flat or with moderate slope. The elevation of the division varies from 717 to 801 m at mean sea level. April is usually the hottest month with mean daily temperature at 33 °C and mean daily minimum at 21 °C. In the hottest season the temperature usually goes above 36 °C with the onset of the monsoon early in June, when there is appreciable drop in day temperature but that of night temperature is less. In October the temperature decreases. December is generally the coolest month with a mean daily maximum temperature of 26 °C and mean daily minimum of 15 °C nights during January which are, however, slightly cooler than during summer. The mean annual rainfall is about 875 mm spread over 50 days in a year. Over half of the annual average rainfall is obtained in the months of August, September and October. In November and December, cyclonic rains caused by the depressions on the eastern coast are experienced. From January to March almost no rain is received. The division has five check dams seasonally filled during the rains and dry in summer and Vrishabhavathi River is flowing in the same area. The soil in the valleys is good and loamy and is formed of fine particles of the decomposed rocks. The soil on the higher grounds is gravelly and reddish in color (Hanjagi 2007) (see Fig. 1).

3.2 Carbon Sequestration Potential of Jnana Bharathi Campus, Bangalore University

The Kyoto Protocol to the UN Framework Convention on Climate Change (UNFCCC 1992) has provided a vehicle for considering the effects of carbon sinks and sources, as well as addressing issues related to fossil fuels emissions. In recent years the urban cities account for 78 % of carbon emissions (Prachi et al. 2010), not only because of rapidly increasing population but also because of the vehicular traffic apart from industrial pollution (Wallace et al. 2009).

Fig. 1 Jnana Bharathi Campus, Bangalore University—study area

In the present study, 449.74 ha of Jnana Bharathi campus, Bangalore University was assessed to calculate total carbon capture and more than 55 different species were recorded in the campus as well as major trees such as *Acacia chundra, Azadirachta indica, Butea monosperma, Cassia fistula, Delonix regia, Dalbergia paniculata, Ficus bengalensis*, *Ficus glomarata, Ficus religosa, Santalum album, Syzigium cumini*, *Tabebuia argentia, Tamarindus indica, Tectona grandis, Terminalia species, Millingtonia hortensis, Pongamia pinnata, Feronia elephantum, Acacia nilotica, Albizzia odoratissima*, *Artocarpus integrifolia, Albizia saman and Polyalthia longifolia.* The carbon sequestration potential of trees in terms of both Above Ground Biomass and Below Ground Biomass in university campus was estimated as an average of 54.8 t/ha. The total amount of carbon dioxide assimilated into the vegetation in terms of both above ground and below ground biomass was estimated as an average of 200.9 t/ha. The study carried out by Chavan and Rasal (2010) in selective tree species of university campus at Aurangabad, Maharashtra, India showed the Above Ground Biomass for trees as follows; *Ficus religiosa* is 4.27 t/tree, *Ficus Benghalensis* 3.89 t/tree, *Mangifera indica* 3.13 t/tree, *Delonix regia* 2.12 t/tree, *Butea monosperma* 2.10 t/tree, *Peltophorum pterocarpum* 2.01 t/tree, *Azadirachta indica* 1.91 t/tree and *Pongamia pinnata* 1.57 t/tree; in another study carried out by Warran and Patwardhan (2005) in and around Pune on Carbon Sequestration Potential of Trees in 2002 showed the rate of carbon sequestered by the trees was found to be 15,000 t/yr. Urbanization and habitat fragmentation seem to be increasing worldwide, substantiated by a case study in Bangalore City. Bangalore has witnessed extensive growth in the last two decade substantially by globalization and urbanization. The demand on amenities is haphazardly increasing and the city spreads beyond into the peri-urban areas, the metropolitan area and outwards, into the Bangalore Metropolitan Region. Hence, the green spaces in Bangalore city are quickly declining. The analysis revealed that increase in built-up area at the city level was by about 164.62 km^2, while the vegetation and water bodies decreased by about 285.72 and 7.2 km^2 respectively (Shetty et al. 2012). However, Bangalore University, Jnana Bharathi campus attains a good vegetation cover and is seen as one of the 'green lungs' of Bangalore city and also helps in reducing global warming at regional level to some extent.

4 Conclusion

Most of the environmental impacts of urbanization are associated with green space. The presence of green space can mitigate these impacts, such as urban heat island effect, energy flow, and urban trees also remove large amounts of air pollutants which consequently improves urban air quality. The strengthening of green space in urban cities can be a potential contributor in reducing concentration of CO_2 in the atmosphere by its accumulation in the form of biomass and also offers citizens aesthetic enjoyments, recreational opportunities and physical and psychological well-being (Chen and Jim 2008). One tonne of carbon storage in the tree represents removal of 44/12 or 3.67 t of carbon from the atmosphere, and the release of 2.67 t of oxygen back into the atmosphere (Prachi et al. 2010) helping to improve the general liveability and quality of urban life.

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