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Biodiversity and Ecosystem Services of Trees Outside Forests: A Case Study from Dr. Harisingh Gour Vishwavidyalaya, Sagar, Central India

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Abstract: Alike forests, trees outside forest play a critical role in providing ecosystem services as well as biodiversity conservation. They include all those trees which has attained 10 cm or more diameters at breast height (DBH), available on land which is not notified as forest or other wooded land. Trees outside forest especially roadside trees have attracted little attention for their role in providing ecosystem services and biodiversity conservation due to their discontinuous occurrence and lack of documentation. The present study was conducted in Dr. Harisingh Gour University campus to document floristic diversity and their potential contribution towards ecosystem services. All the trees and shrubs having 10 cm or more DBH present along roads were documented and categorized for nativity, uses and ecosystem services. A total of 1252 individuals belonging to 85 species, 73 genera and 38 families were recorded. The habitat inhabits *Santalum album*, a vulnerable species and *Cordia macleodii* an endangered species escaped from natural and semi-natural forests indicating suitable habitat for them. The documented species were dominated by native flora (65 sp.) and 20 non-native species. Most of the species were food providing, ethno-medicinal, fodder, fuel wood and timber species. Further, 34 species including 4 religious species (*Aegle marmelos*, *Ficus religiosa*, *Phyllanthus emblica* and *Santalum album*) were found to provide cultural services.

Keywords: Ecosystem services, Trees outside forest (TOF), Biodiversity, Roadside trees, Native and exotic species

It is unequivocal and indisputable that climatic change and biodiversity loss are the greatest threat to humanity and all forms of life on earth. Vegetation destruction and degradation cause biodiversity loss and alteration in ecosystem functioning. Conservation and periodic assessment of diverse ecosystems and a whole range of biological diversity there in, become crucial for long term survival of humans and maintaining the conditions for existence of life on earth. Forests play a crucial role in mitigation of climate change impact through carbon sequestration (Hou et al 2019, Nunes et al 2020), providing habitat for wide variety of flora and fauna and offering a number of ecosystem services (Valdés et al 2020). Many trees growing outside forests, commonly termed as Trees outside forest (TOF), are not included in forest monitoring and inventories, although they provide services similar to those provided by forests (Chakravarty et al 2019, Shrestha et al 2018). TOF concept is defined as 'trees available on lands which are not defined as a forest or other wooded land' (FAO 2005). In India, it is defined as 'all those trees, which has attained 10 cm or more diameters at breast height, available on land which is not notified as forest' (FSI 2011). They do play a vital role in combating global climatic change and reduce biodiversity loss and can be effective component of sustainability (Albrecht and Kandji 2003, Roshetko et al 2007). TOFs are increasingly viewed as an avenue for biodiversity conservation, carbon sequestration, climatic stabilization and livelihood support in rural and urban areas (Acharya 2006). It has potential for providing ecosystem services and ensures continuous tree cover to provide benefits for current and future generations (Ajewole 2010) and therefore, has begun to attract more attention due to their economic importance (De Foresta et al 2013). TOF including agriculture land, plantations, barren lands, road side plantations, various institutional or academic landscape, built on lands including settlements and infrastructures make positive contribution towards living conditions of different towns and cities (Eludoyin et al 2014).

Evaluation of TOF and their services are important to improve our understanding and concern about the status and dynamics of all tree resources. Monitoring and management of trees in institutional landscapes is required (Ananda et al 2014, Singh et al 2017) as they are one of the major component of TOF. Number of studies had been carried out in institutional landscapes of India (Singh et al 2017, Nandal et al 2019, Tamang et al 2019) for floristic diversity and ecosystem services. The present study was conducted in the university campus to enumerate the tree diversity and their potential uses and ecosystem services provided by them.

MATERIAL AND METHODS

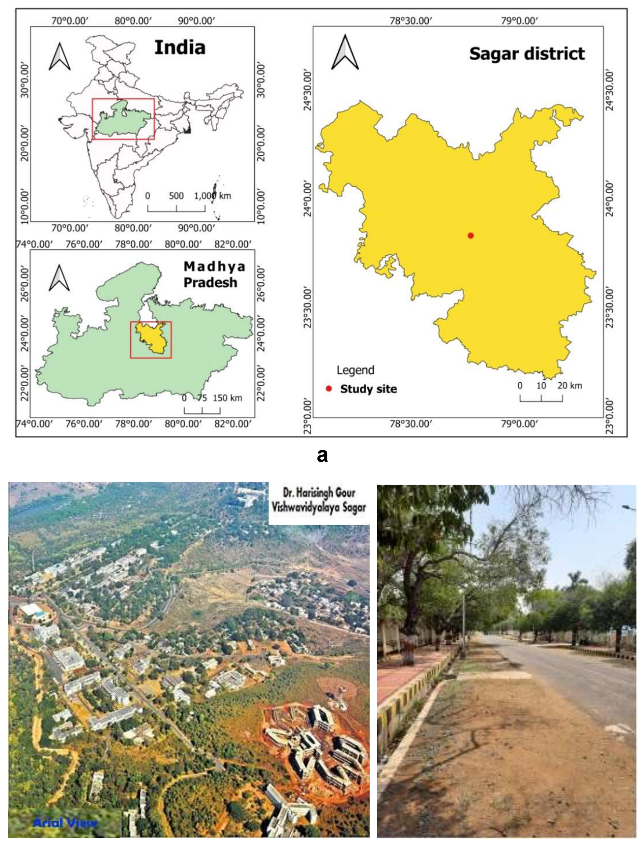
Study area: The present study was carried out in the roadside area of Dr. Harisingh Gour Vishwavidyalaya, Sagar, M.P. campus in the year of 2020-2021.This area is a part of lower Vindhyan range of Central India. The university campus is situated on the plateau of hill with an area of 1500 acre on an elevation of 420 msl. Geographically it lies 23˚49' N and 078˚46' E. Underlying rock is basalt, formed out of igneous rock, with plenty of basalt rounded boulders and with a very thin soil rich in calcium and phosphorus. The type of forests surrounding this area is classified as tropical dry deciduous type (Champion and Seth 1968). Climate of the study area is monsoonal with well-defined summer, rainy and winter seasons. Summer is hot and dry with maximum temperature of 45˚C during April to mid-June. Rainy season begins from late June up to September with average annual rainfall of 1187 mm. Winter is mild with minimum temperature of 5˚C during the month of January. General conditions of areas are dry during seven to nine months in a year. Most of the campus is inhabited by semi-natural forests in north, west and south directions and other areas include departments for different subjects, library, central office, dispensary, stadium, playground, hostels, residences etc. at the center and eastern region. Institutional areas are connected by roads and roadside plantations (Fig. 1 A, B, C).

Methodology

All roadside trees and shrubs along roads were documented. Present study considered only those trees and shrubs having 10 cm or more diameters at breast height (DBH), as they are considered as the TOF according to FSI (2011). Most of the species are identified at the spot as they were previously marked for study purpose; however, other species were mounted on herbarium sheet as per proper herbarium technique and were identified with the help of herbarium of Dr. Harisingh Gour Vishwavidyalaya and forest flora of Madhya Pradesh (BSI 1993, 1997, 2001). Complete enumeration was done for counting the individuals of all the species and classifying them in families and genera. All the areas were visited regularly to observe some of the direct benefits that local people get from the roadside plantations. Documented species were categorized for their nativity, uses and ecosystem services based on reports in literature (Gokhale et al 2011, Shukla and Chakravarty 2012, Raj et al 2018, Tamang et al 2019, Pradhan et al 2020).

RESULTS AND DISCUSSION

Floristics: In all, 1252 individuals of trees with DBH ≥ 10 cm were recorded belonging to 85 species, 73 genera and 38 families (Table 1) (Fig. 2). The contribution among number of individuals was dominated by *Tectona grandis* (11%), *Butea monosperma* (8%), *Mimusops elengi* (7%) and *Delonix regia* (6%). The overall dominant family was Mimosaceae represented by 9 species and 4 genera followed by Fabaceae (8 species and 7 genera), Rutaceae (6 species



source: University websitehttp://dhsgsu.ac.in/images/ dhsgsu_arial_view_photo.jpg

Fig. 1. (A) Study area (B) Arial views of University campus (C) Road side trees of study area

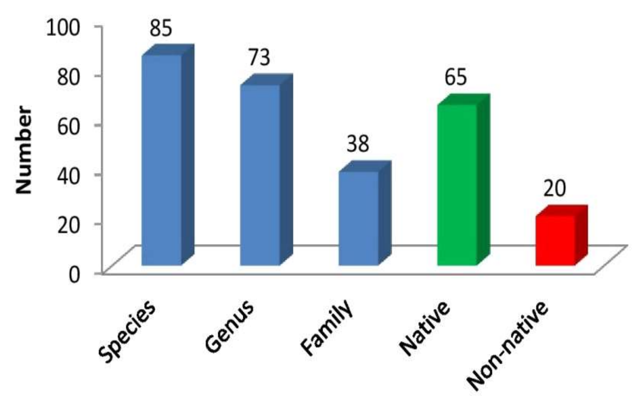


Fig. 2. Number of species, genera, families with no. of native and non-native species of the study area

Table 1. Documented species with their families, number of individuals, nativity, IUCN status, ecosystem services and utilization

Species name	Family	Indivi-duals	N/I	IUCN status	Servi-ces	Species specific benefits
Acacia auriculiformis	Mimosaceae	1	I	LC	P	Timber, fuel wood, apiculture, fodder, tannin, ornamental, gum, medicinal
Acacia catechu	Mimosaceae	1	N	NE	P, R	Medicinal, fodder, fuel, boundary/ support, nitrogen fixing, nectar source, dyeing
Acacia leucophloea	Mimosaceae	44	N	LC	P, R	Medicinal, fodder, fuel wood, nectar source, dyeing, Nitrogen fixing
Acacia nilotica	Mimosaceae	2	N		P	Fodder, food, gum, timber, medicinal
Aegle marmelos	Rutaceae	18	N	NE	P, C	Food, fodder, essential oil, medicinal, religious
Ailanthus excelsa	Simaroubaceae	2	N	NE	P, R	Fodder, fuel, gum, resin, medicine, shade, boundary, soil erosion control, trapping suspended particulate matter
Albizia lebbeck	Mimosaceae	2	N	LC	P, R	Timber, fuel wood, shade, nitrogen fixing, medicinal
Albizia odoratissima	Mimosaceae	2	N	LC	P, R	Timber, fuel wood, fodder, nitrogen fixing
Albizia procera	Mimosaceae	13	N	LC	P, R	Timber, fuel wood, shade, nitrogen fixing, soil improver, fodder
Annona squamosa	Annonaceae	20	I	LC	P	Food, fuel wood, medicinal
Anthocephalus cadamba	Rubiaceae	1	N		P, C, R	Dye food, fodder, ornamental, apiculture, tannin, intercropping
Artocarpus heterophyllus	Moraceae	1	N	NE	P, R	Food, fuel wood, fodder, shade
Azadirachta indica	Meliaceae	60	N	LC	P, C, R	Oil, medicinal, timber, religious, shade, fodder, nitrification inhibitor
Bauhinia racemosa	Fabaceae	2	N	NE	P	Fuel wood, fodder, nectar source, dyeing
Bauhinia variegata	Fabaceae	1	N	LC	P, R	Fuel wood, food, fodder, apiculture, fiber
Bixa orellana	Bixaceae	2	I	NE	C, P	Religious, food, cosmetic product, dye, medicinal
Bombax ceiba	Malvaceae	11	N	LC	P	Fibre, fodder, silk floss, medicinal
Bougainvillea	Lamiaceae	13	I	LC	C	Ornamental
Bridelia retusa	Phyllanthaceae	1	N	LC	P	Medicinal
Buchanania lanzan	Anacardiaceae	5	N	LC	P	Food
Butea monosperma	Fabaceae	97	N	DD	P, C	Aesthetic value, avenue plantation, fodder, timber, dye, resin
Callistemon citrina	Myrtaceae	1	I	NE	P, C	Herbicide, ornamental
Callistemon lanceolatus	Myrtaceae	1	I	NE	C, P	Avenue plantation, aesthetic, essential oil
Calotropis procera	Asclepidaceae	1	I	NE	C, P	Aesthetic value, medicinal
Carica papaya	Caricaceae	2	I	DD	P	Food, Medicinal
Cassia fistula	Caesalpiniaceae	19	N	NE	P, C, R	Fuel wood, fuel, medicine, aesthetic, apiculture, tannin
Casurina equisitifolia	Casurinaceae	3	N	NE	P, C	Ornamental, medicinal
Citrus lemon	Rutaceae	1	N	NE	P	Food, oil, good source of citric acid
Citrus aurantiifolia	Rutaceae	1	N	NE	P	Food, essential oil, medicinal
Cocos nucifera	Arecaceae	1	N	NE	P, C, R	Food, broom stick, lipid, soil improver, intercropping, ornamental
Cordia macleodii	Boraginaceae	2	N	EN	P	Food, medicinal, dye, glue, timber
Dalbergia sissoo	Fabaceae	33	N	LC	P, R	Shade, timber, fuel wood, nitrogen fixing, fiber, apiculture, lipid
Delonix regia	Caesalpiniaceae	71	I	LC	C, R, P	Avenue plantation, aesthetic, shade, fuel wood, gum/resin
Dendrocalamus strictus	Poaceae	32	N	NE	P	Making fence
Diospyros melanoxylon	Ebenaceae	1	N	NE	P	Leaf as Beedi wrapper
Diospyros montana	Ebenaceae	1	N	NE	P	Food, medicinal
Elaeodendron glaucum	Celastraceae	7	N	NE	P	Medicinal
Eucalyptus alba	Myrtaceae	61	I	LC	P, R	Ornamental, fencing, apiculture, fuel wood
Feronia limonia	Rutaceae	1	N	NE	P, C	Food, religious, medicinal
Ficus benghalensis	Moraceae	17	N	NE	R, C, P	Shade, religious, fodder, rubber/latex

Cont...

Table 1. Documented species with their families, number of individuals, nativity, IUCN status, ecosystem services and utilization

Species name	Family	Indivi-duals	N/I	IUCN status	Servi-ces	Species specific benefits
Ficus glomerata	Moraceae	1	N	NE	R, P	Shade, food, fodder, timber, latex, intercropping
Ficus religiosa	Moraceae	58	N	NE	R, P, C	Shade, fodder, religious, nitrogen fixing, soil improver
Flacourtia indica	Flacourtiaceae	3	N	LC	P	Food, alcohol, medicinal, fencing, firewood
Gardenia latifolia	Rubiaceae	3	N	NE	P	Medicinal, timber
Gliricidia sepium	Fabaceae	19	I	NE	P, R, C	Fodder, apiculture, fiber, inter cropping, ornamental
Gmelina arborea	Verbinaceae	2	N	LC	R, P	Shade, timber, fuel wood, apiculture, fiber, gum/resin, soil improver
Grevillea robusta	Proteaceae	6	I	NE	C, P, R	Avenue plantation, aesthetic, timber, latex, fodder, apiculture, soil improver, intercropping
Helicteres isora	Sterculiaceae	1	N	R	P	Medicinal
Holoptelea integrifolia	Ulmaceae	19	N	NE	P	Medicinal, fuel wood
Jacaranda mimosifolia	Bignoniaceae	5	I	VU	P, R, C	Timber, shade, ornamental
Jasminum	Oleaceae	1	N		P, R	Medicinal, oil, intercropping
Kydia calycina	Malvaceae	2	N	LC	P	Fodder, medicine
Lagerstroemia parviflora	Lythraceae	35	N	NE	P, R	Food, medicinal, shade, gum, tannin, dye, fiber
Lawsonia inermis	Lythraceae	2	I	LC	P, C	Dye, medicinal, fiber, ornamental
Lannea coromandelica	Anacardiaceae	1	N	NE	P, C	Food, apiculture, tannin, alcohol, ornamental
Leucaena leucocephala	Mimosaceae	31	I	CR	P, R	Fodder, nitrogen fixation, wood for paper industry
Madhuca latifolia	Sapotaceae	1	N	NE	P	Food, oil, alcohol, fuel
Mallotus philippensis	Euphorbiaceae	1	N	NE	P	Dye, medicine
Mangifera indica	Anacardiaceae	25	N	DD	C, R, P	Shade, food, fodder, timber, fuel wood, religious, soil improver, ornamental
Manilkara zapota	Sapotaceae	1	I	NE	P, R	Fuel wood, rubber/latex, food, apiculture
Miliusa tomentosa	Annonaceae	2	N	NE	P	Food, fodder, fuel wood, timber
Mimusops elengi	Sapotaceae	87	N	LC	R, C, P	Shade, avenue plantation, aesthetic, food, fodder, fuel wood, essential oil, fiber, erosion control
Moringa pterygosperma	Moringaceae	1	N	LC	R, P	Seed cake for water purification, food, fodder, medicinal
Murraya exotica	Rutaceae	2	N	NE	C	Avenue plantation, aesthetic
Murraya koenigii	Rutaceae	1	N	NE	P	Food, medicine
Nerium odoratum	Apocynaceae	10	N	LC	C, P	Ornamental, poison
Peltophorum pterocarpum	Fabaceae	49	N	NE	P, C	Fodder, timber, ornamental
Pithecellobium dulce	Mimosaceae	3	I	LC	P	Food, medicine
Phoenix sylvestris	Arecaceae	1	N	NE	P	Food, medicine, leaves for making mats
Phyllanthus emblica	Phyllanthaceae	8	N	LC	P, R, C	Fiber, essential oil, medicine, soil improver, religious
Plumaria alba	Apocynaceae	1	I		C, P	Ornamental, medicinal
Polyalthia longifolia	Annonaceae	51	N	NE	P, C	Medicinal, aesthetic, fuel wood, ornamental
Polyalthia pendula	Annonaceae	2	N		C, P	Ornamental, wood for making pencil, match stick
Pongamia pinnata	Fabaceae	10	N	LC	R, P	Oil, medicinal, fuel wood, Timber, shade, poison
Psidium guajava	Myrtaceae	6	N	LC	P	Food, medicine, apiculture, erosion control
Roystonia regia	Arecaceae	14	I	LC	C	Avenue plantation, aesthetic
Santalum album	Santalaceae	32	N	VU	P, C	Oil, medicine, religious
Senna siamea	Fabaceae	1	N	NE	P	Fodder, medicine, timber
Syzygium cumini	Myrtaceae	1	N	NE	P, R	Food, fuel wood, shade
Tamarindus indica	Caesalpiniaceae	2	N	LC	P	Food, oil, medicine
Tecoma stans	Bignoniaceae	23	I	NE	C, P	Ornamental, medicine
Tectona grandis	Verbinaceae	140	N	NE	P	Timber, fuel wood, shade
Terminalia arjuna	Combretaceae	4	N	NE	P, R	Fodder, apiculture, tannin, fuel, timber, erosion control, shade
Terminalia catappa	Combretaceae	2	N	LC	P, C, R	Food, ornamental, shade, medicinal, dye/ tannin, resin
Ziziphus jujuba	Rhamnaceae	27	N	LC	P	Food, medicine

NE- not evaluated, LC- least concern, DD- data deficient, EN- critically endangered, VU- vulnerable, N- Native, I- Non-native, P- Provisional service C- Cultural service, R- Regulatory service and 4 genera) and Myrtaceae (5 species with 4 genera) (Fig. 3). Out of 73 genera, the most common was *Acacia* with 4 species followed by *Albizia* (3 sp.) and *Ficus* (3 sp.).

Despite the fact that the university campus was developed in an area having natural forests, the number of individuals with higher DBH was less. Certain species, such as *Bougainvillea spp*, *Callistemon citrina*, *Callistemon lanceolatus*, *Carica papaya*, *Casurina equisitifolia*, *Citrus lemon*, *Citrus aurantiifolia*, *Cocos nucifera*, *Grevillea robusta*, *Manilkara zapota*, *Moringa pterigosperma*, *Murraya exotica*, *Nerium odoratum*, *Psidium guajava*, *Roystonia regia* and *Terminalia catappa* were observed in the study area but were not found in the nearby natural vegetations. Out of 85 tree species, 65 were native and 20 species were non-native species (Table 1) (Fig. 2). Most of the species are neutralized in the surround vegetations. *Gliricidia sepium* shows invasive potential as it is now spreading on its own in almost every corner of the university campus.

All of the trees and shrubs are providing salutary services to local people. They are as follows:

Provisional services: Provisional service is directly assessed by people from the vegetation. Out of the total documented species, 82 species are providing provisioning services to people. Amongst the provisioning service provider species, 33 were food providing species, 31 medicinal species, 29 fodder species, 23 fuel wood species, 21 timber species, 20 oil yielding species, 11 dye yielding species, 7 tannin yielding species and 5 resin yielding species (Fig. 4). Important timber producing species are *Tectona grandis*, *Dalbergia sissoo*, *Azadirachta indica*, *Albizia lebbeck* and *Pongamia pinnata*. Local people collect fuel wood from dried parts of *Pongamia pinnata*, *Tectona grandis*, *Mimusops elengi*, *Albizia lebbeck*, *Dalbergia sissoo*, *Albizia procera* and *Mangifera indica*. The study also documented species with traditional medicinal value like *Azadirachta indica*, *Aegle marmelos*, *Feronia limonia*, *Helicteres isora*, *Phyllanthus emblica* and *Santalum album*.

34 species were found to provide cultural services. From ancient times some of the plants were worshiped by people in Indian culture and were designated as religious trees. *Aegle marmelos*, *Ficus religiosa*, *Phyllanthus emblica* and *Santalum album* are important religious species. Aesthetically important species were *Polyalthia longifolia*, *Polyalthia pendula*, *Butea monosperma*, *Roystonia regia* and *Delonix regia*. Ornamental plants were *Bougaainvillea spectabilis*, *Nerium odoratum*, *Polyalthia pendula* and *Tecoma stans* (Table 1). Cutting and damaging the religious species is prohibited as an old tradition and belief, hence, a way of conservation.

Regulatory services: These are the indirect benefit that keeps the environment congenial. They include decomposition, water purification, flood controlling and soil erosion, climate regulation, air purification, temperature regulation, reducing dust and pollutants and noise. Large and dense canopy trees with thick and fleshy leaves like *Ficus* spp., *Syzygium cumini*, *Mangifera indica*, *Manilkara zapota*, *Mimusops elengi* and *Terminalia catappa* were prominent species to reduce noise, absorb dusts and pollutants and ameliorate the environment providing relief to the visitors especially during summer time (Table 1). 34 species were found providing regulatory services. Large canopy trees such as *Ficus benghalensis*, *Ficus religiosa*, *Mimusops elengi*, *Artocarpus heterophyllus*, *Syzygium cumini* and *Azadirachta indica* were shade and refuge providing not only to humans but also to birds.

Roadside trees of Dr. Harisingh Gour campus harbors a good number of plant species (85 species) which was comparable to 95 species reported from Uttar Banga Krishi Vishwavidyalaya, West Bengal, India (Tamang et al 2019), 98 species from TFRI campus plantations, Jabalpur, M.P., India (Singh et al 2017), 66 tree species from Tripura

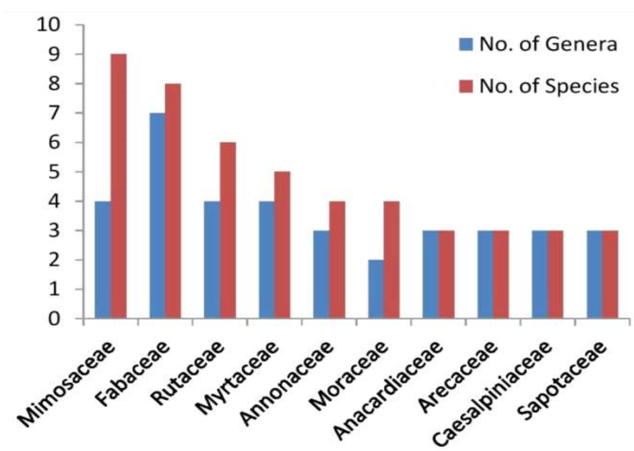


Fig. 3. Prominent families with their species and genera

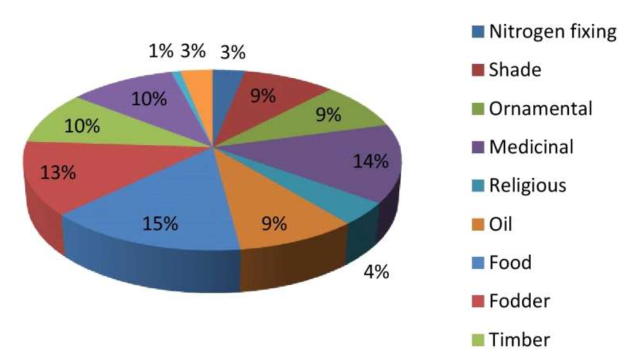


Fig. 4. Prominent ecosystem services provided by the vegetationin our study site

University campus (Deb et al 2016), 236 plant species from Adikavi Nannaya University (Rao 2016), 335 species with 55 tree species from Bharatijar university campus, India (Rajendran et al 2014) and 30 species from Sholapur university campus, Maharashtra, India (Gavali and Shaikh 2016).The difference in number of species in present study with others may be due to the fact that most of the studies have considered whole vegetational area of the campus and in addition to that some of the study considered all type of life forms, while we have considered only road side woody perennials with DBH ≥ 10 cm. Quantifying species richness is not only beneficial for comparisons among different places, but also for addressing the saturation of local communities colonized from regional source pool (Anandan et al 2014). Maximizing species richness is often explicit goal of conservation studies and background rates of species extinction (Airola and Buchholz 1984). In the present study, it was observed that roadside trees of institutional area may act as important ex-situ conservational unit comprising vulnerable and endangered species like urban green spaces studied by Pradhan et al (2020). Identification and documentation of species facing severe threats in different stages of vulnerability is necessary (Padalia et al 2004) as well as other factors influencing the existing vegetation of any region (Parthasarathy 1999). In our study, we found *Santalum album*, a vulnerable species and *Cordia macleodii* an endangered species escaped from natural and semi-natural forests of the study area.

Present study area is dominated by lower diameter class individuals. This might be due to the availability of vacant niche which adds the efficacy of regeneration potential for younger individuals. Further, soil of the present study area is thin with lower nutrient and moisture content which could be another key aspect contributing to the tree size reduction. DBH class distribution is one of the important factors which reflect the degree of stress, anthropogenic disturbance and history of development. Natural forests and public parks are well maintained, therefore, trees of these areas face limited stress and human interference. However, other green spaces like roadside plantations, institutional areas, home gardens etc. are planted for specific purposes to meet individual and community amenity values (Nero et al 2018). Trees along street and near residential areas are more susceptible to stress, hence are more dynamic in population and structure (Sæbø et al 2003, Nero et al 2018).

The flora of present study area, composed of 65 native and 20 nonnative species which was comparable to 66.31% endemic and 33.68% exotic species from institutional area of Uttar Banga Krishi Vishwavidyalaya, Cooch Behar (Tamang et al 2019), 63.35% of exotic species from Doon University campus, Dheradun (Singh et al 2017) and 183 exotic plant species from the Banaras Hindu University campus (Singh 2011). Planting non-native species has always been a debatable issue (Dickie et al 2014, Nitoslawski and Duinker 2016, Sjöman et al 2016). Tree species have been planted widely beyond their natural habitats to provide different ecosystem services. Although non-native or exotic species can provide a number of services (Dickie et al 2014, Castro-Díez et al 2019, Tamang et al 2019, Pradhan et al 2020), ecological characteristics of the habitat can be altered by introduction of exotic species and can be of significant threat to ecosystem (Singh et al 2017, Sakachep and Rai 2021) as they may neutralize and subsequently become invasive and disrupt or transform communities or ecosystems (Dickie et al 2014). It may be considered a sort of biological pollution and a critical outcome of human activities that leads to the extinction of native species (Kumar et al 2021). A well said quote by David Lodge defines them well, “These species are not inherently bad. They're just in wrong place”.

TOF can be found in varying locality factors of all climates, land types, land use and regions having important economic, social and environmental implications on local, national and global scale (De Foresta et al 2013). These plantations act as a catalyst by providing microhabitats and nutrient accumulation. TOF have the potential to provide ecosystem services in the form of preventing soil erosion, nutrient and water cycling, biodiversity conservation and pest control. Therefore, the assessment of TOF and its services are important to enhance our understanding about the state and dynamics of all tree resources. Along with ecosystem services, all the 85 species are helpful for mitigating global climate change by sequestering significant amount of carbon as biomass. Planting trees is an effective tool for restoring biodiversity (Fang and Peng 1997, Zhuang 1997) and all kinds of trees (forests and trees outside forests) play an important role in the global carbon cycle.

CONCLUSION

Present study shows that all the species of study site, irrespective of native and non-native provide a number of ecosystem services to serve mankind. Old growth forests are frequently targeted for conservation since they harbor a large proportion of vulnerable species (disturbance sensitive) and species of restricted distribution. Like forests, all other terrestrial vegetation including urban green spaces, agriculture land and other TOFs are capable of providing ecosystem services and conserve rare and endangered species. Economic valuation of ES can aid assessments of the impacts of projects, programs or policies on ecosystems. A number of studies had reported the existing trade-off between ecosystem services and biodiversity conservation in the urban ecosystems.

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