ENHANCING BIODIVERSITY

My University, My Campus,

It's My Responsibility

Nature has cared for these trees, saved them from drought, disease, avalanches, and a thousand tempests and floods. But it cannot save them from fools…….. John Muir

BIODIVERSITY AUDIT

UNIVERSITY OF MUMBAI

The Biodiversity Audit Team, University of Mumbai & St. Xavier's College, Mumbai

Biodiversity Audit Report
University of Mumbai

By

The Biodiversity Audit Team, University of Mumbai & St. Xavier's College, Mumbai

Preface

Urban sustainability is a critical issue in recent times. The megacities like Mumbai, Delhi, Hyderabad, Bangalore have started witnessing major issues related to the complete deterioration of their bio-physical environment with reckless urbanisation. The quality of urban air is already getting worst. The phenomenon of urban heat island is already on rise in these concrete jungles. The entire situation gets further complicated with the consequences of climate change in the form of torrential rains, flash floods, sea level rise, temperature rise and so on.

At this backdrop, United Nations under the Sustainable Development Goals is vehemently promoting livable and sustainable cities having strong resilience mechanisms set to deal with city sustainability. At the level of planning there have been some efforts to imbibe sustainability as a core value. For example, Smart City Mission. However, at the implementation stage, there are many challenges as out cities are too complex in terms of their socio-economic and spatial dynamics. There have been several researches going on currently. Nonetheless

At this backdrop how academic institutions approach these issues is a major question. One conventional way of dealing with these issues is either academically i.e. in the form of framing them as curricula or through various researches. The effectiveness of curricula depends on how it is delivered and what kind of learning methods are applied. So, the success of imbibing sustainable behaviour among the stakeholders of higher education remains limited as it has subjectivity involved.

The novel way could be initiating practices that would involve the stakeholders in practices that promote sustainable behaviour. Following the same as a part of National Science Day Celebration, it was decided to involve faculties, students in an effort of converting the University Campus into Green Campus. The activity was decided to be the biodiversity audit of the campus. The initiative was interdepartmental with 3 department involved, interinstitutional with involvement of experts from St. Xavier's College, Mumbai, 4 faculties, 24 students and nonteaching staff made biodiversity team.

Acknowledgement

The entire exercise of Biodiversity Audit was only possible because of the very supportive approach of the higher authorities. Prof. Suhas Pednekar, honourable Vice Chancellor immediately supported the idea of conducting biodiversity audit and extended solid support for smooth conduction of the same. Prof. Ravindra Kulkarni, hounourable Pro-Vice Chancellor had been instrumental in organising all kinds of support including the financial support for the successful completion of this exercise. Most importantly, Dr. Anuradha Majumdar, Dean, Science and Technology, University of Mumbai has been a major and fundamental source of support and inspiration to the biodiversity team. Her constant engagement and encouragement provided continuous energy for taking this audit to logical conclusion where all the trees in the campus have QR codes.

Our deepest gratitude to Dr. Rajendra Shinde, Director, Batter Herbarium and Principal St. Xavier's College, Mumbai for extending his unconditional support by deputing experts for identification of trees. Dr. Rajdeo Singh, a taxonomist deputed by him worked very hard, trained the team in identification of the trees and was instrumental in getting identification of trees done correctly. The team is highly indebted to Dr. Rajdeo Singh for all his constant presence and support for this activity. We would also like to thank Dr. Indu George, Head, Department of Life Sciences, Dr, Sanjukta Sattar, Head, Department of Geography who were the major supports for this activity.

The audit would not have been completed without the tremendous hard work and sincerity put by the entire team of biodiversity audit. Faculties - Dr. Nisha Shah, Dr. Suhas Jejurikar and student volunteers from the Department of Life Sciences, Geography and NSS PG unit B 60 have been instrumental in getting the work done by working continuously for the entire period of almost 4 months starting from 28th January, 2021 to 20th April, 2021.

It is a collective community effort to prepare the identify, geotag and barcode the trees on the university campus. The success nevertheless underlines the importance of collective strength and unity.

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BIODIVERSITY AUDIT

UNIVERSITY OF MUMBAI

1. INTRODUCTION

Academic Institutions, especially universities in India are known for their huge campus establishments. Most of these universities are found to have supported the coexistence of natural landscapes in the form of plantations and gardens simultaneously with the built up. The universities located in urban areas / megacities with such natural (plantation) landscapes have proven themselves to be the lungs of the cities. The academic campuses like Jawaharlal Nehru University, New Delhi, Savitribai Phule Pune University, Pune have emerged very vital in sustaining the air quality of their respective mother cities by contributing towards the reduction of air pollution.

University of Mumbai is one of the premier and oldest academic institutions equally contributing to the better health of the city and suburbs. It has 2 main campuses and 2 sub-campuses. The Kalina campus is spread over 243 acres of land and situated in the new central business district, i.e. Bandra-Kurla Complex. The Fort campus occupies 14 acres and situated in the older central business district like Fort. Both the campuses are main campuses and located in highly vibrant, busy and crowded areas of the city and suburbs. Though Fort campus of University of Mumbai is small, it has at least some 100 trees as a part of its decorative landscape amidst its buildings with the Gothic architecture exhibiting its link with the colonial times.

Kalina Campus is comparatively younger and has been developed in early 1970s. Often called as Vidyanagari Campus, it is one of the rarest green patches maintained in the highly concretized pockets of western suburbs of Mumbai. The only green zone serves as the lungs in highly polluted surroundings. With most of the major economic and commercial activities (infotech parks, passport and visa issuing offices, foreign embassies, offices of financial institutions, office space of Mumbai Metropolitan Regional Development Authority, stadium, forensic lab, international and domestic airport and so on) getting concentrated in and around the Vidyanagari Campus in recent decades, the area has emerged as one of the busiest nodes in suburban Mumbai. The area witnesses a major traffic flow from Eastern, Western and Harbour suburbs every day inviting

frequent traffic jams too. To resolve these issues of constant traffic jams, there have been construction of several flyovers, bridges and link roads encouraging cutting of the trees for road expansion and leading to intensive concretization. All these changes have definitely contributed towards the overall degradation of natural environment in and around Kalina Campus. Bandra-Kurla Complex, Sakinaka are the areas with extreme vehicular pollution and have topped in worst air quality index in Mumbai and its suburbs (Bhalerao, 2020).

Kalina campus is located in a low-lying area and geographically it is a flood plain of River Mithi. It can be revealed through the Google Earth images and topographical maps that the entire area where BKC, international and domestic airport and Kalina campus are situated now, were the flood plains of Mithi River formerly. Mithi River watershed extends between latitudes 19_001500N and 19_150000N as well as longitudes 72_450000E–73_00000E. Origin of the Mithi River is at the overflow of the Vihar (Zope, Eldho, & Jothiprakash, January, 2015) Lake and subsequently the overflow of Powai Lake also joins it.

Figure 1 Drainage Pattern - Mithi River

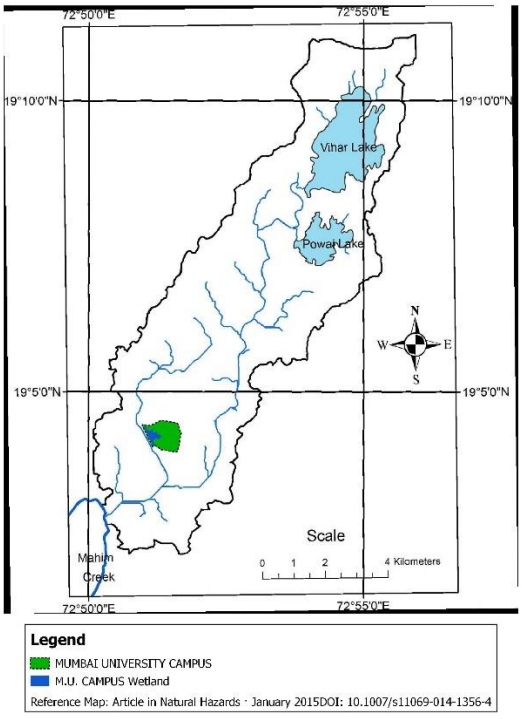
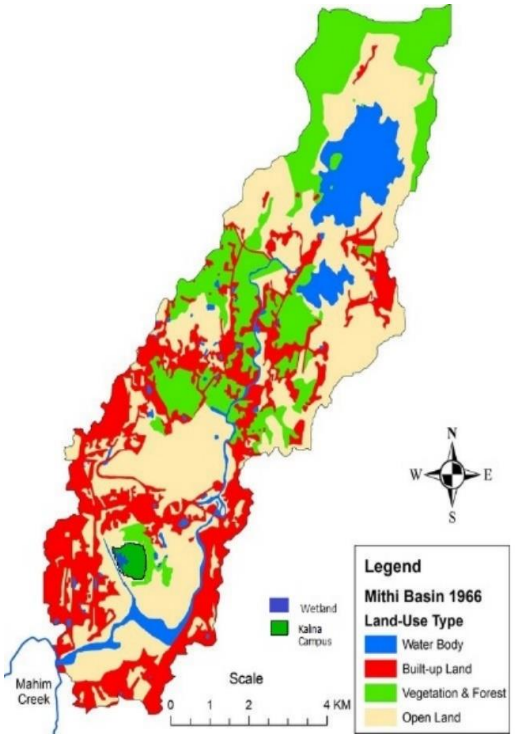


Figure 2 LULC in Mithi River Basin 1966



Source: The maps have been presented by (Zope, Eldho, & Jothiprakash, January, 2015)

Figure 3 LULC Mithi River Basin 2009

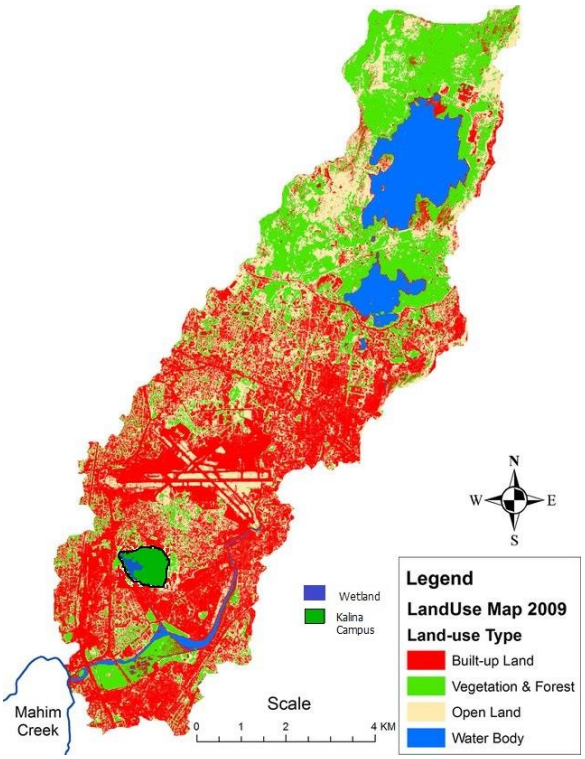
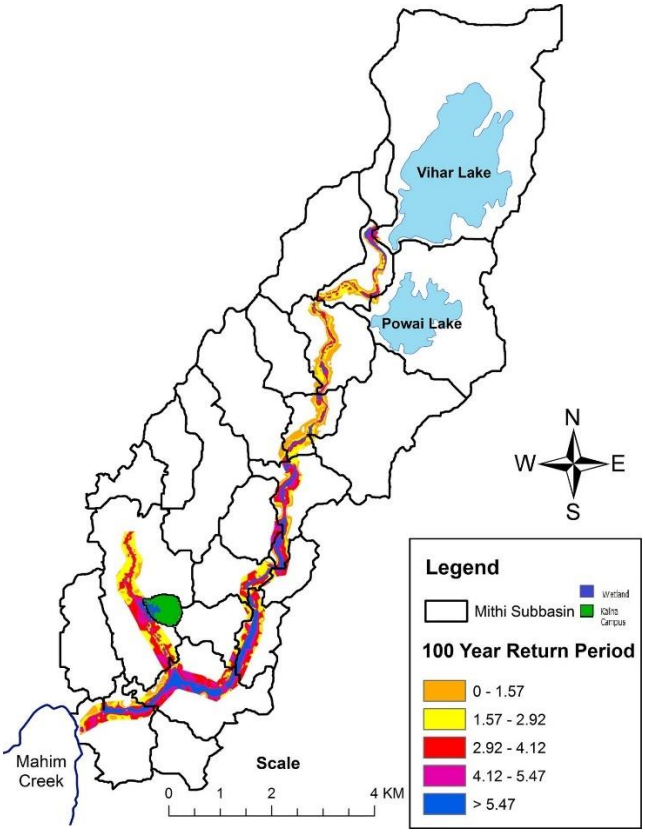


Figure 4 Flood Plain Map for 100 Years Return Period

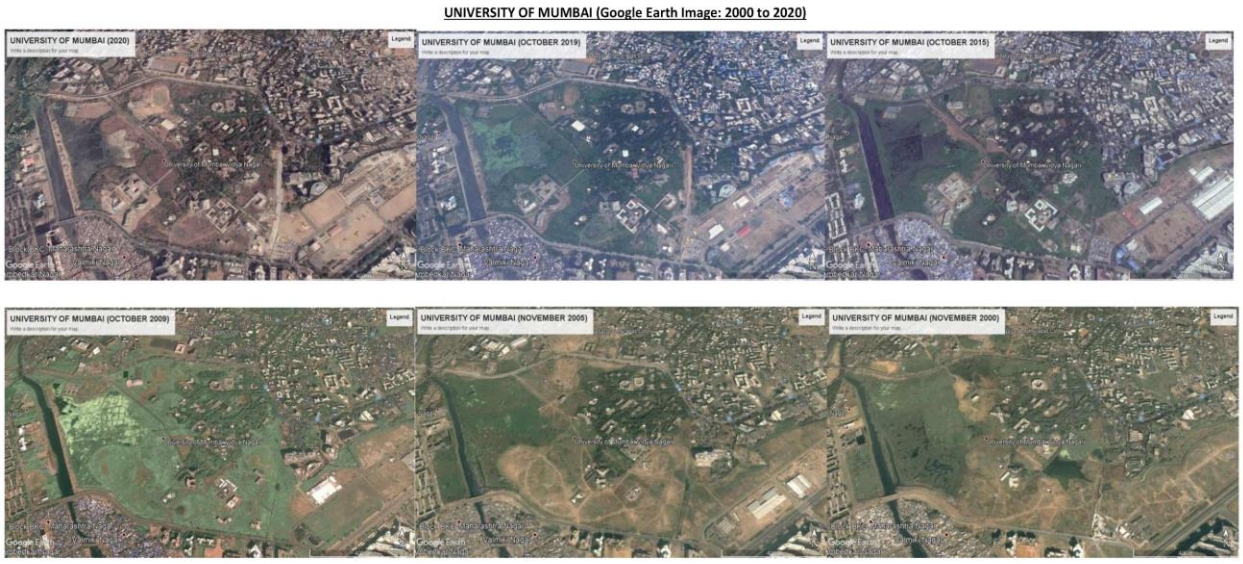


Source: The maps have been presented by (Zope, Eldho, & Jothiprakash, January, 2015)

The researchers from IIT, Mumbai (Zope, Eldho, & Jothiprakash, January, 2015) have studied the entire morphology of River Mithi. The study clearly correlates the higher incidences of water logging and floods with the increased incidences of urbanisation and a rapid expansion of built-up area. Figure 1 represents the actual river basin with drainage pattern of River Mithi from its origin to its meeting point at the Arabian Sea. Figure II & III represent the Land Use Land Cover (LULC) for the year 1966 and 2009. The comparison clearly shows that how the entire river basin has been completely engulfed by the process of urbanisation by the year 2009. It is not only secondary streams but River Mithi as well seen to be shrinking and getting disappeared in the dense residential and commercial clusters. It could be revealed from the figure III that in the downstream region of the Mithi river basin, Kalina Campus and its surrounding area has some greenery. Rest of the area, right from Sanjay Gandhi National Park (SGNP) to Mahim Nature Park, the prominent red colour is indicative of complete concretisation. Though some discrete green patches across

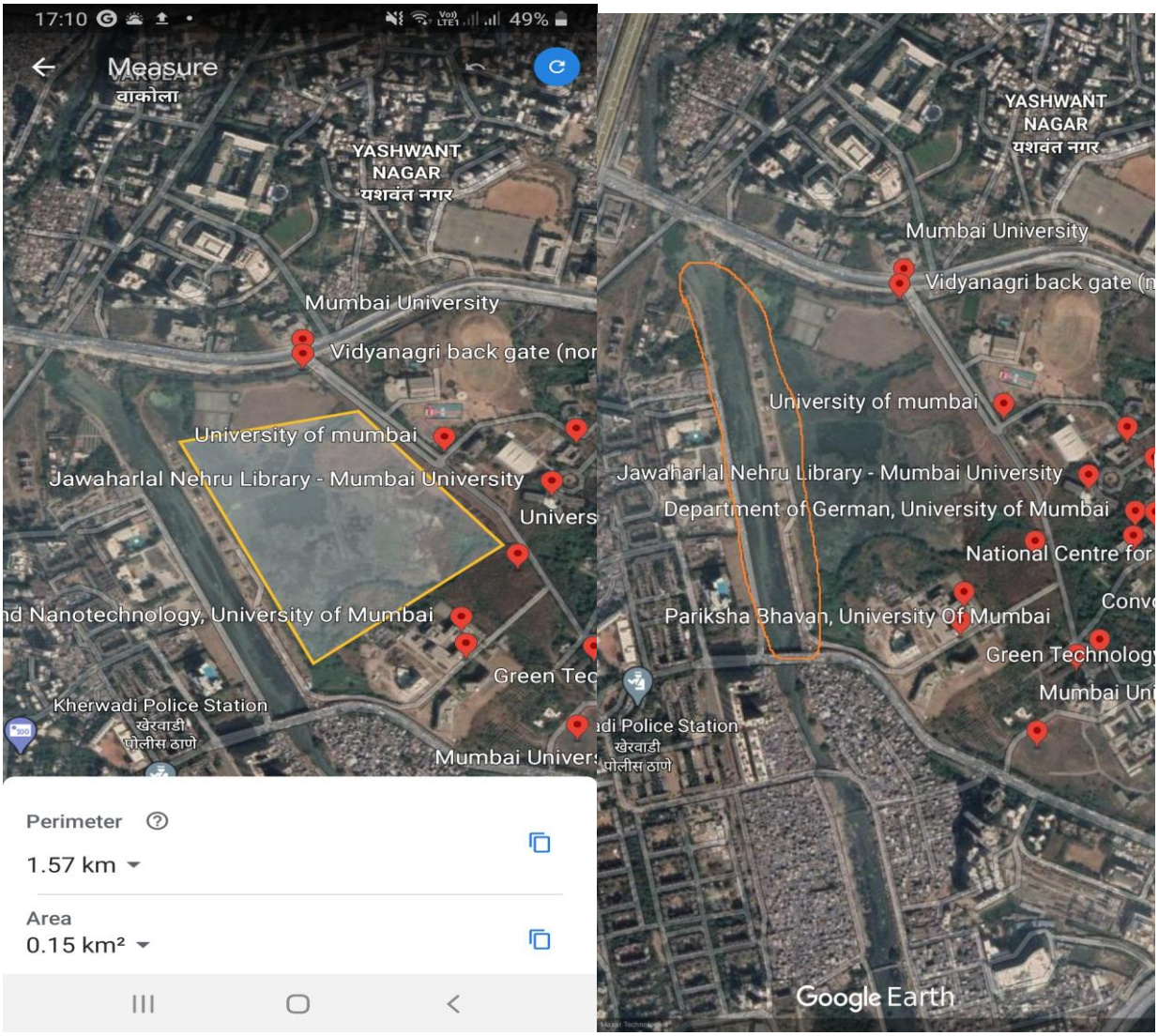
the basin could be seen but as compared to built-up area, they are tiny and scarce. With much more intensive urban development anticipated in future in this area, these tiny green patches ought to be endangered and threatened as they are vulnerable to land use changes with the pressure from the market forces to commercialise every inch of the city. The greenery maintained by the University of Mumbai in Kalina campus is expected to be less vulnerable to such changes as the entire area falls within the jurisdiction of the institution and land use changes can be controlled. To save and maintain this green cover, it is necessary first to create an account of what the greenery is all about. Figure IV represents the flood plain map for 100 years returns period. The Kalina campus can be clearly seen posited in the flood plain of Vakola Nala, a branch of Mithi River. In fact, the wetland under the jurisdiction of the University emerges to be a continuation of flood plain of Vakola Nala of Mithi river. It is an example of riverine wetland roughly measured around 0.15 sq.km. This wetland is of vital importance not only in terms of biodiversity but also as a sink for rain and flood water, the only sink available for seepage and percolation in a concrete jungle. The wetland plays a vital role in arresting severe flooding not only in the campus but also in the entire Kalina area. The wetland is a home for at least 64 species of birds. It welcomes the migratory birds by offering them a conducive habitat. The wetland emerges to be essentially vital in carbon sequestration as water is a good absorbent of carbon.

Figure 5 Impact of Landscape Transformation on the Wetland in the Campus (2000 to 2020)



Source: Google Earth

Figure 6 Location of Wetland and its connectedness with Vakola Nala



Source: Google Earth

The academic, administrative and civic infrastructure in Kalina campus was developed in 1970s. In coming future, it is anticipated that there would be a redevelopment of building infrastructure. Further it is expected to have infrastructural development in the form of new buildings, inner roads, metro line and so on. While allowing such development a proper understanding vis-a-vis physiography, biodiversity hotspots at microscale and wetland habitat needs to be generated at the level of authorities and planning agencies.

A proper documentation of floral and faunal diversity with reference to terrestrial and wetland habitat was essential. As a part of **National Science Day Celebrations, the Biodiversity Audit,** University of Mumbai had been executed by the Department of Geography, Department of Life

Sciences and NSS B 60 postgraduate unit as a joint venture in association with the Blatter Herbarium, St. Xavier's College, Fort, Mumbai. The audit included identification, geotagging of flora and QR coding of the trees. The survey was initiated on 28th January, 2021 and was concluded on 20th April where more than 5,500 trees have been identified, geotagged and QR coded. The identification of fauna was also done where 64 birds, reptiles, spiders, frogs have also been identified.

2. Objectives:

The survey was planned to have a focused study of the floral and faunal biodiversity in the Kalina Campus. We have achieved following objectives through our study.

1. Identification and documentation of the flora mainly trees with the help of Dr. Rajdeo Singh who is a well-known taxonomist,
2. Geotagging the flora using Open Data Kit (Geospatial technology)
3. Mapping of the flora with the help of open-source software QGIS (GIS technology)
4. Preparation of QR codes for each plant species.
5. Species based distribution of plants and number of plants per species have been calculated
6. Suggestions and Solutions for Ecological restoration and management.
7. Planning and promoting conservation practices by involving the nonteaching, teaching and student community.

3. Methodology:

1. Identification of flora and fauna has been done with the help of taxonomist, Dr, Rajdeo Singh by conducting field surveys mainly for identification of trees. Height and trunk size of each tree was recorded.
2. Preparation of IUCN list using the data published by Forest Research Institute, Dehradun
3. Collection of information about the plants – Common name, Botanical Name, Local Name, IUCN status, medicinal use, commercial use, traditional use and other important information
4. Geotagging the flora and fauna using handheld GPS, mobile GPS tracker and ODK collect through primary survey
5. Preparation of various maps representing spatial distribution of trees by using the GIS software like QGIS
6. Calculation of Carbon sequestration and carbon sink

4. Observations and Findings

4.1 Preparation of a comprehensive directory of species found in the campus

The output of the biodiversity audit could be seen in the compilation of detailed information about plants mainly trees that are there in Kalina Campus for decades together. The trees having trunk size more than 10 cm were counted in the audit as per the instructions by Dr. Singh – the taxonomist and as per the set norms of conducting tree census. The plants that have only flowering too were excluded from the audit. For each tree the height and trunk size were recorded as it is needed for calculation of age of the tree and carbon sequestration.

There are total 5357 trees that have been identified and a detailed information has been documented about every tree. Total 137 species of plants have been identified.

Table 1 A List of Species of Trees in Kalina Campus

Sr. no.	Common name	Botanical name	Family	Number of Trees
1	African tulip tree	*Spathodea campanulata* P.Beauv.	Bignoniaceae	189
2	Agasthi	*Sesbania grandiflora* (L.) Pers.	Fabaceae	1
3	Akashneem	*Millingtonia hortensis* L.f.	Bignoniaceae	81
4	Ambada	*Spondias pinnata* (L. f.) Kurz	Anacardiaceae	1
5	Amla	*Phyllanthus emblica* L.	Phyllanthaceae	107
6	Anant	*Gardenia jasminoides* J.Ellis	Rubiaceae	14
7	Apta	*Bauhinia racemosa* Lam.	Leguminosae	6
8	Arjun	*Terminalia arjuna* (Roxb. ex DC.) Wight & Arn.	Combretaceae	24
9	Asana	*Bridelia retusa* (L.) A.Juss.	Phyllanthaceae	29
10	Asupalav	*Polyalthia longifolia* (Sonn.) Thwaites	Annonaceae	339
11	Australian acacia	*Acacia auriculiformis* Benth.	Leguminosae	74
12	Babool	*Acacia nilotica* (L.) Delile	Leguminosae	6
13	Badam	*Terminalia catappa* L.	Combretaceae	90

14	Bahava	*Cassia fistula* L.	Leguminosae	19
15	Baheda	*Terminalia bellirica* (Gaertn.) Roxb.	Combretaceae	8
16	Bakneem	*Melia azedarach* L.	Meliaceae	1
17	Bakul	*Mimusops elengi* L.	Sapotaceae	25
18	Baobab tree	*Adansonia digitata* L.	Malvaceae	3
19	Bel	*Aegle marmelos* (L.) Corrêa	Rutaceae	3
20	Benjamin tree	*Ficus benjamina* L.	Moraceae	3
21	Bhend	*Thespesia populnea* (L.) Sol. ex Corrêa	Malvaceae	12
22	Bhokar	*Cordia dichotoma* G.Forst.	Boraginaceae	15
23	Bitti	*Cascabela thevetia* (L.) Lippold	Apocynaceae	20
24	Bivla	*Pterocarpus marsupium* Roxb.	Leguminosae	2
25	Bor	*Ziziphus jujuba* Mill.	Rhamnaceae	15
26	Bottle palm	*Roystonea regia* (Kunth) O.F.Cook	Arecaceae	97
27	Cannon ball tree	*Couroupita guianensis* Aubl.	Lecythidaceae	37
28	Cassia glauca	*Senna sulfurea* (Collad.) H.S.Irwin & Barneby	Leguminosae	2
29	Cassia grandis	*Cassia grandis* L.f.	Leguminosae	1
30	Cassia nodosa	*Cassia javanica* subsp. *nodosa* (Roxb.) K.Larsen & S.S.Larsen	Leguminosae	1
31	Chandan	*Santalum album* L.	Santalaceae	3
32	Charcoal tree	*Trema orientalis* (L.) Blume	Cannabaceae	26
33	Charoli	*Buchanania cochinchinensis* (Lour.) M.R.Almeida	Anacardiaceae	1
34	Chiku	*Manilkara zapota* (L.) P.Royen	Sapotaceae	21
35	Chinch	*Tamarindus indica* L.	Leguminosae	32
36	Chota taman	*Lagerstroemia thorelii Gagnep.*	Lythraceae	18
37	Christmas tree	*Araucaria columnaris* (G.Forst.) Hook.	Araucariaceae	4
38	Coconut	*Cocos nucifera* L.	Arecaceae	318

39	Copper pod	*Peltophorum pterocarpum* (DC.) K.Heyne	Leguminosae	685
40	Dhatriphal	*Barringtonia acutangula* (L.) Gaertn.	Lecythidaceae	5
41	Dikemali	*Gardenia resinifera* Roth	Rubiaceae	3
42	Fan palm	*Livistona chinensis* (Jacq.) R.Br. ex Mart.	Arecaceae	53
43	Ficus tsiela	*Ficus amplissima* Sm.	Moraceae	4
44	Fishtail palm	*Caryota urens* L.	Arecaceae	58
45	Foxtail palm	*Wodyetia bifurcata* A.K.Irvine	Arecaceae	18
46	Giripuspa	*Gliricidia maculata* ("Humb., Bonpl. & Kunth") Steud	Leguminosae	11
47	Gulmohar	*Delonix regia* (Hook.) Raf.	Leguminosae	131
48	Haldu	*Haldina cordifolia* (Roxb.) Ridsdale	Rubiaceae	5
49	Harda	*Terminalia chebula* Retz.	Combretaceae	2
50	Indian Rubber tree	*Ficus elastica* Roxb. ex Hornem.	Moraceae	19
51	Jackfruit	*Artocarpus heterophyllus* Lam.	Moraceae	38
52	Jamb	*Syzygium samarangense* (Blume) Merr. & L.M.Perry	Myrtaceae	3
53	Jamun	*Syzygium cumini* (L.) Skeels	Myrtaceae	59
54	Jungli badam	*Sterculia foetida* L.	Malvaceae	29
55	Kadamb	*Neolamarckia cadamba* (Roxb.) Bosser	Rubiaceae	29
56	Kadi patta	*Murraya koenigii* (L.) Spreng.	Rutaceae	2
57	Kahandol	*Sterculia urens* Roxb	Malvaceae	1
58	Kajra	*Strychnos nux-vomica* L.	Loganiaceae	2
59	Kaju	*Anacardium occidentale* L.	Anacardiaceae	2
60	Kala kuda	*Holarrhena pubescens* Wall. ex G.Don	Apocynaceae	3
61	Kala umber	*Ficus hispida* L.f.	Moraceae	23
62	Kalamb	*Mitragyna parvifolia* (Roxb.) Korth.	Rubiaceae	52
63	Kanak champa	*Pterospermum acerifolium* (L.) Willd.	Malvaceae	1
64	Kanchan	*Bauhinia purpurea* L.	Leguminosae	37
65	Karambola	*Averrhoa carambola* L.	Oxalidaceae	2
66	Karanj	*Pongamia pinnata* (L.) Pierre	Leguminosae	70

67	Kashid	*Senna siamea* (Lam.) H.S.Irwin & Barneby	Leguminosae	24
68	Katesavar	*Bombax ceiba* L.	Malvaceae	19
69	Kavat	*Limonia acidissima* Groff	Rutaceae	2
70	Khair	*Acacia catechu* (L.f.) Willd.	Leguminosae	4
71	Kokam	*Garcinia indica* (Thouars) Choisy	Clusiaceae	3
72	Kusum	*Schleichera oleosa* (Lour.) Merr.	Sapindaceae	1
73	Laal Chapha	*Plumeria rubra* L.	Apocynaceae	11
74	Laxmitaru	*Simarouba glauca* DC.	Simaroubaceae	2
75	Lettuce tree	*Pisonia umbellifera* (J.R. Forst. & G. Forst.) Seem.	Nyctaginaceae	4
76	Maha neem	*Melia dubia* Cav.	Meliaceae	1
77	Mango	*Mangifera indica* L.	Anacardiaceae	551
78	Mayur pankhi	*Platycladus orientalis* (L.) Franco	Cupressaceae	1
79	Medsheng	*Dolichandrone falcata* (Wall. ex DC.) Seem.	Bignoniaceae	4
80	Moha	*Madhuca longifolia* var. *latifolia* (Roxb.) A.Chev.	Sapotaceae	4
81	Muchkund	*Pterospermum suberifolium* (L.) Willd.	Malvaceae	1
82	Mulberry	*Morus alba* L.	Moraceae	4
83	Nagkesar	*Mesua ferrea* L.	Calophyllaceae	2
84	Narikel	*Pterygota alata* (Roxb.) R.Br.	Malvaceae	2
85	Neem	*Azadirachta indica* A.Juss.	Meliaceae	298
86	Niligiri	*Eucalyptus globulus* Labill.	Myrtaceae	5
87	Noni	*Morinda citrifolia* L.	Rubiaceae	2
88	Padal	*Stereospermum tetragonum* DC.	Bignoniaceae	9
89	Palash	*Butea monosperma* (Lam.) Taub.	Leguminosae	3
90	Paper mulberry	*Broussonetia papyrifera* (L.) L'Hér. ex Vent.	Moraceae	12
91	Parijatak	*Nyctanthes arbor-tristis* L.	Oleaceae	13
92	Payar	*Ficus virens* Aiton	Moraceae	1

93	Peepal	*Ficus religiosa* L.	Moraceae	136
94	Peru	*Psidium guajava* L.	Myrtaceae	106
95	Phandara Chapha	*Plumeria rubra* L.	Apocynaceae	74
96	Plumeria obtusa	*Plumeria obtusa* L.	Apocynaceae	13
97	Putranjiva	*Putranjiva roxburghii* Wall.	Putranjivaceae	79
98	Rai avla	*Phyllanthus acidus* (L.) Skeels	Phyllanthaceae	5
99	Raintree	*Albizia saman* (Jacq.) Merr.	Leguminosae	171
100	Ramphal	*Annona reticulata* L.	Annonaceae	4
101	Ratangunj	*Adenanthera pavonina* L.	Leguminosae	6
102	Ritha	*Sapindus trifoliatus* L.	Sapindaceae	10
103	Rohan	*Aphanamixis polystachya* (Wall.) R.Parker	Meliaceae	2
104	Rose of Venezuela	*Brownea grandiceps* Jacq.	Leguminosae	1
105	Rosy trumpet tree	*Tabebuia rosea* (Bertol.) Bertero ex A.DC.	Bignoniaceae	76
106	Sag	*Tectona grandis* L.f.	Lamiaceae	3
107	Samudraphul	*Barringtonia racemosa* (L.) Spreng.	Lecythidaceae	4
108	Sand paper tree	*Streblus asper* Lour.	Moraceae	8
109	Saptparni	*Alstonia scholaris* (L.) R. Br.	Apocynaceae	42
110	Savar	*Ceiba pentandra* (L.) Gaertn.	Malvaceae	2
111	Shami	*Prosopis cineraria* (L.) Druce	Leguminosae	10
112	Shemat	*Lannea coromandelica* (Houtt.) Merr.	Anacardiaceae	3
113	Sher	*Euphorbia tirucalli* L.	Euphorbiaceae	1
114	Shevga	*Moringa pterygosperma* Gaertn.	Moringaceae	27
115	Shindi	*Phoenix sylvestris* (L.) Roxb.	Arecaceae	5
116	Shisam	*Dalbergia sissoo* DC.	Leguminosae	1

117	Shivan	*Gmelina arborea* Roxb.	Lamiaceae	14
118	Silver oak	*Grevillea robusta* A.Cunn. ex R.Br.	Proteaceae	40
119	Singapore Cherry	*Muntingia calabura* L.	Muntingiaceae	1
120	Sita Ashok	*Saraca asoca* (Roxb.) Willd.	Leguminosae	20
121	Sitaphal	*Annona squamosa* L.	Annonaceae	31
122	Son chapha	*Michelia champaca* L.	Magnoliaceae	1
123	Subabul	*Leucaena leucocephala* (Lam.) de Wit	Leguminosae	140
124	Supari	*Areca catechu* L.	Arecaceae	3
125	Suru	*Casuarina equisetifolia* L.	Casuarinaceae	9
126	Tabebuia heterophylla	*Tabebuia heterophylla* (DC.) Britton	Bignoniaceae	2
127	Tamal patra	*Cinnamomum tamala* (Buch.-Ham.) T.Nees & Eberm.	Lauraceae	1
128	Taman	*Lagerstroemia speciosa* (L.) Pers.	Lythraceae	88
129	Tetu	*Oroxylum indicum* (L.) Kurz	Bignoniaceae	11
130	Umber	*Ficus racemosa* L.	Moraceae	53
131	Undi	*Calophyllum inophyllum* L.	Clusiaceae	2
132	Vad	*Ficus benghalensis* L.	Moraceae	40
133	Vaivarna	*Crateva adansonii* subsp. *odora* (Buch.-Ham.) Jacobs	Capparaceae	1
134	Varas	*Heterophragma quadriloculare* (Roxb.) K.Schum.	Bignoniaceae	1
135	Vavla	*Holoptelea integrifolia* Planch.	Ulmaceae	20
136	Vilayti chinch	*Pithecellobium dulce* (Roxb.) Benth.	Leguminosae	11
137	Yellow Tabebuia	*Tabebuia aurea* (Silva Manso) Benth. & Hook.f. ex S.Moore	Bignoniaceae	22

Source: Survey conducted by the Biodiversity Audit Team

It is revealed through data that many trees belonged to the exotic variety like Gulmohar, Rosy Trumpet, Subabul, Copper Pod, etc and they are also plenty in number. This could be because of the general tendency in the gardeners to plant the trees that grow quickly and turn the landscape

green. These trees offer limited ecological services to the local habitat in maintaining the ecological balance. Nonetheless, there are also native varieties of trees that are uncommon in Mumbai Region. The presence of Banyan tree, Peepal tree, Mango, Amala, Neem balance and support faunal existence. The botanical garden managed by the Mittal Ayurvedic College adds diversity to the trees in the campus. Their ecological significance is much higher than the exotic species of plants.

Figure 7 Saraca Asoca (Roxb.) wild, Tabebuia rosea (Bartol.) and Plumeria rubra L

Source : Dr. Rajdeo Singh

Figure 8 Bombax ceiba L., Butea monosperma (Lam.) Taub and Acacia nilotica (L.) Delile

Source: Dr. Rajdeo Singh

Figure 9 Brownea grandicepts Jacq, Haldina cordifolia (Roxb.) Ridsdale and Ficus benghalensis L.

Source: Dr. Rajdeo Singh

4.2 Geotagging and mapping of the trees

Geospatial Technologies include collecting, collating and compiling the geospatial data through the synchronized system of hardware and software to produce output either in the form of maps, three-dimensional models or digitally through web sites, portals and other digital forms of visualizations. Geospatial data is captured through various modes like satellites to unmanned vehicles like drone through multispectral and / or hyperspectral sensors. The satellite data thus has emerged as one of the vital sources in the study of biodiversity. Global Positioning System on the other hand allows the user to have access to location. The locational data in the form of X, Y and Z coordinates is generally recorded through various GPS devices like handheld GPS, mobile GPS and total station.

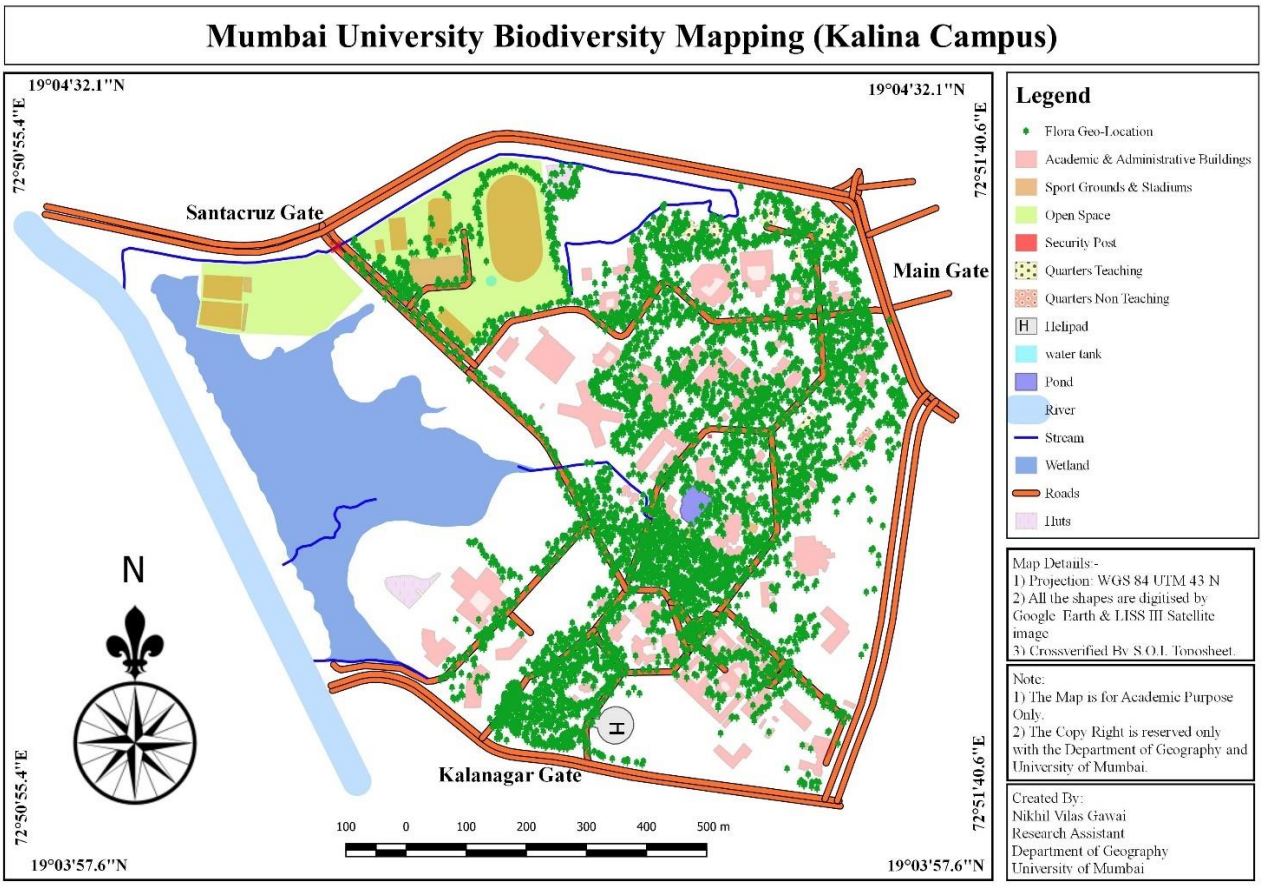
Figure 10 Student Volunteers collecting data and geotagging the trees

Open Data Kit is an open-source software that allows the user to build its own server with google, provides questionnaire building and allows the user to access the same questionnaire in their mobile through ODK collect mobile app. When the user downloads the questionnaire in the mobile, a location is recorded through the mobile GPS in the form of X, Y, Z coordinates. The location accuracy is around 1 to 2 meters. For geotagging the trees, a questionnaire was developed that contained questions related to location, common name, botanical name, height, trunk size, medicinal use, etc. The student volunteers filled this questionnaire for every tree and also captured the location of the tree. The advantage of ODK is, it allows the spatial and nonspatial information to be collected together. So, at a time one has access to qualitative information as well. ODK then prepares two datasets for downloading. One is in *.CSV* form and other is in *.KML* form. The *.CSV* is as good as excel file and provides the data recorded through the ODK collect in the form of table. *.KML* file has the locational information. When these two files are transported to QGIS environment as vector layers, they can be joined with each other. The final layer is having a location with all other information that is collected at that location and / or for that location. When

this layer is opened at the backdrop of any other layer like google maps, BING maps, LANDSAT, they exactly get superimposed on these maps and give great visibility. The locations appear in the form of dots in the map.

A spatial query feature in QGIS allows the user to run various queries to produce specific results. For example, if the spatial distribution of mango trees needs to be shown, a spatial query can be run to produce a map showing the location of mango trees only. Figure 11 represents the location of all the trees that have been geotagged. The trees are shown with the help of dots.

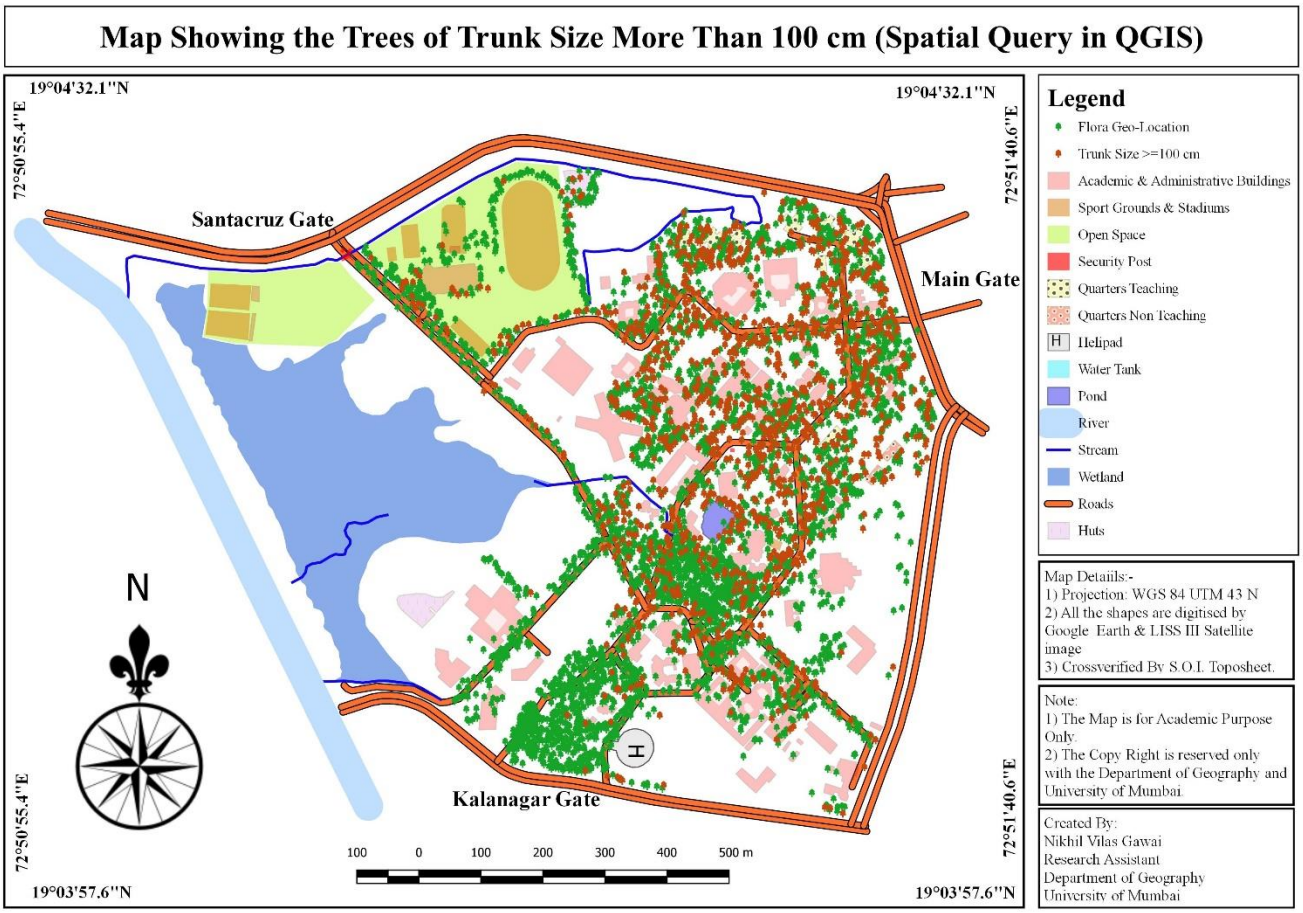
Figure 11 Location of Geotagged Trees in Kalina Campus



Source : Biodiversity Audit Survey

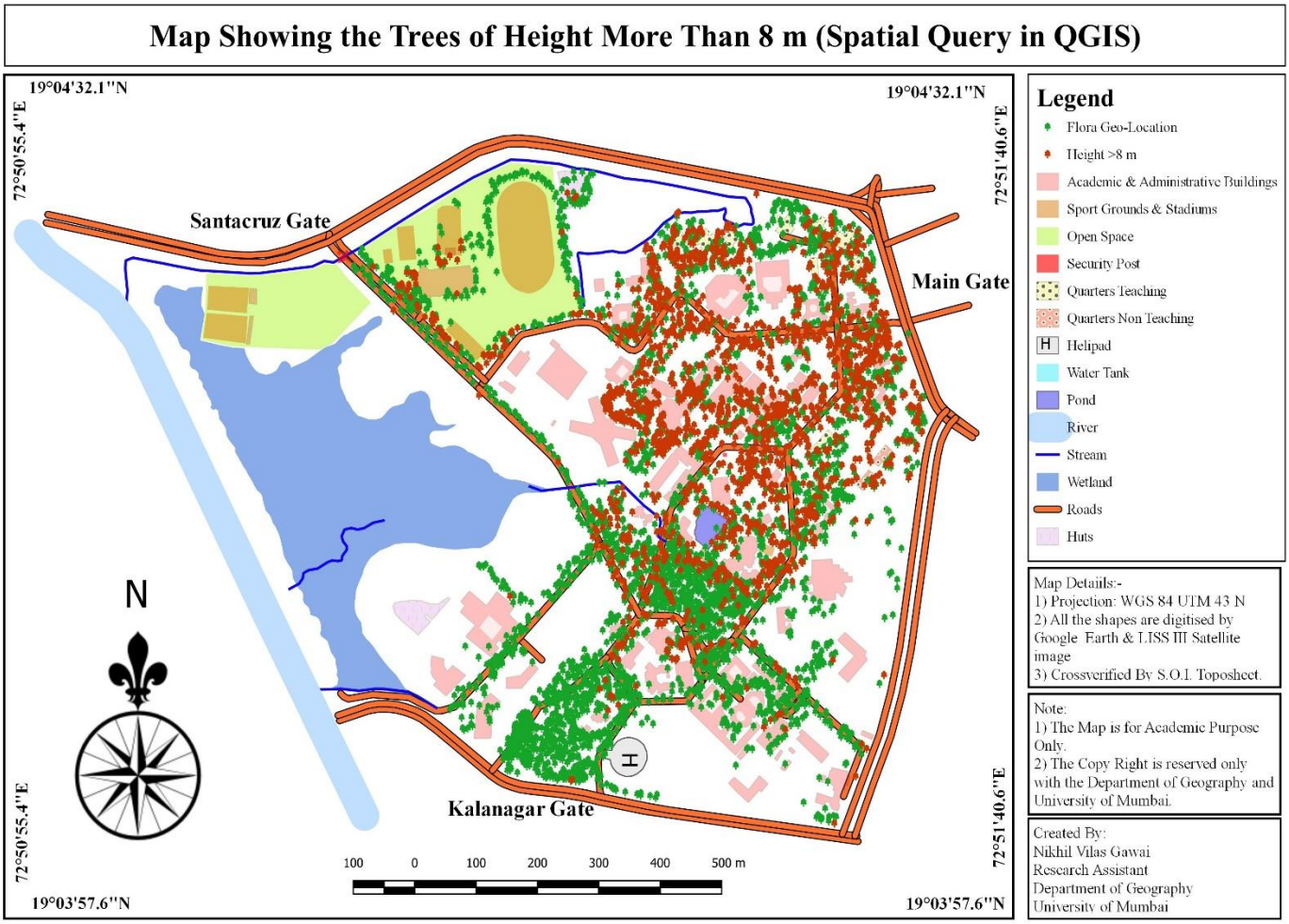
Figure 12, 13 and 14 represent maps showing specific distributions like trees having specific trunk size, specific species, height, etc. Such special purpose maps help in identifying the pattern of distribution of trees, demarcating the faunal zones on the basis of floral and faunal coexistence, taking decision about the future plantation drives and species of plants to be planted.

Figure 12 Trees with more than 100 cm Trunk Size



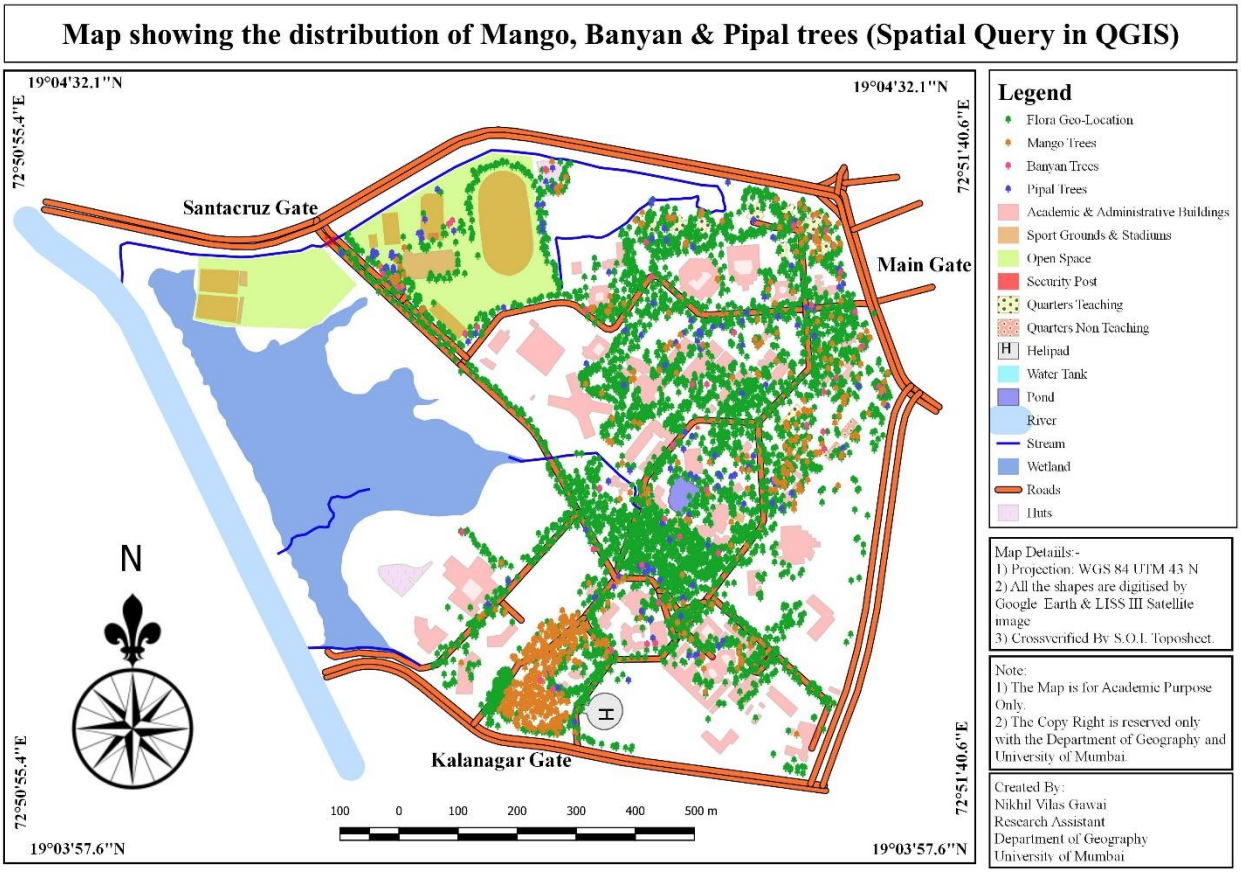
Source : Biodiversity Audit Survey

Figure 13 Trees having Height more than 8 Meters



Source : Biodiversity Audit Survey

Figure 14 Spatial Distribution of Peepal, Banyan and Mango Trees



Source : Biodiversity Audit Survey

4.3 QR Coding of the Trees

Generation of Quick Response Code (QR Code) has been initiated as the next step in arriving at a logical conclusion to the Biodiversity Audit. For each species of trees QR codes have been generated. These QR codes have been installed on the tress in the form of plates. The QR code has all necessary information about the tree like Place, Botanical Name, Common Name, Family, Flowering and Fruiting Season, IUCN Status, Description of Plant Morphology, Medicinal Uses and Miscellaneous information.

The very objective behind putting the QR codes is to create awareness among all stake holders in the university campus about the importance of trees and the kind of biodiversity that is maintained in the campus. It is also expected that the visitors will also be encouraged to scan the codes and

read the information about the trees. Specially the members of younger generation would find the QR codes interesting and would be encouraged to scan and know about the tree as they are more into digital and virtual space.

Figure 15 QR Code and the Description after Scanning

Place : Mumbai University
Tree Number : 1
Botanical name : Tabebuia rosea (Bertol.) Bertero ex A.DC.
Common name : Rosy trumpet tree
Flowering & Fruiting : January - August
Family : Bignoniaceae
IUCN status : Least Concern

Description
Large deciduous tree with a rounded or spreading crown. Leaves are compound, digitate and deciduous. Each leaf has five leaflets of variable size, the middle one being the largest. Flowers are large, in various tones of pink to purple, and appear while the tree has none, or very few, leaves.

Miscellaneous
Native of Tropical America. It is one of the most important timber species in Central America, and is widely harvested for a range of purposes. Timber is used for construction, furniture and cabinet work. It is used as a shade tree in coffee and cocoa plantations.

Source: Biodiversity Audit Team

The QR codes and the wooden name plates as a symbolic gesture have been inaugurated by honourable Pro-Vice Chancellor, Prof. Ravindra Kulkarni, hounourable Dean (Science & Technology), Dr. Anuradha Majumdar and Dr. Rajendra Shinde, Director, Blatter Herbarium and Principal, St. Xavier's College, Mumbai.

Figure 16 National Science Day Celebration

Figure 17 Honourable Pro-Vice Chancellor Prof. Kulkarni, Honourable Dean (Sci. & Tech), Dr. Majumdar, Honourable Principal, Dr. Shinde at Inauguration Ceremony, 28th February, 2021

4.4 Identification of fauna

The fauna experts from student volunteers dedicated themselves for the identification of different types of fauna. The most important location for the birds has been the wetland in the University campus. The wetland of the size 0.15 sq.km., is a major habitat for not only the indigenous species of birds but also the migratory birds. There have been 64 birds spotted on the campus. Around 10 species of frogs, reptiles, spiders have also been spotted. Many different species of ants, insects and butterflies also have been observed. The same indicates that the flora supports the faunal life through ecological association, symbiosis and interdependence. For example, the nest of pagoda ants is also the nest for Rufus Woodpecker. They allow the birds to lay eggs. Otherwise, these ants are very aggressive. In our campus, there are several such Pagoda ants' nests. There has been a clear association between the colony of bats and copper pod trees. Several such symbiotic relationships could be marked while taking the survey in Kalina campus. In ecological settings, hence, there is a tremendous importance to these *Wh* questions like what, where, how and when. The future ecological planning needs to address these delicacies of nature and their interrelationships.

Figure 18 Black Winged Stilt, Tickell's Blue Flycatcher and Paddy field Pipit

Source: Mr. Shridhar Pednekar and Mr. Shantanu Majumdar

Figure 19 Western Marsh Herrier, Plain Prinia and Coppersmith Barbet

Source: Mr. Shridhar Pednekar and Mr. Shantanu Majumdar

Figure 20 Common Sandpiper, Little Stint and White Throated Kingfisher

Source: Mr. Shridhar Pednekar and Mr. Shantanu Majumdar

Figure 21 Marsh, Green and Wood Sandpiper

Source: Mr. Shridhar Pednekar and Mr. Shantanu Majumdar

Figure 22 Wired Tail Swallow, Purple Swamphen and Glossy Ibis

Source: Mr. Shridhar Pednekar and Mr. Shantanu Majumdar

Table 2 List of the Birds Spotted in Kalina Campus

Family	Common Name	Scientific Name	Local Name
1. Anatidae	1. Indian Spot Billed Duck	*Anas poecilorhyncha*	हळदीकुंकू बदक
2. Threskiornithidae	2. Red-Naped Ibis	*Pseudibis papillosa*	काळा शराटी
	3. Glossy Ibis	*Plegadis falcinellus*	मोर शराटी
3. Ardeidae	4. Indian Pond Heron	*Ardeola greyii*	ढोकरी
	5. Grey Heron	*Ardea cinerea*	राखी बगळा
	6. Purple Heron	*Ardea purpurea*	जांभळा बगळा
	7. Cattle Egret	*Bubulcus ibis*	गाय बगळा
	8. Great Egret	*Casmerodius albus*	मोठा बगळा
	9. Little Egret	*Egretta garzetta*	छोटा बगळा
4. Accipitridae	10. Black kite	*Milvus migrans*	घार
	11. Eurasian (Western) Marsh Harrier	*Circus aeruginosus*	दलदली भोवत्या
	12. Shikra	*Accipiter badius*	शिक्रा
5. Rallidae	13. Grey-Headed Swamphen	*Porphyrio poliocephalus*	जांभळी पाणकोंबडी
6. Charadriidae	14. Red Wattled Lapwing	*Vanellus indicus*	टिटवी
	15. Little Ringed Plover	*Charadrius dubius*	छोटा कंठेरी चिखल्या
7. Jacanidae	16. Bronze Winged Jacana	*Metopidius indicus*	कांस्यपंखी कमळपक्षी
	17. Pheasant-Tailed Jacana	*Hydrophasianus chirurgus*	लांब शेपटीचा कमळपक्षी
8. Scolopacidae	18. Marsh Sandpiper	*Tringa stagnatilis*	चिखली तुतारी

	19. Green Sandpiper	*Tringa ochropus*	हिरवी तुतारी
	20. Wood Sandpiper	*Tringa glareola*	ठिपकेवाली तुतारी
	21. Common Sandpiper	*Actitis hypoleucos*	सामान्य तुतारी
	22. Temminck's stint	*Calidris temminckii*	
	23. Common Snipe	*Gallinago gallinago*	
	24. Little Stint	*Calidris minuta*	
9. Laridae	25. Whiskered Tern	*Chlidonias hybrida*	कल्लेदार सुरय
10. Columbidae	26. Rock Pigeon	*Columba livia*	पारवा
11. Psittacidae	27. Rose-Ringed Parakeet	*Psittacula krameri*	पोपट
12. Cuculidae	28. Assian Koel	*Eudynamys scolopaceus*	कोकीळ
13. Centropodidae	29. Southern Coucal	*Centropus s parroti*	भारद्वाज
14. Tytonidae	30. Barn Owl	*Tyto alba*	गव्हाणी घुबड
15. Apodidae	31. Asian Palm Swift	*Cypsiurus balasiensis*	
16. Halcyonidae	32. White-Throated Kingfisher	*Halcyon smyrnensis*	पांढऱ्या छातीचा धीवर
17. Meropidae	33. Green Bee-Eater	*Merops orientalis*	वेडाराघू
	34. Blue-Tailed Bee-Eater	*Merops philippinus*	निळ्या शेपटीचा राघू
18. Megalaimidae	35. Coppersmith Barbet	*Megalaima haemacephala*	तांबट
19. Pittidae	36. Indian Pitta	*Pitta brachyura*	नवरंग
20. Laniidae	37. Long tailed Shrike	*Lanius schach*	लांब शेपटीचा खाटिक
	38. Bay-Backed Shrike	*Lanius vittatus*	उदि पाठीचा खाटिक
21. Rhipiduridae	39. White Spotted Fantail	*Rhipidura albogularis*	पांढऱ्या कंठाची नाचण
22. Monarchidae	40. Indian Paradise	*Terpsiphone paradisi*	स्वर्गीय नर्तक

	Flycatcher		
23. Corvidae	41. House Crow	*Corvus splendens*	कावळा
	42. Indian Jungle Crow	*Corvus macrorhynchos*	डोमकावळा
24. Hirundinidae	43. Wire-Tailed Swallow	*Hirundo smithii*	तारवाली भिंगरी
	44. Barn Swallow	*Hirundo rustica*	माळ भिंगरी
	45. Dusky Crag Martin	*Ptyonoprogne concolor*	धूसर कडा पंकोळी
25. Cisticolidae	46. Ashy Prinia	*Prinia socialis*	राखी वटवट्या
	47. Plain Prinia	*Prinia inornata*	साधा वटवट्या
	48. Common Tailorbird	*Orthotomus sutorius*	शिंपी
26. Pycnonotidae	49. Red Whiskered Bulbul	*Pycnonotus jocosus*	शिपाई बुलबुल
	50. Red Vented Bulbul	*Pycnonotus cafer*	लालबुड्या बुलबुल
27. Acrocephalidae	51. Blyth's Reed Warbler	*Acrocephalus dumetorum*	ब्लीथचा बोरू वटवट्या
28. Phylloscopidae	52. Green Warbler	*Phylloscopus nitidus*	
29. Sturnidae	53. Common Myna	*Acridotheres tristis*	साळुंकी
	54. Chestnut Tailed Starling	*Sturnia malabarica*	करड्या डोक्याची मैना
	55. Rosy Starling	*Pastor roseus*	गुलाबी मैना
	56. Asian Pied Starling (Pied Myna)	*Gracupica contra*	
30. Muscicapidae	57. Oriental Magpie Robin	*Copsychus saularis*	दयाळ
	58. Red-Breasted Flycatcher	*Ficedula parva*	लाल छातीची माशीमार
	59. Tickells blue Flycatcher	*Cyornis tickelliae*	टिकेलची निळी माशीमार
31. Nectariniidae	60. Purple-rumped	*Leptocoma zeylonica*	जांभळ्या पुठठ्याचा

	Sunbird		शिंजीर
32. Motacillidae	61. Paddyfield Pipit	*Anthus rufulus*	धान तीरचिमणी
33. Turdidae	62. Orange-Headed Thrush	*Zoothera citrina*	नारिंगी डोक्याचा कस्तुर
34. Plalacrocoracidae	63. Indian Cormorant	*Phalacrocorax fuscicollis*	भारतीय पाणकावळा

Source: Biodiversity Audit Survey

Figure 23 Indian Honey Bee, Two Striped Jumper and Bull Frog

Source: Mr. Shridhar Pednekar and Mr. Tushar Dalavi

Table 3 List of fauna other than Birds

COMMON NAMES (Frogs, Reptiles, Ants and Spiders)
Frogs : Bull Frog, Skittering Frog, Fungoid Frog, Common Tree Frog, Common Toad Frog
Reptiles: Indian Spectacle Cobra, Common Krait, Common Kukri, Vine Snake, Rat Snake
Ants: Pagoda ant, Weaver ant, Carpenter Ant,
Spiders: Lyx spider, Long jawed spider, Signature spider, Humped silver spider, Spotted orb-weaver spider, Two tailed spider, Spiny orb-weaver spider.

Source: Biodiversity Audit Survey

Figure 24 Yellow waxtail damselfly, Asian Beetle and Beefly

Source: Mr. Shridhar Pednekar and Mr. Tushar Dalavi

Through the biodiversity audit survey, we could capture glimpses of some faunal diversity in Kalina Campus. Yet there is much more to explore, especially in the area of diversity of insects, butterflies, zooplanktons and so on.

In case of floral diversity too weeds, herbs, shrubs, grasses are yet to be covered. In the next phase of the biodiversity audit, the team is determined to work on the above mentioned aspects of biodiversity.

4.5 Floral Biodiversity and Carbon Sequestration

On the basis of detailed information about the tree that has been gathered in the biodiversity audit survey, the team could also arrive at the estimates about the contribution of Kalina Campus in carbon sequestration.

For the calculation of carbon sequestration total tree samples available were 5357. Out of which 5351trees were considered for the carbon sequestration calculation.

Total Tree 'Green Weight Above Ground' is 11687052 Ibs

Total Tree 'Green Weight above Ground + Roots' = 14024463 Ibs

Total Tree 'Dry Weight' = 10167736 Ibs

Total Tree 'Weight of Carbon in the Tree' = 5083868 Ibs
Total Tree 'CO2 Sequestered in the Tree' = 18657795 Ibs
Total Tree 'CO2 Sequestered in the Tree' = 8463026 Kg
Following method has been used for the calculation (Fransen, 2019).

A key "feature" of a tree is that trees sequester carbon – the process of removal and long-term storage of carbon dioxide (CO2) from our atmosphere (Fransen, 2019).
EcoMatcher and its tree-planting partners estimate that the trees planted sequester CO2 at an average of 25 kilos per tree per year; we use an average of 250 kilos over a tree's lifetime. Of course, the sequestration changes with different species. The rate of carbon sequestration depends on the growth characteristics of the tree species, the density of its wood, the location's conditions for growth, and the plant stage of the tree (Fransen, 2019).
As suggested Fransen, 2019, there are four steps to estimate a tree's CO2 sequestration

Step 1: Determine the total green weight of the tree

The green weight is the weight of the tree when it is alive. First, you have to calculate the green weight of the above-ground weight as follows:

$W_{above\text{-}ground} = 0.25\ D^2\ H$ (for trees with D<11)

$W_{above\text{-}ground} = 0.15\ D^2\ H$ (for trees with D>11)

$W_{above\text{-}ground}$= Above-ground weight in pounds

D = Diameter of the trunk in inches (1 cm = 0.3937)

H = Height of the tree in feet

The root system weight is about 20% of the above-ground weight. Therefore, to determine the total green weight of the tree, multiply the above-ground weight by 1.2:

$W_{total\ green\ weight} = 1.2 * W_{above\text{-}ground}$

Step 2: Determine the dry weight of the tree

The average tree is 72.5% dry matter and 27.5% moisture. Therefore, to determine the dry weight of the tree, multiply the total green weight of the tree by 72.5%.

$W_{dry\ weight} = 0.725 * W_{total\ green\ weight}$

Step 3: Determine the weight of carbon in the tree

The average carbon content is generally 50% of the tree's dry weight total volume. Therefore, in determining the weight of carbon in the tree, multiply the dry weight of the tree by 50%.

$W_{carbon} = 0.5 * W_{dry\ weight}$

Step 4: Determine the weight of carbon dioxide sequestered in the tree

CO2 has one molecule of Carbon and 2 molecules of Oxygen. The atomic weight of Carbon is 12 (u) and the atomic weight of Oxygen is 16 (u). The weight of CO2 in trees is determined by the ratio of CO2 to C is 44/12 = 3.67. Therefore, to determine the weight of carbon dioxide sequestered in the tree, multiply the weight of carbon in the tree by 3.67.

$W_{carbon\text{-}dioxide} = 3.67 * W_{carbon}$

Example of CO2 calculation

Tree details:

10 years old tree

5 meter tall or 16.4 feet tall ("H")

25 cm trunk or 9.8 inch trunk ("D")

$W_{above\text{-}ground} = 0.25\ D^2\ H = 0.25(9.8^2)(16.4) = 394$ lbs

$W_{total\ green\ weight} = 1.2 * W_{above\text{-}ground} = 1.2 * 394 = 473$ lbs

$W_{dry\ weight} = 0.725 * W_{total\ green\ weight} = 0.725 * 473 = 343$ lbs

$W_{carbon} = 0.5 * W_{dry\ weight} = 0.5 * 343 = 171.5$ lbs

$W_{carbon\text{-}dioxide} = 3.67 * W_{carbon} = 3.67 * 171.5 = 629$ lbs (1 Ibs = 0.453592 Kg)

So, CO2 sequestered by this tree in 10 years is equal to 285 kg. The growth of each tree is non-linear, and the greatest sequestration stage is in the younger stages of tree growth. Depending on the major growth phases of an individual species, the sequestration of carbon per year drops after passing the peak. Carbon sequestration can differ even within tree species with multiple factors that affect the growth of the individual tree. Though

the accurate calculations of Carbon sequestration are not yet possible, even the estimates can help us in fighting the global issue of climate change and also serve to the localized ecological and microclimatic functions(University, accessed in 2021). On the basis of the girth size of the tree, age of the tree also can be calculated. Roughly, every 2.5 cm of girth represents about one year's growth. So, to estimate the age of a living tree, divide the girth by 2.5. For example, a tree with a girth of 40 cm will be sixteen years old. This technique is also applied to the data collected by the team.

Table 4 Calculation of Age and Carbon Sequestration for each tree

Location:Latitude	Location:Longitude	Location:Altitude	Location:Accuracy	Local_Name	Trunk size (inch)	Approx_Height (ft)	Age of tree	step 1a	step 1b	step2	step3	step 4 in Ibs	Carbon Sequestration in Kg.
19.0682	72.85804	-60.8	4.25	Peru	4.3307	2	4.4	9.37748125	11.2529 8	8.158409	4.079204	14.97068	6.790580652
19.06692	72.86011	-44.84	4.812	Vilayti chinch	4.3307	3	4.4	14.0662219	16.8794 7	12.23761	6.118807	22.45602	10.18587098
19.06873	72.85544	-64.74	4.107	Chandan	4.3307	2	4.4	9.37748125	11.2529 8	8.158409	4.079204	14.97068	6.790580652
19.06769	72.85488	-69.5555	4.837	Laal Chapha	4.3307	2	4.4	9.37748125	11.2529 8	8.158409	4.079204	14.97068	6.790580652
19.07021	72.86026	-58.3433	4.3	Raintree	420	165.354	11	168	45114.2098	54137.05	39249.36	19624.68	72022.58
19.0718	72.86046	-57.44	11	Vad	425	167.3225	14	170	58793.3199	70551.98	51150.19	25575.09	93860.596
19.07069	72.85861	-60.24	8.5	Peepal	450	177.165	12	180	56497.3387	67796.86	49152.73	24576.36	90195.253

Source: Calculation based on method proposed by Fransen, 2019

4.6 Photo Gallery

A photo gallery of the floral and faunal diversity has also been established with 30 movable plates capturing the glimpses of biodiversity of Kalina Campus. The gallery is either planned to be restored in movable plates or as a permanent feature of New Library Building in Kalina Campus. The same can be expanded with the addition of newer information in consecutive surveys that will be planned in future.

Figure 25 Photo Gallery - Biodiversity Audit Kalina Campus

Source: University General Administration Department

5. Suggestions and Conclusions

1. The effort of documenting, geotagging and collecting a detailed information of flora and fauna in Kalina Campus has emerged as one of the innovative endeavours of approaching the current issues relating to ecological and environmental deterioration. The need to create awareness about various environmental problems, could be fulfilled by involving the various stakeholders in the biodiversity audit survey.

2. IUCN listing of biodiversity helped in understanding the ecological status of the habitats within the campus. The IUCN status of trees like Kokam, Chandan, Sita Ashoka is vulnerable. Bilva, Mayurpankhi and Bel trees are near threatened. These trees are planted in the campus. Conservation and growth of such trees could be encouraged.

3. The future path of ecological and sustainable development of the campus should be by promoting the selective afforestation of the indigenous species of plants.

4. Some focused efforts can be directed towards development of wetland as an ecological site for students of life sciences, Geography, Botany and Zoology. In fact, the wetland has to be nourished and maintained to save the campus from frequent flooding.

5. The development of butterfly garden can be encouraged with the help of Mahim Nature Park, Sion.

6. The campus already has one botanical garden. This garden can be developed and expanded to have more diverse plants. The Mittal Ayurvedic Garden needs to be maintained properly as it has some of the rare species of plants. Additionally, there can be more such botanical gardens instead of monotonous plantations.

7. The biodiversity audit survey must be conducted every five years to update the information. As

the trees are geotagged, it is easy to know the status of individual tree in terms of its sustenance, growth and other parameters.

8. Kalina campus can be converted as an important site for educational tours by developing permanent galleries on biodiversity, ecological conservation, etc.

9. Departments like Geography, Life Sciences can be given the responsibility of the Biodiversity Audit along with General Administration Department.

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