A web-based GIS application for mapping the plant biodiversity of NIIT University (Neemrana)

Siddharth Swain[1], Pronoy Dey[2], Nayaz Shaik[3], Avantika Sharma[4]and Siddhartha Khare[5]

[1]M.Tech GIS, NIIT University, Neemrana 1, email: siddharth.swain@st.niituniversity.in
[2]M.Tech GIS, NIIT University, Neemrana 2, email: pronoy.dey@st.niituniversity.in
[3]M.Tech GIS, NIIT University, Neemrana 3, email: nayaz.shaik@st.niituniversity.in
[4]M.Tech GIS, NIIT University, Neemrana 4, email: avantika.sharma@st.niituniversity.in
[5]Assistant Professor, NIIT University, Neemrana 5, email: siddhartha.khare@gmail.com

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Abstract: The significance of plants to people and pretty much all other life on Earth is astonishing. Aside from supplying food to nearly all terrestrial organisms they also play an important role in maintaining the atmosphere, recycling matter in biogeochemical cycles, creating habitats for several organisms and providing resources in the form of firewood, timber, fibres, medicines, dyes, pesticides, oils, and rubber. Located in the industrial hub of the historical town of Neemrana, and being part of Rajasthan (driest region in India), NIIT University faces several challenges such as the depletion of ground water at an average rate of 1.4 meters each year due to rising population, industry pollution, water intensive practices, depleting tree cover and an annual rainfall of less than 600mm. Even though the 100 acre 'Green Campus' has facilities like green air conditioning, drip irrigation, tree farming, solar water heating, check dams, variable frequency drives, building management systems, water, waste paper and kitchen food waste recycling plants and much more, the need for accurate monitoring of plant cover and its quality is crucial to understanding the changes in the landscape over the years. In this regard, Geographic Information Systems (GIS) not only support an in-depth analysis but can also be used for monitoring and managing the biodiversity of a region. A variety of plant species in the university were spotted and their accurate GPS locations were noted to map their geographical distribution through creation of a web application using GIS. Detailed attribute data was collected by ground survey using GPS and integration was done using ArcGIS 10.4.1. This was published on the internet through the ArcGIS Online platform harnessing the capabilities of the Web AppBuilder for ArcGIS as a dynamic & user-friendly web application which can be accessed from both desktop as well as mobile devices for a handy reference and use by people in general.

Keywords: Biodiversity, GIS, ArcGIS, Web Application, Ground Survey.

1. Introduction

Biodiversity is the overall variability among living organisms, including genetic and structural difference between individual and within and between individual and within and between species. There is a total of 1,263,500 species of plants and animals in the world while India has only 51,828 species. It furnishes us with all the prerequisites of life and also plays a major role in sustaining and nourishing us. It is directly associated with the climate regulations of a given region. Climate always changes resulting in evolutionary changes in the respective species. Hence, biodiversity is very important due to various reasons like soil formation and maintenance of soil quality, maintenance of air and water quality, pest control, detoxification and decomposition of wastes, pollination and crop production, climate stabilization, prevention and mitigation of natural disasters and provision of food security [1]. NIIT University is located in the industrial hub of the historical town of Neemrana which is in the state of Rajasthan, India. This town is mostly influenced by semi-arid climate and has an average temperature of 24.8ºC. About 551 mm of precipitation falls annually, the driest month being April which receives hardly 3 mm of rainfall. Most precipitation falls in August, with an average of 210 mm. The warmest month of the year is June, with an average temperature of 33.7 °C. In January, the average temperature is 14.2 °C which is the lowest average temperature of the whole year. The difference in precipitation between the driest month and the wettest month is 207 mm. The average temperatures vary during the year by 19.5 °C [2]. Although the biodiversity of this town is well adapted to the harsh conditions notably infrequent rainfall and high temperatures, there exist several fragile environments that require immediate attention to avoid irreversible loss of natural biodiversity. NIIT University has received the award for the greenest and the most environment-friendly campus in the 'India Today Aspire Education Summit 2012'. Construction of check dams, protection of local species and systematic afforestation of the Aravalli slopes by planting over 1.5 lakh trees have ensured an ecological resurrection of the university campus area. Other facilities include green air conditioning (minimising carbon footprint through Earth Air-Tunnels), drip irrigation, tree farming, solar water heating, check dams, variable frequency drives, building management systems, water, waste paper and kitchen food waste recycling plants and especially walk-only campus. Moreover, the students are passionately engaged in several environmental awareness campaigns leading towards a sustainable green campus [3]. As part of the Master's degree program in GIS, we decided to develop detailed plant collection data which can be stored in a database to further advance plant conservation in the university campus by utilizing the power of GIS for visualization, management, usage optimization and several other analysis. Therefore, the knowledge or a

systematic and suitable data base on the status of prevailing plant resources is significant for an efficient management and that will have profound impact in improving the plant/tree cover particularly to combat the present and future threats arising due to expected climate change. Here, the GIS technology helps in highlighting diversity rich areas, their spatial distribution pattern and variability under the influence of biophysical factors and changing weather/climatic conditions. By and large, higher the variety of habitat types, better is the diversification of plant species and reduction in the risk of unavoidable extinction. Further it may be noted that, GIS is an integrated and intimate geospatial system where the database consists of observations on spatially distributed features and objects which are delineated as points, lines and polygons [4]. In this investigation, a Web based application was developed for the identification and mapping of medicinal plants through creation of various thematic maps under the GIS environment with a multi-layered database containing information like spatial location, extent of layout, utilities, frequency of occurrence, etc. [5]. Another Web based decision support system was also designed for monitoring and mapping the sugarcane crops at farm level in the Medak district of Telangana. The system could be used for forecasting of crop production, identifying the fields which are ready for harvesting, need for the use of fertilizers and application of water, transportation and canal facilities. The end use of such a technology will be felt in obtaining higher productivity, lower overheads, data mining for long-term planning and efficiency improvement, transparency to the management and cost control, enhanced management satisfaction, faster response and optimum utilization of available resources [6]. This surely proves the importance of coupling of remote sensing capabilities with GIS technology to improve decision making for both individuals as well as organisations involved.

2. Methodology

Detailed field surveys were conducted using a Garmin GPS having an accuracy of plus or minus three to five metres (Fig 1).

Fig. 1: ***Garmin GPS (Used for field survey)***

Attribute information was noted separately and later combined with the GPS data using ArcMap 10.4.1. Attribute fields such as the feature's name, type, description and latitude-longitude information were recorded. Expert's help was taken for the careful identification of certain species. We also used the 'PlantNet Plant Identification' app on 'Play Store' to aid us with plant identification. After completing the ground survey, the entire gpx data was loaded in ArcMap 10.4.1 and the 'Gpx to Shapefile' tool was used to convert the gpx point's data into the respective Shapefile format supported by GIS software. Since data was collected for multiple features on different dates, organising and quality checks of the data were done manually using ArcMap 10.4.1. The entire data was separated into different layers (Fig2) like trees, bushes, street lights, lamp posts, utilities, etc.

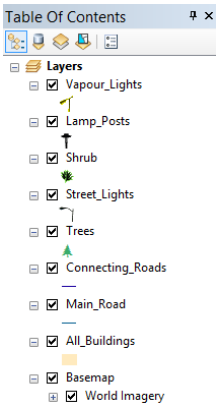

Fig. 2: ***Data layers in the ArcMap document***

'Imagery Basemap' was used to enhance visual interpretation. Proper symbology was assigned to the different layers in ArcMap 10.4.1. A zipped file containing all the shapefiles was uploaded to the ArcGIS Online interface (Fig 3).

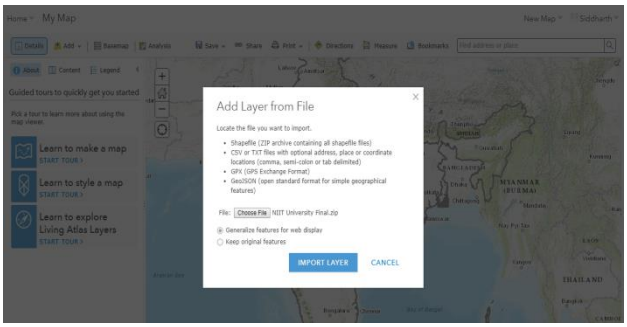

Fig. 3: ***Uploading the zip file to the web map***

Once the file was uploaded the 'Generalize features for web display' option was chosen. Appropriate categories were selected from the menu on the left hand side of the screen which had options to change transparency, visible range, symbol or label, legend, table, style, etc. Each of the layers was configured individually and the final map was saved as a 'Web Map' in the content section of the ArcGIS Online account being used. The 'Web AppBuilder' software was later installed on top of the 'Node.js' framework (Fig 4). It was properly configured and a sample application was created for testing purpose. Appropriate theme, style and layout were given to the application (Fig 5). Then the application was linked to the web map (NIIT University) that was created earlier. Functionalities such as zoom in, zoom out, default extent,

my location, search bar, legend, layer list, attribute table display, etc. were added to the native application.

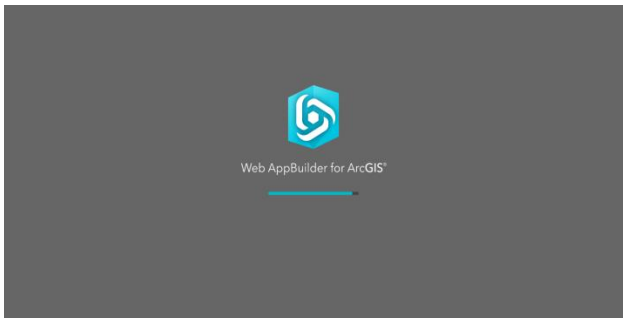

Fig. 4: ***Installing the ArcGIS Web AppBuilder***

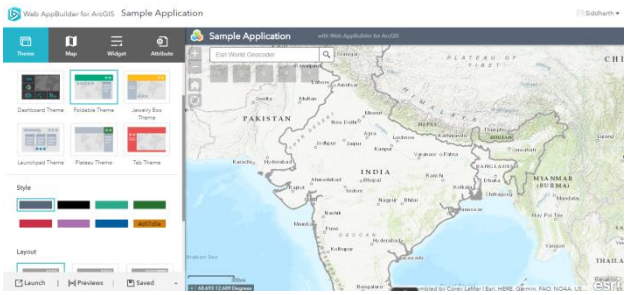

Fig. 5: ***Configuring the Web Application***

Additional changes were made to the application after which it was published as a service for the general public. The flow chart of the methodology has been given below (Fig 6).

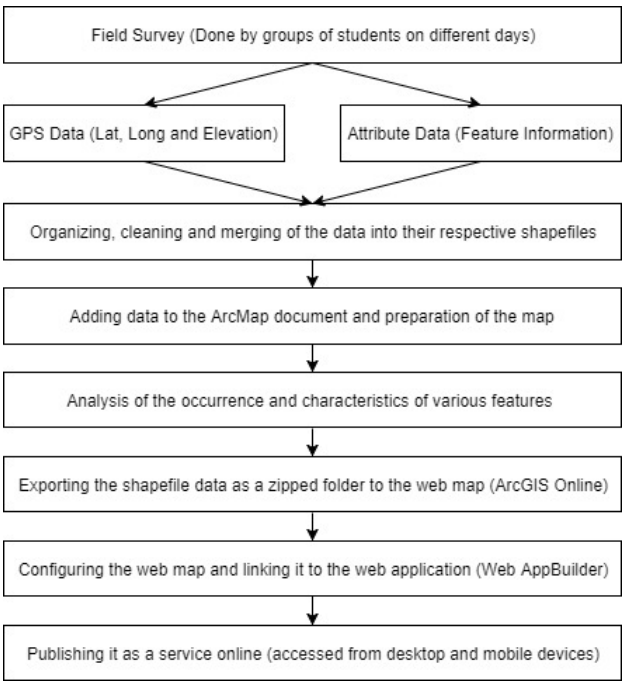

Fig. 6: ***Flowchart of the methodology***

3. Results and Discussion

Detailed map of the university campus was prepared in ArcMap 10.4.1 (Fig 9). Features such as buildings, main roads, connecting roads, etc. were accurately digitized with the help of GPS data collected during the field survey. Layout view was selected in ArcMap 10.4.1 and necessary map elements such as title, north arrow, scale bar, etc. were inserted. The campus has a vast open space with prolific vegetation. This detailed map was prepared since the study area lacks such information for the purpose of ready reference. Other features such as utilities were also mapped and their information was incorporated in the attribute table. The university has several amenities such as academic buildings, separate hostels for boys and girls, security office, basketball court, pool facility, tennis courts, cricket ground, volleyball courts, badminton courts, cafeteria, restaurant and ATM facility (Fig 10).

Fig. 7: ***Garden near Academic Buildings 1 and 2***

Fig. 8: ***Cultivation of Kaner in open spaces***

The entire vegetation found in the campus was delineated into trees, shrubs and herbs. 35 plants belonging to 26 families were identified and their geographical distribution was illustrated through their respective layers. The table contains a list of the most common species that were found in the campus (Table 1). 13 species(Cycas revoluta Thunb.,Tecoma stans (L.) Juss. ex Kunth, Ilex verticillata (L.) A. Gray, Albizia julibrissin Durazz., Pittosporum tobira (Thunb.) W.T.Aiton, Verbena rigida Spreng., Sphagneticola trilobata (L.) Pruski, Caryota urens L., Russelia equisetiformis Schltdl. & Cham., Viburnum tinus L., Calendula officinalis L., Chamaerops humilis L., and Schefflera arboricola (Hayata) Merr.) were chosen and mapped near the Ug 2 & 3 buildings. 17 species (Codiaeum variegatum (L.) Rumph. ex A.Juss., Aucuba japonica Thunb., Calendula officinalis L., Tagetes erecta L., Musa velutina H.Wendl. & Drude, Hibiscus rosa-sinensis L., Catharanthus roseus (L.) G.Don, Hamamelis virginiana L., Tagetes erecta L., Phlox drummondii Hook., Ixora coccinea L., Calendula officinalis L., Cycas revoluta Thunb., Tecoma stans (L.) Juss. ex Kunth, Ilex verticillata (L.) A. Gray, Albizia

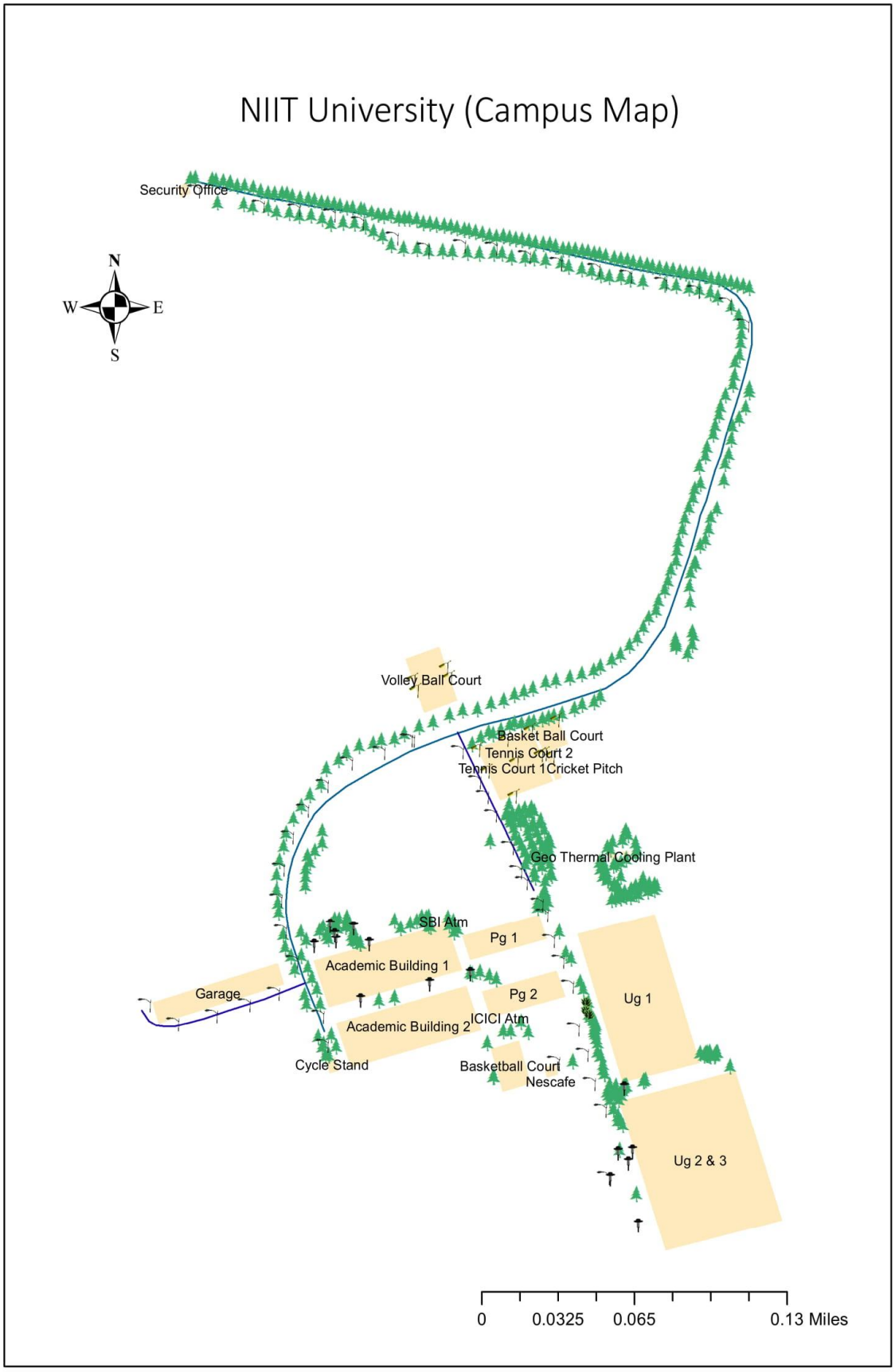

Fig. 9: ***NIIT University (Campus Map)***

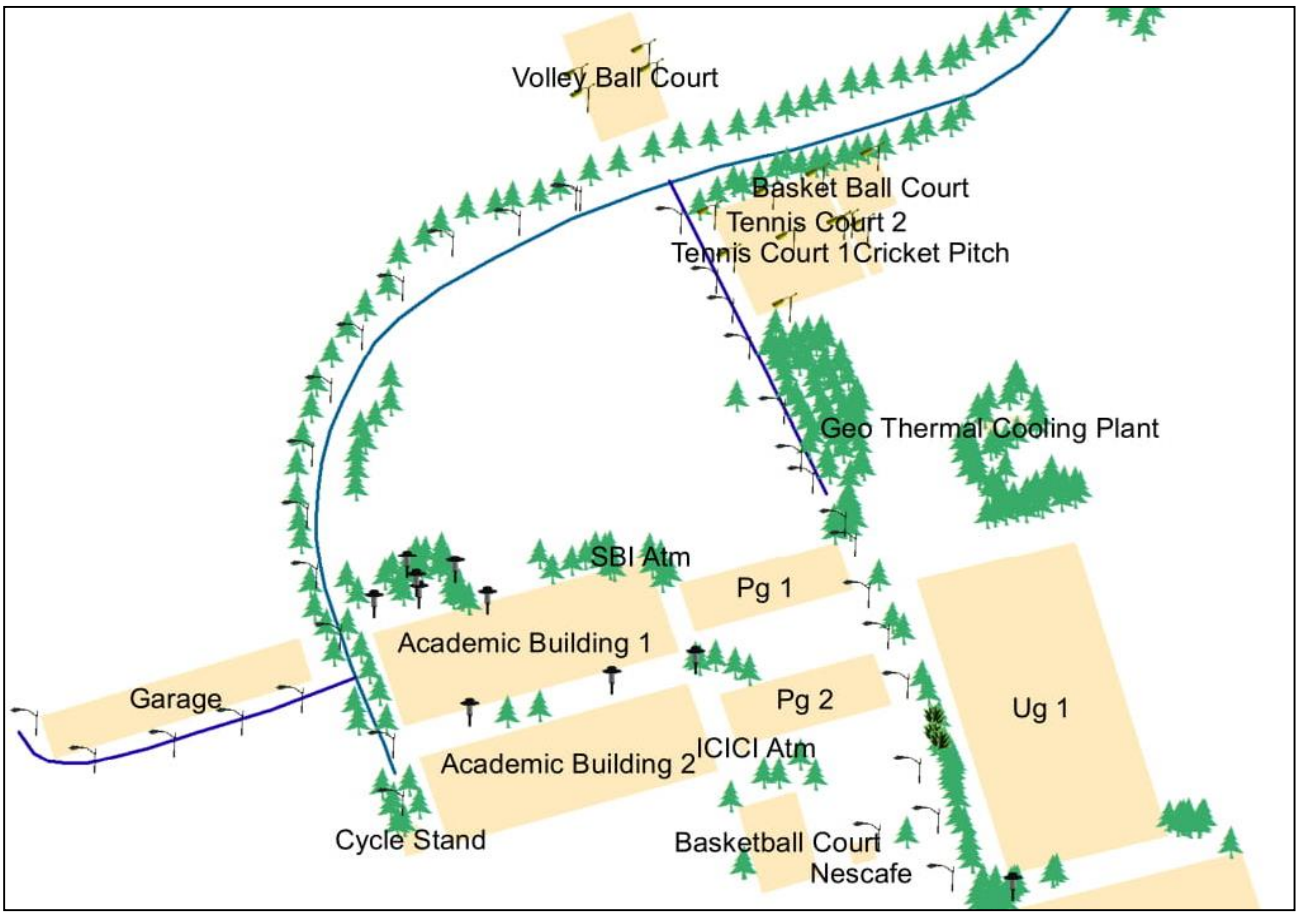

Fig. 10: ***Amenities in NIIT University***

Fig. 11: ***NIIT University Web Application***

Sl No	Category	Name	Common Name	Family	Geographical condition suitable	Utilities
1	Tree	Terminalia Arjuna	Arjun	Combretaceae	The plant naturally occurs in sub- tropical and tropical moist regions of the country. River bank soils, streams, and ravines are its natural habitat. The plant also survives in open sunny and low rainfall areas.	Silk production, Ayurvedic medicine (Improves symptoms in people experiencing chest pain and congestive heart failure), blood detoxification, cholesterol control, anti-oxidant, bone fracture, gum bleeding, Buddhism
2	Tree	Delonix regia	Gulmohar	Fabaceae	It requires a tropical or near tropical climate, but can tolerate drought and salty conditions. It prefers an open, free-draining sandy or loamy soil enriched with organic matter. It flowers more profusely when kept slightly dry.	Wood from the tree is used as fuel & employed locally for agricultural implements; handles carpentry tools, combs, etc. Seed is carminative, purifies and enriches the blood and is used in cases of inflammation, ear ache and chest complaint.
3	Tree	Azadirachta indica	Neem	Meliaceae	It thrives in areas with sub-arid to sub-humid conditions & is a typical tropical to subtropical tree which can grow in regions with annual rainfall less than 400mm, but it depends largely on ground water levels.	It has uses as a vegetable, antifungal, antidiabetic, antibacterial, antiviral, contraceptive, & sedative properties, oil is used for healthy hair, blood detoxification & sugar level balance, animal treatment, cosmetics, bird repellent, lubricant, fertilizer, resin, soap, honey, etc.
4	Tree	Ficus virens	Pilkhan	Moraceae	The tree is a deciduous tree with a spreading crown & is found in the semi- warm temperate zone, climatic condition in this region makes it suitable for its growth, it is evergreen with unique blooming flowers and utilizes the wasp species for pollination.	The tree is harvested from the wild for local use as a medicine, food and source of wood and latex. It is sometimes cultivated, especially in South India and Sri Lanka as shade tree in coffee plantations, and is also grown as an ornamental and shade tree along avenues.
5	Tree	Salvadora oleoides	Jal Peelu	Salvadoraceae	It is very common plant in arid tracts but becomes scarce where rainfall conditions are better. It can withstand great soil salinity. It produces new leaves during April, which on maturity become thick and leathery. The tree coppices fairly well but regenerates freely by root suckers and natural layering.	Natural peelu products provide a healthy way to enjoy fresh breath, as well as healthy gums and teeth without artificial chemicals, toxins or abrasives. The twigs and fibres of this Middle Eastern tree have been used since the time of Prophet Muhammad, who is said to have recommended its use to clean teeth and purify the mouth.
6	Shrub	Hibiscus rosa-sinensis	Hibiscus	Malvaceae	It is widely grown as an ornamental plant throughout the tropics and subtropics. As it does not tolerate temperatures below 10 °C (50 °F), in temperate regions it is best grown under glass. However, plants in containers may be placed outside during the summer months or moved into shelter during the winter months.	The flowers are edible and are used in salads in the Pacific Islands. The flower is additionally used in hair care as a preparation. It is also used to shine shoes in certain parts of India, as a pH indicator, medicinal uses, anti-solar agent, flowers dried to use in tea, etc.

7	Shrub	Tecoma stans	Tecoma	Bignoniaceae	It is perennial and grows in tropical climate. It grows upto a height of 7m and is drought tolerant and grows well in warm climates. It grows in open woodlands, grasslands, forest margins, waste areas, rocky places, sandy lake shores and disturbed sites in tropical and subtropical environments.	It is an effective diuretic, tonic, antisyphilitic & vermifuge herb. It is used for the treatment of diabetes (lowers the blood pressure). Its flowers & bark are used for stomach pain and is taken orally to treat syphilis & intestinal worms.
8	Herb	Asparagus setaceus	Asparagus	Asparagaceae	They grow best in bright, indirect light without any full sun. Direct, hot sunlight can scorch the 'needles', while insufficient light will often cause them to yellow or drop. They thrive in daytime temperatures of 70°-75° with it 10° cooler at night. They tolerate short periods of drought but grow best when they are given plenty of water. In low light conditions, it needs less water, especially during the winter months. They appreciate higher humidity and an occasional misting.	The cuts sprays of the asparagus fern are ornamental favorites among florists for its beauty and lasting quality. In Mexico a decoction of the branches are used for pulmonary infections; decoction of roots used as a diuretic. In Tanzania, the Lobedu drink a cold infusion of leaves and stem for malaria. In Pakistan, root tubers used with boiled milk and sugar for dysentery and diarrhea.
9	Herb	Bougainvillea	Bougainvill -ea	Nyctaginaceae	Bougainvillea is a frost-sensitive, tropical or subtropical plant that cannot withstand sub-freezing temperatures. Native to South America, it prefers temperatures that remain above 60 degrees Fahrenheit at night and can withstand daytime temperatures that exceed 100 F.	Bougainvillea leaves are used to cure variety of disorders like for diarrhoea, and to reduce stomach acidity. It is used for cough and sore throat. Infusion of flowers used as treatment for low blood pressure. Leaves are used to cure diabetes 2. Stems help in hepatitis.
10	Shrub	Acalypha Hispida	Chenille	Euphorbiaceae	It is usually grown as a houseplant or seasonal annual for its unusual tassel-like flowers. It thrives in hot, humid summer climates. In tropical locations it will become a large shrub, but can be maintained as a small plant by continual pruning.	It can be used for hemoptysis, laxative, diuretic for gonorrhoea, bark used as expectoramt & for asthma, antimicrobial, anti-ulcer, phytochemical, anthocyanins, leaf for leprosy, etc.
11	Shrub	Aloe vera	Aloe vera	Asphodelaceae	It grows in a wide variety of warm weather climates and soils. In summer it tolerates lows from 50 to 60 degrees Fahrenheit, and in winter it does not do well in temperatures under 40 degrees Fahrenheit. Indoors, it can tolerate dry air. Aloe requires full sun for flowering, but can adapt to partial shade in some areas.	Prevents signs of aging, moisturizes skin, reduces acne, helps with sunburns, reduces tan and stretch marks, promotes hair growth, reduces dandruff, conditions hair, Reduces inflammation, eases heartburn & acid reflux, maintains oral health, builds immunity, lowers risk of cancer, etc.
12	Shrub	Cascabela thevetia	Yellow Oleander	Apocynaceae	The yellow oleander is predominantly found in Mexico and Central America, and blooms from summer to autumn. It doesn't require close attention to soil quality and can thrive in almost any climatic condition, including drought.	Its seeds and leaves are used to make medicine, for heart conditions, asthma, epilepsy, cancer, painful menstrual periods, leprosy, malaria, ringworm, indigestion, and venereal disease, to cause abortions, sometimes applied to the skin to treat skin problems and warts.

13	Herb	Foeniculum Vulgare	Fennel	Apiaceae	It can grow in a wide variety of soils, it usually prefers full sun, tolerates light shade, moisture can be medium to dry, it is fairly drought tolerant in nature. It prefers fairly neutral soil with a pH value between 6.1 and 7.0.	It helps to regulate blood pressure, reduces water retention, tea is helpful for constipation, bloating, IBS & indigestion, seeds reduces asthma, helps purify blood, improves eyesight, cools the body, great for acne, keeps cancer away, etc.
14	Shrub	Catharanthus Roseus- (White/Pink)	Periwinkle	Apocynaceae	It is prevalent in areas that are tropical to sub-tropical. However, in areas that are more moderate, the periwinkle is considered an annual, due to the frosty conditions of the fall. It is also commonly found in Texas, Louisiana, Mississippi, Florida, Georgia, and South and North Carolina.	It has uses like it reduces blood pressure & excitement, anti-diabetic, anti-cancer, antiviral, antibacterial, cures skin diseases, helps in mouth ulcer, anti-malaria, treats asthma, against insect bites, diuretic in nature, anti-inflammatory, etc.
15	Shrub	Cycus Revoluta Thumb	Japanese Sago Palm	Cycadaceae	It is one of the most widely cultivated cycads, grown outdoors in warm temperate and subtropical regions, or under glass in colder areas. It grows best in sandy, well-drained soil, preferably with some organic matter. It needs good drainage or it will rot. It is fairly drought-tolerant and grows well in full sun or outdoor shade, but needs bright light when grown indoors.	The leaves are used in the treatment of cancer and hepatoma. The terminal shoot is astringent and diuretic. The seed is emmenagogue, expectorant and tonic. It is used in the treatment of rheumatism. Substances extracted from the seeds are used to inhibit the growth of malignant tumours.
16	Shrub	Pittosporum tobira (Thunb.) W.T.Aiton	Australian Laurel, Japanese Cheesewoo -d	Pittosporaceae	Thrives in full sun or part shade in average, slightly acidic, moderately fertile, well-drained soils. Drought tolerant once established. It is also salt tolerant & a great choice for seaside plantings.	It is a good choice for screens and informal hedges. It can also be closely sheared to create formal hedges and topiary although I think there are better shrubs for this purpose.
17	Shrub	Albizia julibrissin Durazz.	Mimosa Constanti - nople	Mimosaceae	It is very frequently planted in semi-arid areas like California's Central Valley, central Texas and Oklahoma. Although capable of surviving drought, growth will be stunted and the tree tends to look sickly. As such it should be given infrequent, deep waterings during the summer, which will benefit growth and flowering.	Its flowers and bark are among the most valued of Chinese botanicals for relieving anxiety, stress, depression, insomnia, amnesia, sore throat & contusion. Chinese people traditionally recommend its use for anyone who is suffering from grief as a result of a severe loss.
18	Shrub	Codiaeum variegatum (L.) Rumph. ex A.Juss.	Garden Croton	Euphorbiaceae	This tropical plant, with its brilliant colour combinations, is the ideal foliage plant for warm climates. Colours range from bright oranges and reds to mahogany, green, yellow and cream. Many hybrids are now available. It is at its most beautiful in autumn. As it is tender, it is not ideal for cold climates. It tolerates heavy pruning. The sap can stain clothing permanently, so take care when pruning or cutting this plant.	It is used as abortifacient, anti-amoebic, antibacterial, anticancer, antifungal, antioxidant, emmenagogue, purgative and sedative, ease fevers, treat sores & fungal infections, treatment gastric ulcers, leaf sap is drunk and applied topically to treat a snake bite, stomach ache and give temporary relief from toothache.

Table 1: ***Most common species found in the NIIT University campus.***

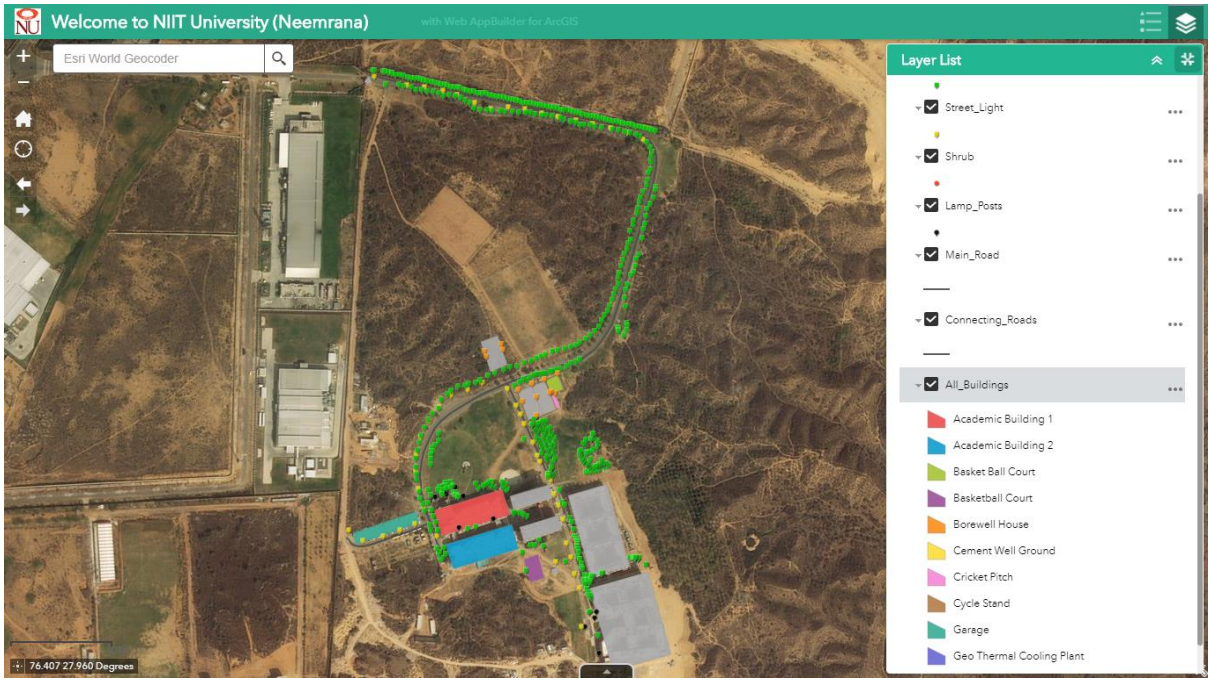

Fig. 12: ***Viewing the list of different layers***

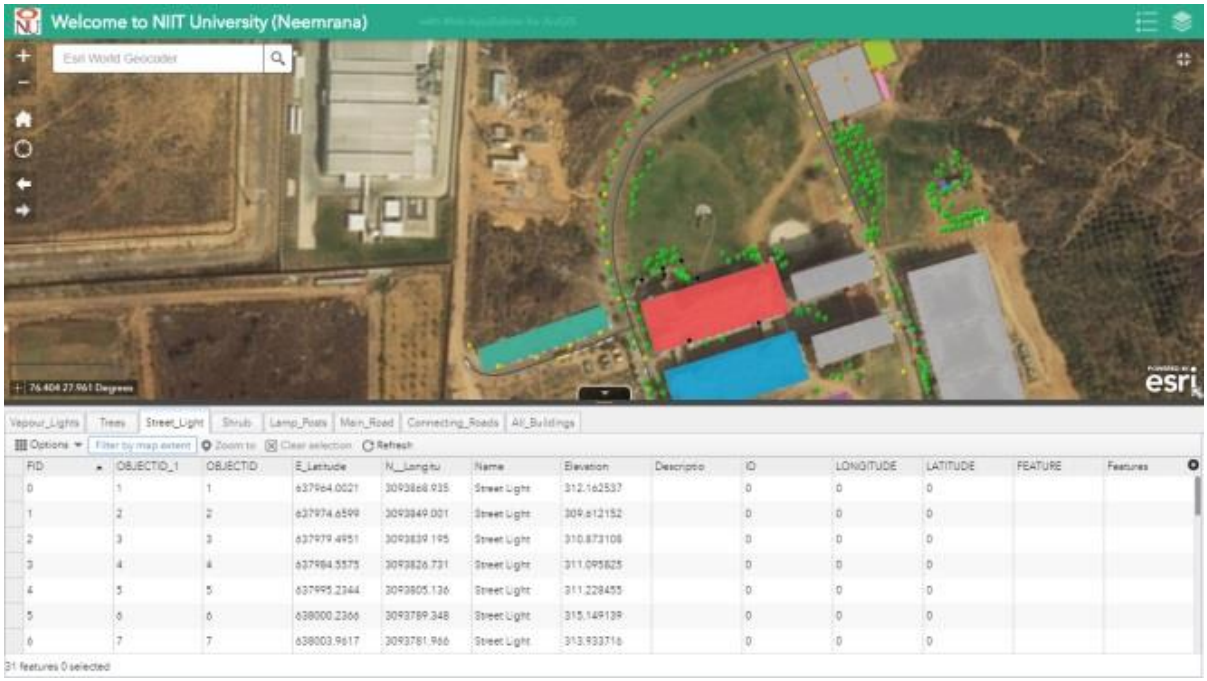

Fig. 13: ***Viewing the attribute table information***

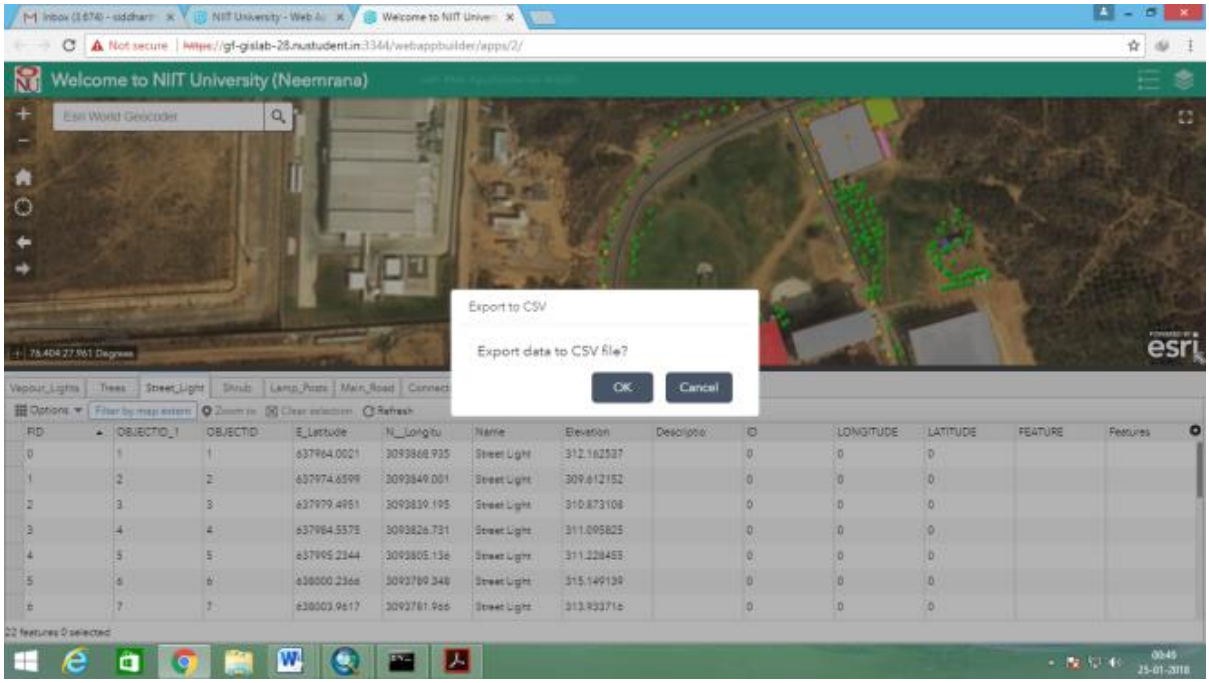

Fig. 14: ***Exporting data to a csv file***

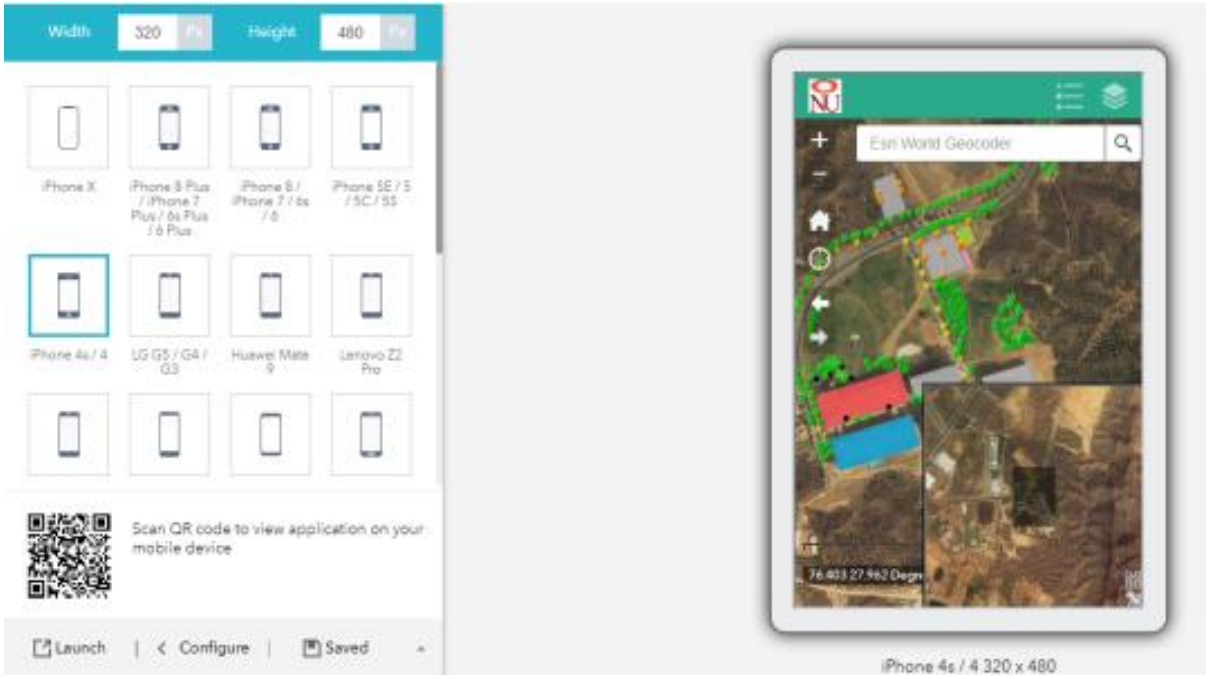

Fig. 15: ***Application preview on iPhone 4s***

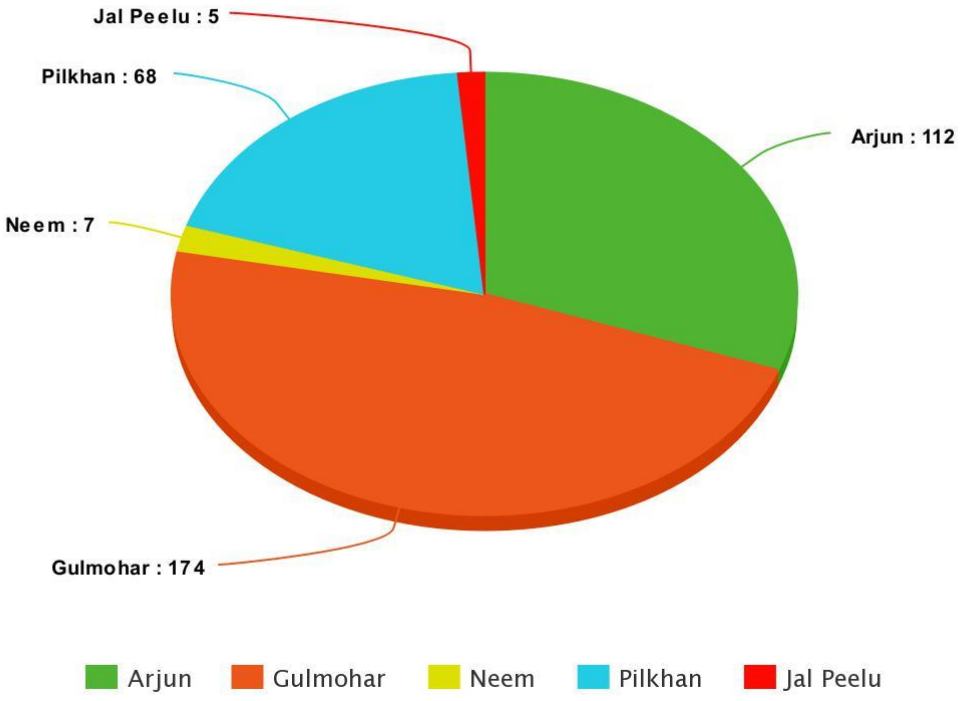

Fig. 16: ***Pie chart of trees in the campus***

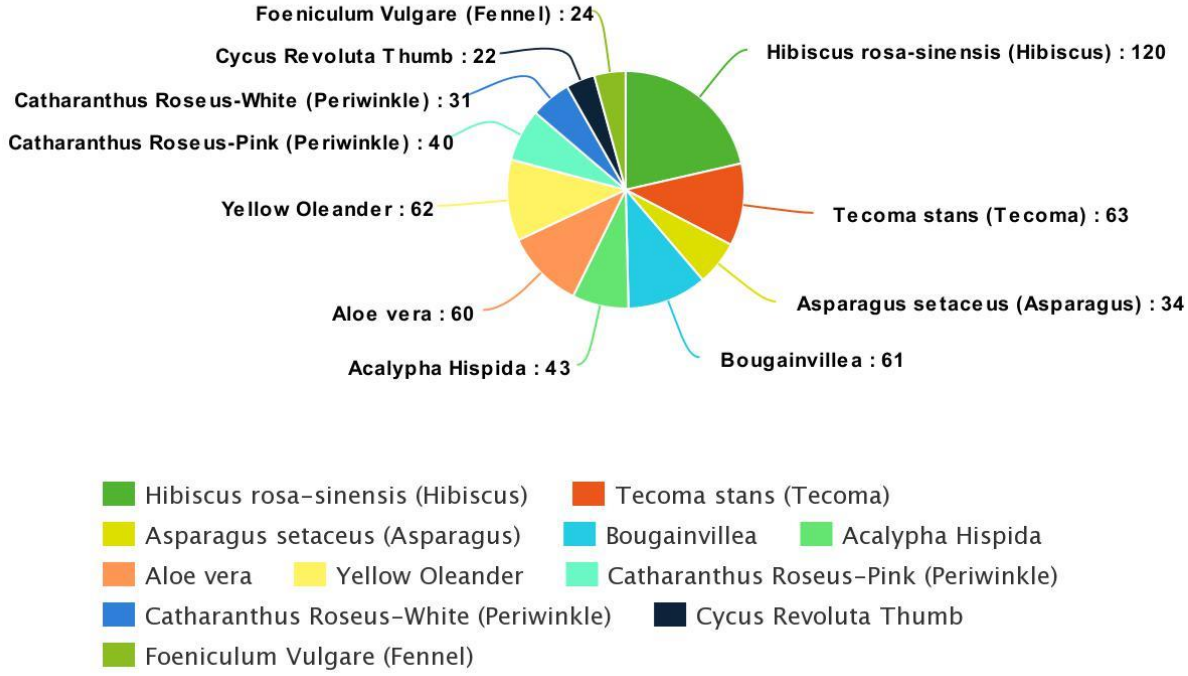

Fig. 17: ***Pie chart of shrubs and herbs in the campus***

Fig. 18: ***Pictures collected during ground survey:*** **1.** ***Jal Peelu, 2. Pilkhan, 3. Arjun, 4. Gulmoha,r 5. Neem, 6. Catharanthus roseus, 7. Tecoma stans, 8. Ilex verticillata, 9. Pittosporum tobira, 10. Garden Marigold, 11. Phlox drummondii, 12. Tagetes erecta, 13. Hibiscus rosa-sinensis, 14. Aucuba japonica Thunb, 15. Codiaeum variegatum, and 16. Verbena rigida Spreng.***

-julibrissin Durazz., and Pittosporum tobira (Thunb.) W.T.Aiton) were chosen and mapped near the Academic Buildings (1 and 2). There has been a separate garden (Fig 7) where several species of plants are being grown near the Academic Buildings. There is also a vast open space near it where 'Kaner plant' is being cultivated in an organised manner (Fig 8).Most of the trees found in the campus were notified as one among the following: Terminalia Arjuna, Delonix regia, Azadirachta indica, Ficus virens, and. Salvadora oleoides (Fig 16). Shrubs and herbs found in the campus were mostly Hibiscus rosa-sinesis, Tecoma stans, Asparagus setaceus, Bougainvillea, Acalypha Hispida, Aloe vera, Cascabela thevetia, Foeniculum Vulgare, Catharanthus Roseus (White/Pink), and Cycus Revoluta Thumb (Fig 17).The study revealed that 47 percent of the species in the campus were Gulmohar, 30 percent of the species were Arjun and around 18 percent of them were Pilkhan. Hibiscus, Yellow Oleander, Aloe Vera, Tecoma and Bougainvillea were the most popular among shrubs and herbs.The species name, common name, family, climatic conditions in which they can be grown and their uses have been mentioned [7] [8] [9] [10] [11] [12] [13] [14] [15] as shown in Table 1. There are several other species which are growing in the wilderness could not be mapped. The study clearly indicates that the campus has a rich biodiversity present inside and a good amount of effort is being taken by the university management to maintain it. Pictures taken during the ground survey have been given for reference (Fig 18).

Finally, the web application was properly configured and made ready for reference purposes. Options to search for location, zoom in, zoom out, go to default extent, next and previous extent, show your location, see the legend, view different layers, attribute table information, export data to csv, etc. (refer Fig 11, 12, 13 and 14) have been integrated in the application which can also be opened in tabs or mobile devices like iPhone, LG, Huwai Mate, Lenovo, Xiaomi, HTC, Samsung, Google Nexus, etc. (Fig 15).

4. Conclusion

This paper clearly brought out the biodiversity in the NIIT university campus inside and the amount of effort is being taken by the university management to maintain it routinely. This being a case study, it is further understood that, we humans play an important role which affect our planet earth in many ways. In the past few decades the changes in the society and the rising pace of development have also resulted in major threats to plant species and their habitats. Specific reasons may include habitat loss and degradation, invasive species, climate change, over exploitation of resources, etc. However, the plant diversity is particularly critical in the light of the fact that it can support the functioning of all ecosystems, as well as furnishes us with several direct benefits as noted from this GIS based analysis. That is why their knowledge and associated database and its systematic update is crucial for understanding changes in our surrounding environment and working towards sustainable development in the future. Conservation can be enhanced when it is integrated by such technologies and this paper addresses exactly this by building upon a multi-layer detailed database for the biodiversity in this NIIT university campus so that its natural resources can be regularly monitored and taken care of. This is only one application of GIS in the domain of plant conservation and monitoring and there are many other solutions that can be explored and used in the future to map similar areas more easily with more information in lesser time.

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