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WEB GIS BASED IDENTIFICATION AND MAPPING OF MEDICINAL PLANTS : A CASE STUDY OF AGRA (U.P.), INDIA

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Abstract

Knowledge of medicinal plants and the use of the same as medicine has been an integral part of Indian culture since ancient days. They are found naturally and can grow in extremes of climate. However, their overexploitation, unintentional removal and lack of identification and mapping are matters of grave concern. Occurrence of medicinal plants in dense built up areas are a rarity. The St. John's College of Agra (Taj city) having ample open space was chosen for the present investigation to identify and map the exact GPS location of medicinal plant species found in this area. A total of 56 plant species from 33 families were identified and their exact GPS locations were recorded to map their geographical distribution through creation of various thematic maps under GIS environment. The multilayered database so created had information like spatial location and extent of college layout, faculty information, location of plant species, utilities, frequency of occurrence, etc. The thematic maps and attribute data were integrated through ArcGIS 10.2 and was then published on Web GIS platform through ArcGIS online in a dynamic interactive Web application for ready reference and use by others.

Key words : Medicinal plants, GIS, GPS, ethno-botanical, *in-situ*.

Introduction

India is known for its rich biodiversity and is one of the 12 mega diversity centers. In Indian culture, plants are not only viewed as resource, but also given proper reverence by its induction in various religious rituals and are considered sacred (like *Ocimum sanctum, Ficus religiosa, Ficus benghalensis, Musa paradisiaca* etc.). Ayurvedic medicine, since ancient days has been an important aspect in Indian medical scenario. The traditional knowledge base in respect of use of medicinal plants for therapeutic use in India is widely acknowledged all over the world. *Charak Samhita* and *Sushrut Samhita* embody this rich legacy. Use of plant extracts for treatment of various ailments dates back to the Vedic period (Biswas, 2012). However, anthropogenic reasons along with overexploitation of medicinal plants are putting a heavy strain on the existing resources, causing a number of species to be either threatened or endangered. There is increased biotic pressure due to excessive increase in human population and over exploitation of nature and natural resource, resulting in increased attention to bio-prospecting (Kipgen, 2013). Around 70% of India's medicinal plants are found in various forests distributed in tropical areas. Analysis of medicinal plant indicated that about 34% are trees, 34% are shrubs and the remaining 32% are composed of herbs, grasses and climbers (Batugal *et al*., 2004). A very small portion of medicinal plants belong to lower plants like lichens, ferns, algae, etc. while majority are classified as higher flowering plants (Maiti, 2004). It is an exhaustible resource but inexhaustible if necessary sustainable measures are taken.

Socio-economic factors like low educational levels and lack of access to western health care have been cited as important reasons for reliance on indigenous modes of medicines. In most medicinal plants, bark and underground parts are mainly utilized. A lot of collection is unrestricted and trees are becoming endangered in the process. Regulations are now being imposed and many institutions are now coming up with the idea of proposing the use of leaves instead of bark and underground parts as conservation strategies.

It is estimated that around 70-80% of world's population relies upon non-conventional sources of medicines. The most serious threat in extracting medicines from plants is habitat loss, habitat degradation and over-

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harvesting. In developing a market for natural products, conservation strategies need to be developed so that more damage is not done to the resources. Conservation of medicinal plants in biocultural perspective not only implies conservation of biodiversity but also implies conservation of cultural diversity.

An important step towards conservation of medicinal plants is to map their habitat, so that proper conservatory measures can be taken. Identifying spatial location is a prerequisite for conservation strategies of medicinal plants (Al Bakri *et al*., 2011). This will also prevent accidental destruction. GIS has been used as a "map maker" (Murty, 2012). Plant species and area can be identified to develop GIS based mapping using available software for visualizing, analyzing, creating, and managing data with a geographic component (Qayum *et al*., 2014).

Use of GIS in ethno-botanical work is an upcoming research field. Geo-visualization research in last 15 years directed considerable efforts towards enhancing dynamic and interactive maps (MacEachren *et al*., 2008). Use of Geographic information system (GIS) as an important tool in conservation of medicinal plants through spatial analysis has been reported in many studies (Mustalish *et al*., 1996; Schumaker, 1996; Sperduto and Congalton, 1996; Menon and Bawa, 1997; Debinski *et al*., 1999; Roy and Tomar, 2000; Porwal *et al*., 2003; Anderson *et al*., 2005; Yang *et al*., 2006). GIS, is by far the most articulate tool used nowadays for studying the vegetation cover of a particular area. Several researches have proved that GIS, along with remote sensing can be an impressive instrument for cataloguing vegetation data obtained from ground surveys into mapping and analysis.

One of the challenges faced by researchers while mapping medicinal plants is information on physical attributes and approachability of an area. Remote sensing can very comprehensively be used to solve the above problem. Also land use and vegetation cover can be accounted for using the same.

The spatial distribution and their abundance are widely affected by the physical, biological and environmental variables of plants. Integration of GIS with RS can be done for building databases of; effect of these variables on occurrence of these plants. Spatial analysis in GIS can be used in preparing maps of MH plants with respect to landscape and anthropogenic factors. GIS is an intricately woven software of various functions, all of which are used to generate digital data. They can be used to make digital layers of slope and slope aspect, extracting data from topographic maps or for creation of 'buffers' around areas, which have undergone landscape disturbance. Upon examination, these maps will have intersection areas. These areas can be utilized to derive data from different layers and to export them for further analysis and comparison. This is a both time and cost-effective method.

Roy and Behera (2005) utilized GIS capabilities which could identify the species diversity along various altitudes. Identification of economically important medicinal and endemic species was carried out by intersection of different GIS layers of vegetation, biogeographic and altitude zones. The distribution of these widely affected with altitude and disturbance levels.

The present investigation was undertaken with the following objectives; (i) Geo-spatial study of the medicinal plants in the study area; (ii) Preparation of geo-botanical map of the study area incorporating various geo-ethnobotanical information through GIS for management and conservation of the plants; (iii) Methodology for allowing web browser users to share the collected data through web app using web GIS.

Methodology

The study was conducted during the monsoon and post-monsoon season from July to November, 2016. Based on primary data observation and documentation of the species which were obtained from field survey of the study area only those species were selected which are unique, having medicinal value and special benefits. The sampling was done among all the trees, herbs and shrubs found in the study area. While collecting data, photographs of certain species were taken for reference.

Data representation on map and publication of the data for use in academic and research field is an important step in geographical study. ArcGIS 10.2 was used first to prepare the college layout map and simultaneously the botanical map of the study area. The mapping of the vegetation survey was done through GPS. The X, Y coordinates derived was tabulated into Excel software along with spatial and utility information of each species. The spatial data was converted to attribute data in GIS platform for each species and was simultaneously linked with the base layout map. The Geodatabase had four separate domains (scientific name of plant species, common name of plant species, locational attribute, utility and availability of each species) that were linked with attribute field in feature class. The coordinate reference system used is EPSG: 4326, WGS 84. The database was then published on Web GIS platform through ArcGIS online after generating a URL (http://arcg.is/2fY2GxD) in a dynamic interactive Web application for ready

reference and use by others.

Study area

St. John's College, located in Agra city of Uttar Pradesh of India having an area of approximately 21.20 hectare has been chosen for the present study (fig. 1). It is located at 27°11'30" N to 27°11'41.44" N and 77°00'18" E to 77°59'49" E at an elevation of 175 meters above MSL. Because of its huge areal extent, the institute hosts a great diversity of flora and fauna (birds). Naturally growing medicinal species is an important aspect of the flora found in the ample open space of the institute.

The city is covered by Pleistocene to sub-recent alluvial deposits of the rivers of the Indo-Gangetic system which have traversed this area (Joshi, 1965). The soil mostly consists of the quaternary sediments of older alluvium of the Indo-Gangetic plains. It consists of recent unconsolidated fluvial formations containing sand, silt, clay and *Kanker*. Its texture is mostly fine. The city has a slope between 1-5% denoting very gentle sloping. River Yamuna forms the major drainage of the city. Groundwater occurs under unconfined to semi-confined conditions. The depth to bedrock is at around 80 inches from the surface. According to 2011 census, the city has a total population of 1,775,130. The region has a semi-arid climate having sub-tropical monsoon type. The city features cold winters, hot and dry summers and a comparatively low monsoon season. It receives rainfall mainly from the South-West monsoon, which is effective between July to September. The annual rainfall is 679 mm of which 90% is contributed by the South-West monsoon. Average annual minimum and maximum temperatures are 19°C and 32.3°C, respectively. The Land use land cover map of the study area (fig. 2) proves that built up area is the major land use type.

Results and Discussion

Herbal medicine forms the traditional medicinal knowledge base of India. Medicinal plants, which generally grows in wild without requiring any major agricultural care is an essential instrument for biodiversity conservation and generation of secondary income sources. A number of works based on ethno-botanical studies has been done both in India and outside (Qayum *et al.*, 2016; Verma *et al*., 2007; Pandey and Tripathi, 2010). GIS based mapping of medicinal plants found wild is also rapidly gaining ground. However, mapping of the same in sprawling educational institutes with vast open space is comparatively a new concept in which significant works have not been done. However, GIS based ethno-botanical study and database of medicinal plants in educational institutes through creation of multi layers information system will serve the dual purpose of spreading the knowledge of medicinal plants and their identification among the students along with help in conservation of the same. In the wake of rapid urbanization and deforestation, it is very important to conserve medicinal plants. Identification of medicinal plants and mapping of the same is thus a prerequisite for proper *in situ* conservation practices that can be followed. Although deforestation and increase in built up area is not a pressing problem in the study area (being an educational institute), however due to lack of knowledge of medicinal plants and their identification, these plants are often cleared away along with the rest of weeds and hedges from time to time. With the advancement in information technology and use of satellite imaginary techniques, integration of GIS and ethno-botanical studies will catalyze the process of sustainable development and use of medicinal plants.

Medicinal plants which do not require any major care can easily grow in wild in adverse climatic conditions. However their availability in very dense urban areas is quite a rarity. Educational institutes within the cities have vast open space having naturally growing medicinal plants. Knowledge and identification of medicinal plants among the young generation is a rarity which hampers sustainable development and conservation. These forms the basis for selection of St Johns College, Agra city as the venue for the present work. The study integrates ground truth verification, providing the exact location of the medicinal species and a detailed database on their utilities and allied information. Users can select a plant (feature) or any other feature class in the college layout map to view its attribute details which opens up as tiny pop-up box in the map window.

College Layout map

The study area (St. John's College, Agra, India) is a sprawling academic institute. Vast patches of open space with lush vegetation during rainy season are a common feature in this area. During the rest of the year vegetation reduces due to climatic condition. Since the study area lacks any map for ready reference, thus a detailed map was first made. While mapping and digitizing through ArcGIS software, the entire college was divided into five main sections based on utility and infrastructure-Departments, Amenities, Hostels, Administrative office and Residence (staff). Shape files of each of these were created based on their exact areal extent and geographical location. Information of the names of faculties for each department was also incorporated in the database.

The college has a host of amenities which were

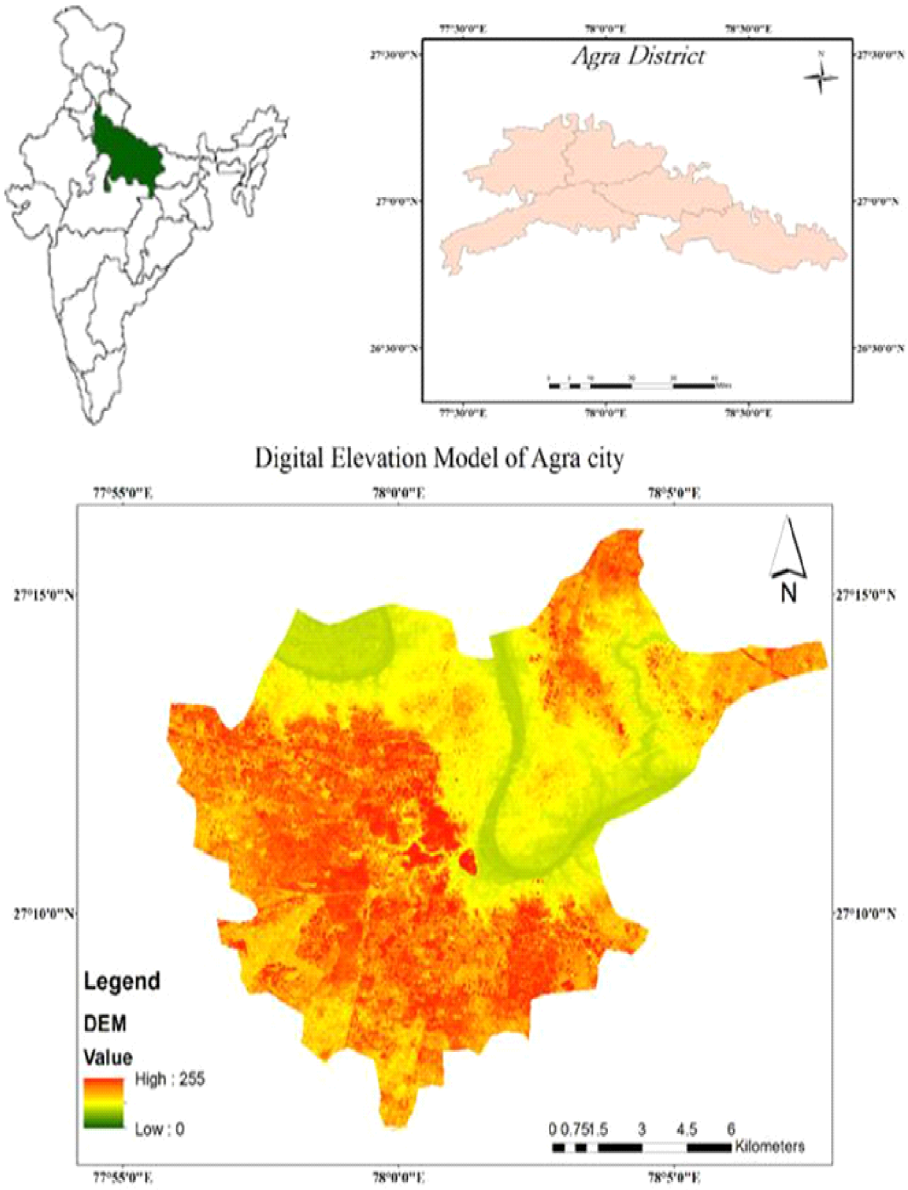

Fig. 1 : Map of the Study area.

digitized and mapped. A total of 14 such amenities were mapped based on their exact areal extent and geographical location. Information of each of these were incorporated in the database. The college has both boys and girls hostel. These were mapped and digitized for the preparation of the layout map of the study area. The administrative wing of the college houses Principal's office, Accounts, and Computer section. This was also mapped in the layout of the college. A total of six residential units in the college meant for the purpose of teaching and non-teaching staff has been identified and mapped for the present purpose. This includes- Principal's residence and five other residential campuses. Along with mapping of each of these based on geographical extent, their identification details were also included in the database. The details of the various shape feature class created in the college layout map has been given in table 1 and represented in fig. 3.

Analysis of plant species

The study area having ample open space has a host of naturally growing trees, herbs and shrubs. Although, almost all vegetation type has medicinal value, but in the present investigation only few of them were selected based on their dominance, uniqueness, medicinal value, and special benefits. The vegetation type was delineated into trees, herbs and shrubs. Of the 386 families and 2200 genera of medicinal plants recorded in India, the families *Asteraceae, Euphorbiacae, Lamiaceae, Fabaceae, Rubiaceae, Poaceae, Acanthaceae, Rosaceae* and

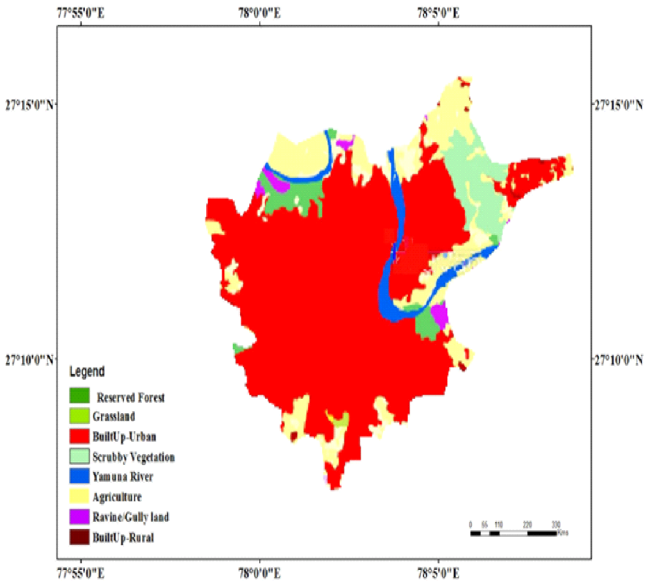

Fig. 2 : Land use Land cover map of Agra city. Courtesy : Bhuvan.

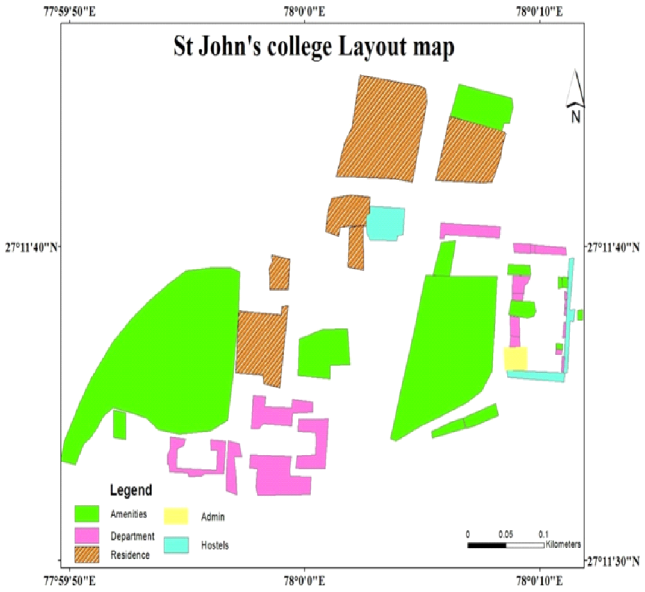

Fig. 3 : Study area layout map.

Table 1 : College layout map details.

Departments	Amenities	Hostels	Administrative office	Staff Residence
BBA	College Hall	Davies House (Girls')	A single unit	Principal
IGNOU	Canteen	Bishop French (Boys')		Staff
Psychology	Chapel	Hallibury (Boys')		Staff
Geography	Students' Parking			Staff
Commerce	Indoor games & swimming pool			Staff
Statistics and Maths	Basketball court			Staff
Computer science	Football field			
History	Cricket ground			
Economics	Indoor games			
Political science	Central library			
Languages	Seminar hall			
Commerce	Staff room			
Physical Education	Bank			
B.Ed	Staff club			
Physics				
Chemistry				
Zoology & Botany				
Classrooms				
Botany PG				

Apiaceae comprise the largest proportion of medicinal plant species, with the highest number of species (419) falling under *Asteraceae* (Maiti 2004). 56 plants belonging to 33 families were identified and their geographical distribution illustrated through GIS layers and simultaneous maps.

Analysis of trees : The study area has numerous trees owing to the ample open space. However, for the present study, total 34 trees from 22 families were identified. Their exact geographical location was incorporated in the base map. The list of the selected trees along with their utilities is listed in table 2 and

Table 2 : Sampled trees prevalent in the study area.

S. no.	Name	Common name	Family	Geographical condition suitable	Utilities
1	*Acacia arabica*	Babool	Fabaceae	Arid and semi-arid regions	Used for curing skin diseases and cancer
2	*Adasonia digitate*	Baobab	Malvaceae	Native to African sub-continent	Used for treating malaria and microbial infections
3	*Aegle marmelos*	Bael	Rutaceae	Indian sub-continent	Dyspensia, Anti-Diabetic properties
4	*Ailanthus excels*	Mahanimb	Simarouba-ceae	Indigenous to India	Fever cure and tonic
5	*Alstonia scholaris*	Saptaparni	Apocynaceae	Conditions of the Indian sub-continent	Used for treating dyspepsia, diarrhea & dysentery
6	*Azadirachta indica*	Neem	Meliaceae	Semi-arid to Semi-humid conditions	Anti-microbial, contraceptive & sedative
7	*Bauhinia variegata*	Kachnar	Fabaceae	Native to south east Asia	Used as an astringent and tonic
8	*Butea monosperma*	Palash	Fabaceae	Indian sub-continent	Used for treating leucorrhea and retention of urine
9	*Cassia fistula*	Amaltas	Fabaceae	Moist forests, woodlands & mountain	Treatment of epilepsy and hematuria
10	*Cassia siamea*	Kassod tree	Fabaceae	Tropical climate	Leaves, tender pods and seeds are edible, gastrointestinal, diabetes, diuretic
11	*Cordia myxa*	Lasura	Boraginaceae	Indo-malayan ecozone	Used for treating burns and fractures
12	*Crataeva religiosa*	Temple plant	Capparida-ceae	Sub-Alpine zones along streams and rivers	Root, leaves, bark have therapeutic properties, used in diuretic, kidney stones, antilithiatic, rubefacient and anti-inflammatory disorders
13	*Delonix regia*	Gulmohar	Fabaceae	Hot and Arid Climate	Anti-inflammatory, Carminative
14	*Eucalyptus tereticornis*	Eucalyptus	Myrataceae	Native of hilly areas	Upset stomach and used to loosen coughs
15	*Feronia elephantum*	Wood apple	Rutaceae	Indo-Malayan region	Astringent, jam preparation, fruit juice
16	*Ficus glomerata*	Cluster fig	Moraceae	Plains and Low Terrain	Treating dental aches, dysentery & wounds
17	*Ficus krishnai*	Makhan katori	Moraceae	Monsoon and rain forests	Anti-diabetic and Anti-hyperlipidemic
18	*Ficus religiosa*	Peepal	Moraceae	tropical & subtropical climates	Traditional medicinal plant used in treating asthma, diabetes, diarrhea, epilepsy, gastric problems, inflammatory disorders
19	*Holoptelea integrifolia*	Chilbil	Ulmaceae	Semi-open deciduous regions	Used to relieve leprosy and rheumatic pains
20	*Jacaranda mimosifolia*	Black poui	Bignoniaceae	Tropical to sub-tropical regions	Anti-microbial
21	*Jatropha*	Jatropha	Euphorbac-eae	Plains, grow even on poor quality soil	A very popular bio diesel plant

Table 2 continued...

Table 2 continued...

22	*Lawsonia inermis*	Heena	Lythraceae	Cooler, slightly moist conditions but can survive semi-arid conditions	Dysentery, Liver disorders and baldness. A very popular use is its application for hand art
23	*Mimusops elengi*	Spanish cherry	Sapotaceae	Tropical forest, semi-evergreen forest	Dental ailments such as bleeding gums, pyorrhea, dental caries, anthelmintic
24	*Morus alba*	Mulberry	Moraceae	Indian sub-continent to southern Europe	Used to treat edema and promote urination
25	*Nyctanth arbor-tristis*	Harsingar	Oleaceae	Suited for growth in tropical and temperate regions	Treatment of Alopecia, Sciatica
26	*Phoenix sylvestris*	Khajur	Arecaceae	Thrives from plains to coast	Immunity booster and laxative
27	*Phyllanthus emblica*	Amla	Phyllanth-aceae	Dry open forests	Multiple benefits ranging from good skin to proper functioning of heart.
28	*Plumerica acuta*	Frangipani	Apocyana-ceae	Warm climate, well-drained soil	Purgative, for fighting Diarrhea, bronchitis
29	*Polyalthia longifolia*	False ashoka	Annonaceae	Native to India	Alleviating noise pollution, antibac-terial, antioxidant, antifungal
30	*Pongamia pinnata*	Karanja	Fabaceae	Native in tropical and temperate Asia	Useful in piles, relieves worm infestation
31	*Pterospermum acerifolium*	Kanak champa	Sterculiaceae	Tropical regions	Cures blood impurity and impotency
32	*Saraca indica*	Ashoka	Caesalpini-aceae	Plains	effective in treating gynaecological disorders
33	*Thevetia peruviana*	Peeli kaner	Apocynaceae	Tropical and sub-tropical regions	Used in intermittent fevers and amenorrhea
34	*Thuja indica*	Cedar	Cupresssa-ceae	Cold and dry conditions	Anti-rheumatic, pest repellent, vermifuge substance

represented in fig. 4.

Five trees (*Ailanthus excels, Ficus glomerulata, Ficus religiosa, Pongamia pinnata* and *Polyalthia longifolia*) were selected from cricket field area, which is of 2.78 hectares. Six trees from B.Ed. section having medicinal properties were chosen and mapped in the layout base map. They were *Aegle marmelos Ficus glomerulata, Jatropha, Lawsonia inermis, Plumerica acuta* and *Thuja indica*. Six trees were chosen and mapped near Chemistry department - *Alstonia scholaris*, *Azadirachta indica, Cordia myxa, Delonix regia, Jacaranda mimosifolia,* and *Polyalthia longifolia.* Five trees were chosen and mapped in front of Physics department of the college which are- *Alstonia scholaris, Cassia siamea, Crateva religiosa, Pongamia pinnata,* and *Thevetia peruviana*.

Twelve trees of medicinal value were identified in the open space behind Physics department, which are- *Aegle marmelos, Alstonia scholaris, Azadirachta indica, Delonix regia, Ficus krishnai, Mimosops elengi, Nyctanthes arbor-tristis, Phoenix sylvestris, Polyalthia longifolia, Pterospermum acerifolium, Thuja indica* and *Thuja occidentalis*.

Nine trees were identified in front of Botany (UG & PG) department which are- *Adasonia digitata, Azadirachta indica, Bauhinia variegata, Butea monosperma, Cassia fistula, Feronia elephantum, Morus alba, Phyllanthus emblica* and *Polyalthia longifolia.*

There is a vast open space in front of Central library section of the college which is the home of numerous species. Twelve trees were identified from this area which are - *Acacia arabica, Ailanthus excelsa, Azadirachta indica, Cassia fistula, Cassia siamea, Eucalyptus tereticornis, Holoptelea integrifolia, Jacaranda mimosifolia, Phoenix sylvestris Polyalthia*

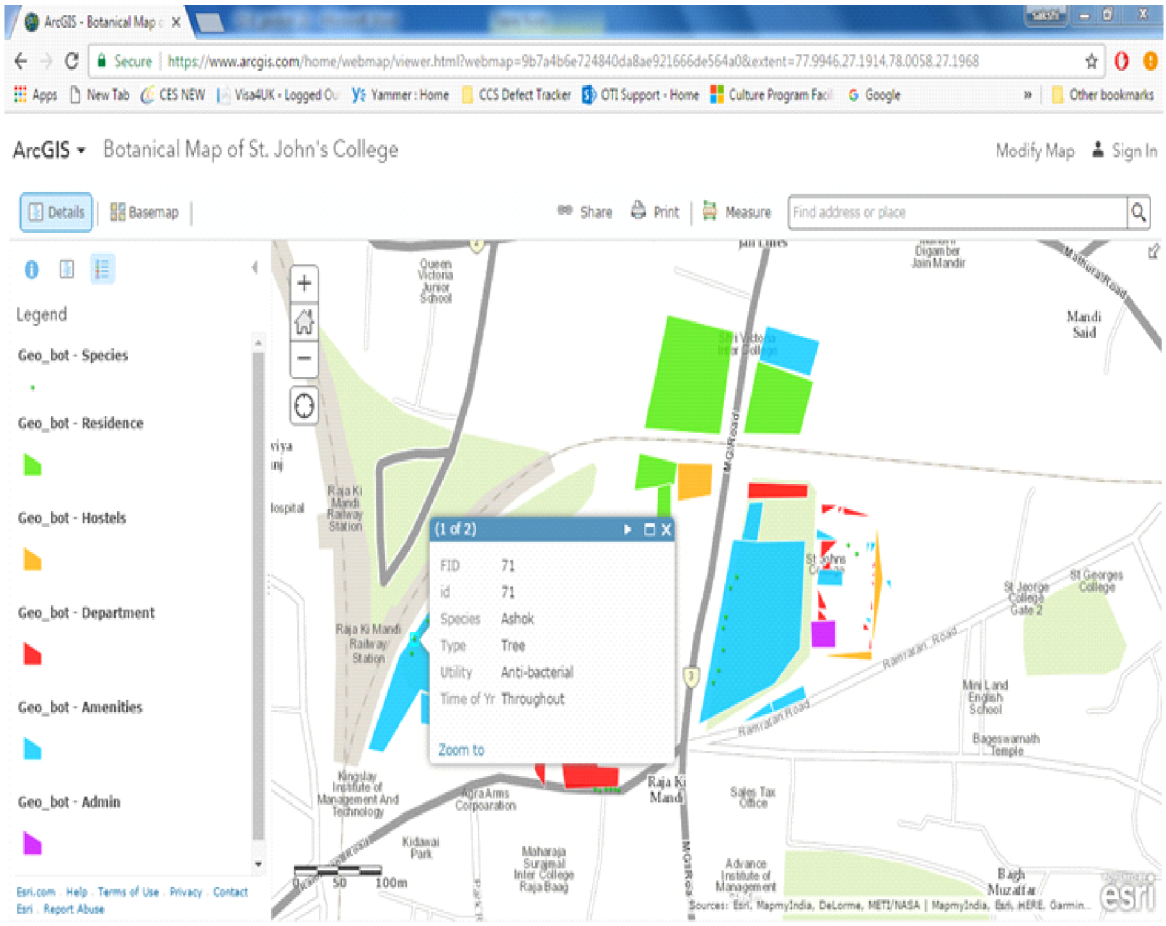

Fig. 4 : Trees layout map and its representation in Web browser.

longifolia, Pongamia pinnata and *Thevetia peruviana*. Three trees of medicinal value were identified in the football ground of the college which are – *Azardirachta indica*, *Polyathia longifolia* and *Thuja occidentalis*.

Analysis of Herbs : Although, the study area has numerous herbs owing to the ample open space, however for the present study 14 herbs from 9 families were identified. Their geographical location was incorporated in the base map. The list of the selected herbs along with their utilities are listed in table 3 and represented in fig. 5. Except two herbs, which are annual, all are seasonal mainly prevalent during August to November.

Fourteen herbs were identified in Botany (UG & PG) department which are- *Achyranthus aspera, Aloe vera, Asparagus densiflorus, Asparagus plumosus, Asparagus racemosus, Barleria prionitis, Cannabis sativum, Crinum asiaticum, Datura stramonium, Ocimum sanctum, Pedilanthus tithymaloides, Sansevieria cylindrica, Sansevieria trifasciata* and *Withania somnifera. Aloe Vera* is found in Chemistry department.

Analysis of Shrubs : Eight species of shrub from 7 families were identified in the study area of which six are seasonal found during monsoonal season while the rest are found throughout the year. The list of the selected shrubs along with their utilities are listed in table 4 and represented in fig. 6. Two species were identified in the cricket field area of the college- *Calotropis procera* and Ounga, while four species were identified from the football ground of the college which are - *Acalypha indica, Abutilon indicum, Ageratum conzyzoides* and *Murraya paniculata* while two species were identified in front of Botany (UG & PG) department -*Abutilon indicum* and *Atriplex* spp. There is a vast open space in the study area in front of Hallibury Boys' hostel which houses many shrubs. *Hibiscus rosa-sinensis* and *Lantana indica* among them were identified.

Biodiversity conservation is the primary requirement for sustainable development. India is a home to a vast variety of medicinal plant species; however with population pressure the dual approach of deforestation and over exploitation of medicinal plants has reduced the same to a great extent. Within the context of combining biodiversity conservation and poverty alleviation, not only

Table 3 : Sampled herbs prevalent in the study area.

S. no.	Name	Common name	Family	Geographical condition suitable	Utilities
1.	*Asparagus densiflorus*	Asparagus fern	Asparagaceae	Temperate region, woodland, forest edge	Mashed leaves are applied to cuts and tubers are given to children for stomach ache
2.	*Asparagus plumosus*	Climbing Asparagus	Asparagaceae	Temperate region, woodland, forest edge	Pulmonary infections, diuretic, dysentery and diarrhea
3.	*Asparagus racemosus*	Shatavari	Asparagaceae	Grows in gravelly,rocky soil at an elevation of 1,300 to 1,400 mts	Used to relieve hyperacidity and as a uterine tonic
4.	*Achyranthes aspera*	Chaff flower	Amaranthaceae	Weed of crops, grasslands, forestry, waste lands	Medicinal purposes, especially in obstetrics and gynecology, including abortion, induction of labor
5	*Aloe vera*	Aloe vera	Asphodelaceae	Tropical climate	The most effective herb for skin care and all related problems
6	*Barleria prionitis*	Vajradanti	Acanthaceae	Mainly found in tropical regions	It is a very effective dental medicine
7	*Cannabis sativum*	Hemp, marijuana	Cannabaceae	Man-made or disturbed habitats	Source of industrial fibre, seed oil, food, recreation, religious and spiritual moods, and medicine, marijuana
8	*Crinum asiaticum*	Nagadamani	Amaryllidaceae	Grows in tropical climate	Antirhuematic and diaphoretic
9	*Datura stramonium*	Dhatura	Solanaceae	Grown in warm and temperate regions	Used to cure all types of inflammations. Also used as an analgesic and anaesthetic.
10	*Ocimum sanctum*	Tulasi, Basil	Labiateae	India sub-continent, cultivated	Sacred plant, insect repellent, multiple medicinal properties
11	*Pedilanthus tithymaloides*	Agia	Euphorbiaceae	Tropical to sub-tropical regions	Anti-inflammatory and anti-oxidant properties
12	*Sansevieria cylindrica*	Snake plant	Asparagaceae	warmer climates	Yield fiber, air cleaner
13	*Sansevieria trifasciata*	Snake plant	Asparagaceae	warmer climates	Yield fiber, air cleaner
14	*Withania somnifera*	Ashwagandha	Solanaceae	Plant is a native of India	Used to increase health and vitality and and also used to cure ulcers and cancers.

in situ preservation of valuable wild plant species should be given attention, but also *in domo* conservation (Ros-Tonen and Wiersum 2005).

Knowledge of medicinal plants in India has been quite rich and deep and the legacy has been passing through the ages in the form of Vedic literature, Ayurveda, Unani etc. In the backdrop of increased need of conservation and management of medicinal plants, the intellectual class must take up the burden of awareness of the same. Most of the higher educational institutes in the country can practice *in situ* and *ex situ* conservational strategies in their open space, which not only will enhance conservation of these plants but will also educate the younger generation on the same. The study area which too has vast open space, most of it lying unutilized must take up *in situ* and *in domo* conservation strategies of the otherwise wasted resource naturally growing within its geographical boundaries. The study area already has a small botanical garden managed by the Botany department (fig. 7). The vast open space in the cricket ground, football ground, library field etc. can also be used to develop herbal garden of some selected endangered

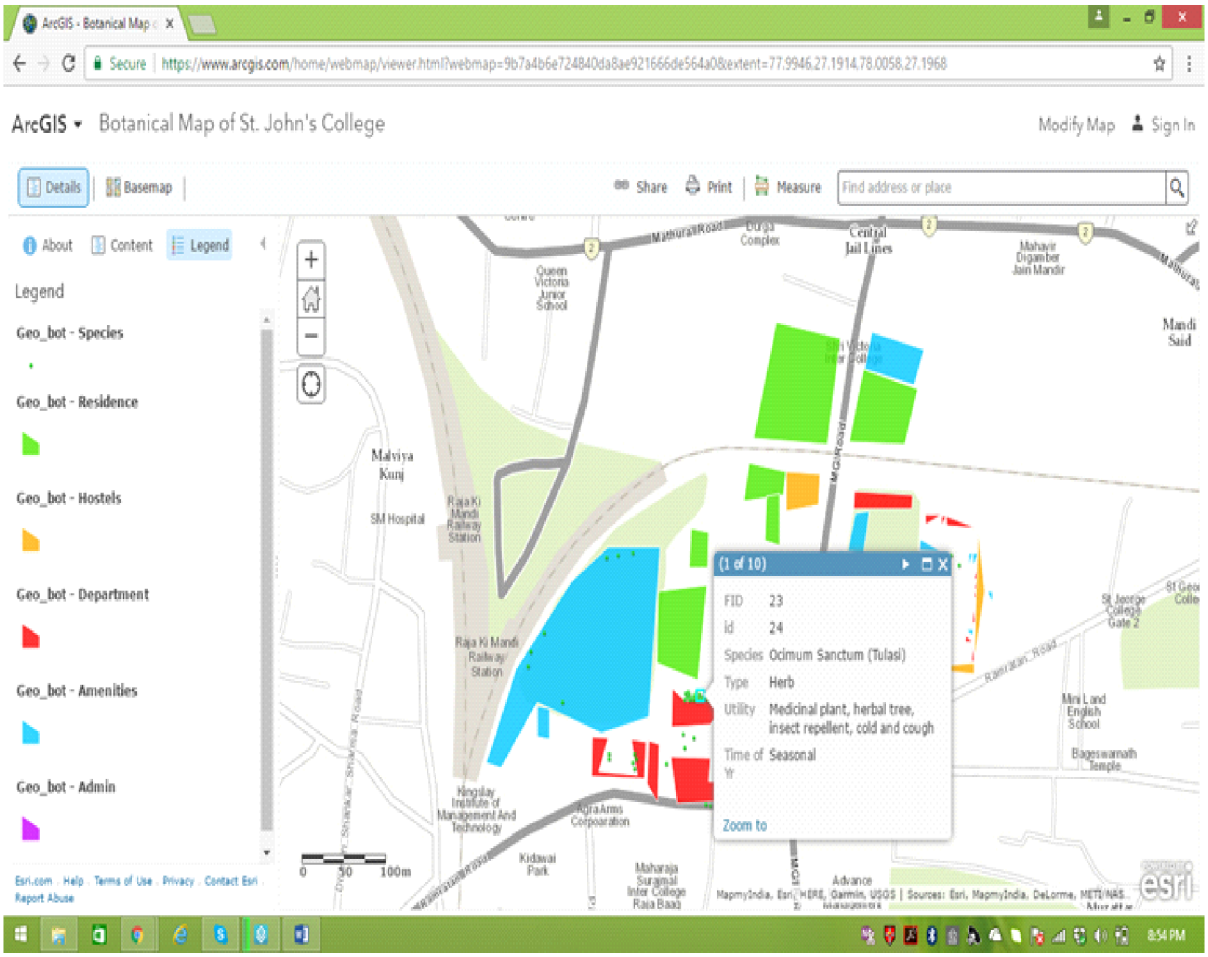

Fig. 5 : Herb layout map and its representation in Web browser.

Table 4 : Sampled shrubs prevalent in the study area.

S. no.	Name	Local name	Plant family	Geographical condition suitable	Utilities
1	*Abutilon indicum*	Atibala	Malvaceae	Tropical to sub-tropical regions	Diuretic and expectorant
2	*Acalypha indica*	Kuppi	Euphorb-iaceae	Occurs throughout the plains of India	Used in bronchitis and asthma
3	*Ageratum conzyzoides*	Jangali pudina	Asteraceae	Tropical to sub-tropical climate	Used in epilepsy and to heal wounds
4	*Atriplex* spp.	Salt bush	Amarantha-ceae	Dry, arid climate	Fodder crop
5	*Calotropis procera*	Sodom apple	Asclepiada-ceae	Dry, arid climate, tropics of Asia and Africa	Latex has been used in leprosy, eczema, inflammation, cutaneous infections, syphilis, malarial and low hectic fevers
6	*Hibiscus rosa-sinensis*	Gurhal	Malvaceae	Tropical climate	As a component of face packs and for relieving menstrual cramps
7	*Lantana indica*	Raimuniya	Verbenaceae	Tropical climate	Carminative and as an antidote to snake venom.
8	*Murraya paniculata*	Kamini	Rutaceae	Tropical to sub-tropical climate	Anti-nociceptive & anti-inflammatory properties

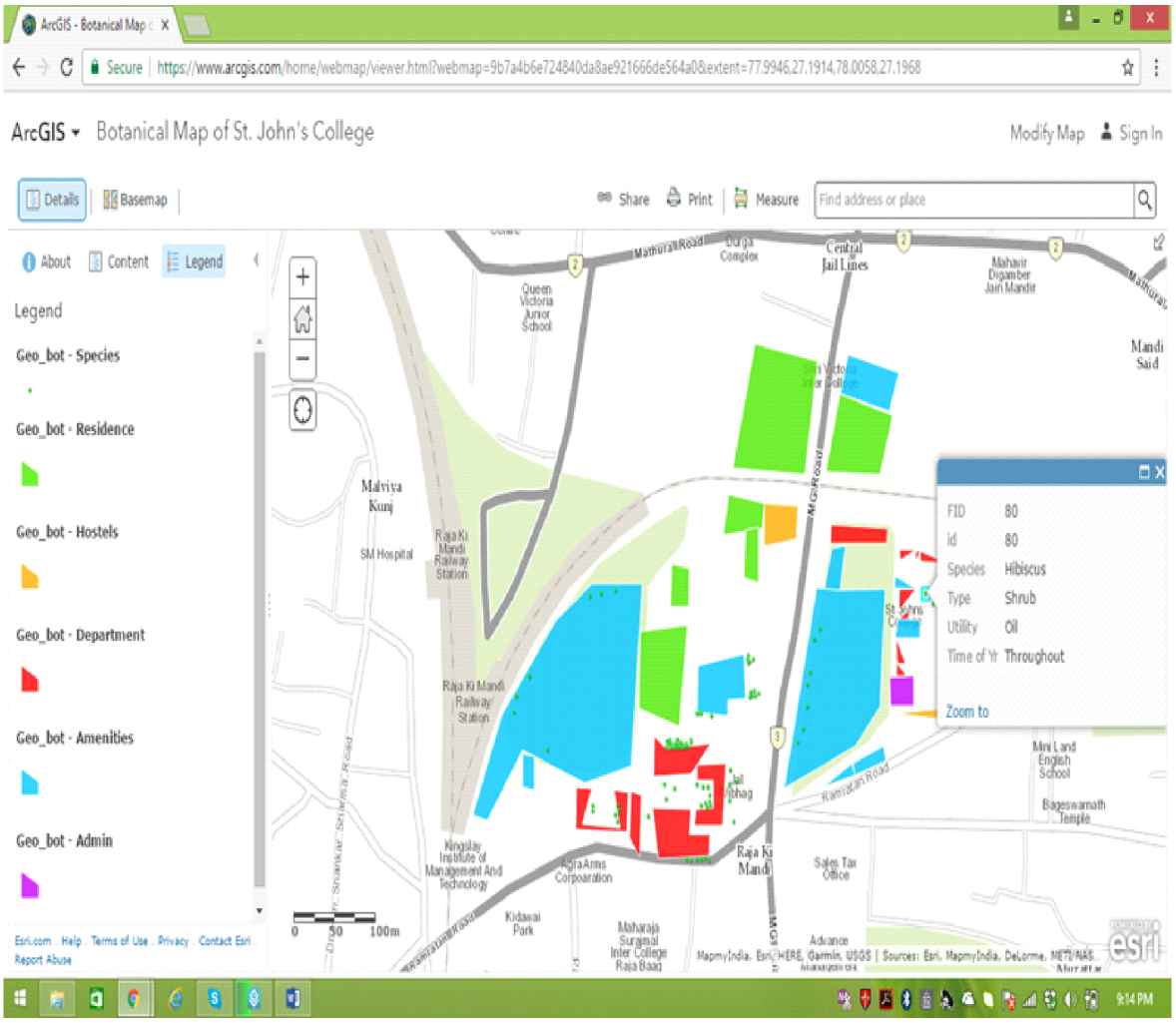

Fig. 6 : Shrub layout map and its representation in Web browser.

species like *Rauvolfia serpentina*, *Withania somnifera,* etc., which will serve the dual purpose of conservation and will also generate extra income source for the institution.

The college harbors a vast amount of empty space in front of central library. This area can be utilized to set up a small herbal cum utility garden. Plants like *Allium sativum, Coriandrum sativum, Cumin cyminum, Curcuma longa, Ferula asafoetida, Foeniculum vulgare, Mentha piperita, Ocimum basilicum, Ocimum sanctum, Piper nigrum* and *Thymus vulgaris* serve more purposes as they find their uses in applications apart from serving as medicinal plants. Hence, this empty space can be utilized for their growth, conservation, sustainable development and for multi utility purposes. As discussed earlier they can be used as a source to generate income.

Plants like Basil, *Lavender, Lemongrass, Lemon thyme, Mentha piperata, Rosemary, Nasturtiums* act as good insect repellents. Also, *Cymbopogon citratus, Artemisia* spp., and *Andrographis paniculata* act as good snake repellants. These can be planted around residential areas as insects and pests in these areas are not welcomed at all. At the same time their conservation is guaranteed. A small "Bonsai" garden can also be set up. hydroponics and aeroponics are also suitable methods of rearing plants which are susceptible to damages even on slight changes in the environment These ensures conservation of endangered species, which otherwise is a difficult task.

Conclusion

For ages now, man has exploited plants for his use. They have served mankind for various purposes like food, shelter, medicines, clothes etc. In his quest to excel man has forgotten that he has nearly destroyed his silent friend. This has led to certain extremely harmful implications like global warming. Also one of the most beneficial gifts of plants are medicines. Herbal products and medicines are cost effective and are devoid of any side effects.

Fig. 7 : Botanical garden of the study area.

As times have changed, so has technology. It's time now for technology to come to the rescue of plants. Conservation strategies can be greatly enhanced if they are integrated by technology. In the paper the authors have lined traditional plant knowledge with GIS for dynamic knowledge based mapping.

The findings of this paper have dealt elaborately upon how Geographical Information System can be used for medicinal plants conservation. In the given area, plants were mapped and conservation strategies advocated. While doing so, a database of plants and their uses has been made. Their uses are of paramount importance and this natural resource is regularly damaged by unknowingly uprooting them. The developmental strategies in the comparatively small area of the institution which houses 33 families of varied plant species can be used as a lighthouse in the sea of conservation strategies and sustainable development of medicinal plants in the densely populated areas elsewhere.

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