BIODIVERSITY, ECOLOGY, ENERGY, LANDSCAPE DYNAMICS & HYDROLOGY OF AGASTYA FOUNDATION CAMPUS, KUPPAM

Ramachandra T. V.	Harish R. Bhat	Bharath H. Aithal
Rao G. R.	Sudarshan P.Bhat	Vinay S.
Ganesh Hegde	Gouri Kulkarni	Vishnu D. Mukri

Energy & Wetlands Research Group,
Centre for Ecological Sciences,
Indian Institute of Science
Bangalore 560012, India

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Energy & Wetlands Research Group,
Centre for Ecological Sciences, TE 15
New Bioscience Building, Third Floor, E Wing
Indian Institute of Science
Bangalore 560012, India
http://ces.iisc.ernet.in/energy
http://ces.iisc.ernet.in/biodiversity

Email: cestvr@ces.iisc.ernet.in, energy@ces.iisc.ernet.in
sahyadri@ces.iisc.ernet.in, envis@ces.iisc.ernet.in

Environmental Information System (ENVIS), CES, IISc

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New Bioscience Building, Third Floor, E Wing, Indian Institute of Science
Bangalore 560012, India
http://ces.iisc.ernet.in/energy
http://ces.iisc.ernet.in/biodiversity
E Mail: cestvr@ces.iisc.ernet.in; wetlands@ces.iisc.ernet.in
envis@ces.iisc.ernet.in; sahyadri@ces.iisc.ernet.in
ENVIS: ENVironmental Information System, CES, IISc, Bangalore 560012

BIODIVERSITY, ECOLOGY, ENERGY, LANDSCAPE DYNAMICS & HYDROLOGY OF AGASTYA FOUNDATION CAMPUS, KUPPAM

Executive Summary

Agastya International Foundation is a non-profit educational trust that seeks to transform and stimulate the thinking of economically disadvantaged children. This has been done by bringing innovative science education to the doorstep of Government schools in various states in India (http::://www.agastya.org).

Agastya Foundation Campus is located between 12°48'30" to 12°49'41" N latitude and 78°14'56" 78°15'29"E longitude, 733 m asl elevation in the Deccan Plateau with an spatial extent of 70 hectares (~172 acres) at Gudivanka village, Kuppam of Andhra Pradesh. The campus borders three Indian States - Andhra Pradesh, Karnataka, and Tamil Nadu while sharing flora and fauna of these three regions. The campus comprises mainly scrub jungle, rocky outcrops interspersed with plains. The topography of the campus is undulating with a few hills and valleys with pleasant weather throughout the year. The area is rich in Deccan Plateau flora and fauna with many rare species.

Agastya International Foundation approached us on 9th October 2014 with a request to prepare a scientific document focusing on "Biodiversity, ecology, energy, landscape dynamics and hydrology of Agastya Foundation Campus, Kuppam" (e mail dated 9th Oct 2014 from Dr. AjithBasu, Chief Program Executive, Agastya International Foundation". In Response to the invitation, field investigations were carried out during 27th to 29th November 2014. The research team consisted of 8 researchers – T.V. Ramachandra, Harish R Bhat, Bharath H. Aithal, Rao G R, Ganesh Hegde, SudarshanBhat and Vishnu D. Mukri. Subsequently, Indian Institute of Science communicated to M/s Agastya International Foundation about the scope of the study (CP 7308/0303/15-967, dated 16th March 2015). ***Scope of the research included***:

The investigation aims at generating scientific information using high resolution remote sensing data with photographs of select species among wild native flora. The objective is to design this information to form the basis for choosing species for landscape planning and further greening of the campus. Objectives of the work are

1. Understanding land use land cover [LULC] dynamics of the campus;
2. Inventorying and mapping of flora with ground surveys using GPS and remote sensing data;
3. Mapping of fauna (birds, butterflies) distribution in the campus;
4. Renewable energy potential assessment.

The main purpose of the investigation is to get acquainted with biodiversity, energy and ecology that helps foster interest and eco-consciousness.

Flora and fauna: About 600 species of plants with the majority of them are native. The campus is being afforested and rejuvenated during the last decade. Examples of rejuvenated habitats are rare in the Eastern Ghats. The campus has become a habitat to diverse fauna. The conservation initiatives have yielded desired results evident from the transformation to a biodiversity rich landscape. There has been a total transformation of the campus in the past decade resulting in rocky wasteland being converted to a green campus with rich biodiversity. There are numerous shrubs of medicinal importance or aid as host plants for butterflies.

- During summer, *Butea monosperma* tree with red flowers (Flame of the forest, also called 'Muttuga' in Kannada and 'Palasha' in Sanskrit) and thousands of bees swarming around for nectar. The leaves of this tree are used for making plates (used for serving food during community meals). The tree bark is quite medicinal and the stems are considered holy for several rituals.
- During March-April months *Cassia fistula (*golden shower tree; in Kannada 'Kakke Mara') with yellow oleander flowering droops like a yellow light chandelier. It is said that flowering indicates the arrival of monsoon. The tree bark is used for folklore medicine. Fruits are elongated dark pods which are preferred by many animals. Amongst the scrub jungle, between thorny bushes one can appreciate a special type of tree,
- *Dichrostachys cinerea* (Chinese lantern tree) with unique type of flowers. There are two colours of flowers in single stalk - upper set of flowers is yellow and lower ones are pink colour and are sterile flowers. Entire tree is thorny and dry with small leaves. This tree is native to Africa but has been introduced to India.

Monoculture plantations of Acacia give the appearance of wooded forest, with less diversity. Rose-ringed Parakeets have adapted to pecking the pods of these trees, inviting many such birds that forage for food. *Acacia auriculiformis* are exotic plants from Australia, being planted in large scale by the forest department to enhance the green cover and also to provide fuel wood. Leaf like part generally seen are not true leaves, but the leaf stalk modifying to leaf like part called 'Phyllode' for reducing the transpiration and water dependent activities as they survive arid conditions too. The young seedlings will have small leaflets which will fall away after sometime, once the leaf stalk modifies. The flowers attract hundreds of honey bees. The soil in the plantation region is with very less plant or animal life. The surrounding area is with several drier tract plants.

- About 137 species of birds were recorded of which 20% are migratory and arrive every winter. Several rare species of birds take shelter as the habitat is quite unique with undulating topography, rich with vegetation.
- 49 species of butterflies and at least 60 % breed regularly due to the presence of their hosts and nectar plants. Several of the butterfly species found on campus are quite rare and unique.

- 16 species of amphibians and 21 species of reptiles were recorded - reptiles like the *Geckoella kollegalensis*, Barred Wolf Snake, Golden Gecko, etc. are reported for the first time in the Eastern Ghats. This proves the richness of their habitat on the campus.
- 16 species of rare spiders (the Social Spider, found only in Africa and India, is abundant in the Campus).
- Several mammals like the Black-naped Hare, Pangolin, Porcupine, Indian Jackal, Spotted Deer, traces of leopard and sloth bear through scat and foot prints reveals that the campus is very rich and healthy with native vegetation and the habitat is preserved intact, which is helping to protect and conserve Biodiversity. Elephants are regular visitors in Kuppam every summer during the last five years and have entered Agastya Foundation Campus few times.

Landscape Dynamics: Large scale land-use land-cover (LULC) dynamics leading to deforestation is one of the drivers of global climate changes and alteration of biogeochemical cycles. This has given momentum to investigate the causes and consequences of LULC by mapping and modelling landscape patterns and dynamics and evaluating these in the context of human-environment interactions in the rapidly transforming landscapes. Human induced environmental changes and consequences are not uniformly distributed over the earth. However their impacts threaten the sustenance of human-environmental relationships. Land cover refers to physical cover and biophysical state of the earth's surface and immediate subsurface and is confined to describe vegetation and manmade features. Thus land cover reflects the visible evidence of land cover of vegetation and non-vegetation. Land use refers to use of the land surface through modifications by humans and natural phenomena.

Temporal remote sensing data offers aided an important means of in detecting and analysing changes occurring in the landscape. Remote sensing methods have been widely applied in mapping land surface features. Spatial data acquired through satellite borne remote sensors offers a tremendous advantage over historical maps or air photos, as it provides consistent observations over a large geographical area, revealing explicit patterns of land cover and land use. It presents a synoptic and repetitive view of the landscape at low cost. Recent advancements in remote sensing technologies offer multi-resolution (spatial, spectral and temporal) datasets that are used to assess spatial structure and pattern of changes in the landscape. Spatial patterns of changes in the landscape is understood by analysis of land use changes. Human induced land use and land cover (LULC) changes have been the major driver of the landscape dynamics at local levels. Land use assessment was carried using the maximum likelihood classification technique. This method has already been proved as a superior method as it uses various classification decisions using probability and cost functions. Analysis revealed an increase in vegetation cover from 11.19 (2001) to 18.76 (2014) % is noticed mainly in the campus and immediate vicinity.

Hydrology: The region receives about 626 mm annual rainfall and mostly during north eastern monsoon. Integration of spatial data (digital elevation model, land use, etc.) aided in the identification of locations suitable for optimal harvesting of rainwater. This also helps in addressing water stress in the campus during post monsoon. Among these two locations, lake/tank already exists in the campus behind discovery center (near the Karnataka border). The catchment of this lake is about 8.03 Ha (19.85 acre), with catchment yield of about 25 million liters. A new lake is proposed across two streams that connects near the north western boundary. This lake will have catchment area of 16.05 Ha (36.68 acre), with yield of 50 million liters (with an annual rainfall of 320 mm).Riparian vegetation of native species helps (mix of shrubs and tree species suitable for aquatic ecosystems) in rejuvenating water sources. Watershed based approach with plating of native species of grass, shrub and trees in the catchment would aid in the infiltration of water as well as retaining of water. RCC based arch dam (instead of earthen gravity dam) taking advantage of valley. (for the existing lake same could be followed).

Wetlands: Wetlands help in maintaining the ecological balance of the region. They have numerous valuable functions such as recycling of nutrients, purify water, attenuate floods, maintain stream flow, maintaining microclimate of the region, recharge ground water and also serve in providing drinking water source, fish, fodder, fuel, recreation to the society The stability of wetlands depends upon the balance between production and consumption of energy and matter at different trophic levels present in the system. The present study was done to understand the status of the lake ecosystems, which are located around Agastya Foundation campus at Kuppam. The physico-chemical and biological composition of the lakes were studied using standard protocols. The water quality of the studied lakes was found to be good with less nutrient content and organic matter. Presence of filamentous algal species and floating and submerged macrophytes species further confirms of a healthy ecosystem.

Renewable Energy: The electric energy requirement is mainly for lighting the roads and buildings (lighting, fans, computers, projectors and for the operation of science models). Most of the loads in the organisation are low power loads and heating loads (met by solar water heaters). Sustained supply of electricity to meet the demand in the campus is possible by harvesting renewable sources through appropriate technologies. Source wise renewable energy potential assessment was done to explore the scope of renewable energy harvesting technologies. Harvesting renewable sources of energy helps in achieving sustainability and also helps in demonstrating students about energy alternatives.

- **Solar energy:** Kuppam being in arid region receives abundant solar energy throughout the year. Agastya campus at Kuppam receives cloud free solar irradiance for over 7 months, which can be harvested for thermal and electric energy requirements in the campus. The region receives highest insolation of 6.51 kWh/m^2/d during March whereas lowest is observed in November (4.17 kWh/m^2/d). The average solar insolation in the region is about 5.16 kWh/m^2/d. This potential is adequate to generate heat and electric energy to meet domestic energy demand.

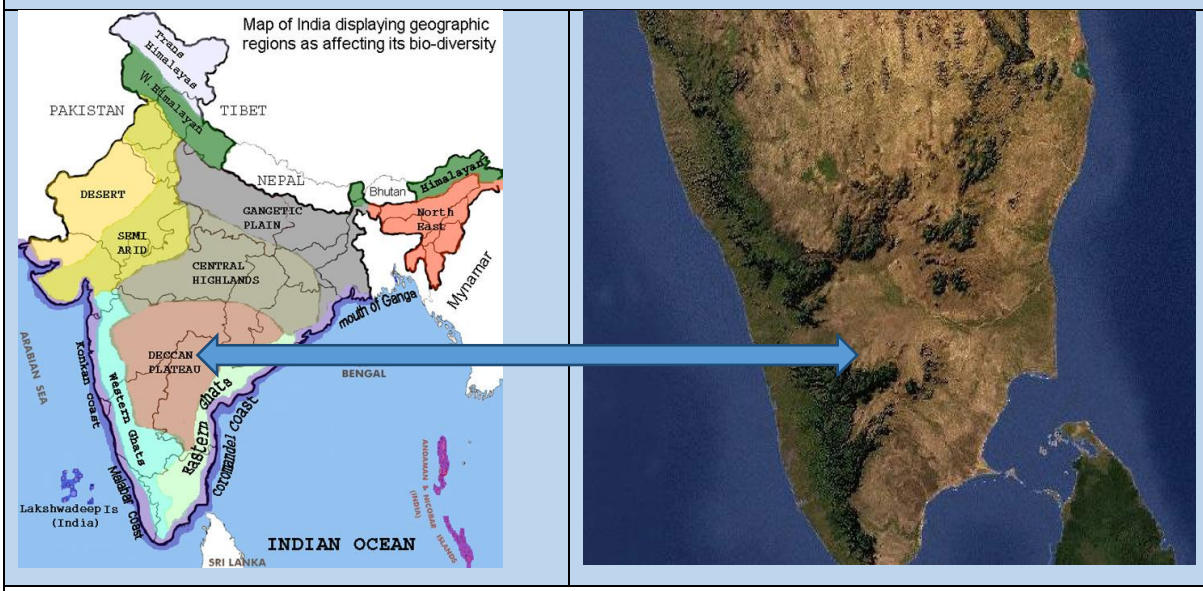
- **Wind energy scenario:** Region has a lower average wind speed which less than 2.5 m/s in most of the months. During June and July region experiences higher wind speed of over 3 m/s. The wind power density ranges from 3.64 W/m^2 (October) to 20.5 W/m^2 (June) in the region. It shows that, low speed vertical axes wind turbines are feasible for small capacity electricity generation, which may be integrated with solar PV systems.
- **Bioenergy prospects:** Agastya foundation is spread over 172 acres which mainly has scrub/grass land with few trees. There are few patches with exotic species - Acacia (*Acacia auriculiformis*) and Nilgiri (*Eucalyptus tereticornis*) in the region, and the biomass may be used for energy. Biomass gasifier can be used to generate electricity which can meet the motive (water pumps) and mechanical (workshop/construction) electricity demand. The organisation is located in the arid region and suitable for energy plantations. The biomass harvested from trees are mostly dry due to the weather which can be further dried in sunlight for better combustion. The fuel wood may be used either directly in wood burning stoves and boilers or processed into methanol, ethanol and producer gas. The energy plantations provide inexhaustible renewable sources (with recycle time of 3-8 years) of energy and provide reliable electricity.
- **Biogas generation:** The organization has cattle which produce sufficient dung to produce biogas. Hundreds of students come to the organization every day, who produce significant amount of food waste which can be used along with animal residue to produce biogas. The wet organic residues offer very high potential of biogas production which can meet the cooking fuel demand in guest house or of employee colony. The slurry generated in the biogas production is good manure which can be used to prepare compost or directly fed to agricultural or horticultural plantations.

Vegetation: The vegetation survey indicate that there are 141 plant species belonging to 57 families, comprising of 68 species of Trees, shrubs 12, climbers 11 and herbs with 50 species.Commonly seen larger trees *are Pterocarpus santalinus, Azadirachta indica, Syzygium cumini, Cassia siamea, Cassina glauca, Terminalia arjuna* etc. Important medicinal plants include *Balanites sp, Cassia fistula, Salacia chinensis, Tinospora cordifolia, Evolvulus alsinoides, Gloriosa superba, Pterocarpus santalinus, Sida acuta* etc. Many Vanas and gardens hosted these plants in the campus area. Grasslands also harboured large number of medicinal plants and hence have to be conserved. This report (ETR 89) summarises the outcome of the research being carried out in the campus at Kuppam(since November 2014).

1.0 Agastya Foundation Campus, Kuppam: Introduction

Agastya Fundation Campus is located between 12º48'30" to 12º49'41" N latitude and 78º14'56" 78º15'29"E longitude in the Deccan Plateau with an spatial extent of 70 hectares (~172 acres) at Gudivanka village, Kuppam of Andhra Pradesh. The campus borders three Indian States - Andhra Pradesh, Karnataka, and Tamil Nadu while sharing flora and fauna of these three regions. The campus comprises mainly scrub jungle, rocky outcrops interspersed with plains. The topography of the campus is undulating with a few hills and valleys. The area is rich in Deccan Plateau flora and fauna with many rare species.

Deccan Plateau, India



India with Deccan Plateau, Remote sensing data depicting landscape (http://earth.google.com)

The **Deccan Plateau** is a large plateau in peninsular India, in the southern part of the country. It rises a hundred meters high in the north, and more than a kilometer high in the south, forming a raised triangle within the familiar downward-pointing triangle of the Indian subcontinent's coastline. It extends over central and southern India covering eight Indian states with a wide range of natural habitats.

It is located between three mountain ranges: the Western Ghats form its western boundary, and the Eastern Ghats its eastern boundary. Each rises from their respective nearby coastal plains and nearly meet at the southern tip of India.

Deccan plateau is separated from the Gangetic plain to the north by the Satpura and Vindhya Ranges, which form its northern boundary. The name *Deccan* is an anglicised form of the Prakrit word *dakkhin*, itself derived from the Sanskrit word *dákṣiṇa*, meaning "south". The climate of the region varies from semi-arid in the north to tropical in most of the region with distinct wet and dry seasons. Rain falls during the monsoon season from about June to October. March to June can be very dry and hot, with temperatures regularly exceeding 40°C.

The volcanic basalt beds of the Deccan were laid down in the massive Deccan Traps eruption, which occurred towards the end of the Cretaceous period between 67 and 65

million years ago. Some paleontologists speculate that this eruption may have accelerated the extinction of the dinosaurs. Layer after layer was formed by the volcanic activity that lasted many thousands of years, and when the volcanoes became extinct, they left a region of highlands with typically vast stretches of flat areas on top like a table. The volcanic hotspot that produced the Deccan traps is hypothesized to lie under the present day island of Reunion in the Indian Ocean.

Agstya Foundation campus with diverse picturesque landscape elements

Number of flowering plants in the globe	~2,58,650
Number of flowering plants in India	~ 17,500
Agasthya Campus at Kuppam	~ 600

2.0 Exploring Biodiversity of Agastya Foundation Campus, Kuppam

Plants play a pivotal role in sustaining life on the Earth through oxygen production, carbon sequestration, water cycling, etc. The photosynthesis conducted by land plants and algae is the ultimate source of energy and organic material in nearly all ecosystems. Many animals rely on plants for shelter as well as oxygen and food. Land plants are key components of the water cycle and several other biogeochemical cycles. Some plants like legumes have coevolved with nitrogen fixing bacteria, making plants an important part of the nitrogen cycle. Plant roots play an essential role in soil development and prevention of soil erosion. Plant species adapt and grow with respect to the topography, geographical location, type of landscape and weather condition. The survival of plants in the campus is due to management with proper nourishment, water and protection. The campus is located in the typical deccan plateau landscape, with the diverse landscape of boulders, hillocks, vast crop fields, dry tracts with scrubs, human habitations, etc. Tall bottle palms at the entrance leads to the shining black statue of Sage Agasthyeshwara.

Agastya Foundation Campus, Kuppam

Sage Agasthya's statue

Quadrangle at entrance

Rose ringed Parakeet feeding on Acacia pods at Acacia plantation

Highlights of the campus flora and fauna: About 600 species of plants with the majority of them are native. The campus is being afforested and rejuvenated during the last decade. Examples of rejuvenated habitats are rare in the Eastern Ghats. The campus has become a habitat to diverse fauna. The conservation initiatives have yielded desired results evident from the transformation to a biodiversity rich landscape. There has been a total transformation of the campus in the past decade resulting in rocky wasteland being converted

to a green campus with rich biodiversity. There are numerous shrubs of medicinal importance or aid as host plants for butterflies.

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Diverse Flora and Fauna of the Campus

Butea monosperma (Flame of the forest)

Cassia fistula (Yellow oleander)

Dichrostachys cinerea

Bombax malabaricum (Red silk cotton)

Wrightia tinctoria (dyers's oleander)

Acacia auriculiformis

Pied Harrier

Sirkeer malkoha

Common jezebel

Striped Tiger

Cat Snake

Barred Wolf Snake

Social Spider

Signature Spider

Wolf Spider

3.0 Land use dynamics

Large scale land-use land-cover (LULC) dynamics leading to deforestation is one of the drivers of global climate changes and alteration of biogeochemical cycles. This has given momentum to investigate the causes and consequences of LULC by mapping and modelling landscape patterns and dynamics and evaluating these in the context of human-environment interactions in the rapidly transforming landscapes. Human induced environmental changes and consequences are not uniformly distributed over the earth. However their impacts threaten the sustenance of human-environmental relationships. Land cover refers to physical cover and biophysical state of the earth's surface and immediate subsurface and is confined to describe vegetation and manmade features. Thus land cover reflects the visible evidence of land cover of vegetation and non-vegetation. Land use refers to use of the land surface through modifications by humans and natural phenomena. Land use is characterized by the arrangements, activities and inputs people undertake in a certain land cover type to produce, change or maintain it. Alteration the structure of the landscape through large scale LULC has influenced the functioning of landscape, which include nutrient, regional water and bio-geo chemical cycles (Ramachandra et al., 2013).

Temporal remote sensing data offers aided an important means of in detecting and analysing changes occurring in the landscape. Remote sensing methods have been widely applied in mapping land surface features (Ramachandra et al., 2015). Spatial data acquired through satellite borne remote sensors offers a tremendous advantage over historical maps or air photos, as it provides consistent observations over a large geographical area, revealing explicit patterns of land cover and land use. It presents a synoptic and repetitive view of the landscape at low cost (Bharath, H.A., 2012, Ramachandra et al., 2012, 2014). Recent advancements in remote sensing technologies offer multi-resolution (spatial, spectral and temporal) datasets that are used to assess spatial structure and pattern of changes in the landscape. Spatial patterns of changes in the landscape is understood by analysis of land use changes. Human induced land use and land cover (LULC) changes have been the major driver of the landscape dynamics at local levels. Land use assessment was carried using the maximum likelihood classification technique. This method has already been proved as a superior method as it uses various classification decisions using probability and cost functions (Duda et al., 2000; Ramachandra et al., 2012, 2014). Analysis revealed an increase in vegetation cover in the study region.

Study area: Study area considered for analysis was Agastya foundation campus at Kuppam. The campus is located 12°48'30" to 12°49'41" N latitude and 78°14'56" 78°15'29"E longitude. The study region consisted of campus and 3.5km buffer from the campus boundary. This was considered to understand the regional landscape change influence. Study area is as shown in the Figure 1.

Data: Land use dynamics was analysed using temporal remote sensing data of the period 2000 to 2014. The time series spatial data of year 2000, 2006 and 2010 were acquired from Landsat Series Thematic mapper (28.5m) sensors. IRS P6 LISS4MX data for the year 2014 of resolution 5m was procured from the National Remote Sensing Centre (http://nrsc.gov.in), Hyderabad.

Survey of India (SOI) topographic maps of 1:50000 and 1:250000 scale were used to generate base layers (boundary, etc.) etc. Ground control points to register and geo-correct spatial data were collected using handheld pre-calibrated GPS (Global Positioning System), Survey of India Topographic maps (http://www.surveyofindia.gov.in) and online remote sensing data portals [Google earth, http://earth.google.com, BHUVAN http://bhuvan.nrsc.gov.in).

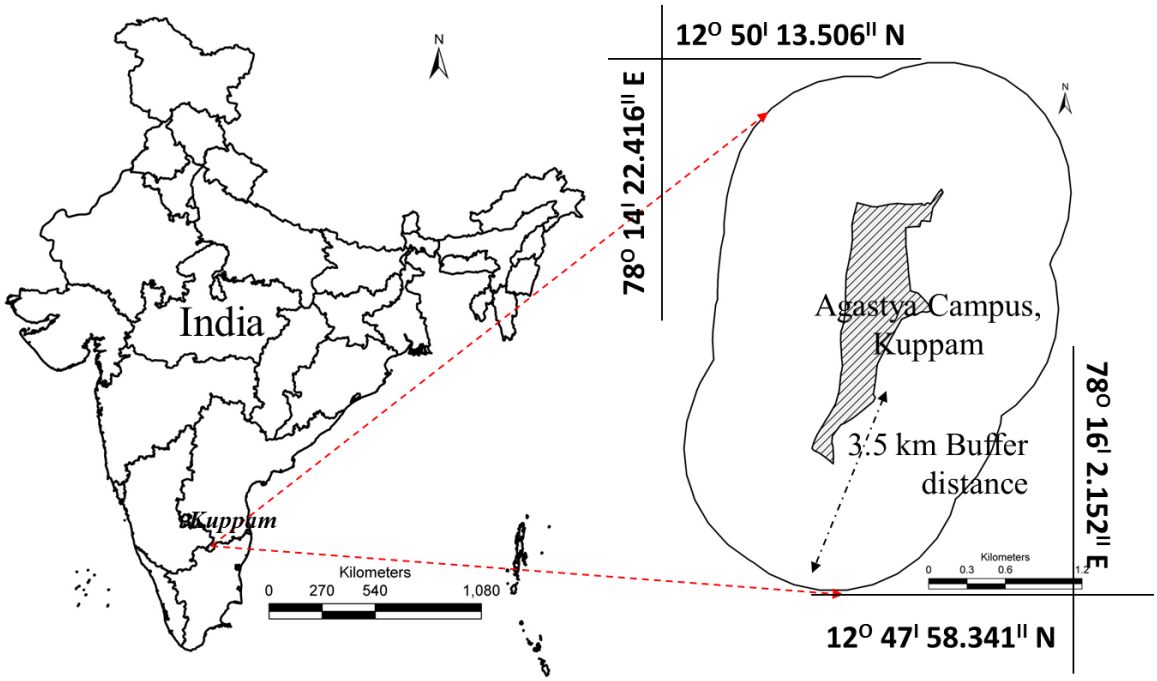

Figure 1: Study area Agastya foundation campus at Kuppam (with 3.5 km buffer)

Method: Assessment of land use dynamics involved:

- *Procuring spatial data* and compilation of collateral data (discussed in the earlier section)
- *Data pre-processing:* The remote sensing data obtained were geo-referenced, rectified and cropped pertaining to the study area. Geo-registration of remote sensing data (Landsat data) has been done using ground control points collected from the field using pre calibrated GPS (Global Positioning System) and also from known points (such as road intersections, etc.) collected from geo-referenced topographic maps published by the Survey of India and from online BHUVAN portal (http://bhuvan.nrsc.gov.in).
- *Preparation of False Colour Composite:* False colour composite (Figure 2) is the representation of earth features in their non-original colours, which facilitated identification of heterogeneous landscape elements (for geo-rectification and also training data collection). FCC is prepared by combination of spectral bands NIR, GREEN and RED bands.
- *Preparation of training data set:* training datasets (training polygons) required to classify the remote sensing data into various land use classes were compiled for various land use

categories based on the site knowledge [Field data, Topographic maps (the Survey of India), Google earth (http://www.googleearth.com), Bhuvan (http://bhuvan.nrsc.gov.in), and also considering spectral properties of landscape elements (from FCC). Training data is collected so as to cover at least 25% of the total area and spread uniformly across the study area.

Figure 2: False colour composite of the campus with 3.5 km buffer

- *Land use analysis using temporal satellite image:* Land use analyses were carried out using supervised pattern classifier - Gaussian maximum likelihood classifier (GMLC) for Landsat and IRS data. The method involved (Ramachandra *et al*., 2012): i) generation of False Colour Composite (FCC) of remote sensing data (bands – green, red and NIR). This helped in locating heterogeneous patches in the landscape ii) selection of training polygons (these correspond to heterogeneous patches in FCC) covering 25% of the study area and uniformly distributed over the entire study area, iii) loading these training polygons co-ordinates into pre-calibrated GPS, vi) collection of the corresponding attribute data (land use types) for these polygons from the field. GPS helped in locating respective training polygons in the field, iv) supplementing this information with Google Earth (latest as well as archived data), v) 60% of the training data has been used for classification, while the balance is used for validation or accuracy assessment. Land use was computed using the temporal data through open source program GRASS - Geographic Resource Analysis Support System (http://ces.iisc.ernet.in/grass). Land use categories include i) water bodies (lakes/tanks, rivers, streams, ii) built up (buildings, roads or any paved surface, iii) open spaces iv) vegetation cover (tree cover). Supervised pattern classifier based on Gaussian

maximum likelihood algorithm computes the mean and variance of digital numbers under each training data set, based on which unknown pixel is categorized under a land use class. Recent remote sensing data (2014) was classified using the training data collected from field using pre-calibrated GPS and online data portal. Classification of earlier time data, training polygon along with attribute details were compiled from the historical published topographic maps, vegetation maps, revenue maps, etc. Of the overall signatures, 65% of the total signatures are considered in classification of the image and 35% of the pure signatures are used for assessing the accuracy.

- *Accuracy assessment:* Accuracy assessment was done to check the integrity of classified data with reference to the reference data (either field data or collateral data). Statistical assessment of classifier performance based on the performance of spectral classification considering reference pixels is done which include computation of kappa (κ) statistics and overall (producer's and user's) accuracies. Kappa is estimated as a measure of agreement between the reference map and the classified map.

Results

Land use analysis: Temporal land use analyses considering remote sensing data of the period 2001 to 2014 were done as discussed in the methods section and results are presented in figure 3 and table 1. Figure 4 depicts the land cover in the region (based on temporal Google images). Land use analyses reveals of an increase in vegetation cover in the study region during 2001 to 2014. The data considered here are of January month (except 2006, April month). The increase in vegetation cover from 11.19 (2001) to 18.76 (2014)% is noticed mainly in the campus and immediate vicinity. Other category includes open area, open lands, cultivation fields, etc. The urban growth is specific to villages and some pockets in the campus. Shrinkage in water spread area highlights the need for watershed based interventions (ecological and engineering) to harvest rainwater and sustain water resources in the region.

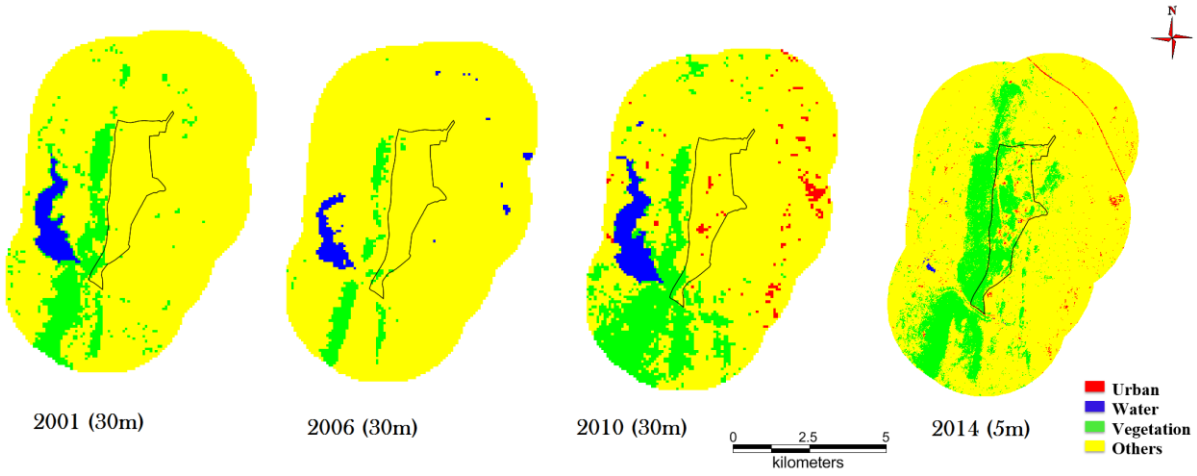

Figure 3: Land use dynamics in the study region - Agastya campus, Kuppam with 3.5 km buffer

	2001	2006 (April)	2010	2014
Urban	0.02	0.02	1.75	0.81
Water	2.9	2.1	3.99	0.09
Vegetation	11.19	4.13	16.67	18.76
others	85.89	93.75	77.58	80.33

Table 3: Category-wise land uses (%) in the study region - Agastya campus, Kuppam with 3.5 km buffer

Overall accuracy of the land use classification ranged from 86.4% (2000), 80.3% (2006), 96.2% (2010) and 93.34% (2014) with kappa of 0.82 (in 2000), 0.71 (2006), 0.92 (2010) and 0.91(2014) indicating that the classified information was comparable to the reference data (compiled from field study for validation).

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Figure 4: Google earth data reflecting land use dynamics in the study region.

2009 (May)

2011 (December)

2012 (April)

2013 (February)

4.0 Hydrology

Agastya foundation campus is located at Kuppam. Monthly rainfall variation is depicted in figure 1. The region receives about 626 mm annual rainfall and mostly during north eastern monsoon.

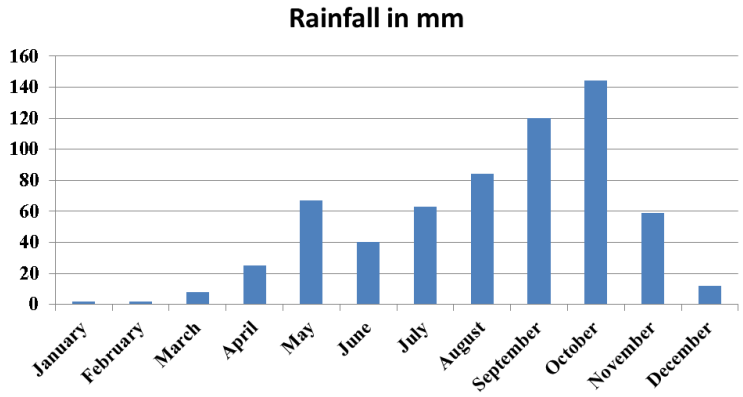
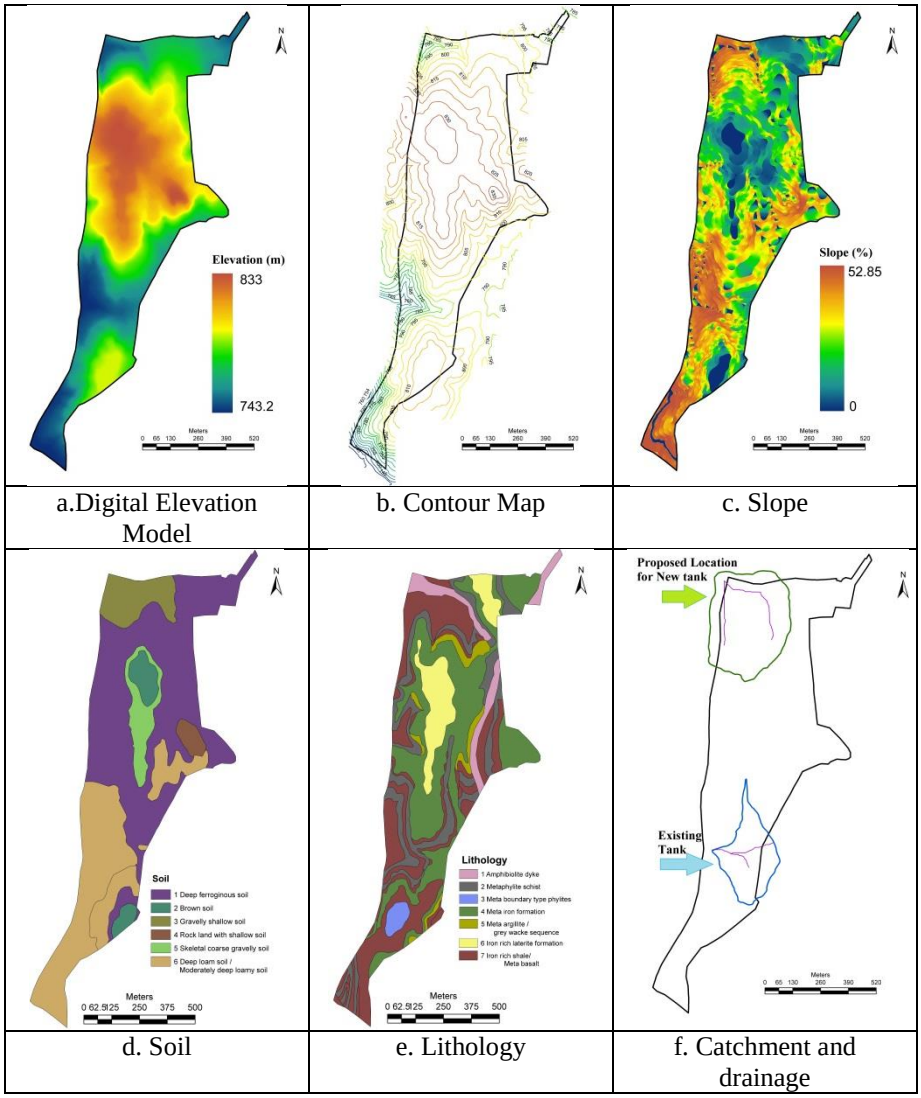


Figure 1. Rainfall dynamics in Agastya Foundation

The digital elevation model (figure 2a) was developed using the contour information (figure 2b) provided by Agastya foundation. Figure 2c depicts the slope variation based on the digital elevation model generated using CARTOSAT 2.5 m spatial resolution data. This aided in order to delineate the stream network. Figure 2d depicts the soil profile and Figure 2e gives the lithological details of the campus. Integration of these spatial data aided in the identification of locations (Figure 2f) suitable for optimal harvesting of rainwater. This also helps in addressing water stress in the campus during post monsoon. Among these two locations, lake/tank already exists in the campus behind discovery center (near the Karnataka border). The catchment of this lake is about 8.03 Ha (19.85 acre), with catchment yield of about 25 million liters. A new lake is proposed across two streams that connects near the north western boundary. This lake will have catchment area of 16.05 Ha (36.68 acre), with yield of 50 million liters (with an annual rainfall of 320 mm). Table 1 provide the information of different depths of the tank with water holding capacities.

Table 1: Volumetric storage in relation with bund height

FRL	Depth (m)	Surface Area(sq.m)	Volume (cum)
775.25	0.00		0.00
777.5	1.75	76.05	42.19
780	4.25	161.02	847.13
782.5	6.75	2736.89	6213.52
785	9.25	4226.2	14062.23
787.5	**11.75**	**6275.38**	**26562.52**
790	14.25	9291.98	43930.35



a.Digital Elevation Model	b. Contour Map	c. Slope
d. Soil	e. Lithology	f. Catchment and drainage

Figure 2: Topography

Proposed lake/tank in the campus:

- The sub surface is gravelly, and drains of water easily, it is recommended to use clay soil for pitching up to the FRL with minimal thickness over 25 to 30mm, compacted and supported by grasses (the same can be made for all the ponds in the campus in order to avoid seepage of water to the substrata).
- Depth of about 11 m would have storage capacity of 26 Million liters.
- Slope of the shore could be 1:100 and with grass turfing to enhance hydrological function of the shore
- Riparian vegetation of native species helps (mix of shrubs and tree species suitable for aquatic ecosystems) in rejuvenating water sources.
- Watershed based approach with plating of native species of grass, shrub and trees in the catchment would aid in the infiltration of water as well as retaining of water.
- RCC based arch dam (instead of earthen gravity dam) taking advantage of valley (for the existing lake same could be followed).

5.0 STATUS OF LAKES AROUND AGASTYA FOUNDATION CAMPUS, KUPPAM

SUMMARY

Wetlands are vital productive freshwater resources on the Earth. They help in maintaining the ecological balance of the region. They have numerous valuable functions such as recycling of nutrients, purify water, attenuate floods, maintain stream flow, maintaining microclimate of the region, recharge ground water and also serve in providing drinking water source, fish, fodder, fuel, recreation to the society The stability of wetlands depends upon the balance between production and consumption of energy and matter at different trophic levels present in the system. The present study was done to understand the status of the lake ecosystems, which are located around Agastya Foundation campus at Kuppam. The physico-chemical and biological composition of the lakes were studied using standard protocols. The water quality of the studied lakes was found to be good with less nutrient content and organic matter. Presence of filamentous algal species and floating and submerged macrophytes species further confirms of a healthy ecosystem.

INTRODUCTION

Wetlands (and lakes) constitute the most productive ecosystems with a wide array of goods and services. These ecosystems serve as life support systems; serve as habitat for a variety of organisms including migratory birds for food and shelter. They aid in bioremediation and hence aptly known as 'kidneys of the landscape'. Major services include flood control, wastewater treatment, arresting sediment load, drinking water, protein production, and more importantly recharging of aquifers apart from aiding as sinks and climate stabilizers. The wetlands provide a low cost way to treat the community's wastewater, while simultaneously functioning as wild fauna sanctuary, with public access. These ecosystems are valuable for education and scientific endeavours due to rich biodiversity. Wetlands help in maintaining the ecological balance of the region. Wetlands, natural and manmade, freshwater or brackish, provide numerous ecological services. They provide habitat to aquatic flora and fauna, as well as numerous species of birds, including migratory species. The density of birds, in particular, is an indication of the ecological health of a particular wetland. Wetlands also provide freshwater for agriculture, animal husbandry, and domestic use, drainage services, and provide livelihoods to fisher-folk. Larger wetlands may also comprise an important resource for sustainable tourism and recreation.

Wetlands are transition zones on earth that plays a major role in nutrient dynamics and governs the primary productivity. They have numerous valuable functions such as recycle nutrients, purify water, attenuate floods, maintain stream flow, maintaining microclimate of the region, recharge ground water and also serve in providing drinking water source, fish, fodder, fuel, recreation to the society (Kiran and Ramachandra, 1999).

The stability of wetlands depends upon the balance between production and consumption of energy and matter at different trophic levels present in the system. The trophic structure includes various trophic levels as producers (algae, bacteria), primary consumers (zooplanktons and grazers), secondary consumers (small fish), tertiary (large fish, birds, etc.). Algae being the primary producers, synthesize carbohydrates during photosynthesis and releases oxygen as a major end product. The CO_2 released in large amounts gets transformed into algal biomass. This reduces GHG (Greenhouse gases) in the environment and thus, helps to combat global warming. Thus, the trophic structure and material exchange in wetlands plays a major role (Ramachandra et al., 2014). The interaction of man with wetlands during the last few decades has been a concern largely due to the rapid population growth accompanied by intensified industrial, commercial and residential development, further leading to pollution of wetlands by domestic, industrial wastewaters and agricultural runoffs as fertilizers, insecticides, and feedlot wastes (Kiran and Ramachandra, 1999). The dumping of solid waste in the catchment of lakes and or sustained inflow of partially or untreated wastewater leads to enrichment of nutrients, leading to adverse health impacts and reduction in the ecological and environmental services. The study was done to understand the status of lakes, which are located in and around Agastya Foundation campus at Kuppam.

OBJECTIVE: Objective of the current investigation is to assess the physico-chemical and biological composition of lakes within 2 km boundary of Agastya Foundation campus at Kuppam.

MATERIAL AND METHODS

Study area: Agastya Foundation campus is situated at Gudivankaat the intersection of three rapidly developing Southern states, Andhra Pradesh, Karnataka and Tamil Nadu.The present study was carried out at 4 lakes (Neradi, Chinnakere, Checkdam and Atinattam) which are situated in the buffer zone within 2 km from boundary of Agastya Foundation (Figure 1 and 2).

Analysis of physico-chemical parameters: The water temperature, pH, electrical conductivity (EC) and dissolved oxygen (DO) were determined on spot at the time of sampling. Other parameters like nitrate, phosphate, total alkalinity, calcium hardness, total hardness, chlorides, COD (Chemical oxygen demand), sodium and potassium were analysed in the laboratory by using standard methods prescribed by Trivedi and Goel (1986) and APHA (1998)(Table1).

Macrophyte collection and identification: Macrophyte samples were collected and washed to get rid of adhering materials. They were identified using Cook CDK (1996).

Analysis of phytoplankton: The algal species were identified based on their key morphological features, according to Prescott (1954), Desikacharya (1959).

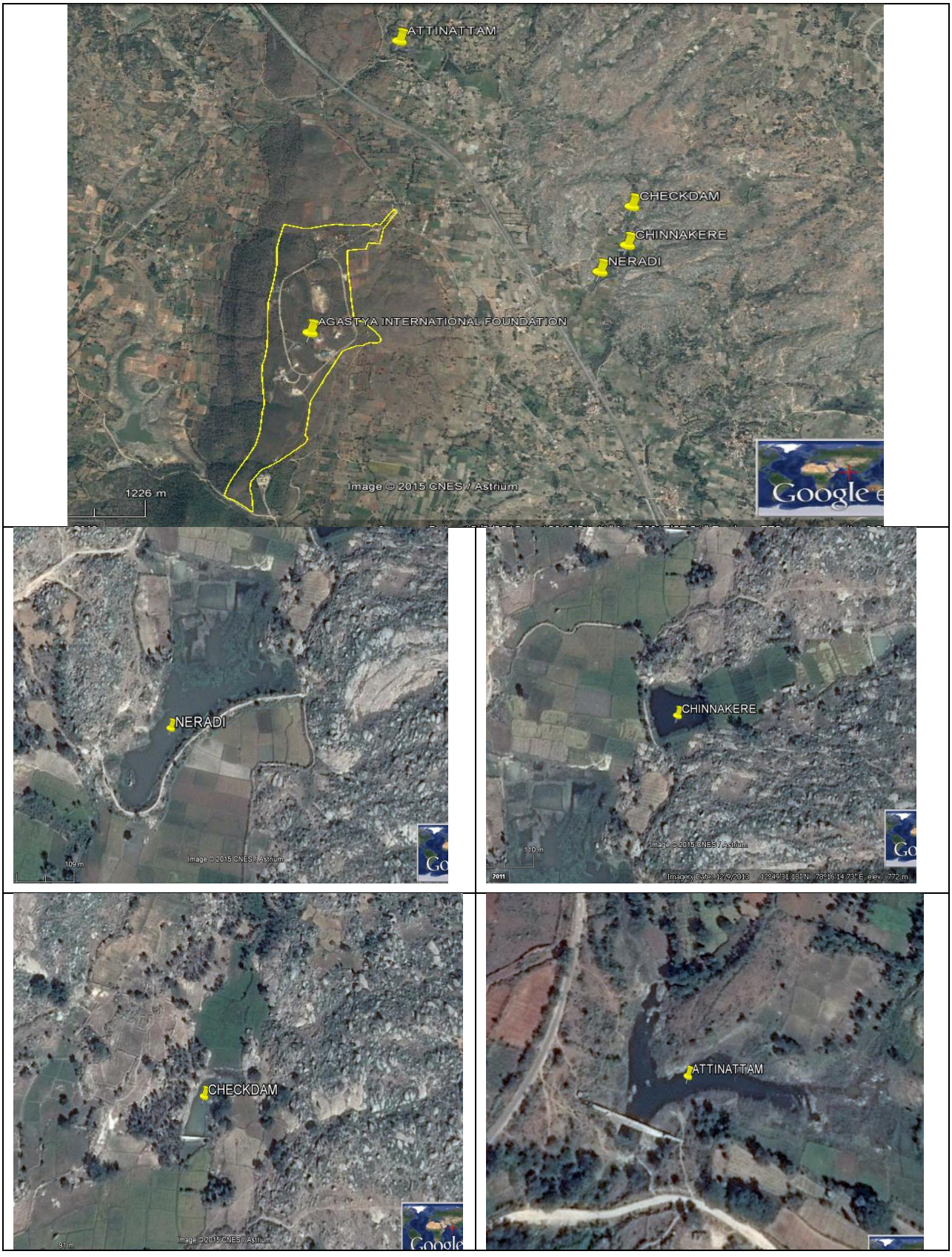

ATTINATTAM
CHECKDAM
CHINNAKERE
NERADI
AGASTYA INTERNATIONAL FOUNDATION
1226 m
Image © 2015 CNES / Astrium
Google
NERADI
CHINNAKERE
CHECKDAM
ATTINATTAM

Figure 1: Google map showing the study area with studied lakes

Figure 2: Studied lakes

Table 1: Standard methods followed for water quality analysis

Parameters	Methods	Reference
Onsite Measurements		
pH	Probe	(Eutech pH 110)
Electrical Conductivity (µS)	Probe	(Eutech pH 110)
Total Dissolved Solids (mg L^{-1})	Probe	(Eutech pH 110)
Dissolved Oxygen (mg L^{-1})	Probe	(APHA, 4500-O B)
Turbidity (NTU)	Probe	(2100P HACH Turbidimeter)
Laboratory Measurements		
Chemical Oxygen Demand (mg L^{-1})	Closed Reflux, Titrimetric Method	(APHA, 5220 C)

Biological Oxygen Demand (mg L^{-1})	5-Day BOD Test	(APHA, 5210 B)
Alkalinity (mg L^{-1})	HCl Tritrimetric Method	(APHA, 2320 B)
Calcium Hardness (mg L^{-1})	EDTA Titrimetric Method	(APHA, 3500-Ca B)
Total Hardness (mg L^{-1})	EDTA Titrimetric Method	(APHA, 2340 C)
Chlorides (mg L^{-1})	Argento metric Method	(APHA, 4500-Cl- :)
Sodium (mg L^{-1})	Flame Emission Photometric Method	(APHA, 3500-Na B)
Potassium (mg L^{-1})	Flame Emission Photometric Method	(APHA, 3500-K B)
Phosphates (mg L^{-1})	Stannous Chloride Method	(APHA, 4500-P D)
Nitrates (mg L^{-1})	Phenol Disulphonic Method	NEERI (1988)

Table 2: Onsite Parameters

	NERADI	CHINNANAKERE	CHECKDAM	ATTINATTAM
AT(°C)	24	24	26.1	26
WT(°C)	23.5	25	25.2	25.5
TDS(mg/l)	66	96	105	217
pH	7.6	7.2	7.42	7.45
EC(µS)	151	222	232	426
ORP(mV)	112	120	118	109
Turbidity(NTU)	12	6	36	5
DO(mg/l)	9.52	5.48	9.84	6.13
GPS	12.82297N, 78.26844E	12.82538N, 78.27047E	12.82717N, 78.27091E	12.83854N, 78.25774E

Table 3: Offsite Parameters

	PHOSPHATE (mg/l)	NITRATE (mg/l)	COD (mg/l)	BOD (mg/l)	CHLORIDES (mg/l)	ALKALINITY(mg/l)	TH (mg/l)	CH (mg/l)	Na (mg/l)	K (mg/l)
NERADI	0.32	0.65	4	10.08	17.89	120	24.8	6.09	36.4	0.4
CHINANKERE	0.26	0.64	12	3.02	18.46	158	33.2	8.82	53.6	1.2
CHECKDAM	0.29	0.73	28	8.06	19.31	192	42	11.7	60	0
ATTINATTAM	0.28	0.63	12	2.02	36.35	208	140	36.55	64.4	1.2
TAP WATER	0.23	0.62	4	5.04	79.52	478	580	136.27	73.6	6

RESULTS AND DISCUSSION

Physico-chemical parameters of lake

Temperature: It is an important factor for aquatic life as it regulates the maximum dissolved oxygen concentration of the water, controls the rate of metabolic activities, reproductive activities and therefore, life cycles. The temperature of studied lakes ranges between 23.5^{0}C (Neradi) to 25.5^{0}C (Attinattam).

Dissolved Oxygen: Dissolved oxygen (DO) is the most essential feature in aquatic system that helps in aquatic respiration as well as detoxification of complex organic and inorganic mater through oxidation. The presence of organic wastes imposes a very high oxygen demand on the receiving water leading to oxygen depletion with severe impacts on the water ecosystem. The effluents also constitute heavy metals, organic toxins, oils, volatile organics, nutrients and solids. The DO of the analysed water samples varied between 5.48 to 9.84mg/l. As per IS 2296 the minimum DO for irrigation, fish culture etc. is 4 mg/l and for outdoor bathing 5 mg/l. The analysed water samples had DO higher than 5 mg/l and suitable for outdoor bathing and irrigation.

Electrical Conductivity (EC): EC is the measure of the ability of an aqueous solution to convey an electric current. This ability depends upon the presence of ions, their total concentration, mobility, valence and temperature. The EC varied from 150 to 426 µS.

pH: pH is a numerical expression that indicates the degree to which water is acidic or alkaline, with the lower pH value tends to make water corrosive and higher pH provides taste complaint and negative impact on skin and eyes. The pH value ranged from 7.2 to 7.6. The desirable range for pH as per IS 2296 is 6.5-8.5. The studied lakes found to be within this range.

Turbidity: Clarity of water is a very important aspect for human consumption. Turbidity in water is caused by suspended and colloidal matter such as clay, silt, finely divided organic and inorganic matter, plankton and other microscopic organisms, waste discharge and sediments from erosion. The maximum permissible limit of turbidity as per BIS and World Health Organization (WHO) is 5 NTU. Turbidity values ranged from 5 to 36 NTU in most of the samples. The maximum turbidity of 36 NTU was in check dam due to presence of algae and dissolved silt matter.

Total Dissolved Solids (TDS): TDS affect the water quality in myriad of ways impacting the domestic water usage for cleaning, bathing etc. as well as drinking purposes. Total dissolved solids originate from organic sources such as leaves, silt, plankton, industrial waste and sewage. Other sources come from runoff from urban areas, road salts used on street, fertilizers and pesticides used on lawns and farms [APHA, 1995]. Surface as well as groundwater with high dissolved solids are of inferior flavor and induce an unfavorable physiological reaction to the dependent population. A limit of 500 ppm TDS is desirable for drinking waters. The TDS values in the samples analysed, ranged from 66 to 217ppm across all locations. This shows that there are less contamination in these lakes.

Chlorides: Chlorides are essentially potential anionic radicals that imparts chlorosity to the water. An excess of chlorides leads to the formation of potentially carcinogenic and chloro-organic compounds like chloroform, etc. Excess of chloride in inland water is usually taken as index of pollution. Chloride values in samples ranged from 17 to 79ppm. The desirable range for chlorides as per IS 2296 is 250 mg/l. In addition to the adverse taste effects, high chloride concentration

levels in the water contribute to deterioration of domestic plumbing, water heaters and municipal water works equipment.

Sodium: Sodium (Na) is one of the essential cations that stimulate various physiological processes and functioning of nervous system, excretory system and membrane transport in animals and humans. Increase of sodium ions has a negative impact on blood circulation, nervous coordination, thence affecting the hygiene and health of the nearby localities. According to WHO guidelines the maximum admissible limit is 200 ppm. In this study the concentration of sodium ranged from 36- 73ppm.

Potassium: Potassium (K) is an essential element for both plant and animal nutrition, and occurs in ground waters as a result of mineral dissolution, decomposing of plant materials and also from agricultural runoff. Potassium ions in the plant root systems helps in the cation exchange capacity to transfer essential cations like Ca and Mg from the soil systems into the vascular systems in the plants in replacement with the potassium ions. Incidence of higher potassium levels in soil system affects the solute transfer (active and passive) through the vascular conducting elements to the different parts of the plants. The potassium content in the water samples ranges between 0-6ppm.

Alkalinity: Alkalinity is a measure of the buffering capacity of water contributed by the dynamic equilibrium between carbonic acid, bicarbonates and carbonates in water. Sometimes excess of hydroxyl ions, phosphate, and organic acids in water causes alkalinity. High alkalinity imparts bitter taste. The acceptable limit of alkalinity is 200 ppm. The lake water samples analysed were having lower alkalinities (120-208 mg/l) because of higher acidic environment in the soil systems. The tap water showed high alkalinity of 478 mg/l.

Total hardness: Hardness is the measure of dissolved minerals that decides the utility of water for domestic purposes. Hardness is mainly due to the presence of carbonates and bicarbonates. It is also caused by variety of dissolved polyvalent metallic ions predominantly calcium and magnesium cation although, other cations like barium, iron, manganese, strontium and zinc also contribute. In the present study, the total hardness ranged between 24 to 140 mg/l.Only the tap water had highest hardness of 580mg/l. According to WHO guidelines the maximum admissible limit is 300 ppm.

Calcium: Calcium (Ca) is one amongst the major macro nutrients which are needed for the growth, development and reproduction in case of both plants and animals. The presence of Ca in water is mainly due to its passage through deposits of limestone, dolomite, gypsum and other gypsi-ferous materials. Caconcentration in all samples analysed periodically ranged between 6 to 136ppm.

Nutrients (nitrates and phosphates): Nutrients essentially comprise of various forms of N and P which readily dissolve in solutions that are up-taken by microbes and plant root systems in the form of inorganic mineral ions. Phosphate occurs in natural water in low quantity as many aquatic

plant absorb and store phosphate many times their actual immediate needs. Accumulation of N as nitrates and P as inorganic P in aquatic ecosystems causes significant water quality problems due to higher net productivity. Together with phosphorus, nitrates in excess amounts in streams and other surface waters can accelerate aquatic plant growth causing rapid oxygen depletion or eutrophication in the water. Nitrates at high concentrations (10 mg/l or higher) in surface and groundwater used for human consumption are particularly toxic to young children affecting the oxygen carrying capacity of blood cells(RBC)causing cyanosis (methemoglobinemia). In the present study, nitrate values ranged from 0.62 to 0.73 ppm and phosphate values ranged between 0.23 to 0.32 ppm. The desirable limits as per IS 10500 for nitrates is 45 mg/l.

COD and BOD: BOD and COD are important parameters that indicate the presence of organic content.

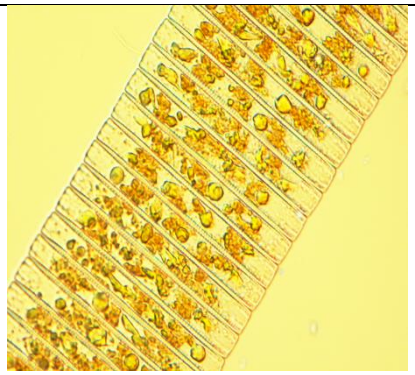
- ***Biochemical oxygen demand (BOD):*** Biochemical oxygen demand (BOD) is the amount of oxygen required by bacteria while stabilizing decomposable organic matter under aerobic conditions. Sources of BOD include leaves and woody debris; dead plants and animals; animal manure; effluents from pulp and paper mills, wastewater treatment plants, feedlots, and food-processing plants; failing septic systems; and urban storm water runoff.It is required to assess the pollution of surface and ground water where contamination occurred due to disposal of domestic and industrial effluents. The BOD ranged between2 and 10.08 mg/l.
- ***Chemical oxygen demand (COD):*** COD is important parameter that indicates contamination with organic wastes. Chemical oxygen demand (COD) determines the oxygen required for chemical oxidation of most organic matter and oxidizable inorganic substances with the help of strong chemical oxidant. COD test is helpful in indicating toxic conditions and the presence of biologically resistant organic substances. In this study the COD values ranged from 4-28 mg/l.

Algal species found in lakes: The dominant algal species found in the lakes were given in table. The lakes were dominated by filamentous algae like *Nitella, Chara, Spirogyra,* etc.

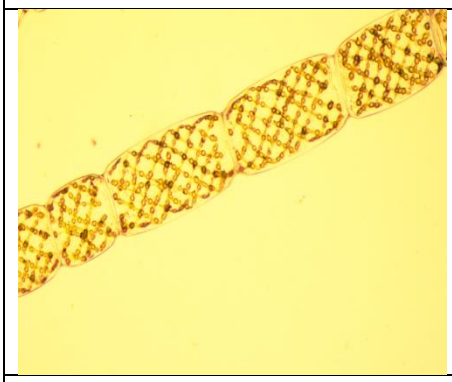
Table 4: Algal species found in the lakes

Algae	Neradi	Chinnankere	Checkdam	Attinattam
Chara spp.	+	+		
Nitella sp.	+	+		
Spirogyraspp	+	+		+
Oscillatoria	+	+		
Stigeocloniumsp		+	+	
Desmidium				+
Nitzschiasp			+	
Lyngbyasp	+		+	
Synedrasp			+	+

Oscillatoria



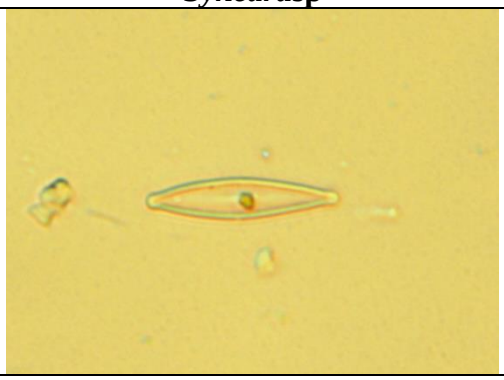
Desmidium



Spirogyra

***Lyngbya*sp**

***Synedra*sp**



***Nitzschia*sp**

Figure 3: Dominant algae present in the lakes (images not to scale)

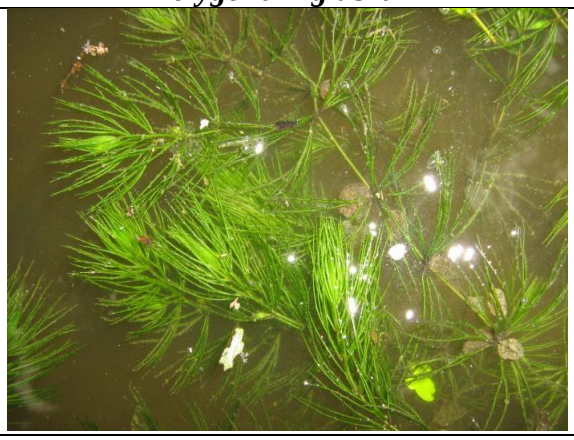
Macrophyte diversity

Macrophytes, the aquatic macroscopic plants confine themselves to the shallow euphotic zone of the water bodies. In the littoral zone, macrophytes are the chief exploiters of plant nutrients from the sediments, which otherwise, are lost temporarily from the water. The nutrients so logged in the body material are released only after death, decay and subsequent mineralization, thus, they play a role in nutrient dynamics and primary productivity of shallow systems. Therefore, seasonal growth rate patterns and population dynamics of macrophytes are very important. When there is enough room for colonization and abundant availability of nutrients, macrophytes show a high growth rate. They assimilate nutrients directly into their tissues.

There were mainly 11 species found in the lake. *Polygonum glabrum, Potomogetan natans, Cyperus*sp1,*Cyperus sp2, Nymphaea sp, Hydrilla verticillata, Ceratophyllum demersum, Ipomea carnea, Alternanthera philoxeroides*were the main macrophyte species found in the lakes. *Potomogetan natans, Hydrilla and Ceratophyllum* were the dominant macrophytes present in the lake. Thus the lakes mainly consisted submerged and floating macrophyte species. Emergent and invasive species of macrophytes were absent in the studied lakes. This indicates that the quality of water is good.

Polygonum glabrum

Potomogetan natans



Ceratophyllum demersum

Hydrilla verticillata

Nymphaea sp

Alternanthera

Ipomea carnea

***Cyperus* sp1**

Cyperus sp2

Figure 4: Major macrophytes found in the lakes

CONCLUSION

The physico-chemical and biological composition of the lakes were studied using standard protocols. The water quality of the studied lakes was found to be good with less nutrient content and organic matter. The lakes consisted of filamentous algal species and floating and submerged macrophytes which also indicates a healthy ecosystem.

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6.0 Prospects of Renewable Energy in Agastya Foundation campus, Kuppam

Energy is essential for economic and social development of a region or a nation. However, consumption of fossil fuels is the major cause of air pollution and climate change. The threat posed to sustainability by greenhouse gas emissions and deterioration of the natural resource base (for example oil crisis, Fuel wood scarcity, etc.) has caused worldwide concern. Improving energy efficiency and de-linking economic development from energy consumption (particularly of fossil fuels) is essential for sustainable development of a region. The energy sector, on one hand, is a part of the economy and on the other hand it itself consists of parts such as energy supply and energy demand interacting with each other. Both these interactions are of immense complexity. Energy is required for all the economic activities. Energy supplies are essential for both intermediate production as well as final consumption. So, economic development is dependent on the energy system of the country. In turn, the implementation of technologies or improvement of the energy system is dependent on economic factors such as capital costs, energy prices etc. Also, the demand supply balances involve the flow of energy from source as primary energy to service as useful energy. At each stage of the energy flow, technologies are involved with different conversion efficiencies and losses

India has abundant renewable energy resources such as solar, wind, biomass, etc. which are environmentally benign and can effectively meet energy demand. About 5200 MW of power generating capacity based on renewable energy sources has been installed in the country so far, which constitutes about 3.8% of the total installed capacity. The effective transition from a fossil fuel driven energy system to the renewable energy systems is possible only through the policy shift, capacity building, strengthening institutions and building infrastructure. There is a need for strengthening of existing research institutions and creation of a few centers of excellence that have state of the art research / testing facilities for renewable energy technologies.

Centralised energy planning exercises cannot pay attention to the variations in socio-economic and ecological factors of a region which influence success of any intervention. Decentralised energy planning advocated these days is in the interest of efficient utilisation of resources, ensuring more equitable sharing of benefits from development. The regional energy planning endevaour needs to focus on the area based decentralised energy plans for meeting energy needs for subsistence and development with least cost to the environment and the economy. The regional planning mechanisms take into account all resources available and demand in a region. This implies that the assessment of the demand and supply, and the intervention in the energy system which may appear desirable due to such exercises, must be at a similar geographic scale. For example, bioresource assessment of supply and demand at the aggregate level is likely to be misleading as scarcity and surplus is always at a localised level. Consequently, the energy interventions in the form of energy supply enhancement, containing demand and/or encouraging alternative fuels may be aimed at the wrong area or target group.

India's present energy scenario calls for the effective management of all available resources in order to attain national objectives. A well-balanced fuel mix, in which all energy resources are appropriately utilized, is essential for sustainable development. An energy resource that are renewed by nature and whose supply is not affected by the rate of consumption is often termed as renewable energy. Planned interventions to reduce energy scarcity can take various forms, such as

1. energy conservation through promotion and use of energy efficient stoves for cooking and water heating, compact fluorescent and LED bulbs in place of ordinary incandescent bulbs,
2. supply expansions of bio-resources through agroforestry, farm forestry and community forestry, and
3. alternatives—renewable sources of energy such as micro/ mini/small hydropower plants and wind, solar and biomass- based systems

Ecologically sound development of the region is possible when energy needs are integrated with the environmental concerns at the local and global levels. Energy planning entails preparation of area based decentralised energy plans for meeting energy needs for subsistence and development with least cost to the environment and the economy. The need to search for renewable, alternate and non-polluting sources of energy assumes top priority for self-reliance in the regional energy supply. This demands an estimation of available energy resources spatially to evolve better management strategies for ensuring sustainability of resources. The spatial mapping of availability and demand of energy resources would help in the integrated regional energy planning through an appropriate energy supply - demand matching.

Insights to Renewable Energy harvesting in the campus of Agastya Foundation, Kuppam

The electric energy requirement in Agastya Foundation is mainly for lighting the roads and buildings (lighting, fans, computers, projectors and for the operation of science models). Most of the loads in the organisation are low power loads and heating loads (met by solar water heaters). Sustained supply of electricity to meet the demand in the campus is possible by harvesting renewable sources through appropriate technologies. Source wise renewable energy potential assessment is done to recommend suitable renewable energy harvesting technologies.

Solar energy: Kuppam being in arid region receives abundant solar energy throughout the year. Agastya campus at Kuppam receives cloud free solar irradiance for over 7 months, which can be harvestedfor thermal and electric energy requirements in the campus. Figure 1 gives the monthly variation of solar insolation in the region. The region receives insolation over 6 kWh/m^2/d during summer (February to May) which reduces in monsoon and winter.

The region receives highest insolation of 6.51 kWh/m^2/d during March whereas lowest is observed in November (4.17 kWh/m^2/d). The average solar insolation in the region is about 5.16

kWh/m^2/d. This potential is adequate to generate heat and electric energy to meet domestic energy demand [1].

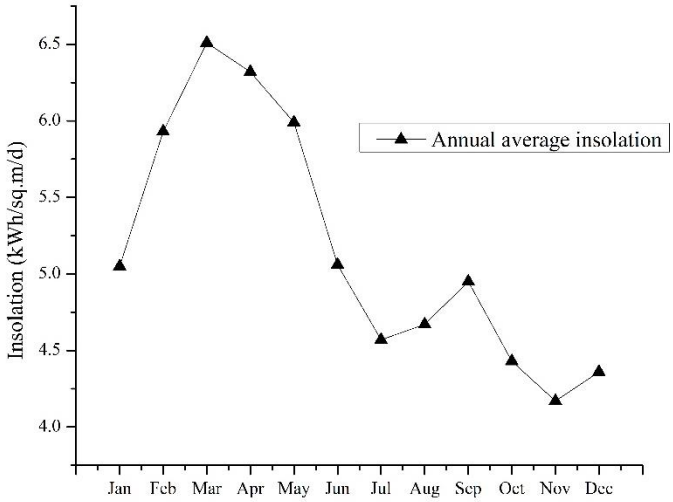


Figure 1: Monthly variation in solar insolation

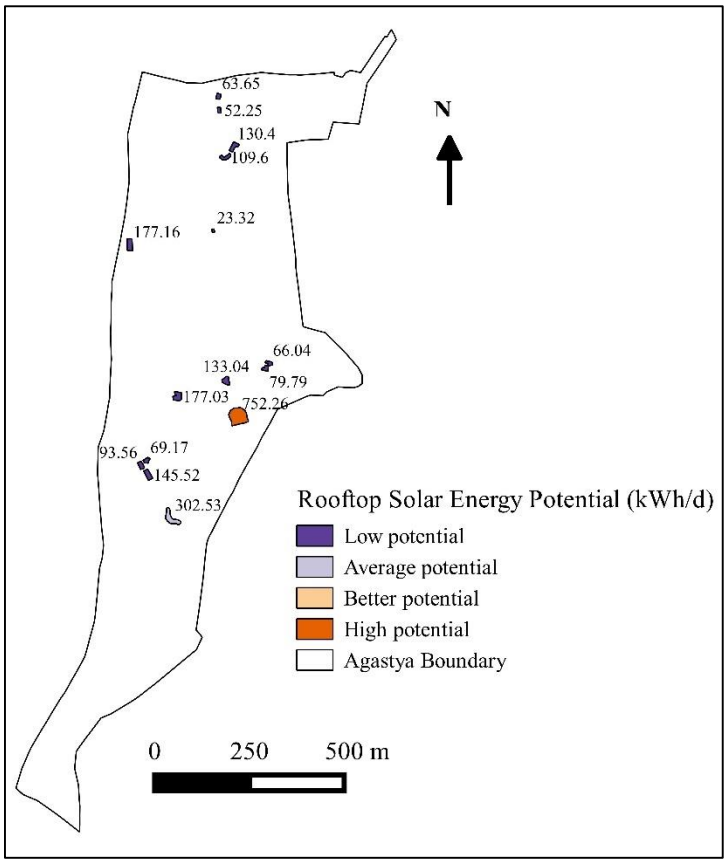


Figure 2: Harvestable rooftop electricity potential from SPV installation

The organisation has buildings (such as guest house, labs, workshop, auditorium etc.)with reinforce concrete flat roofs. Most of these buildings require electricity during day time except guest houses where the electricity is mainly used for lighting, fans and computer operation. Similar loads are found in guest houses where the operation is mostly during evening and night. Rooftop mounted solar photovoltaic (SPV) systems can conveniently meet the electricity demand in both scenarios [2]. Figure 2 shows the daily harvestable electricity from every rooftop in the organisation (at η=10% and 80% of the roof area), which have been classified into 4 categories (high, better, average, low). In this study, the analysis shows that the building with higher spatial extent roof area generates higher electricity since 80% of the area is considered for PV panel installation. However, area of installation is directly proportional to the energy generation with same efficiency and irradiation.

The auditorium has the highest roof area which has the potential to generate about 750 kWh of electricity every day while lowest is found to 23 kWh/day. Nevertheless, all buildings can be self-reliant of electricity by SPV installation in a fraction of rooftop area [3].

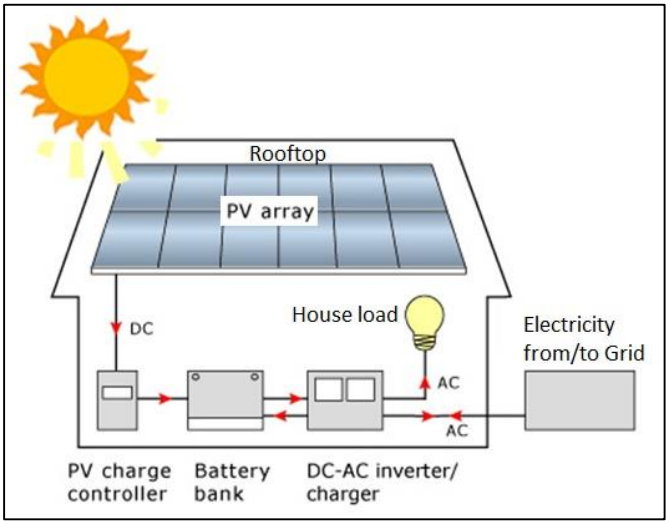


Figure 3: Rooftop solar PV technology

Figure 3 illustrates the installation and grid connection of rooftop SPV system. The electricity generated can be directly used in the building and the extra energy can be exported to the grid. Most of the states and also Ministry of New and Renewable Energy are encouraging solar PV installation through feed in tariff and providing generation based incentives (GBI) [4]. The return on investment mill be higher with supplying unused electric energy to electricity supply companies. Rid connected systems do not require energy storage devices (batteries) which reduces the capital and maintenance cost. The rooftop systems for guest houses may require batteries since lights, fans etc. can be used after sunset.

Typical solar rooftop system for Parijata guest house: Table 1 shows the typical rooftop solar PV system which can be installed in the guest house. Capital cost and technical specification to the load of one room is computed which can be deduced to any number of rooms and estimation holds good for other guest house in the organisation.

Table 1: Techno-economic specifications of Rooftop SPV system

Component	**Specification**	**Cost (INR)**
Electric Load per room	2 Fans + 2 CFL/LED Lamps = (80*2) + (15*2) = 160 + 30= 190 (200 W)	
Hours of usage	6 hours (full load)	
Total energy required	200*6= 1.2 kWh	
Battery capacity	200 Ah (Inverter efficiency = 90%, battery efficiency = 85% and depth of discharge = 70%)	~ 20,000 (10,000 per 100 Ah, 2 batteries)
PV Panel	600 W_p	42,000 – 45,000 (3 panels of 200 W_p each)
Inverter	250 VA	5000-8000
Roof area required	1.5m^2 for each panel. (4.5 m^2 for 3 panels or per room)	
Total cost	Approximately 75,000 excluding fitting, mounting and labour costs.	

Solar Street light is one of the applications of SPV system which helps to provide light to remote locations. Agastya organisation has already installed few solar street lights (and few of them were non-functional). Battery is an important component of the solar street light system which needs regular maintenance and observation. It must be placed in a water proof dry container and shielded from dust, moisture and insects. Distilled water level in the battery should be checked once in 3-4 month and complete charge drain (or over changing) be avoided to enhance the life of these batteries. Panels shall be cleaned regularly since dust accumulation and bird droppings are common. Regular maintenance and servicing will enhance the lifespan with higher conversion efficiencies.

Wind energy scenario: Region has a lower average wind speed which less than 2.5 m/s in most of the months. During June and July region experiences higher wind speed of over 3 m/s. Figure 4 gives the monthly variation in wind power density in Agastya foundation region. The wind power density ranges from 3.64 W/m^2 (October) to 20.5 W/m^2 (June) in the region. It shows that,

low speed vertical axes wind turbines are feasible for small capacity electricity generation, which may be integrated with solar PV systems.

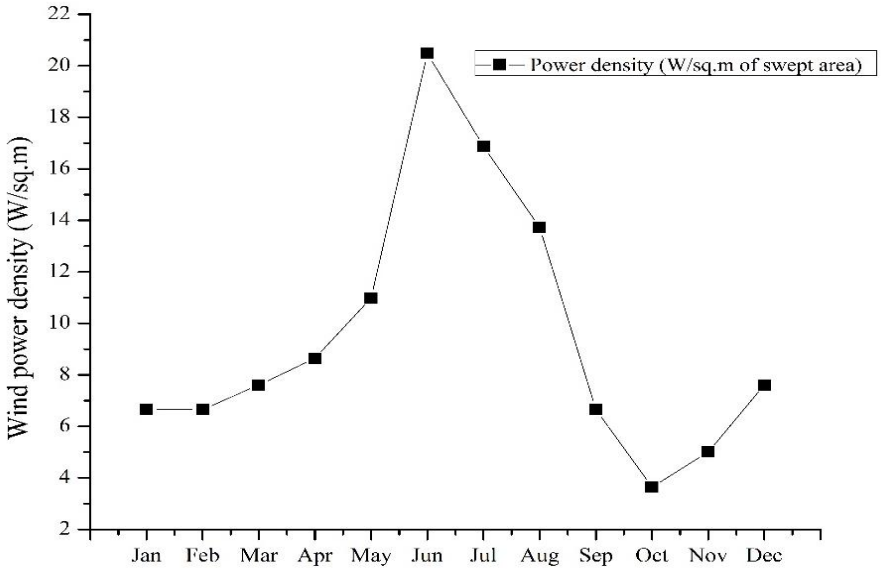


Figure 4: Variation in wind power density

Wind energy conversion systems

Wind Energy Conversion System (WECS) uses wind to convert mechanical energy into electrical energy. Main components of WECS are blades, gears, turbine, a generator and a pillar to mount all the equipment at the required height. Wind potential assessment is a prominent pre-installation procedure to assure perfect selection of a site to harness maximum energy.

Power generated by the wind turbine is directly proportional to the cube of the wind speed and swept area. Maximum power obtained from any WECS is limited to 59.3% of the total kinetic power available in wind which is given by Betz constant (C_p). Power harnessed by WECS can be obtained using the expression given below [5];

$$P_{avail} = (1/2)*\rho*A*V^3*C_p \quad (3)$$

where, P_{avail} – wind power, ρ – air mass density, A – swept area (area of wind flow), V – wind velocity and C_p – Betz constant (maximum = 59.3%) assumed as 0.4 (40%).

Table 2: Available small-scale wind turbines [6]

Rated power, P_{rated} (kW)	**Rotor swept area (m^2)**	**Sub-category**
P_{rated} < 1 kW	A < 4.9 m^2	Pico wind
1 kW < P_{rated}< 7 kW	A < 40 m^2	Micro wind
7 kW < P_{rated}< 50 kW	A < 200 m^2	Mini wind
50 kW < P_{rated}< 100 kW	A < 300 m^2	(Not defined)

Bioenergy prospects

Agastya foundation is spread over 172 acres which mainly has scrub/grass land with few trees. There are few patches with exotic species - Acacia (*Acacia auriculiformis*) and Nilgiri (*Eucalyptus tereticornis*) in the region, and the biomass may be used for energy. Biomass gasifier can be used to generate electricity which can meet the motive (water pumps) and mechanical (workshop/construction) electricity demand. The organisation is located in the arid region and suitable for energy plantations. Technically, energy plantation refers to growing high biomass yielding species of trees and shrubs which are harvestable in a comparably shorter time and are explicitly meant for fuel. The biomass harvested from trees are mostly dry due to the weather which can be further dried in sunlight for better combustion. The fuel wood may be used either directly in wood burning stoves and boilers or processed into methanol, ethanol and producer gas. The energy plantations provide inexhaustible renewable sources (with recycle time of 3-8 years) of energy and provide reliable electricity. The key features of energy plantations are given in Table 3.

Table 3: Features of Energy plantation and comparison with coal

	Wood	**Coal**
Energy density (GJ/dry tonne)	19.8	29.3
Heat rate (kJ/kWh)	7200 - 18000	10900
% Carbon	25.3	24.1
Total Carbon (kg C/GJ)	26.62	24.65
1 dry tonne of wood displaces 370 kg of coal Carbon		

Selection of multipurpose species provides a number of by-products like oils, organic compounds, fruits, edible leaves, forage for livestock, etc. [7]. Data collected from Forest Department reveals that annual woody biomass available is in the range 11.9 to 21 t/ha/yr. An energy forest raised at Hosalli village in Tumkur district to support a wood gasifier plant has annual yield of 6 t/ha/yr. Singh and Tokay [8] have concluded that energy plantations of different species shown net productivity of 15.7 to 32.62 ton/ha/yr. after 4 years of planting, which is shown in the Table 4.

Agastya organisation shall promote energy plantation is few specific places which have been delineated, shown in Figure 5. Plantation can be dine in a phased manner which will help in irrigating the saplings, managing protecting the young plants and also helps in regular biomass harvesting. About 3 ha of area near the western boundary of the region is specified for which already has few Acacia (*Acacia auriculiformis*) and Nilgiri (*Eucalyptus tereticornis*) trees. The adjacent forested area also has *Eucalyptus* plantation which will connect the landscape for movements of animals, reptiles and insects.

Table 4: Net productivity of Energy plantation [8]

Species	No. of trees/ha	Net productivity (ton/h/yr) after 4 yrs.
Acacia Nilotica	2770	15.7
Eucalyptus Teriticornis	14933	29.19
LeucaenaLeucocephala	19689	32.62

Trees can be planted in the periphery of football playground selecting some fruit bearing trees which also give shades and biomass. Grasslands are to be retained un-disturbed which shelters vast insects and grass hoper which is linked to the bird diversity. However, few fruit bearing trees and scrub flora can be planted in these areas which help bird nesting and attract butterflies. The organisation has many *Acacia auriculiformis* and *Eucalyptus tereticornis* trees, which may be harvested in phased manner and planting of native species suitable for bioenergy would help in addressing the energy requirement while enhancing the local ecology.

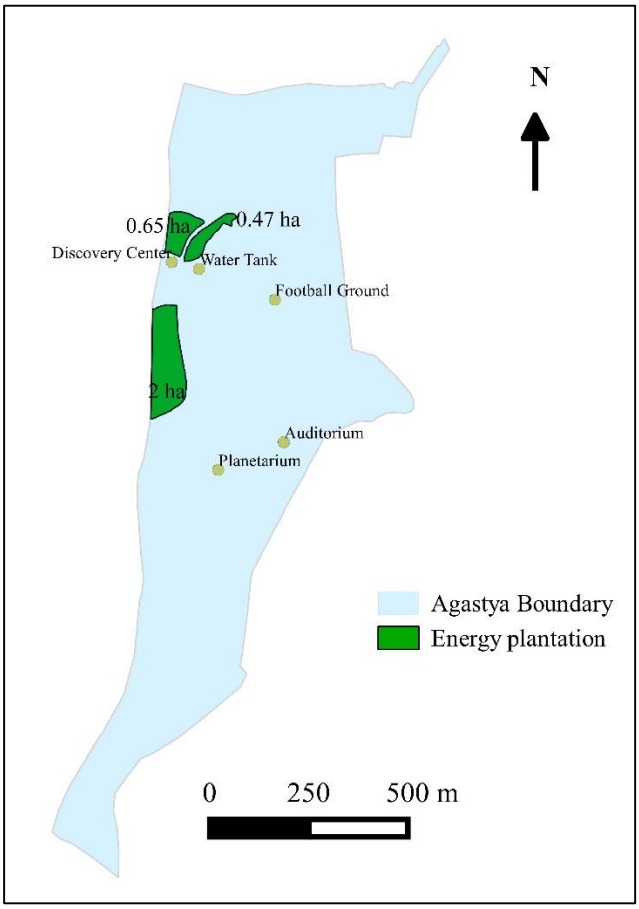


Figure 5: Areas for energy plantation

Electricity generation from biomass gasification

Fuel wood can be converted into gas using thermo-chemical processes with only 2 - 4% of ash. Gasification is carried out in oxygen starved environment to generate carbon monoxide and hydrogen which are combustible. The reactions are carried out in elevated temperature of 500-1,400 °C and pressure of 33 bar (480 psi). Air based gasifiers normally produce gas with high nitrogen content, whose calorific value varies between 4 and 6 MJ/Nm^3 (100-1200 kilo calories/Nm^3). Oxygen and steam based gasifiers produce gas with relatively high calorific value of 10 to 20 MJ/Nm^3. Gas generated from biomass is also called as Producer gas which is highly combustible [9].

Pyrolysis is the primary step of converting biomass into gas in which it gets decomposed, produces volatile materials (75-90%) in the form of gas and liquid, and char which is non-volatile. Later, volatile hydrocarbons and char are converted to combustible gas. Figure 6 shows the biomass gasification process and by-products generated in the process. Many types of biomass gasifiers (Table 5) have been developed depending upon the flow of fuel and oxidants and means of supporting structures [10].

Table 5: Types of gasifiers

Gasifies type	Flow direction		Type of support
	Fuel	Oxidant	
Updraft fixed bed	Down	Up	Grate
Downdraft fixed bed	Down	Down	Grate
Bubbling fluidized bed	Up	Up	None
Circulating fluidized bed	Up	Up	None

(Source: NREL)

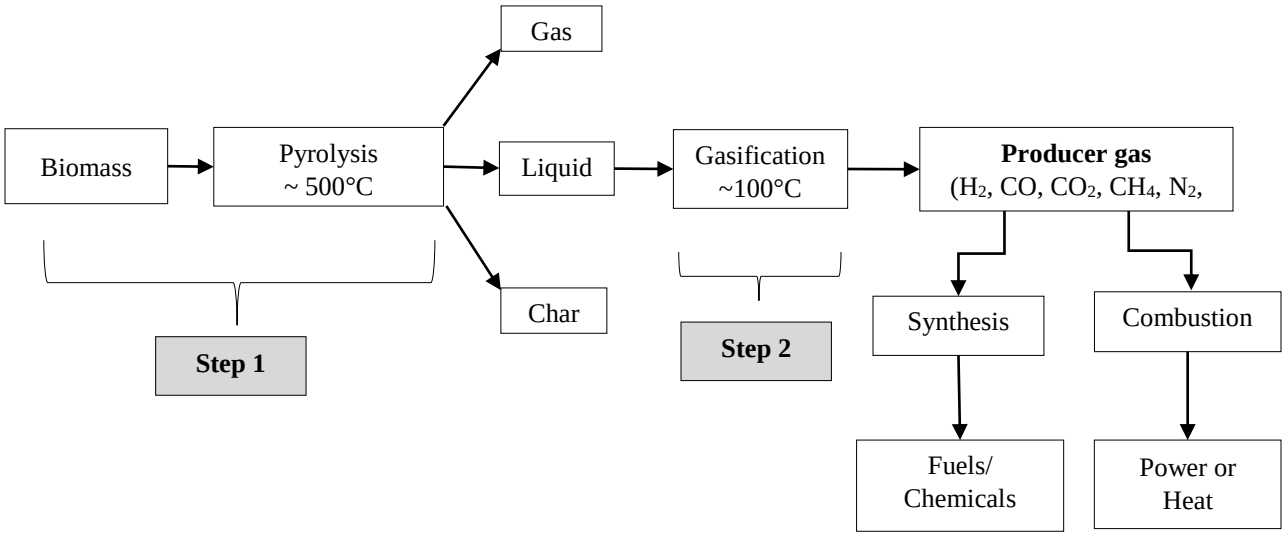


Figure 6: Process of Gasification

The combustible gas (producer gas) generated during gasification may either be used for cooking or electricity generation. The combustible gas may be directly fed to external combustion engines which are connected to alternators. Table 6 shows the cost comparison of different non-conventional power plants.

Table 6: Capital cost comparison of different power plants

Type of technology	**Capital cost (million rupees/MW)**
Solar photovoltaic	300-400
Micro-hydel	40-60
Wind	40-50
Biomass	20-40

(Source: Biomass gasifier-based power generation system back to basics, with a difference, The Energy and Resource Institute. (http://www.teriin.org/index.php?option=com_content&task=view&id=59))

The capacity of the biomass based electricity generation ranges from few kilowatts few hundreds of kilowatt. Fuel requirement for gasifier is about 1.2 kg to generate 1 kWh of electricity which runs for 4 to 5 hours/day. These types of systems are best suited for distributed generation, have the capacity to meet the demand of domestic electricity consumption. Remote area electrification is possible where the conventional grid supply is not feasible [11]. Producer gas can be used with conventional fuels such as diesel or natural gas which allows 60-80% savings in fossil fuel consumption. MNRE (Ministry of New Renewable Energy, http://www.mnre.gov.in) is encouraging gasifier projects for both in community level and for individual household. Central Financial Assistance (CFA) is being provided for various components of gasifier plants from 15,000 per kW to 5 lakhs (one time) depending upon the application and benefitting population. Also the ministry organizes technical courses for technicians in order to understand the technology and for effective implementation [12].

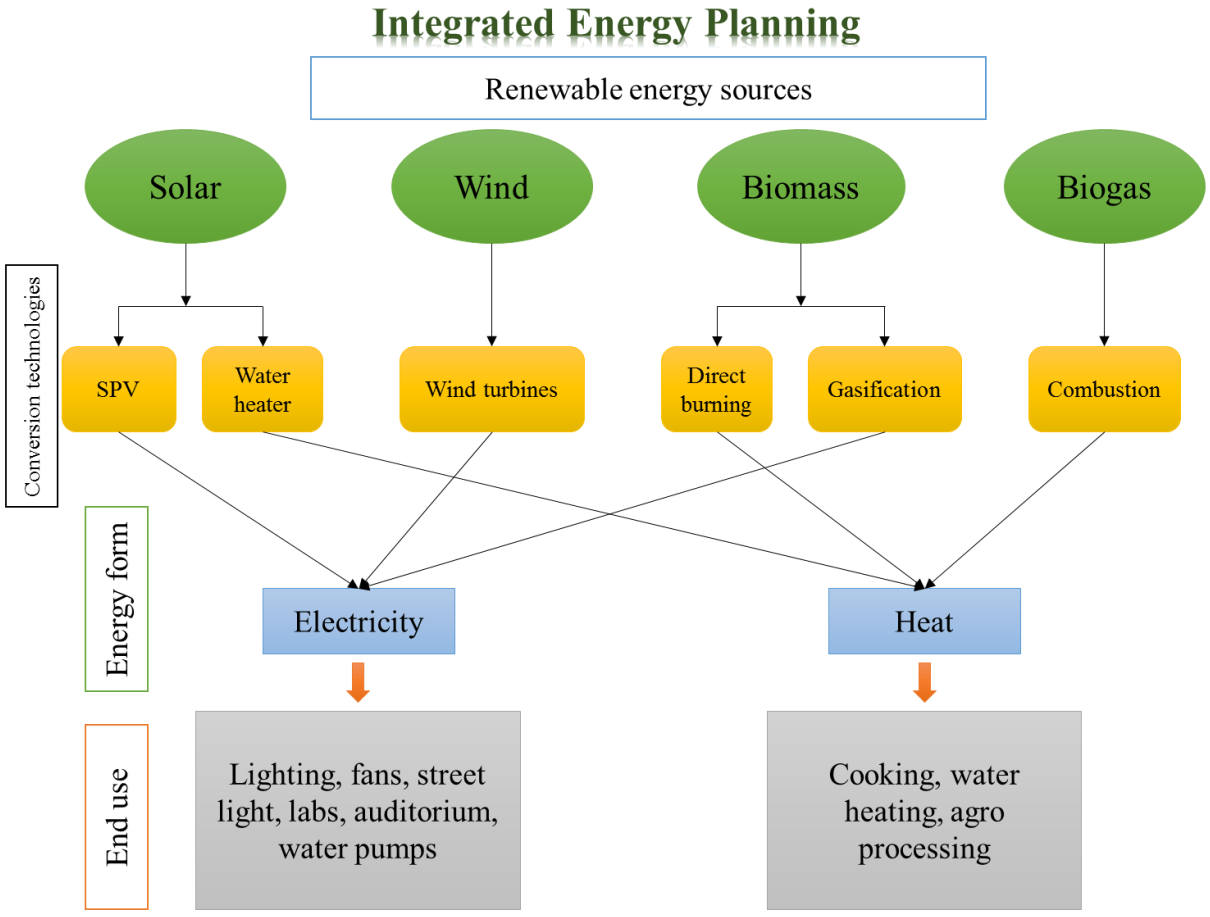
Biogas generation

The organization has few cattle which produce sufficient dung to produce biogas. Hundreds of students come to the organization every day, who produce significant amount of food waste which can be used along with animal residue to produce biogas. The wet organic residues offer very high potential of biogas production which can meet the cooking fuel demand in guest house or of employee colony. The slurry generated in the biogas production is good manure which can be used to prepare compost or directly fed to agricultural or horticultural plantations. Biogas mainly comprises of methane (60-65%) and carbon dioxide (35-40%) having a small fraction Hydrogen sulphide and water vapour. Biogas generation from dung, organic waste or agricultural and horticultural residues is dependent on temperature, carbon-nitrogen ratio (C:N), pH and retention period. Temperature is the most prominent factor that affects the biogas generation; The optimum conditions for biogas generation are: temperature 30-35°C, pH 6.8-7.5, carbon : nitrogen ratio (C:N) 20-30, solid contents 7-9%, retention time 20-40 days. The retention period decides the rate of digestion, longer the retention time more the gas generated for a given amount

of waste. There are many technologies available for biogas generation depending upon the availability of resources. The most widely used technologies are:

- Fixed Dome model (40 and 55 days retention period)
  - Deenabandhu brick masonry
  - DeenabandhuFerro-cement in-situ construction
- Floating Dome model (30,40 and 55 days retention period)
  - KVIC (Kadhi and Village Industries Commission) floating metal drum
  - KVIC reinforced cement concrete (RCC) digester
- Prefabricated Model for limited field trial (40 days retention period)
  - Sintex - HDPE pre-fabricated Deenbandhu
- Optimized design developed by Application of Science and Technology to Rural Areas (ASTRA) of IISc [13, http://astra.iisc.ernet.in].
- Fixed dome type designed by University of Agricultural Sciences - Bhagyalaxmi design.

Arrangements may be made to collect food waste. Waste collection and transportation to the biogas plant will be easier and effective. Significant amount of biogas can be generated from above mentioned technologies which can be used for coking or electricity generation.



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7.0 FLORISTIC DIVERSITY AND LANDSCAPE PLANNING OF AGASTYA FOUNDATION CAMPUS AREA, KUPPAM

The vegetation of the area presently consists of grassland with scattered trees and scrub forest. However the natural vegetation of the area broadly comes under dry deciduous type being nearer to the foot hills of Eastern Ghats. Rainfall also being lesser than 1000 mm/year support more of drier forest adapted to water paucity. Some of the areas have been planted with Western Ghats plants and other exotics. Hence the vegetation of the area can be broadly divided into

- Tropical dry deciduous
- Scrub thickets
- Grasslands
- monoculture plantation
- aquatic plants
- introduced plant species

METHOD: Campus area vegetation was opportunistically surveyed (for 3 days) for plant diversity mainly, trees, shrubs, climbers and herbs. Bigger trees and tree clumps were documented using GPS (Global positioning system). Other parameters such tree girth, tree height and canopy size were recorded.

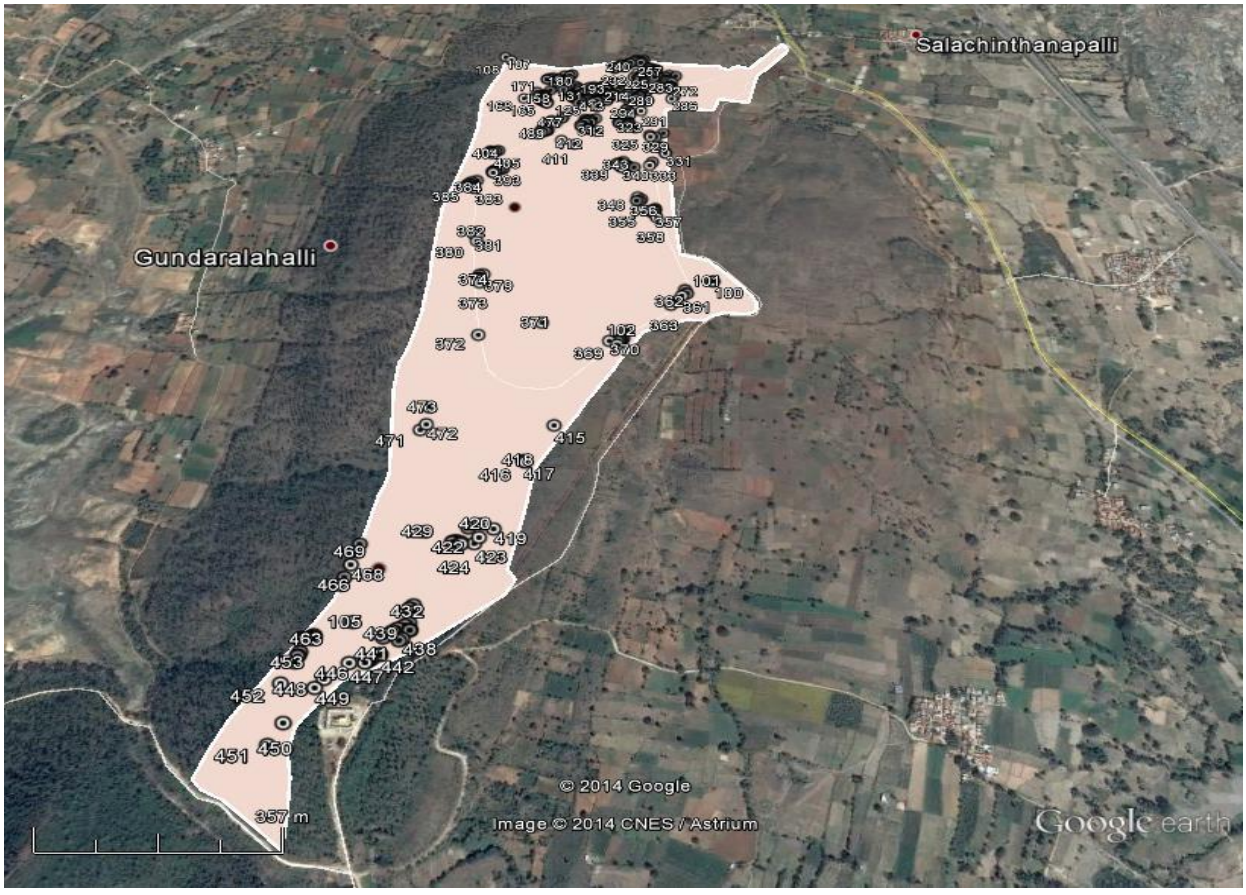


Figure 1: trees mapped in the campus area (numbers indicate tree or tree clumps)

RESULTS AND DISCUSSION

The vegetation survey yielded a total of 141 plant species belonging to 57 families, comprising of 68 species of Trees, shrubs 12, climbers 11 and herbs with 50 species. Largest families are shown in figure 2.

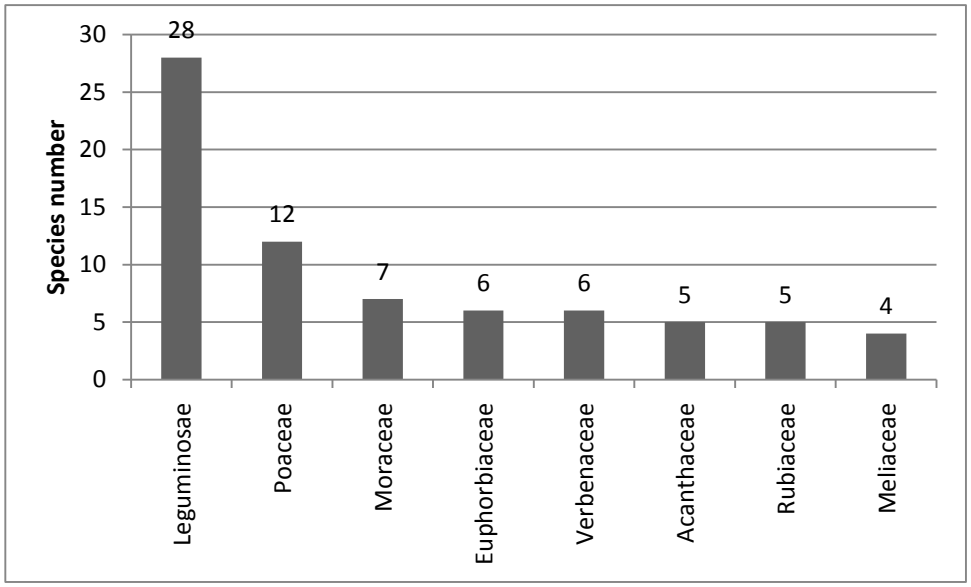


Figure 2: Family wise flora with the number of species

Common plant species in the campus area: As the area comes under the low rain fall zone, coupled with earlier disturbances, the area mainly comprised of grasslands and scrub thickets with very less woody vegetation. Commonly seen larger trees *are Pterocarpus santalinus, Azadirachta indica, Syzygium cumini, Cassia siamea, Cassina glauca, Terminalia arjuna* etc. (table 1).

Table 1: Most commonly seen trees in the campus.

Sn	**Most common trees**		
1	*Acacia auriculiformis*	12	*Pterocarpus santalinus*
2	*Syzygium cumini*	13	*Ficus benghalensis*
3	*Cassia siamea*	14	*Albizzia lebbeck*
4	*Azadirachta indica*	15	*Holoptelia integrifolia*
5	*Cassine glauca*	16	*Madhuca indica*
6	*Terminalia arjuna*	17	*Pongamia pinnata*
7	*Ficus religiosa*	18	*Butea monosperma*
8	*Eucalyptus sp*	19	*Tamarindus indicus*
9	*Mangifera indica*	20	*Artocarpus integrifolius*
10	*Bauhinia purpurea*	21	*Cassia fistula*
11	*Calophyllum inophyllum*		

Common shrub species in grassland-scrub areas are *Dodonaea viscosa, Toddalia asiatica, Cocculus hirsutus, Gloriosa superba, Crotolaria auriculata, Hyptis suaveolens, Leucas aspera, Argyrea cuneata, Canthium parviflorum, etc.*

Among the herbs, *Lepidagathis cristata, Euphorbia hirta,Evolvulus alsinoides, Andrographis serpyllifolia, Indigogera tinctorea, Hybanthus* enneaspermus,*Justicia simplex, Leuca slinifolia,* etc were common. Commonly found grasses include *Apluda mutica, Chryosopogon fulvus, Aristida setacea, Heteropogon contortus,* etc.

Medicinal plants in campus area: A total of 71 medicinal plants were noted in this short survey. The detailed list is given in the table 2. Important medicinal plants include *Balanites sp, Cassia fistula, Salacia chinensis, Tinospora cordifolia, Evolvulus alsinoides, Gloriosa superba, Pterocarpus santalinus, Sida acuta* etc. Many Vanas and gardens hosted these plants in the campus area. Grasslands also harboured large number of medicinal plants and hence have to be conserved.

MANAGEMENT OPTIONS FOR CAMPUS PLANTS AND WILDLIFE

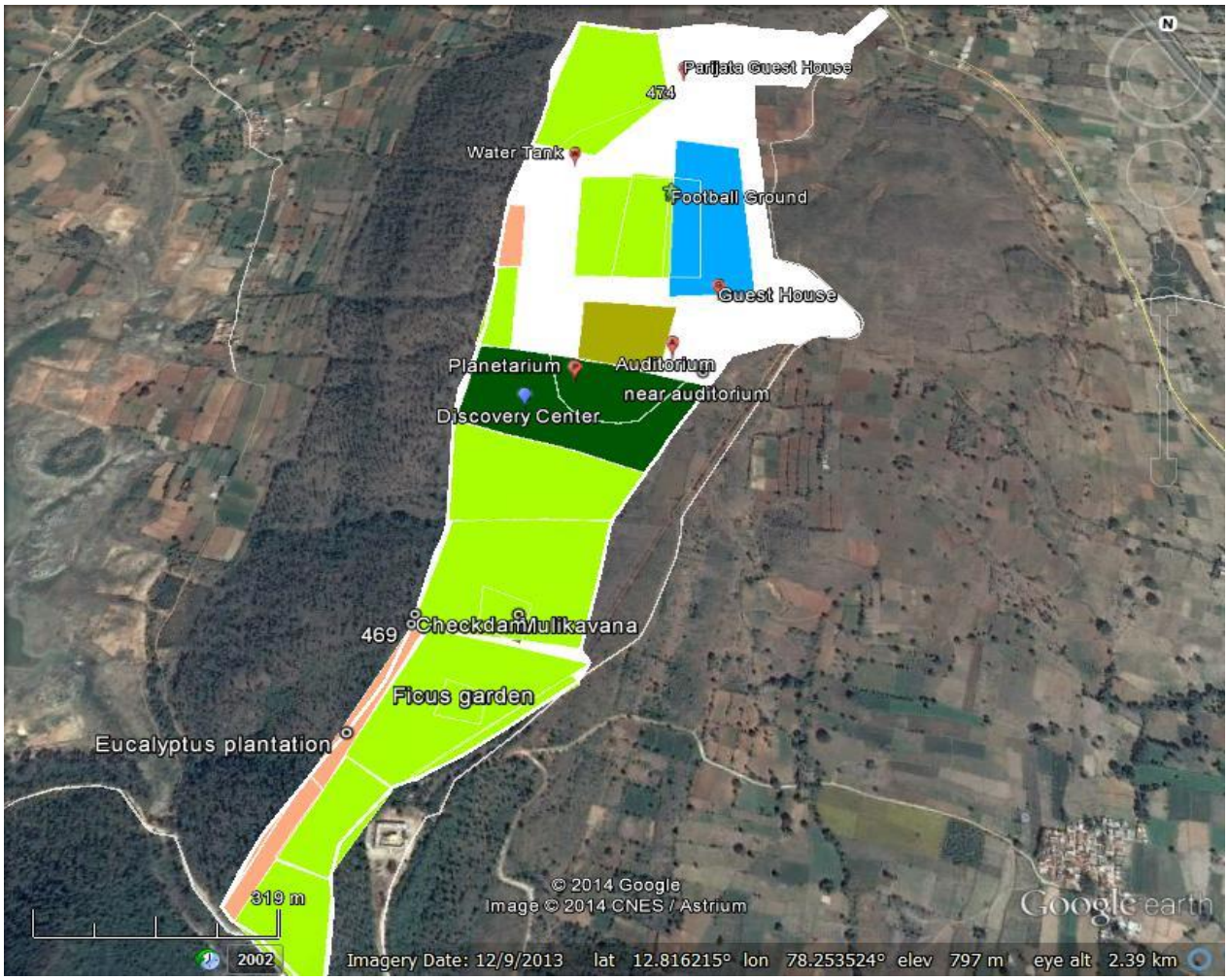


Figure 3: Google image mapped for existing vegetation landscape types for management planning (Colours: *Light green*-Pure grasslands with sparse scrub, Orange-*Eucalyptus* plantations, *Dark green*-Scrub thickets with some native trees planting along with *Acacia auriculiformis*, *Olive green*-Dodonea shrub mix grassland, *Blue*- Western ghats and other plantation trees planted scrubby area. *White*- scrubby grassland used for mango plantations, *Acacia* plantations, Western Ghats saplings, and some exotics).

The area has been under random planting from its earliest initiation with both native and exotic trees.

1. **Grassland areas (Light green areas in figure 3):** Large expanse of the southern campus are with grasslands which support many rare and native shrub, herb and grass species. These areas also along with scrub- thicket hills until auditorium also support wild mammals. Hence these regions including the ones marked for vana and other medicinal gardens are to be conserved. Random planting in the grasslands should be avoided. The heterogeneity of the landscape be enhanced in some areas with native tree species preferably those adapted to lower rain fall areas such *Acacia leucophloea, Garuga pinnata, Holoptelia integrifolia, Albizzia sp, Dalbergia sp, Pterospermum santalinus,Pongamia pinnata,Schleichera oleosa, Syzgium cumini, Bauhinia vahliii, Mallotus philippensis, Phyllanthus emblica, Sterculia villosa, Bombax ceiba, Buchanania lanzanAnogeissus latifolia, Terminalia paniculata, Terminalia alata, Chloroxylon swietenia, Dolichandrone acuata, Wrightia tinctoria, Vitex altissimaStrychnosnux-vomica, Sapindus emarginatus, Drypetess epiaria, Pterospermum canescens, Drypetes ferrea, Cordia dichotoma, Flacourtia indica, Canthium parviflorum,Ziziphus rugosa and Grewia tilifolia.* The selective planting of diverse native trees helps as fire line in preventing the spread of fires in grasslands during summer.
2. **Eastern Ghats forest planting (Dark green area in figure 3):** the regions of scrub thickets and low lying drainage areas be planted with sapling from eastern ghats such *Terminalia alata, Xylia xylocarpa, Anogeissus latifolia, Dillenia pentagyna, Pterocarpus marsupium, Pterospermum santalinus, Pongamia pinnata,Schleichera oleosa, Syzgium cumini, Bauhinia vahliii, Mallotusphilippensis, Phyllanthus emblica, Sterculia villosa, Bombax ceiba, Buchanania lanzan, Anogeissus latifolia, Terminalia paniculata, Chloroxylon swietenia, Dolichandrone arcuata, Wrightia tinctoria, Vitex altissimaStrychnos nux-vomica, Sapindus emarginatus, Drypetes sepiaria, Pterospermum canescens, Drypetes ferrea, Cordia dichotoma, Ficus sp, Flacourtia indica, and Grewia tilifolia.*
3. **Western Ghats plants (Blue shaded areas in figure 3)**:Western Ghats trees needs soil moisture, which requires regular monitoring. Hence theirspecies sapling be planted in the regions with good water retaining abilities (valleys, etc.) Percolation ponds / trenches in wild areas also help in recharging of groundwater resources and also maintenance of moisture in the soil. Planting of the Western Ghats species in in drier areas be avoided due to water stress.
4. **Exotic trees:** Non-native plant species be avoided and native plants with aesthetic branching, flowers, etc. be planted near guest houses, media library etc.
5. **Native tree groves:**Groves of native fruiting trees, flowering trees, nectar gardens, medicinal gardens be developed in plain areas (white shaded areas in Figure 3) with appropriate soil and water conservation measures. These will help as a food and nectar source for birds, butterflies, and many other faunal communities.
6. **Wetland areas:**Creation of water bodies (as discussed in the previous section) would support wild fauna (birds, mammals, etc.) apart from increasing ground water table.

Development of wetlands (with aquatic emergent flora) at the inlet of water body would also help in remediation of water.

7. **Energy plantations and other uses:**Plantations of exotic species such as *Eucalyptus* in southern campus be replaced in phased manner with native species (*Pongamia pinnata*, etc.) These having huge trees have both the use of temporary residence for faunal communities and their aesthetic looks. Planting *Acacia auriculiformis*, *Eucalyptus* should be avoided.

Over all Light green shaded areas should be exclusively used for Grassland conservation, improvement with very sparse dry deciduous tree clumps. Necessary water conservation techniques can be done here. Dark shaded areas (in Figure 3) are suitable for exclusive Eastern ghats plants and olive green shaded areas (in figure 3) with*Dodonea viscosa* shrub and grasses be maintained without any changes.

Table 2: Checklist of Trees (T), Shrubs (S), Climbers (C), and Herbs (H), in the Campus area along with their family, endemic status and medicinal value.

Sn	Species	Habit	Family	Endemics	Medicinal value (M)
1	*Acacia auriculiformis*	T	Leguminosae		M
2	*Acacia catechu*	T	Leguminosae		M
3	*Acacia farnesiana*	S	Leguminosae		M
4	*Acacia sp*	T	Leguminosae		
5	*Aeglemarmelos*	T	Rutaceae		M
6	*Albizialebbeck*	T	Leguminosae		
7	*Alysicarpusvaginalis*	H	Leguminosae		
8	*Andrographisserpyllifolia*	H	Acanthaceae	Endemic	M
9	*Anthocephaluscadamba*	T	Rubiaceae		
10	*Apludamutica*	H	Poaceae		
11	*Aponogetonsp*	H	Aponogetonaceae		
12	*Argyriacuneata*	S	Convolvulaceae	Endemic to South India	M
13	*Aristidasp*	H	Poaceae		
14	*Aristida setacea*	H	Poaceae		
15	*Arthraxonsp*	H	Poaceae		
16	*Artocarpushirsutus*	T	Moraceae	Endemic	M
17	*Artocarpusintegrifolius*	T	Moraceae		
18	*Azadirachtaindica*	T	Meliaceae		M
19	*Balanitesaegyptiaca*	T	Zygophyllaceae		M
20	*Barleriabuxifolia*	S	Acanthaceae	Endemic to peninsular India.	
21	*Bauhinia purpurea*	T	Leguminosae		
22	*Bauhinia racemosa*	T	Leguminosae		
23	*Bauhinia variegata*	T	Leguminosae		M
24	*Beciumfilamentosum*	H	Lamiaceae		
25	*Bombaxceiba*	T	Bombacaceae		M
26	*Borassisflabellifer*	T	Arecaceae		
27	*Buteamonosperma*	T	Leguminosae		M
28	*Callistemon sp*	T	Myrtaceae		

29	*Calophylluminophyllum*	T	Clusiaceae		
30	*Canthiumdicoccum*	T	Rubiaceae		M
31	*Careyaarborea*	T	Lecythidaceae		M
32	*Cassia auriculata*	S	Leguminosae		
33	*Cassia fistula*	T	Leguminosae		M
34	*Cassia siamea*	T	Leguminosae		
35	*Cassineglauca*	T	Celastraceae		M
36	*Celastruspaniculata*	C	Celastraceae		M
37	*Chrysopogon fulvus*	H	Poaceae		
38	*Chukrasiatabularis*	T	Meliaceae		M
39	*Cinnamomummalabatrum*	T	Lauraceae	Endemic	M
40	*Clitoreatinctorea*	C	Leguminosae		M
41	*Cocculushirsutus*	C	Menispermaceae		M
42	*Crotalaria retusa*	S	Leguminosae		M
43	*Curculigoorchioides*	H	Hypoxidaceae		M
44	*Cymbopogonsp*	H	Poaceae		
45	*Dactylocteniumaegyptium*	H	Poaceae		M
46	*Dalbergialatifolia*	T	Leguminosae		M
47	*Delonixregia*	T	Leguminosae		
48	*Desmodiumsp*	H	Leguminosae		
49	*Desmodiumtriflorum*	H	Leguminosae		M
50	*Dichanthiumpertusum*	H	Poaceae		
51	*Dichrostachyscinerea*	S	Leguminosae		
52	*Digitariasp*	H	Poaceae		
53	*Dilleniaindica*	T	Dilleniaceae		
54	*Dodonaeaviscosa*	S	Sapindaceae		
55	*Echinochloacolona*	H	Poaceae		
56	*Elaeocharissp*	H	Cyperaceae		
57	*Eucalyptus sp*	T	Myrtaceae		
58	*Euphorbia bonplondianum*	H	Euphorbiaceae		
59	*Evolvulusalsinoides*	H	Convolvulaceae		M
60	*Ficusbenghalensis*	T	Moraceae		M
61	*Ficushispida*	T	Moraceae		M
62	*Ficusinfectoria*	T	Moraceae		
63	*Ficusmysorensis*	T	Moraceae		
64	*Ficusracemosa*	T	Moraceae		
65	*Ficusreligiosa*	T	Moraceae		M
66	*Flacourtiaindica*	S	Flacourtiaceae		
67	*Garciniacambogia*	T	Clusiaceae	Endemic	M
68	*Garugapinnata*	T	Burseraceae		M
69	*Gloriosasuperba*	H	Liliaceae		M
70	*Hackelochloagranularis*	H	Poaceae		
71	*Hemidesmusindicus*	C	Asclepiadaceae	Endemic to Peninsular India	M
72	*Heterophragmaroxbhurgii*	T	Bignoniaceae	Endemic to Peninsular India	M

73	*Heteropogoncontortus*	H	Poaceae		
74	*Holopteliaintegrifolia*	T	Ulmaceae		M
75	*Hybanthusenneaspermus*	H	Violaceae		M
76	*Hyptissuaveolens*	S	Lamiaceae		M
77	*Indigoferatinctorea*	H	Leguminosae		
78	*Iphigenia indica*	H	Liliaceae		
79	*Jatrophacurcas*	H	Euphorbiaceae		
80	*Justicia simplex*	H	Acanthaceae		M
81	*Lantana camara*	S	Verbenaceae		
82	*Lepidagathiscristata*	H	Acanthaceae		M
83	*Leucasapera*	H	Lamiaceae		
84	*Leucenaleucocephala*	T	Leguminosae		
85	*Loranthussp*	H	Loranthaceae		
86	*Madhucaindica*	T	Sapotaceae		M
87	*Mangiferaindica*	T	Anacardiaceae		M
88	*Marseliasp*	H	Marsileaceae		
89	*Meliadubia*	T	Meliaceae		M
90	*Mitragynaparvifolia*	T	Rubiaceae		M
91	*Mollugopentaphylla*	H	Molluginaceae		M
92	*Moringatomentosa*	T	Moringaceae		
93	*Muntingiacalabura*	T	Elaeocarpaceae		M
94	*Murrayapaniculata*	T	Rutaceae		M
95	*Nympheasp*	H	Nymphaeaceae		
96	*Partheniumhysterophorus*	H	Asteraceae		
97	*Passiflorafoetida*	C	Passifloraceae		
98	*Pavoniaodorata*	H	Malvaceae		M
99	*Peltophorumroxbhurgii*	T	Leguminosae		
100	*Pennisetum pedicellatum*	H	Poaceae		
101	*Phyllanthusemblica*	T	Euphorbiaceae		M
102	*Phyllanthus simplex*	H	Euphorbiaceae		
103	*Phyllanthus maderaspatensis*	H	Euphorbiaceae		
104	*Plumeria alba*	T	Apocynaceae		
105	*Pongamiapinnata*	T	Leguminosae		M
106	*Premnatomentosa*	T	Verbenaceae		M
107	*Pterocarpussantalinus*	T	Leguminosae		M
108	*Pterospermumdiversifolium*	T	Sterculiaceae		M
109	*Salaciachinensis*	C	Celastraceae		M
110	*Santalum album*	T	Santalaceae	Endemic to India	M
111	*Sapindusemarginatus*	T	Sapindaceae		
112	*Saracaasoca*	T	Leguminosae		M
113	*Schefflerasp*	T	Araliaceae		
114	*Schoenoplectussp*	H	Cyperaceae		
115	*Sidaacuta*	H	Malvaceae		M

116	*Spermacocearticularis*	H	Rubiaceae		M
117	*Spermacocehispida*	H	Rubiaceae		M
118	*Stachytarpetaindica*	H	Verbenaceae		M
119	*Strigalutea*	H	Scrophulariaceae		
120	*Stylosanthesfruiticosa*	H	Leguminosae		
121	*Sweiteniamacrophylla*	T	Meliaceae		
122	*Symplocossp*	T	Symplocaceae		
123	*Syzygiumcumini*	T	Myrtaceae		M
124	*Tamarindusindicus*	T	Leguminosae		M
125	*Tecomastans*	S	Bignoniaceae		
126	*Tectonagrandis*	T	Verbenaceae		
127	*Terminaliaarjuna*	T	Combretaceae		
128	*Terminaliabellerica*	T	Combretaceae		M
129	*Thunbergiaalata*	C	Acanthaceae		
130	*Tinosporacordifolia*	C	Menispermaceae		M
131	*Toddaliaasiatica*	C	Rutaceae		M
132	*Tragiainvolucrata*	C	Euphorbiaceae		M
133	*Tremaorientalis*	T	Ulmaceae		M
134	*Tribulusterrestris*	H	Zygophyllaceae		M
135	*Trichodesmazeylanicum*	H	Boraginaceae		
136	*Tridaxprocumbens*	H	Asteraceae		
137	*Tylophorasp*	C	Asclepiadaceae		
138	*Vitexnegundo*	S	Verbenaceae		M
139	*Vitextrifoliata*	T	Verbenaceae		
140	*Wrigtiatinctorea*	T	Apocynaceae		M
141	*Zorniadiphylla*	H	Leguminosae		M

8.0 Flora of Agasthya Foundation Campus, Kuppam








Flora of Agasthya Foundation Campus, Kuppam, Andhra Pradesh District

	*Abutilon indicum* Common name: Indian Abutilon Family: Malvaceae Native: India Description: Erect branched shrub, velvety-tomentose to glabrescent. Leaves simple, alternate, and orbicular to ovate. Calyx much shorter than petals, spreading in fruit[1]. Flower, Fruit: August- February
Acacia polyacantha Common name: White Thorn Family: Fabaceae Native: Africa, India, the Indian Ocean and Asia Description: Trees branches white pubescent. Leaves 12 cm long, stipular spines straight, 0.7 cm long. Corolla white, slightly longer than calyx. Pod slightly thick, many-seeded[2]. Flowers: March – June Fruits: August - February	
	*Acacia chundra* Common name: Red Chundra Family: Fabaceae Native: India Description: Moderate-sized tree. Branches are with curved red prickles. Leaves are alternate and pinnately compound with glands present on the rachis. Flowers are small, pale yellow in terminal spikes[1, 2]. Flower, Fruit: May - October
Acacia leucophloea Common name: White Babool, White-Barked Acacia, Family: Fabaceae Description:A medium-sized tree with alternate or clustered, bipinnately compound leaves having glands on the rachis. Flowers are small, cream to yellow-coloured and aggregate into globose. Pod is brown, flat, curved and densely hairy[2]. Native: Indo-malayan region Flower, fruits: August - November	

Acacia nilotica
Common name: Gum Arabic Tree
Family: Fabaceae
Description: Moderate-sized thorny tree. Leaves alternate, bipinnate, elliptic, entire, rounded. Flower solitary globose head, golden yellow. Fruit pod. Seeds 13[2].
Native: Africa
Flower, fruit: August – October

Acalypha indica
Common name: Indian Acalypha
Family: Euphorbiaceae
Native: Africa to Malesia
Description: Annual erect herbs, young branches pubescent. Petiole to 6 cm long. Inflorescence lax, often terminated by an abnormal female flower. Bracts ovate, shallowly dentate, eglandular Schizocarp hairy[2].
Flower, fruit: August - December

Acanthospermum hispidum
Common name: Bristly Starbur
Family: Asteraceae
Native: Tropical America
Description: Erect branched hairy Herb. Leaves opposite, simple, ovate, acute, cuneate at base, hairy heads 2.5-3 cm across. Yellow colour flowers. Fruit an achene, spinous[1, 2].
Native: Tropical America
Flower, Fruit: January-July

Achyranthes aspera
Common name: Devil's Horse Whip
Family: Amaranthaceae
Native: Southeastern Asia
Description: An erect herb. tem stiff and quadrangular. Leaves are thick, elliptic or obovate, entire and obtuse. Flowers are greenish-white, small, numerous, stiffly deflexed against the rachis, in elongated terminal spike. Perianth scaly, glabrous and shiny. Fruit is a utricle[2].
Flower, fruits: September-April

Acrocarpus fraxinifolius
Common name: Indian Ash
Family: Fabaceae
Native: India, Sri Lanka
Description: An unarmed lofty deciduous tree with buttressed trunk; leaves are bipinnate, pinnae 3-5 pairs, each with 5-6 pairs of large leaflets, which are bright red when young. Flowers are green with crimson stamens. Pod is flat with the upper suture winged[2].
Flowers, Fruits: February-March

Adhatoda zeylanica
Common name: Malabar nut
Family: Acanthaceae
Description: A very bushy shrub with many branches. Leaves large elliptic to lanceolate in shape, dark green in colour above and pale green underneath. Flowers are in short, dense clusters. Corolla with short tube and spreading lobes. Fruits are oblong, slightly pointed capsules[1, 2].
Flowers, Fruits: August -November

Aegle marmelos
Common name: Bael Tree
Family: Rutaceae
Description: A medium-sized tree with spiny branches. Leaves alternate, compound with three leaflets. Flowers are borne on branched axillary inflorescence. Fruit is globose with a hard rind[1, 2].
Native: India
Flower, Fruit: March – April.

Aerva lanata
Common name : Polpola
Family: Amaranthaceae
Native: Afrotropics
Description: An erect or prostrate herb with many hairy branches. Leaves are alternate, elliptic to obovate, obtuse or acute, entire with cottony hair beneath. Flowers are tiny, white and are crowded in compact axillary spikes[1, 3].
Native: Afrotropics
Flower, Fruit : October-April

Ageratum conyzoides
Common name: Goat Weed
Family: Asteraceae
Native : Tropical America, Caribbean
Description: Herb. Leaves opposite, ovate, crenate, palmately 3-nerved. Heads in panicles; bracts sometimes glandular hairy. Flowers white or purple. Achenes sparsely scabrous [2].
Native: Tropical America, Caribbean
Flower, fruits: December-June

Alangium salvifolium
Common name : Sage-leaved Alangium
Family: Alangiaceae
Native: Tropical Asia
Description: Deciduous Tree; Leaves lanceolate, simple, ex-stipulate, greyish below, dark green above; Flowers in a panicle, sweet smelling; Petals linear hairy on the back; Filament short than petals; Fruit a berry, ellipsoidal, purplish red when ripe, calyx persistent[1, 2].
Flowers, Fruits: February-May

Albizia lebbeck
Common name: East Indian Walnut
Family: Fabaceae
Description: A large deciduous tree with compound leaves. Flowers are greenish-white in head inflorescence. Fruit is a pod, which is yellowish-brown, flat and carries 6-10 seeds. Bark is brownish grey, rough with numerous sharp irregular cracks[1,2, 3].
Native: Asia
Flower, Fruit : March -December

Albizia amara
Common name: Oil-cake Tree
Family: Fabaceae
Description: An unarmed small to medium sized deciduous tree with a rounded crown and fissured, rough bark; leaves are bipinnate with a gland on the petiole, pinnae 6-15 pairs, leaflets 10-46 pairs; flowers are small and in a head inflorescence, white or flushed pink; corolla is yellow ; stamens are long with pinkish filament. Pod is thin, flat, brown and distinctly stalked with 6-8 seeds[1,2].
Native: India, Sri Lanka, Tropical Africa
Flower, Fruit: March-June

Albizzia odoratissima
Common name: Black Siris
Family: Fabaceae
Description: Moderate sized unarmed tree. Leaves compound, alternate with a swollen leaf base. Flowers minute, fragrant with slender long exserted stamens and aggregated into compact head inflorescences which in turn are borne terminally on highly branched axis. Fruit pods are thin and brown flat[1,2].
Native: Tropical Asia
Flower, Fruit : March-April

Aloe vera
Common name: True Aloe
Family: Xanthorrhoeaceae
Description: A large perennial herb (50-100 cm.). Roots are slender and fibrous. Leaves arise from the base of the plant, all from the same level. They are thick, fleshy with apex drawn out into a pointed structure with prickly margins. Perianth red segmented equaling tube. Flowers arise on a terminal elongated erect inflorescence, older ones being at the base and the youngest at the apex. Stamens are six and shortly exserted. Fruit is an ellipsoidal and three-angled capsule[1,2].
Native: Mediterranean
Flower, Fruit: September –January

Alternanthera pugens
Common name: Khaki Weed
Family: Amaranthaceae
Description: A spreading herb. Leaves are simple, stalked, opposite. Flowers are small, inconspicuous and aggregated into a head-like inflorescence[1,2].
Native: Neotropics
Flower, Fruit: Throughtout the year.

Alternanthera sessilis
Common name: Joy Weed
Family: Amaranthaceae
Description: A low growing perennial herb rooting at the nodes, prostrate. Leaves linear-elliptic, simple, opposite with variable size and shape. Flowers minute, globose in compact axillary inflorescences.Tepals 5, glabrous. Stamens 3-5, alternating with filamentous staminodes[1,2].
Native: Southern Asia
Flower, Fruit : Throughout the year

Alysicarpus vaginalis
Common name : Alyce Clover
Family: Fabaceae
Description: Scandent herb. Leaves 1-foliate, simple, alternate, ovate. Flowers are borne on an erect inflorescence. Petal lobes are exserted and are attractive. The pod is 4-8-jointed, compressed and subterete[1,2].
Native : India, Asia, N. America
Flower, Fruit : August -November

Alysicarpus longifolius
Family: Fabaceae
Description: Small glabrous herbs. Leaves are linear to lanceolate, acute. Raceme is 15-25 cm long. Calyx imbricate in fruit, hairy on the back. Pod moniliform, reticulate[2].
Native: South Western India
Flower, Fruit: November – Febuary

Amaranthus spinosus
Common name: Spiny Amaranth
Family: Amaranthaceae
Description: Branched herbs with prickles. Leaves ovate to lanceolate. Perianth 5 segments. Stamens 5. Seeds compressed, shining and brown[2].
Native: Caribbean & Tropical Asia
Flower, Fruit: Throughout the year

Amaranthus viridis
Vernacular name: Chelakeerae soppu
Family: Amaranthaceae
Description: Unarmed herbs with slightly pinkish stem. Leaves ovate, emarginate at apex. Inflorescence spike. Perianth 3 segments. Stamens 3. Seeds Black[2].
Native: Tropics
Flower, Fruit: March - April

Andrographis paniculata
Common name : Creat
Family: Acanthaceae
Description: An erect herb, branched. Leaves ovate – elliptic, acute, glabrous. Inflorescence racemes terminal. Calyx-lobes glandular. Corolla upto 1.5 cm long, darker on the lower lip. Capsules linear- oblong. Seeds 12, orbicular[2].
Native: Tropics
Flower: September - November

Andrographis serpyllifolia
Common name: Creeping Creat
Family: Acanthaceae
Description: Herb. Leaves are orbicular and glabrous. Flowers subsessile, mostly solitary with small bracts. Corolla is white, lower lip is with violet blotches. Fruit is a capsule[1,2].
Native: India
Flower, Fruit: June-September

Anisomeles indica
Common name: Indian Catmint
Family: Lamiaceae
Description: Aromatic undershrubs. Stem acutely tetragonus, Cymes sessile. Corolla blusih white to pink. Nutlets 4[1,2, 3].
Native: Indomalaysia, China
Flower, Fruit : September –November

Annona squamosa
Common name : Custard Apple
Family: Annonaceae
Description: Tree or shrub. Leave elliptic, acute at base, glabrous. Flowers solitary or fascicled. Sepals small. Fruit greenish when ripe[1,2, 3].
Native: West Indies
Flower, Fruit : May-January

Anthocephalus chinensis
Family: Rubiaceae
Common name: Kadamb Tree
Description: Deciduous tree flowers are yellow or orange and aggregated into globose and yellow when ripe[2, 3].
Native: India
Flower, Fruit: July - September

Argemone mexicana
Common name : Mexican Poppy
Family : Papaveraceae
Description: Prickly herbs. Leaves glaucous, pinnatifid, subsessile and amplexicual above. Flowers 3-4 cm across, yellow. Capsule with many seeds[2, 3].
Native : West Indies
Flower, frui: Throught out the year

Argyreia cuneata
Vernacular name : Surohanni, Kad Dasala
Family: Convolvulaceae
Description: Silky Suberect shrubs. Leave obovate- lanceolate, broadly cuneate at base, glabrous above. Sepals ovate. Corolla funnel-shaped, bright red. Berry yellow to brown, leathery[1,2, 3].
Native: South India
Flower, Fruit: August – January

Aristolochia indica
Common name : Indian Birthwort
Family: Aristolochiaceae
Description: A shrubby twining plant with long slender stem. Leaves are very variable. Flowers are few in a bunch with pale greenish-white petals in a cylindrical tube having a trumpet-shaped mouth. Fruit is a brown globose oblong capsule. Seeds are flat and oval[1,2, 3].
Native : India, Nepal, Sri Lanka, Bangladesh
Flower, Fruit : November - December

Artocarpus heterophyllus
Common name : Jack fruit
Family: Moraceae
Description: Moderate sized tree. Leaves alternate, oblong-obovate, entire obtuse, acute at base, dark-green above. Inflorescence in oblong heads, axillary and on old trunk. Flower sunisexual. Fruit multiple, seeds large oblong[1,2, 3].
Native: India
Flower, Fruit : February

Asclepias curassavica
Common name : Garden Silk-Weed
Family: Asclepiadaceae
Native : Southern United States, West Indies
Description: A tall erect herb with milky latex. Leaves lanceolate, glabrous except when young. Apex acute to acuminate. Corona lobes long, bright orange[1,2, 3].
Flower, Fruit : Throughout the year

Asparagus racemosus
Family : Liliaceae
Description: A scandent shrub. Leaves linear-subulate with conical spinous spurs. Racemes solitary or fascicled, simple or branched. Flowers white, pedicels jointed at the middle. Berry globose[1,2, 3].
Flower: September – January

Azadirachta indica
Common name : Neem Tree
Family: Meliaceae
Native : India
Description: A large tree upto 15 m. Leaves compound, ovate- lanceolate, acuminate, leaf rachis to 30 cm long, leaflets 8*2 cm. Flowers elongated, sepals 5, free. Seeds enclosed in a hard shell[1,2, 3].
Flower, Fruit : January-July

Bacopa monnieri Common name: Memory plant Native: India, Nepal Family: Plantaginaceae Description: Prostrate herb with ascending branches. Leaves entire, oblong or obovate. Flowers axillary, pedicelled. Capsule ovoid, apiculate, with peristent style[1,2, 3]. Flower, fruit: Throughtout.	
	*Balanites aegyptiaca* Common name: Desert Date Family: Zygophyllaceae Native: India, Myanmar Description: A small tree with grey pubescent. Branches usually terminating as thorns. Leave compound, leaf rachis to 1 cm. elliptic-lanceolate, entire, cuneate at base. Cyme 3-6 flowered. Pedicel 0.8 cm long. Calyx lobes ovates. Drupe ovoid-oblong, shortly appressed pubescent[2]. Flower, Fruit: April - May
Balanites aegyptiaca Common name: Desert Date Family: Zygophyllaceae Description: Tree up to 10 m. Leaves made up of two leaflets, variable in size and shape. Flowers are small, inconspicuous, fragrant, and yellowish-green. Fruit is edible, yellow, single seeded.	
	*Balanites sp*. Family: Zygophyllaceae

Bambusa arundinacea
Common name: Thorny Bamboo
Famiy: Poaceae
Native: Southeast Asia
Description: A tall woody bamboo with thorny culms, upto 40 m tall. Leaves thin, linear. Inflorescence is a panicle of enormous size, the branchlets with cluusters of spikelets[2,3].
Flowers: Infrequent.

Barleria buxifolia
Common name: Hopehead
Family: Acanthaceae
Native: Indian Archipelago
Description: undershrubs erect to 0.75 m. Leaves sessile, spinous-tipped, hairy, 1*0.8 cm. Flowers solitary and outer calyx lobes large, elliptic, acute, spinoustipped. Corolla to 2.5 cm long, lobes purple[1,2].
Flower, Fruit: July - February

Bauhinia purpurea
Common name: Butterfly tree
Family: Fabaceae
Description: A moderate-sized tree up to 6.5 m high. Leaves alternate, simple, broadly ovate-orbicular, cleft to middle, lobes rounded. Inflorescence a raceme. Flowers are in a panicle, rose to pink. Fruit a pod, flat bean-like, pubescent[1,2, 3].
Flowering and fruits: October and May
Native: India, Burma, Vietnam

Bidens pilosa
Family: Asteraceae
Description: Herbs, quadrangular stem. Leaves opposite, ovate-lanceolate, apex acute, base truncate, serrate hairy. Head 1 cm across. Achenes 2.5 mm, setae 2-4 3 mm long[3,4].
Native: Tropical America
Flower, Fruit: March - October

Biophytum sensitivum
Common name: Little tree plant
Family: Oxalidaceae
Native: Indomalesia
Description: Herb, slender stem. Leaf rachis 1-6 cm, nearly glabrous, main nerves many, prominent. Peduncle shorter than or as long as leaves. Seeds brown with sharp ridges without tubercles[2,3].

Bixa orellana
Common name: Lipstick tree
Family: Bixaceae
Native: America
Description: A large shrub. Leaf simple, 14*9 cm, 5-nerved. Flowers pink. Sepals obovate, obtuse at tip. Capsule ovate, acute, 6*28 cm. grown as ornamental[1,2].
Flowers, Fruits: August - October

Blepharis maderapatensis
Common name: Creeping Blepharis
Family: Acanthaceae
Native: India
Description: Prostrate herbs. Leaves whorled, oblong-lanceolate, acute – acuminate, sessile or shortly petioled. Flowers solitary, axillary, corolla to 17 cm long, white[1,2].
Flowers, Fruits: November - February

Boerhavia diffusa
Common name: Common Hogweed
Family: Nyctaginaceae
Native: India
Description: A perennial spreading herb. Leaves simple, opposite. Flowers tiny, aggregated at the apex of elongated inflorescence[1,2].
Flowers, Fruits: July - September

Bombax ceiba
Common name: Silk Cotton tree
Family: Malvaceae
Native: Tropical Asia
Description: Large tree with buttresses with conical prickles on the stem. Leaves are palmately compound. Flowers are large, crimson red, sometimes appearing white when the tree is leafless. Fruit is a capsule. Seeds embedded[2].
Flowers, Fruits: February - May

Borreria articulata
Common name: Jointed Button Weed
Family: Rubiaceae
Native:
Description: Herbs initially erect, then procumbent. Leaves elliptic – lanceolate. Calyx 4-lobed, corolla bluish-white[2,5].
Flowers, Fruits: August - January

Boswellia serrata
Common name: Indian Olibanum tree
Family: Burseraceae
Native: India
Description: A large sized deciduous tree. Leaves unipinnate and crowded at the branch end. Flowers are small, white and occur in fascicled racemes. Fruit is 3 lobed drupe[2,3].
Flowers, Fruits: February – May

Buchanania lanzan
Common name: Cuddapah Almond
Family: Anacardiaceae
Native: Indomalayan
Description: A large sized evergreen tree. Leaves simple, thickly coriaceous, broad, tomentose beneath with swollen petiole. Inflorescence is a panicle of racemoses. Fruit is a drupe[2,3].
Flowers: January – February,
Fruits: April – May.

Butea monosperma
Common name: Flame of the Forest
Family: Fabaceae
Description: moderate sized deciduous tree up to 8 m high. Leaves alternate, 3-foliate, pulvinate, brown silky pubescent when young. Inflorescence a raceme. Fruit a pod, flat, thickened on the sutures, leathery, oblong. Seed solitary, compressed, obovate[1,2,3].
Native: India
Flowering and Fruits: February

Cadaba fruticosa
Vernacular name : Maragacha (Kannada)
Family: Capparaceae
Description: A large shrub or small tree. Leaves simple, elliptic-oblong, acute. Petals 4. Fruit 2 valvular, with orange-red pulp[1,2].
Native: India sub-continent
Flower, Fruits: Throughout the year

Caesalpinia coriaria
Common name: Divi divi
Family: Fabaceae
Description: Unarmed tree. Branches glabrous, with numerous lenticles. Leaves compound, alternate. Flowers are small. Greenish- yellow. Pod twisted glossy, glabrous[1,2].
Native: Tropical America
Flower, Fruits: July – December

Caesalpinia pulcherrima
Common name: Peacock Flower
Family: Fabaceae
Description: A large shrub or small branched tree. Leaves compound. Flowers in long racemes. Petals subequals, scarlet, red and yellow. Pod obliquely, oblong, compressed, glabrous[1,2].
Native: Tropical America

	*Calophyllum inophyllum* Common name: Common Poon Family: Clusiaceae Description: A medium to large size tree with milky latex. Leaves simple. Opposite decussate, oblong- ovate with several closely set parallel lateral veins. Flowers axillary, few-flowered corymbose inflorescence. Fruit hard, globoid[2]. Native: Tropical Asia Flower, Fruits: October - April
Canthium dicoccum Family: Rubiaceae Description: evergreen tree. Leaves acuminate bright green above, coriaceous flowers white in axillary cymes. Fruit globose, black[1.2]. Native: South India, Burma Flower, Fruit: December -January	
Calotropis gigantea Common name: Giant Milk- weed Family: Asclepiadaceae Description: Perennial shrub with milky latex. Leaves simple in opposite pairs. Flowers showy. Fruits is a pair of follicles with innumerable seeds having white long silky hairs at the end[1.2]. Native : Tropical Asia, Tropical Africa Flower, Fruit: Throughtout the year	
	*Canscora diffusa* Common name: Kilwar Family: Gentianaceae Description: Herb. Leaves ovate, elliptic, narrowed at both ends. Flowers in fascicles, sometimes solitary. Corolla pink[1.2]. Native: Tropical Africa to Indomalaysia Flower, Fruit: October - January

Canthium parviflorum
Common name: Carray Cheddle
Family: Rubiaceae
Description: Shrubs armed. Leaves ovate-obovate. Inflorescence a few-flowered cyme. Flowers 4-merous. Fruit drupe, furrowed, obcordate[1.2].
Native: India
Flower, Fruit: April to January

Capparis sepiaria
Common name: Hedge Caper, Wild Caper Bush
Family: Capparaceae
Description: A large erect or climbing shrub with recurved spines. Leaves are simple, dark green. Inflorescence is an umbel. Fruit is a globose berry with a hard rind[1.2].
Native: India, Sri Lanka
Flower, Fruit: April - September

Capparis zeylanica
Common name: Ceylon Capper
Family: Capparaceae
Description: A much- brancehed climbimg shrub. Leaves rough in texture, broadly lanceolate with short, curved spines. Flowers are extra-axillary with 4 greenish white petals. Fruits are ovoid berries, bright scarlet with many seeds[1.2].
Native: India
Flower: Throughtout the year

Cardiospermum halicacabum
Common name: Ballon Vine
Family: Sapindaceae
Description: A annual climbing herb. Leaves alternate, broad, segmented with toothed margin. Flowers are small in axillary umbels. Fruit is 3-angled and inflated[1.2].
Native: India
Flower, Fruit: December - February

Carissa spinarum
Family: Apocynaceae
Description: An erect shrub. Leaves simple, thin and broadly ovate or sub orbicular. Inflorescence is a cyme. Flowers white. Fruit is Berry[1,2].
Native: India
Flower, Fruit: February - March

Cassia fistula
Common name: Indian laburnum
Family: Fabaceae
Description: Tree up to 5 m high. Leaves alternate, pinnate, leaflets up to 8 pairs, ovate-oblong, inflorescence a lax raceme, and drooping up to 50 cm long. Fruit a pod, pendulous, black, cylindrical[1,2,3,4].
Native: India, China, Southeast Asia
Flower, Fruits: March – May; Sep.

Cassia hirsuta
Common name: Hairy Sickle Pod
Family: Apocynaceae
Description: Annual hirsute herb. Branchlets are grey –tomentose. Leaves elliptic –oblong. Fruit berry globose or sub-globose[1,2,3].
Native: Australia
Flower, Fruits: April - May

Cassia siamea
Common name: Siamese Tree Senna
Family: Fabaceae
Description: Trees. Leaves Compound, long, estipulate, eglandular. Antheriferous stamens[2,3].
Flower, Fruits: March - February
Native: South East Asia.

Cassia absus
Common name: Hairy Cassia
Family: Fabaceae
Description: Herb. Branches covered with viscid glandular hairs. Leaves alternate, pinnately compound, often glands on petile. Pod flat, covered with stiff glandular hairs. Seeds black, ovoid, shining[2,3].
Native: Africa
Flower, Fruit: September - February

Cassia auriculata
Common name: Tanner's Cassia
Family: Fabaceae
Description: A large shrub, most colourful when in flower. Leaves pinnately compound with glands opposite to leaflets. Flowers in corymbose racemes are golden yellow. Fruit pod, long[2].
Native: South America
Flower, Fruit: Throughout the year

Cassia occidentalis
Common name: Coffee Weed
Family: Fabaceae
Description: A glabrous undershurbs. Leaves compound, alternate, acuminate, elliptic-ovate. Inflorescence racemes. Fruit pod linear, turgid but compressed, brown with yellow margins[2].
Native: Central and South America
Flower, Fruit: October - February

Cassia tora
Common name: Foetid Cassia
Family: Fabaceae
Description: An Annual herb. Leaves with subulate glands between the leaflets, obovate – oblong. Flowers in axillary[1,2,3].
Native: Tropics
Flower, Fruit: August - November

Cassine glauca
Common name: Ceylon Teak
Family: Celastraceae
Description: A Mediun to large size evergreen tree. Leaves are simple, ovate to ovate-elliptic with entire or crenate margin. Flowers are white with a green disk and yellow anthers. Fruit drupe[2].
Native: Tropics
Flower, Fruit: August - February

Catharanthus roseus
Common name: Periwinkle
Family: Apocynaceae
Description: Branched shurb with smooth grey stem with milky latex. Leaves are shining green, elliptic with narrow base and blunt apex. Fuit is a pair of slender follicles[2].
Native: Madagascar
Flower, Fruit: Throughout the year

Celastrus paniculatus
Common name: Staff Tree
Family: Celastraceae
Description: An unarmed climbing shrub. Leaves are simple, elliptic to ovate or obovate with crenate – serrate margin. Flowers are unisexual, white. Fruit is a globose, bright yellow septicidal capsule. Seeds are enclosed in a fleshy scarlet aril[1,2].
Native: India, Sri Lanka, Thailand
Flower, Fruit: February - September

Chromolaena odorata
Common name:
Family: Asteraceae
Description: An erect undershrub. Leaves opposite and palmately veined, crenate-serrate. Corolla white to purple. Heads are in corymbose panicles and homogamous, bisexual. Achenes angular[2,1].
Native: South America
Flower, Fruit: Novemeber - April

Cissampelos pareira Common name: Velvet Leaf Climber Family: Menispermaceae Description: Twining herbs. Leaves broadly ovoate to suborbicular, rounded to acute at apex. Flowers greenish- white. Drupe scarlet, pubscent[1,2]. Native: Tropics Flower, Fruit: July – October.	
	*Clausena dentata* Common name: Black Currant Grape Family: Rutaceae Description: A small aromatic evergreen glabrous tree.Bark black. Leaves are odd pinnate. Inflorescence is a raceme and flowers are greenish-white ,4 merous. Fruit is a ovoid berry, white with age, pulp edible[2]. Native: Indo-malayan Flower, Fruit: April – August
Cleome gynandra Common name: Spider Flower Family: Capparaceae Description: Erect glandular herbs. Leaves compound, subsessile, elliptic- oblanceolate, acute, pubscent. Inflorescence racemose, elongated. Fruit siliqua cylindric, concentrically tribbed and echinate[1,2]. Native: Tropics Flower, Fruit: October	
	*Cleome viscosa* Common name: Wild dog Mustard Family: Capparaceae Description: Erect annuals, glandular-pubescent. Leaves compound, flowers in leaf racemes. Fruit siliqua cylindric. Seeds dark, brown, with faint concentric ribs and strong cross ribs[1,2]. Native: Indomalesia Flower, Fruit: August - February

Clerodendrum inerme
Common name: Common Hedge Bower
Family: Verbenaceae
Description: A large Climbing shurb with spreading branches. Leaves simple, opposite, small, ovate and leathery. Flowers in clusters of 3, axillary, fragant. Fruit is small 1-2 seeds[1,2].
Native: India, Sri Lanka
Flower, Fruit: Throughout the year.

Clerodendrum serratum
Common name:
Family: Verbenaceae
Description: Herbs or shurbs. Leaves sharply serrate, obovate, acuminate, cuneate and entire at base. Corolla blusih purple. Fruit is drupe purple[1,2].
Native: India, Sri Lanka
Flower, Fruit:August - September

Corchorus fascicularis
Family: Tiliaceae
Description: Annual herb. Leaves elliptic or ovate-lanceolate, serrate. Petal glabrous. Capsules oin clusters, densely hairy[2].
Fruit, Fruit: December

Corchorus trilocularis
Common name: Three Locule Corchorus
Family: Tiliaceae
Description: A sub- Shrub with purplish stem. Leaves are elliptic, ovate or lanceolate. Inflorescence of 1-3 flowered cymes. Fruit capsule[2].
Native: India, Sri Lanka, Old World Tropics
Flower, Fruit: September – December.

Crotalaria pallida
Common name: America Crotalaria
Family: Fabaceae
Description: A large herb. Leaves are trifoliate. Inflorescence racemes many-flowered. Corolla twice as large as calyx and exserted. Pof oblong, much exceeding the calyx[2].
Native: Africa
Flower, Fruit: September- April

Crotalaria prostrata
Common name:
Family: Fabaceae
Description: Herbs. Leaves estipulate, obovate-oblong, rounded or obtuse at apex. Raceme leaf-opposed, 2-5 flowered. Pod exserted, glabrous, 10-20 seeded[2].
Native: India, Java
Flower, Fruit: October - April

Croton bonplandianus
Family: Euphorbiaceae
Description: Perennial shurb. Leaves are simple, alternat, lanceolate with blunt-toothed margin. Inflorescence terminal, both male and female flowers are on the same branch. Flowers small, inconspicuous. Fruit three-lobed, dehiscing into single seeded bits[2].
Native: Temperate South America
Flower, Fruit: Throughout the year.

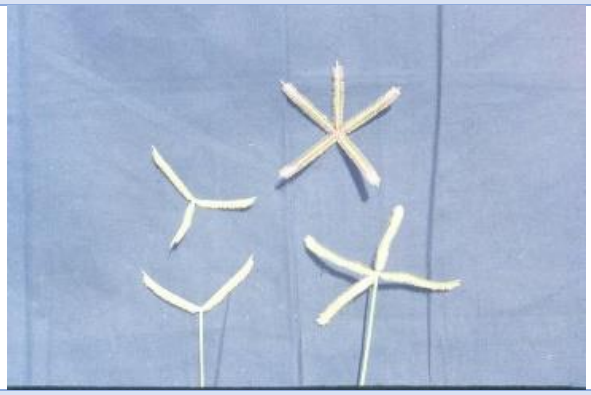
Cryptolepis buchananii
Common name: Wax-leaved Climber
Family: Asclepiadaceae
Description: A perennial twiner with latex and shiny. Leaves simple opposite. Flowers on branched inflorescence. Fruit is a pair of follicles. Seeds many and coma silky –white[2].
Native: China, Indian subcontinent
Flower, Fruit: March - September

Cucumis melo
Common name: Musk Melon
Family: Cucurbitaceae
Description: Perennial, prostrate, slender, monoecious herbs with thick root stock. Leaves suborbicular, palmately lobed. Flowers solitary, small. Berry rounded or ellipsoid, obscurely trigonous, smooth[1,2].
Native: Paleotropics
Flower, Fruit: September - March

Curculigo orchioides
Common name: Yellow Groundstar
Family: Liliaceae
Description: Perennial herb. Leaves are strap like on a shortened stem with parallel veins. Flowers are solitary and borne on a long stalk that arises from the base. Fruit is three-lobed capsule[1,2].
Native: India
Flower, Fruit: India

Cymbopogon nardus
Family: Poaceae
Description: Perennail Blade lanceolate, acuminate, glaucous. Panicle often purplish under dry conditions[2].
Native: South India, Sri Lanka
Flower, Fruit: July – September

Cynanchum callialata
Commonn name:
Family: Asclepiadaceae
Description: Climber. Leaves linear-oblong, pubescent on margin, whitish beneath. Peduncles sparsely pubescent. Follicles winged[2].
Native: Burma, South India

Cynodon dactylon Common name: Dhub grass Family: Poaceae Description: A perennial grass, extensively creeping by rhizomes. Leaves distichous at base of the culms. Spikes digitate, green or purplish. This grass is found in irrigated field, wetlands and also used for lawns[2,3]. Flower, Fruit: August – November.	
	*Cyperus rotundus* Common name: Nut Grass Family: Cyperaceae Description: A perennial herb with slender rhizome. Leaves dark grees above. Inflorescence of 3-9 spreading rays bearing large spikelets[2,3]. Flower, Fruit : Throughout the year Native : Africa
Dactyloctenium aegyptium Common name: Egyptian Grass Family: Poaceae Description: An annual grass. Culms erect or prostrate. Leaves are linear- acuminate, glaucous. Spikes digitately radiating. Lemmas cuspidate[2,3]. Native: Old World Tropics Flower, Fruit: Throughout the year.	
	*Dalbergia sissoo* Common name: North Indian Rosewood Family: Fabaceae Description: Tall Deciduous tree. Leaves pinnately compound. Flowers are small, pale yellow, in axillary panicles. Fruit pods are tongue-shaped, borne on long stalks[2,3]. Native: India Flower, Fruit: February - October

Dalbergia latifolia
Common name: East Indian Rosewood
Family: Fabaceae
Description: A large erect deciduous tree. Leaves are compound, which are broad at the free end. Flowers are small, white, appear on an axillary panicle. Fruit is 1-4 seeded, rather flattedned pod[2,3].
Native: India
Flower, Fruit: May - September

Delonix elata
Common name: White Gulmohar
Family: Fabaceae
Description: Tall tree. Leaves are compound, chartaceous, base cuneate, margin entire. Racemes terminal corymbose. Flowers yellowish white. Pod pale to dark brown, linear or oblanceolate, glabrous[2].
Flower, Fruit: December – June

Desmodium triflorum
Common name: Three Flowered Ticktrefoil
Family: Fabaceae
Description: Wiry, Spreading herbs, rooting at basal node. Leaves 3 foliate, obtuse of emarginate apex. Calyx incised more than halfway. Pod linear, continuous along upper suture[2,3].
Native: Old World Tropics
Flower, Fruit: September - December

Dichrostachys cinerea
Common name: Sickel Bush
Familiy: Fabaceae
Description: Shurb. Leaves are compound, pubescent beneath. Spikes are 45 cm long, yellow flowers, pod with 6-10 seeded, indehiscent [2].
Native: Indo-malaysia. Australia
Flower, Fruit: November

Dioscorea pentaphylla
Family : Dioscoreaceae
Description: Climber. Leaves 3-5-foliate. Leaflets digitate, ovate-elliptic. Male spikes in axillary or terminal panicles. Female racemes 2-3-nate. Fruit Capsule longer than broad. Seeds winged only at base[2].
Native: Tropical Africa to Malaysia
Flower, Fruit: August – November

Diospyros montana
Common name: Mountain Persimmon
Family: Ebenaceae
Description: Tree. Leaves compound, leaf blade elliptic- oblong. Male flowers in cymese. Flowers 4-merous. Fruit berry globose, glabrous. Seeds 8, smooth[2,3].
Native: India, Sri Lanka, Malaysia, Australia
Flower, Fruit: March - April

Dodonaea viscosa
Family: Sapindaceae
Description: A small tree. Leaves simple, linear –oblong to marrowly oblanceolate. Flowers are polygamous, corolla is white with recurved margin. Fruit is capsule broad with wings[2,3].
Native: India, Sri Lanka Tropics
Flower, Fruit: October - March

Diplocyclos palmatus
Common name: Lollipop climber
Family: Cucurbitaceae
Description: Slender, tuberous herbs. Leaves membranous upper scabrous, lower smooth opr slightly scabrous. Flowers fascicled, small, greenish-yellow[2,3].
Native: India, South east Asia, Tropical Africa
Flower, Fruit: August – September

Echinops echinatus
Family: Asteraceae
Description: Woody Herb. Leaves lanceolate, amplexicaul pinnatisect with creanations. Head densely bearded. Floret white[2].
Native: Afghanistan, India
Flower, Fruit: February - March

Eclipta prostrata
Common name: Field Aster
Family: Asteraceae
Description: A small herb. Leaves opposite, sessile, lanceolate. Flowers in axillary or terminal peduncled heads. Achenes cuneate[2].
Native: India
Flower, Fruit: November - February

Emilia sonchifolia
Common name: Pink Emilia
Family: Asteraceae
Description: A diffuse annual herb. Leaves are simple, auriculate at base. Flowers heads small, clusters on long stalk. Cypsela are slender, ribbed[2].
Native: Old World Tropics
Flower, Fruit: September - December

Erythroxylon monogynum
Common name: Red cedar
Family: Erythroxylaceae
Description: Shurb to Small tree. Leaves simple, alternate, rarely distichous, slender, grooved above, glabrous, chartaceous. Flowers white, soliatry, Fruit a drupe, glabrous, reddish, seed one[3,5].
Flowering and Fruit: Throughout the year

Euphorbia heterophylla
Common name: Green Poinsettia
Family: Euphorbiaceae
Description: erect herbs. Leaves alternate below, opposite above, cyathia in clusters of 1-3, gland circular, Schizocarp glabrous. Seeds coarsely and bluntly tuberculate, angular[3].
Native: Tropical America
Flower, Fruit: Throughout the year.

Euphorbia thymifolia
Common name: Gulf Sandmat
Family: Euphorbiaceae
Description: An annual delicate herb. Leaves elliptic with oblique base. Inflorescence are clustered in leaf axils. Male flowers several, slightly exceeding involucres, female flower 1 with short stipe[3].
Native: Caribbean Territory
Flower, Fruit: June – November.

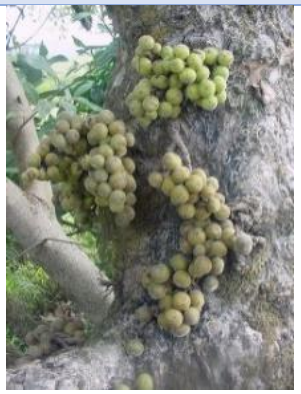
Eucalyptus Sp.
Family: Myrtaceae

Euphorbia hirta
Common name: Common Spurge
Family: Euphoribaceae
Description:Procumbent herbs. Leaves opposite, obliquely elliptic, acute, hairy. Cyathia axillary, in capitate cymes, gland minute. Seeds angular[3].
Native: India, Nepal, Sri Lanka
Flower, Fruit: Throughout the year

Evolvulus alsinoides
Common name: Little Glory
Family: Convolvulaceae
Description: small herb, stem is slender. Leaves are ovate- elliptic, alternate and silky hairy. Flowers are small and solitary. Fruit is globose capsule[3,4].
Native: Tropical Africa, Asia
Flower, Fruit: July – November

Ficus religiosa
Common name: Peepal tree
Family: Moraceae
Description: A deciduous large tree. Leaves are simple, heart-shaped with the apex drwan into a tail –like structure. Figs are globose, small and purplish. Bark yellowis or grey-brown, smooth becoming scaly with age[3,4].
Native: India, Burma
Flower, Fruit: March - April

Ficus racemosa
Common name: Cluster Fig
Family: Moraceae
Description: a large tree with latex. Leaves are simple, ovate, glossy green. Galls are found on the leaf. Figs on short, tomentose when young, obovoid, reddish when ripe[3,4].
Native: India
Flower, Fruit: Throughout the year.



Gloriosa superba
Common name: Malabar Glory Lily
Family: Liliaceae
Description: Climbing Shrub. Leaves oblong to ovate – lanceolate. Stigma introrse. Capsule green, smooth, oblong[1,2,3,4].
Native: Paleotropics
Flower, Fruit: August - October

Gmelina arborea
Common name: White Teak
Family: Verbenaceae
Description: Unarmed deciduous tree. Leaves broadly heart-shaped, entire, ovate, acuminate, chartaceous. Flowers arise in branching clusters towards the end of twigs. Drupe is 2-3 cm long and yellow when ripe[1,2,3].
Native: India
Flower, Fruit: April - May

Gmelina asiatica
Common name: white Teak
Family: Verbenaceae
Description: Armed shrub to tree. Leaves chartaceous, elliptic, ovate, glabrous, glaucous beneath. Flowers in axillary, puberulous without. Drupe yellow, obovate, seeds 2[1,2,3].
Flower: May- August, Fruit: November - February

Gymnema sylvestre
Common name: Periploca of the woods
Family: Asclepiadaceae
Description: Climber. Leaves ovate to oblong, sparsely to densely pubescent. Corolla lobes 2-4 mm long, pale yellow[1,2,3].
Flower, Fruit: April - October

Hackelochola granularis
Family: Poaceae
Description: Annual Culm erect. Leaf blade linear- lanceolate, Racemes 5-15 mm long. Spikelet sessile. Pedicelled spikelet 1.5 – 2.5 mm long[4].
Native: Tropics
Flower, Fruit: June - September

Heliotropium indicum Common name: Indian Heliotrop Family: Boraginaceae Description: An annual, erect, branched herb. Leaves ovate to oblong – ovate. Flowers are small with green calyx, ovary four – lobed[2]. Native: India, Sri Lanka, Nepal Flower, Fruit: April – July	
	*Hemidesmus indicus* Common name: Indian Sarasa parilla Family: Asclepiadaceae Description: A straggler with milky latex. Leaves are simple, opposite decussate, glabrous abobe. Flowers are crowded in subsessile cymes. Fruit is a follicle and seeds are with brownish-white hairs[2,3]. Native: India, Sri Lanka Flower, Fruit: Throughout the year
Heteropogon contortus Common name: Tangle head Grass Family: Poaceae Description: Annual or perennial grass with strongly- tufted stems. Leaf blade are lanceolate. Solitary Inflorescence, spike like silky hairy raceme with minute flowers[2]. Native: Californa Flower, Fruit: July – November	
	*Hibiscus – rosa-sinensis* Common name: China Rose Family: Malvaceae Description: large shrub to small tree. Leaves simple, alternate, shiny. Flowers are glorious, solitary, Fruit Capsule glabrous, ovoid[1]. Native: East Asia

Holarrhena pubescens Common name: Tellicherry bark Family: Apocynaceae Description: A small deciduous tree. Leaves acute or shortly acuminate at apex. Flowers white fragrant. Fruit in long paired follicles, white dotted, curved[2]. Native: India- Malay Peninsula Flower, Fruit: March - June	
	*Holoptelea integrifolia* Common name: Jungle Cork Tree Family: Ulmaceae Description: Deciduous tree. Leaves are simple, entire with lateral and membranous stipules. Flowers are unisexual and are borne in fascicles. Samara emarginate at apex with persistent stigma[2,3]. Native: India and South-east Asia Flower, Fruits: October - February
Hybanthus enneaspermus Common name: Orange Spade Flower Family: Violaceae Description: Herb. Leaves are linear-lanceolate with shallowly –crenate margin. Flowers are axillary, bilipped. Fruit is a capsule. Seeds striate[2,3]. Native: Tropics, South Asia Flower, Fruit: July- December	
	*Hyptis suaveolens* Common name: American Mint Family: Lamiaceae Description: Aromatic herbs. Leaves ovate, obtuse, rounded at base. Flowers are small, pale blue, in axillaryu compact clusters at the branch apices. Fruit is a group of four nutlets[2,3]. Native: Tropical America Flower, Fruit: September - February

Ichnocarpus frutescens
Common name: Slender Dog-Bane
Famliy: Apocynaceae
Description: An Evergreen woody liana wuthg milky sap. Leaves are elliptic-oblong or lance-shaped. Flowers are borne in many flowered clusters, fruit is follicle[2,3].
Native: Tropical Asia
Flower, Fruit: August - December

Indigofera astragalina
Common name: Silky Indigo
Family: Fabaceae
Description: A hardy annual with dense silky hairs on the stems. Leaves are compound, leaflets elliptic and rounded at the apex. Flowers are small, clustered in long. Pod ios hairy[2,3].
Native: India, Sri Lanka
Flower, Fruit: September - February

Indigofera tinctoria
Common name: Common Indigo
Family: Fabaceae
Description: Undershurb. Leaves compound, opposite, obovate- oblong. Pod linear, slightly curved, sparsely hairy. Seeds 6- 10[2].
Native: Tropics

Indoneesiella echioides
Family: Acanthaceae
Description: Herb. Leaves oblong to oblanceolate, apex obtuse or rounded, margin entire, ciliate, base acute. Racemes axillary, shorter than leaves. Capsule ellipsoid. Seeds 4, ovoid- oblong[2].
Native: Tropics
Flower, Fruit: Augist – December

Ipomoea pes-caprae Common name: Goat's foot creeper Family: Convolvulaceae Description: Herb. Leaves deeply 2-lobed, sometimes merely emarginate, parallel veined. Flowers usually solitary, Sepals unequal, apiclate, glabrous. Capsules ovoid to depressed – globular. Seeds densely brownish- tomentose[2]. Flower, Fruit: November - February	
	*Ixora arborea* Common name: Small flowered Ixora Family: Rubiaceae Description: Shrubs or trees. Leaves elliptic – lanceolate, coriaceous. Calyx teeth obscute. Corolla white, shortly lobed. Drupe red, slightly lobed[2] Native: India, Sri Lanka Flower, Fruit: February – March
Jasminum roxburghianum Family: Oleaceae Description: Climbing Shrub. Leave ovate, subcordate, Calyx lobes 5, hairy, rounded, Corolla white, ovate, acute[2,4]. Native: India Flower, Fruit: June - September	
	*Jatropha glandulifera* Family: Euphorbiaceae Description: Shrub. Leaves palmately 3-5-lobed, margin glandular, serrate, shortly acuminate. Flowers greenish-yellow, bracts lanceolate, with gland-tipped hairs on the margin. Sepals free. Schizocarp rugose[2,3,4]. Native: Tropcial Africa, Sri Lanka

Jatropha curcas
Common name: Purging nut
Family: Euphorbiaceae
Description: Shurb. Sap is watery. Leaves are broad, angular with 3-5 lobes ending in sharp points. Male and female on the same plant, greenish –yellow. Fruit is distnctly three lobes[2].
Native: Tropical America
Flower, Fruit: December - June

Justicia simplex
Common name: Common small Justicia
Family: Acanthaceae
Description: Creeping herbs. Leaves subsessile, ovate-linear. Spikes many-flowered, bracts broad, scarious. Fruit capsule with few seeded[2,3,4].
Native: India, Nepal, Sri Lanka, Pakistan
Flower, Fruit: July - September

Kirganelia reticulata
Family: Euphorbiaceae
Description: shurb. Leaves alternate, distichous, elliptic-oblong. Perianth lobes oblong – obovate, with scarious margin. Fruit globosem bluish-black when ripe[2].
Native: Paleotropics
Flower, Fruit: September – April

Lantana camera
Common name: Sweet Sarah
Family: Verbenaceae
Description: Shrub, recurved prickles. Leaves opposite, ovate, acuminate, cordate- acute at base. Spikes corymbose – umbellate. Corolla pink, red or yellow, pubescent outside[2,3].
Native: Tropical America
Plants aromatic, very troublesome and spreading rapidly.

Lepidagathis cristata
Family: Acanthaceae
Description: Creeping herb. Leaves linear-oblong, glabrous, Spikes capitate, mostly crowded on lower nodes. Calyx lobes bract-like with a short spine. Corolla hairy, white, lower lip with middle lobe larger[2,3].
Native: India
Flower, Fruit: Throughout the year
Endemism: Peninsular India

Leucaena leucocephala
Common name: Wild tamarind
Family: Fabaceae
Description: Scrubby tree. Leaves compound, leaflets oblong-lanceolate, acute. Calyx 2-3 mm long. Corolla pale green. Pod straight, flat. Seeds 15-20[2,3].
Native: Tropical America
Flower, Fruit: June- October

Leucas aspera
Common name: Common Leucas
Family: Lamiaceae
Description: Herb up to 50 cm tall. Leaves linear or narrowly oblong-lanceolate, base acute or cuneate. Verticilis axillary and terminal, distantly arranged, many-flowered, bracts – linear, ciliate. Nutlets smooth, brown, truncate at apex[2,3].
Flower, Fruit: Throughout the year

Limonia acidissima
Common name: Wood Apple
Family: Rutaceae
Description: Deciduous tree. Leaves are compound pinnately and aromatic. Flowers are small and arranged in panicles. Fruits are large, globose, of the size of a tennis ball with a hard shell[2,3].
Native: India
Flower, Fruit: March - April

Madhuca longifolia
Family: Sapotaceae
Description: Deciduous tree with milky latex and spreading branches. Leaves are crowded at the branch ends. Sepals ovate-lanceolate. Fruit berry globose, often with oblique apex[2,3].
Native: India
Flower, Fruit: February - March

Mallotus philippensis
Common name: Kamala tree
Family: Euphorbiaceae
Description: Evergreen tree. Leaves simple, ovate-lanceolate and strongly three-nerved with minute glands underneath. Flowers are unisexual, male and female flowers occuring on different trees in terminal elongate inflorescence. Fruit is a three-lobed orange –red small capsule[2,3].
Native: Asia
Flower, Fruit: November

Mangifera indica
Common name: Mango
Family: Anacardiaceae
Description: Evergreen tree. Leaves are simple, acute or acuminate at apex. Flowers are small, bisexual, reddish-white or yellowish-green. Fruit is a single-seeded fleshy drupe[2,3].
Native: India
Flower, Fruit: January - June

Maytenus emarginata
Common name: Thorny Staff Tree
Family: Celastraceae
Description: Shurb. Leaves glabrous, obtuse and serrate. Capsule globose up to 0.5 cm long. Seeds arillate in the lower half[2,3].
Native: Indomalesia
Flower, Fruit: December - February

Michelia champaca
Common name: Champak Tree
Family: Magnoliaceae
Description: Evergreen tree. Leaves are alternate and simple, margin entire and wavy. Flowers are solitary, showy and fragrant. Fruit is an aggregate of follicles[2,3].
Native: India, Malaysia
Flower, Fruit: May - December

Mimosa pudica
Common name: Tocuh- me-not
Family: Fabaceae
Description: Prickly herb. Compound leaves, acute at apex. Head globose.
Pod is flat with constrictions between seeds[2,3].
Native: South America
Flower, Fruit: July - October

Mitragyna parviflora
Common name: True Kadamb
Family: Rubiaceae
Description: Deciduous tree with buttressed stem. Leaves simple, opposite. Flowers are creamy white, globose heads. Fruit is a composite dry globose head[2,3].
Native: India, Sri Lanka, Bangladesh
Flower, Fruit: May- August

Mollugo pentaphylla
Common name: Carpet Weed
Family: Aizoaceae
Description: Herb, glabrous. Leaves in whorls, linear-lanceolaye yo obovate, acute. Flowers white, numerous in lax xorymbose cymes.
Capsule is oblong[2,3].
Native: India, Sri Lanka, Tropical America
Flower, Fruits: July- January

Mucuna pruriens
Common name: Velvet Bean
Family: Fabaceae
Description: Climbing Shrub. Leaves are trifoliate, leaflets are ovate-rhomboid and acute. Flowers are in axillary clusters, fruits are cylindrical, densely hairy[2,3].
Native: Tropical Africa, India, Caribbean
Flower, Fruit: November - January

Muntingia calabura
Common name: Bird's Cherry
Family: Elaeocarpaceae
Description: Moderate sized tree with drooping branches. Leaves lanceolate, serrate, acute, densely tomentose, linear tomentose. Flowers extra-axillary, solitary, subulate. Fruit berry, globose-ovoide, brownish-black. Seeds many, embedded in pulpy juice[2,3].
Native: South America
Flower, Fruit: January

Mukia maderaspatana
Common name: Madras Pea Pumkin
Family: Cucurbitaceae
Description: Climbing annual herb. Leaves alternate, slightly lobed, triangular, varying in shape and size. Flowers are small, axillary. Fruit is fleshy, small and often striped[2,3].
Native: India
Flower, Fruit: August - October

Nerium oleander
Common name: Oleander
Family: Apocynaceae
Description: A large shrub. Leaves linear-lanceolate, tapering at both ends, glabrous. Flowers pink/white. Follicles cylindrical up to 10 cm[2,3].
Native: Mediterranean region
Flower, Fruit: More or less throughout the year

Nymphaea nouchali
Common name: Star water Lily
Family: Nymphaeaceae
Description: A perennial aquatic herb with large floating leaves. Flowers are large, fragrant, showy and open throughout the day[2].
Native: India
Flower, Fruit: January - December

Opuntia stricta
Family: Cactaceae
Description: Branching shrub. Joints flat, obovate, flattened yellowish spines. Flowers 8 cm long. Petals bright yellow. Fruit berry globose, fleshy, areolat[2].
Native: America
Flower : January - August

Oxalis corniculata
Common name: Common Sorel
Family: Oxalidaceae
Description: Small herb with underground tuber. Leaves trifoliate. Flowers small on few flowered elongated inflorescence. Fruit capsule[2].
Native: Cosmopolitan
Flower, Fruit: January - December

Parthenium hysterophorus
Common name: Congress Weed
Family: Asteraceae
Description: herb. Leaves pubescent, lobes entire, acute. Flowers are minute and aggregated into a compact flower-like inflorescence. Fruit is small[2].
Native: West Indies, Central & North America
Flower, Fruit: Throughout the year

Passiflora foetida
Common name: Foetid Passion Flower
Family: PAssifloraceae
Description: Climbing shrub with simple alternate lobed leaves and tendrils. Flowers are 4cm or more across, attractive and solitary. Fruit is globose[2].
Native: Tropical South America
Flower, Fruit: November - July

Pavonia odorata
Family: Malvaceae
Description: Herb. Leaves ordicular- ovate, acute. Calyx 0.4 cm long, lobed to below middle. Corolla 1.3 cm long[2].
Native: East Tropical Africa
Flower, Fruit: September - October

Peltophorum pterocarpum
Common name: Copper pod
Family: Fabaceae
Description: A large deciduous tree, upto 20 m high. Leaves are bipinnately compound and pubescent. Flowers are in a terminal panicle, golden yellow with brownish stripes. Fruit is a pod 5-10 cm long, copper coloured[2,3].
Flowering: Summer months
Native: Sri Lanka, Sutheast Asia

Pergularia daemia
Common name: Trellis Vine
Family: Asclepiadaceae
Description: Climbing shrub with milky latex. Leaves are ovate, base deeply cordate and apex acuminate. Inflorescence in umbelliform racemes. Follicles paired, curved and echinate all over[2,3].
Native: Tropical Asia, Africa
Flower, Fruit: July - January

Phyla nodiflora
Common name: Purple lippia
Family: Verbenaceae
Description: Herb. Leaves small having characteristic toothed marginal lobes. Flowers are tiny on terminal small compact heads. Fruit a small nut[2,3].
Native: India, Sri Lanka, Nepal
Flower, Fruit: Throughout the year

Phyllanthus maderaspatensis
Family: Euphorbiaceae
Description: Erect Herb. Leaves obovate, glabrous with cuneate base. Flowers are axillary, solitary. Capsule smooth[2,3].
Native: Inida, Sri Lanka, Old World Tropics
Flower, Fruit: Throughout the year

Phyllanthus urinaria
Family: Euphorbiaceae
Description: Erect herbs. Stipules peltate, ovate-lanceolate, oblong-elliptic. Perianth lobes 6, Fruit capsule verucose. Seeds transversely ridged[2,3].
Native: Tropics
Flower, Fruit: May – September

Phyllanthus virgatus
Family: Euphorbiaceae
Description: Herb. Leaves alternate, elliptic-oblong, subsessile. Flowers are pedicellate, male flowers on shorter pedicels with oblong sepals. Fruit is a globose capsule[2,3].
Native: China
Flower, Fruit: April - September

Phyllanthus emblica
Common name: Indian Gooseberry
Family: Euphorbiaceae
Description: tree. Leaves apiculate, obtuse, rounded or cordate at base, glaucous beneath. Flowers usually monoecious. Fruit fleshy more than 1.5 cm in diameter[2,3].
Native: India, South-east Asia
Flower, Fruit: July - February

Phyllanthus fraternus
Family: Euphorbiaceae
Description: erect herb. Stipules lanceolate, basally attached. Leaf blade oblong – elliptic, obtuse at apex. Perianth 5 lobes, filaments connate, anther subglobose. Seeds trigonous, minutely tubercled in regular concentric lines[2,3].
Native: Tropics except Australia
Flower, Fruit: Novemeber - July

Physalis minima
Common name: Country gooseberry
Family: Solanaceae
Description: Herb. Leaves sinuate or toothed, ovate, entire. Fruiting calyx 1.5 – 2 cm long, scarious, teeth connivent. Corolla yellow, sometimes purplish withinin at base, fruit berry. Seeds minutely rugose[2,3].
Flower, Fruit: August - January

Pithecellobium dulce
Common name: Manila Tamarind
Family: Fabaceae
Description: Deciduous tree. Leaves are alternate, compound with small leaflets. Flowers are minute with tufts of long projecting stamens. Pod is twisted, few-seeded with constrictions between seeds[2,3].
Native: Mexico, South America, West Indies
Flower, Fruit: February - March

Plumbago zeylanica
Common name: White Plumbago
Family: Plumbaginaceae
Description: Herb. Leaves simple, alternate. Flowers with a long narrow tube. The sepals are covered with conspicuous glands. Fruit capsule[2,3].
Native: India, Sri Lanka, Pantropics
Flower, Fruit: December - April

Plumeria alba
Family: Apocynaceae
Description: Small tree. Leaves narrow, large, oblong – lanceolate. Strongly perfumed white flowers with a yellow centers. Fruit are cylindrical pods[2,3].
Native: Central America, Caribbean

Polycarpaea corymbosa
Family: Caryophyllaceae
Description: An erect herb. Leaves are simple, linear, opposite whorls. Flowers are small in compact bunches of white with pink tinge. Fruit is a capsule. Seeds compressed[2,3].
Native: Africa, Asia, Australia
Flower, Fruit: August – March

Polygala arvensis
Common name: Common Polygala
Family: Polygalaceae
Description: An erect herb with woody rootstock. Leaves sesile, elliptic or oblanceolate. Flowers are in axillary racemes. Fruit capsule[2,3].
Native: India
Flower, Fruit: June - January

Pongamia pinnata
Common name: Indian elm
Family: Fabaceae
Description: Moderate sized tree upto 7 m high. Leaves alternate, pinnate, stipules small, oblong, cadcous. Inflorescence a panicled raceme, axillary and terminal. Fruit a pod, oblong-obovoid, compressed, woody. Seeds solitary, reniform, brown at both ends[2,3].
Native: India
Flowering and Fruits: March – April

Pterocarpus marsupium
Common name: Indian Kino Tree
Family: Fabaceae
Description: Deciduous tree with often straight trunk. Leaves alternate, pinnately compound with leathery and entire leaflets. Flowers terminal, highly branched inflorescence. Fruit winged one-seeded indehiscent pod[2,3].
Native: India
Flower, Fruit: August - October

Pterocarpus santalinus
Common name: Red sandalwood
Family: Fabaceae
Description: Small to medium-sized tree. Leaves usually imparipinnate, leaflets 3, rarely 4-5, broadly ovate or orbicular, coriaceous. Flowers yellow, borne a few together in simple ot sparingly branched racemes. Fruit pods pbliquely orbicular. Seeds 1-2, reddish –brown, smooth, leathery[3].
Native: Peninsular India
Flower, Fruit: September – January

Pterolobium hexapetalum
Common name: White brasiletto climber
Familiy: Fabaceae
Description: shrub. Leaf rachis 12 -18 cm long, prickly, oblong, obtuse or retuse at apex. Calyx rose, corolla yellowish-white. Filaments villous. Pod pinkish-red[2,3].
Native: India
Flower, Fruit: August - February

Rhynchosia minima
Family: Fabaceae
Description: Herbs. Stipules lanceolate, leaflets rhomboid, acute. Raceme 6-9 cm long, 7-9-flowered. Corolla yellow. Pod oblong, slightly bent upwards[2,3].
Native: Tropics
Flower, Fruit: May - January

Rothia indica
Family: Fabaceae
Description: Annual herbs. Leaflets obovate-oblong to oblanceolate, acute or obtuse, membranous. Pod appressed-villous[2,3].
Native: India, Sri Lanka, Australia
Flower, Fruity: August - October

Santalum album
Common name: Sandal wood
Family: Santalaceae
Description: small evergreen semi-parasitic native tree. Leaves are simple, opposite, glossy and elliptic. Flowers are small, purplish-brown, borne in loose clusters in terminal as well as axillary paniculate cymose inflorescence[2,3].
Native: India
Flower, Fruit: late summer and between October - December

Saraca asoca
Common name: Flowering ashoka
Family: Fabaceae
Description: Trees, upto 3.5 m high. Leaves alternate, pinnate, upto 20 cm long, rachis glabrous. Inflorescence a corymb, axillary. Fruit a pod, linear-oblong, black, narrow at both filaments slender[2,3].
Native: India, Sri Lanka
Flower, Fruit : March -August

Scutia myrtina
Common name: Cat Thorn
Family: Rhamnaceae
Description: Prickly shrub. Leaves simple and opposite. Flowers small axillary clusters. Fruit globose, small and smooth[2,3].
Native: India, Sri Lanks, Myanmar, Africa
Flower, Fruit: February - September

Sebastiania chamaelea
Common name: Creeping Sebastiana
Familiy: Euphorbiaceae
Description: Herb. Leaves linear-oblong, obtuse or apiculate, apex, acute at base. Calyx lobes usually fimbriate. Schizocarp with 2 rows of reddish[2].
Native: Paleotroics
Flower, Fruit: August - November

Securinega virosa
Family: Euphorbiaceae
Description: Deciduous shrubs. Leaves obovate, elliptic-oblong, apiculate or emarginate at apex. Fruit white with age[2].
Native: Paleotropics
Flower, Fruit: April - May

Sesbania grandiflora
Common name: Vegetable Humming Bird
Family: Fabaceae
Description: Small wooded tree. Leaves upto 30 cm long. Leaflets glabrous or pubescent on both surfaces, Racemes 2-4-flowered. Flowers 5-10 cm long. Corolla sickle-shaped, red, pink or white. Pod tetragonous, margin thickened[2].
Native: Indonesia
Flower, Fruit: February -March

Sida acuta
Family: Malvaceae
Description: Erect herb. Stipules linear-lancelate, Petiole to 5 mm long, blade ovate or linear-lanceolate, serrate. Pedicels equal to or longer than petiole. Calyx lobes triangular, acute. Cocci 7, shortly awned[2,3].
Native: Pantropical
Flower, Fruit: August - February

Sida cordata
Common name: Heart-leaved Sida
Family: Malvaceae
Description: Herb. Leaves simpke, ovate-cordate, serrate with stellate hairs. Flowers yellow. Ovary 5-carpellate, sparsely hairy at the apex, beakshort, 2-dentate[2,3].
Native: India, Sri Lanka, Tropical Africa
Flower, Fruit: July - February

Sida cordifolia
Common name: Country Mallow
Family: Malvaceae
Description: A branched herb, soft hairy. Leaves are ovate with cordate base and toothed. Flowers are small, axillary. Fruits are round with fruitlets having 2 short spines[2,3].
Native: India
Flower, Fruit: October - February

Sida rhombifolia
Family: Malvaceae
Description: A branched minutely hairy herb. Leaves are variable, ovate-elliptic or rhomboid, coarsely-toothed. Flowers are in cymose clusters[2,3].
Native: India, Nepal
Flower, Fruit: January - December

Solanum americanum
Common name: Black Nightshade
Family: Solanaceae
Description: Herb. Leaves broadly ovate, entire or slightly lobed. Flowers axillary umbellate cymes, 4-8 flowered. Petals white. Fruit is a black berry[2,3].
Native: India, Sri Lanka
Flower, Fruit: Throughout the year

Solanum xanthocarpum
Common name: Yellow berried Nightshade
Family: Solanaceae
Description: Prickly prostrate herbs with armed spines. Flowers axillary, voilet. Fruit berry 25 mm across, reddish, smooth, seeds flate, not pitted[4].
Native: Pantropical
Flower, Fruit: Throughout the year

Sopubia delphinifolia
Common name: Common Sopubia
Family: Scrophulariaceae
Description: An erect herb. Leaves are opposite, long, linear and needle-like. Flowers olitary, axillary or in few flowered inflorescence. Corolla is trumpet-shaped with the frre lobes spreading. Fruit is capsule[2].
Native: India
Flower, Fruit: August- January

Stachytarpheta jamaicensis
Common name: Devil's Coach
Family: Verbenaceae
Description: Tall herb. Leaves elliptic-ovate, obtuse or acute at apex, cuneate and decurrent at base, glabrous on both surfaces. Calyx compressed. Corolla 8-11 mm long, blue-purple[2].
Native: Tropical America
Flower: More or less throughout the year

	*Stachytarpheta indica* Family: Verbenaceae Description: A perennial undershrub. Leaves are simple, opposite with characteristic toothed margin. Flowers are small[2]. Native: Tropical America Flower, Fruit: October - April
	*Synedrella nodiflora* Common name: Cindrella weed Family: Asteraceae Description: An erect herb. Leaves are opposite, elliptic and palmately veined. Flowering heads many, sessile, axillary. Florests yellow. Achenes black. Pappus is of 2-3 bristly awns[2]. Native: West Indies Flower, Fruit: July - December
Syzygium cumini Common name: Indian Blackberry Family: Myrtaceae Description: An elegant tall tree. Leaves simple, elliptic, lush-green abd leathery with insect galls. Numerous flowers aggregate into dense cluster with numerous long, white stamens. Edible fruits are globose to oblong, which are deep-purple to black when ripe. Bark grey and rough[2]. Native: South-east Asia Flower, Fruit: February - September	
	*Tabernaemontana divaricata* Common name: East Indian Rosebay Family: Apocynaceae Description: Small tree. Leaves elliptic-oblong, unequal, glabrous, shining, apex, margin entire. Flowers white. Follicles turgidly oblong, spreading and recurved. Seeds with a fleshy red aril[2]. Native: India Flower, Fruit: Throughout the year

Tamarindus indica
Common name: Tamarind
Family: Fabaceae
Description: medium to large size deciduous tree. Leaves are pinnately compound with small leaflets. Flowers are small on long inflorescence, pale green and pink colour with 3 unequal sized petals. Fruit is a bean like pod, fleshy, green at first, ripening cinnamon-brown[1,2].
Native: Tropical Africa
Flower, Fruit: Late Summer

Tecoma stans
Common name: Yellow Bells
Family: Bignoniaceae
Description: An evergreen shrub. Leaves compound with variable number of leaflets. Flowers in terminal panicles showy and yellow. Fruit linear capsule. Seeds winged[2,3].
Native: Tropical America
Flower, Fruit: January onwards

Tephrosia purpurea
Common name: Common Tephrosia
Family: Fabaceae
Description: Erect undershrub. Leaves are even pinnate. Inflorescence is a many-flowered raceme. Fruit is a pod which is slightly curved[2,3].
Native: India, Sri Lanka, Old World Tropics
Flower, Fruit: All seasons

Tephrosia villosa
Common name: Shaggu wild Indigo
Family: Fabaceae
Description: A hairy herb. Leaves compound, alternate with 11-19 pairs of leaflets. Leaflets lanceolate and retuse. Flowers in terminal clusters. Fruit is a flattened, curved and hairy pod with 6-8 seeds[2,3].
Native: India, Sri Lanka, Tropical Africa
Flower, Fruit: July - September

Terminalia arjuna
Common name: White Murdah
Family: Combretaceae
Description: An evergreen tree with buttressed trunk and drooping branchlets. Leaves simple, oblong, crenulate and leathery in texture. Flowers are small, white and borne on catkins. Fruit is ovoid with 5-7 angles or wings[2,3].
Native: India
Flower, Fruit: May- February

Terminalia bellirica
Common name: Belliric Myrobalan
Family: Combretaceae
Description: Trees. Leaves clustered at ends of branchlets, coriaceous, broadly elliptic, rarely obtuse, cuneate at base. Spikes clustered towards apex, simple, flowers creamy –white. Fruits ovoidm slightly 5-ridged, brown-pubescent[2,3].
Native: India
Flower, Fruit: January - September

Thunbergia alata
Common name: Black-eyed Susan Vine
Family: Acanthaceae
Description: Slender climber. Leaves simple opposite, heart-shaped. Flowers are large, showy, brown-centered with pair of broad wing-like structure. Fruit is a few-seeded capsule[2,3].
Native: Tropical Africa
Flower, Fruit: October - November

Thespesia populnea
Common name: Portia tree
Family: Malvaceae
Description: Tree upto 8 m high. Leaves alternate. Flowers axillary, solitary, bracteoles caducous. Fruit a capsule, subglobose, covered with peltate scales, yellow latex present. Seeds ovoid, channelled along the back, pubescent[2,3].
Native: India, Africa, Pacific Isles
Flower, fruit: Monsoon

Tinospora cordifolia
Common name: Heartleaf Moonseed
Family: Menispermaceae
Description: Climbing shurb. Leaves cordate and glabrous. Flowers are unisexual in racemes. Petals 6 and greem. Stamens 6 and free. Female flowers consists of Staminodes. Fruit is a drupe, globose, green turning orange to red[2,3].
Flower, Fruit: September – April
Native: India, Myanmar, Sri Lanka

Toddalia asiatica
Common name: Orange Climber
Family: Rutaceae
Description: Climbing shrub with prickles on stem, petiole and lower surface of leaves. Leaf elliptic or oblanceolate, obtuse at apex. Corolla white. Fruit distinctly lobed[2,3].
Native: South India
Flower, Fruit: January - September

Tragia involucrata
Common name: Forget-me-not
Family: Euphorbiaceae
Description:Herb wityh stinging hairs. Leaves simple, ovate-lanceolate, margin serrate. Flowers axillary, very small, pale yellow with 3 petals. Fruit 3-lobed capsule[2].
Native: India, Sri Lanka, Nepal
Flower, Fruit: November - January

Tribulus terrestris
Common name: Puncture Vine
Family: Zygophyllaceae
Description: Herb. Leaves compound, opposite, lanceolate stipules. Flowers pedicelled, solitary, axillary, sepals 5, acute, yellow, equalling sepals, hairy. Mericarps with 2 large and 2 smaller spines[2].
Native: Paleotropics
Flower, Fruit:

Trichodesma indicum
Common name: Indian Borage
Family: Boraginaceae
Description:Herb. Leaves simple, alternate, hairy on the upper and lower surface. Flowers are white, solitary. Calyx lobes ovate, acuminate. Corolla white, lobes rounded, apiculate. Nutlets smooth[2].
Native: India, Nepal, Sri Lanka
Flower, Fruit: August - October

Tricholepis glaberrima
Family: Asteraceae
Description: Erect glabrous herb. Leaves sessile, lower leaves obovate or spathulate, upper linear-lanceolate, margin serrate. Heads ovoid, involucral bracts linear-lanceolate, suberect or slightly recurved. Florets purple. Achenes oblong, faintly –ribbed, pappus shorter than the achenes[2].
Native:
Flower, Fruit: September - November

Triumfetta rhomboidea
Common name: Common Burbush
Family: Tiiliaceae
Description: A small perennial shrub. Leaves simple, alternate, heart-shaped, slightly 3-lobed. Flower small in terminal or leaf-opposed clusters. Sepals are five, long. Petals are five. Fruits are small, globose and bristly[2].
Native: India, Nepal
Flower, Fruit: August- December

Wedelia trilobata
Common name: Coat Buttons
Family: Asteraceae
Description: Pernennial hairy herb. Leaves simple. Flowers tiny heterogamous heads. Fruit dark with a crown of hairs[2]
Native: Central America
Flower, Fruit: Throughout the year

Urena lobata
Common name: Caesarweed
Family: Malvaceae
Description: Undershrub. Leaves pubescent presence of nectaries on primary nerves. Flowers axillary or solitary or in cluster clothed with rigid hairs. Corolla pinkish with dark center. Fruit is a globose, trigonous, pubescent schizocarp. Seeds reniform, angular[2].
Native: India
Flower, Fruit: September- March

Ventilago madraspatana
Common name: Red Creeper
Family: Rhamnaceae
Description: Shrub with brownish branchlets. Leaf blade shiny, ovate-oblong to ovate – elliptic. Flowers in treminal or axillary panicles. Fruit drupaceous and winged[2].
Native: Sri Lanka, Myanmar
Flower, Fruit: December - February

Vernonia cinerea
Common name: Ash Fleabane
Family: Asteraceae
Description: Herb. Leaves simple. Flowers are tiny in compact terminal inflorescences. Fruit are tiny achenes[2].
Native: India, Nepal, Sri Lanka
Flower, Fruit: January

Vicoa indica
Common name: Golden Daisy
Family: Asteraceae
Description: Herb. Leaves ovate-lanceolate, acute, cordate-hastate, scadrid along margin. Head 1.3 – 1.5 cm across solitary on long peduncles, bracts lanceolate. Ray florest about 22, elliptic-oblong, bright yellow florest many. Achene glabrous in female, hairy in bisexual, pappus scanty[2].
Native: Central and Western Peninsular India, Sri Lanka
Flower, Fruit: November - April

	*Vitex negundo* Common name: Common Chaste Family: Verbenaceae Description: Large shrub. Leaves with 3-5 leaflets, lanceolate, acute. Upper surface of leaf is smooth and lower surface covered with silvery white soft hairs. Flowers small in stalked bunches with bluish-purple 5 lobed petals. Fruits are globose black berries[2]. Native: India, Nepal, Bhutan, Pakistan and Sri Lanka Flower, Fruit: Throughout the year
Waltheria indica Common name: Boater Bush Family: Sterculiaceae Description: Herb. Leaves simple, alternate, stipulate with characteristic crenate –serrate margin. Flowers in axillary or terminal fascicles. Fruit is a capsule[2]. Native: India Flower, Fruit: August - January	
	*Wrightia tinctoria* Common name: Milky Way Tree Family: Apocynaceae Description: Small Deciduous tree. Leaves elliptic –lanceolate, acute or acuminate at apex, acute at base, glabrous. Flowers in axillary or terminal lax, spreading cyme. Corolla white or yellowish. Follicles cylindrical, cohering at the apex[2]. Flower, Fruit: March - April
Ziziphus oenoplia Common name: Jackal Jujube Family: Rhamnaceae Description: Prickly shrub with recurved prickles. Leaves ovatem 3-4 nerved with tomentum. Flowers are axillary, sessile. Petals are greenish. Fruit is a drupe, black when rip[2]e. Native: India, Sri Lanka, Pantropics Flower, Fruit: April - June	

Ziziphus mauritiana
Common name: Indian Jujube
Family: Rhamnaceae
Description: Tree. Leaves are simple, elliptic-ovate, palmately nerved with stipules. Flowers are small, in axillary clusters. Fruit is an orange red berry[2].
Native: India
Flower, Fruit: December - January

Zornia gibbosa
Family: Fabaceae
Description: Herb. Leaflets lanceolate, acute. Corolla yellow, standrad cordate. Prickles on the pod scabrid[2].
Native: Tropics
Flower, Fruit: August - October

Reference:

1. Flora of Bangalore District, S V Ramaswamy, B A Razi, Published by the Director, Prasaranga, University of Mysore, Manasagangotri, Mysore – 570012, pp L+740
2. Digital Flora of Karnataka http://florakarnataka.ces.iisc.ernet.in/hjcb2/
3. Indian Biodiversity Portal http://indiabiodiversity.org/
4. eFloras.org http://efloras.org/
5. Flowers of India http://www.flowersofindia.net/
6. http://ces.iisc.ernet.in/biodiversity
7. http://ces.iisc.ernet.in/energy

9.0 Butterflies of Agastya Foundation Campus, Kuppam

Butterflies are part of the class of insects in the order Lepidoptera. The group comprises the true butterflies (superfamily Papilionoidea), the skippers (superfamily Hesperioidea) and the moth-butterflies (superfamily Hedyloidea). Butterfly fossils date to the mid Eocene epoch, 40–50 million years ago. Butterflies have 4 stages of life cycle: Egg; Larva; Pupa and Adult. Butterflies in their adult stage can live from a week to nearly a year depending on the species. Adult butterflies have large, often brightly coloured wings, and conspicuous, fluttering flight. Many species have long larval life stages while others can remain dormant in their pupal or egg stages and thereby survive winters. Butterflies are very particular of host plants, on which the female lays eggs. Butterfly larvae, or caterpillars, consume host plant leaves and spend practically all of their time in search of food. Host plants often have toxic substances in them and caterpillars are able to sequester these substances and retain them into the adult stage. This makes them unpalatable to birds and other predators. Such unpalatibility is advertised using bright red, orange, black or white warning colours. The toxic chemicals in plants are often evolved specifically to prevent them from being eaten by insects. Insects in turn develop countermeasures or make use of these toxins for their own survival. This "arms race" has led to the coevolution of insects and their host plants. (Ehrlich, P. R.; Raven, P. H. (1964). "Butterflies and plants: a study in coevolution". Evolution **18** (4): 586–608) Butterflies feed primarily on nectar from flowers. Some also derive nourishment from pollen, tree sap, rotting fruit, dung, decaying flesh, and dissolved minerals in wet sand or dirt. Butterflies are important as pollinators for some species of plants, although, in general, they do not carry as much pollen load as bees. They are, however, capable of moving pollen over greater distances. (Gilbert, L. E. (1972). "Pollen feeding and reproductive biology of *Heliconius* butterflies". *Proceedings of the National Academy of Sciences* **69** (6): 1402–1407). There are between 15,000 and 20,000 species of butterflies worldwide and in India there are about 1,800 *species.*

The Agastya Foundation Campus at Kuppam with diverse landscape elements has varied types of habitats for host plants and nectar plants. This has contributed to flourishing of butterflies in the area. Interactive butterfly garden was established with planting of host plants and creating an artificial pond. Each host plant was named along with a pictorial board indicating the dependent butterfly and its life cycle. Several butterfly species breed and interact with the host plants, which helps students visiting the campus to have a hands on session regarding butterfly. During the study, 49 species of butterflies were recorded in the campus (Table 1).

Table 1: Butterfly Species in the Agastya Foundation Campus at Kuppam

Sl. No	**Common Name**	***Scientific Name***
1	Blue Tiger	*Tirumala limniace*
2	Tawny Coaster	*Acrea violae*
3	Mottled Emigrant	*Catopsilia pyranthe*
4	Common Emigrant	*Catopsilia pomona*
5	Common Grass Yellow	*Eurema hecabe*
6	Common Castor	*Ariadne merione*
7	Angled Castor	*Ariadne ariadne*
8	Common Tree Brown	*Lethe rohria*
9	Indian Cabbage White	*Pieris canidia*
10	Common Rose	*Astrophaneura aristolochiae*
11	Crimson Rose	*Astrophaneura hector*
12	Plain Tiger	*Danus chrysippus*
13	Striped Tiger	*Danus genutia*
14	Yellow Pansy	*Junonia hierta*
15	Lemon Pansy	*Junonia lemonias*
16	Blue Pansy	*Junonia orithiya*
17	Danaid Egg-fly	*Hypolimnas misippus*
18	Great Egg fly	*Hypolimnas bolina*
19	Yellow Orange Tip	*Ixias pyrene*
20	White Orange Tip	*Ixias marianne*
21	Lime Butterfly	*Papilo demolecus*
22	Common Three Ring	*Ypthima asterope*
23	Common Four Ring	*Ypthima huebneri*
24	Grass Blue	*Pseudozizeera maha*
25	Red Pierrot	*Talicada nyseus*
26	Common Jezebel	*Delias eucharis*
27	Common Crow	*Euploea core*
28	Common Silver Line	*Spindasis vulcanus*
29	Common Sailor	*Neptis hylas*
30	Tailed Jay	*Graphium agamemnon*
31	Common Jay	*Graphium doson*
32	Common Evening Brown	*Melanitis leda*
33	Black Rajah	*Charaxes solon*
34	Common Palmfly	*Elymnias hypermnestra*
35	Baronet	*Euthalia nais*
36	Blue Mormon	*Papilio polymnestor*
37	Crimson Tip	*Colotis danae*
38	Small Orange Tip	*Colotis etrida*
39	Great Orange Tip	*Hebomoia glaucippe*
40	Yellow Orange Tip	*Ixias pyren*
41	White Orange Tip	*Ixias marianne*
42	Pioneer	*Belenois aurota*
43	Common Psyche	*Leptosia nina*
44	Tiny Grass Blue	*Zizula hylax*
45	Dark Grass blue	*Zizeeria karsandra*
46	Lesser Grass blue	*Zizina otis*
47	Grass Jewel	*Freyeria trochylus*
48	Scare Shot Silver Line	*Cigaritis elima*
49	Plains Cupid	*Chilades pandava*

Butterflies of Agastya Foundation Campus, Kuppam

Common Jezebel

Common Grass Yellow

Common Evening Brown

Blue Pansy

Yellow Pansy

Lemon Pansy

Common Crow

Common Bush Brown

Common Leopard

Common Silver Line

Common Mormon

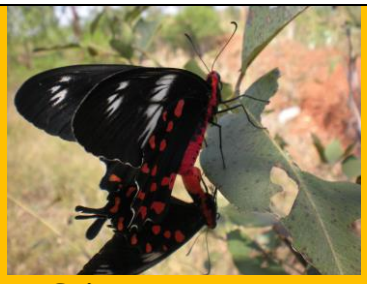
Scare Shot Silver Line

Plain Tiger

Striped Tiger

Great Eggfly

Daniad Eggfly



Crimson Rose

Common Three Ring

Common Crow Caterpillar

Common Baron Caterpillar

Pupa

Atlas Moth

Butterfly Garden

Mottled Emigrant

10.0 Spiders (ARANEIDS) of Agastya Foundation Campus, Kuppam

Kingdom	Animalia
Phylum	Arthropoda
Class	Arachnida
Order	Araneae (Spiders)
Suborder	Mygalomorphae and Araneomorphae

Spiders with more than 41000 species occur almost everywhere in the globe. They are able to live in all climate zones, in or on water, air and ground. Spiders are related to scorpions, pseudoscorpions, harvestmen, ticks and mites, all are ARACHNIDS, 8-legged animals. These arachnids are generally predators (catch live prey), except for some parasites (ticks and some mites). Spiders come in many different sizes, shapes and colours, and exist everywhere. Spiders are known for their venom and silk.

- VENOM is used in attack and defense: to catch live food, and to protect against predators, parasites, and aggressive relatives. Most spider venom is completely harmless to humans, and only very few spider species can be lethal to people.
- SILK: Spiders are unique for possessing silk glands; 3 pairs of spinnerets used for silk production. Spider silk is an elastic, strong and sometimes adhesive material. Spiders use silk for many purposes: to protect their young, catch food, make homes and move around. They are the only animals that use silk in almost every part of their daily lives. Silks differ depending on the temperature and speed at which they are spun, on the spider's diet, and on the purpose of the silk.

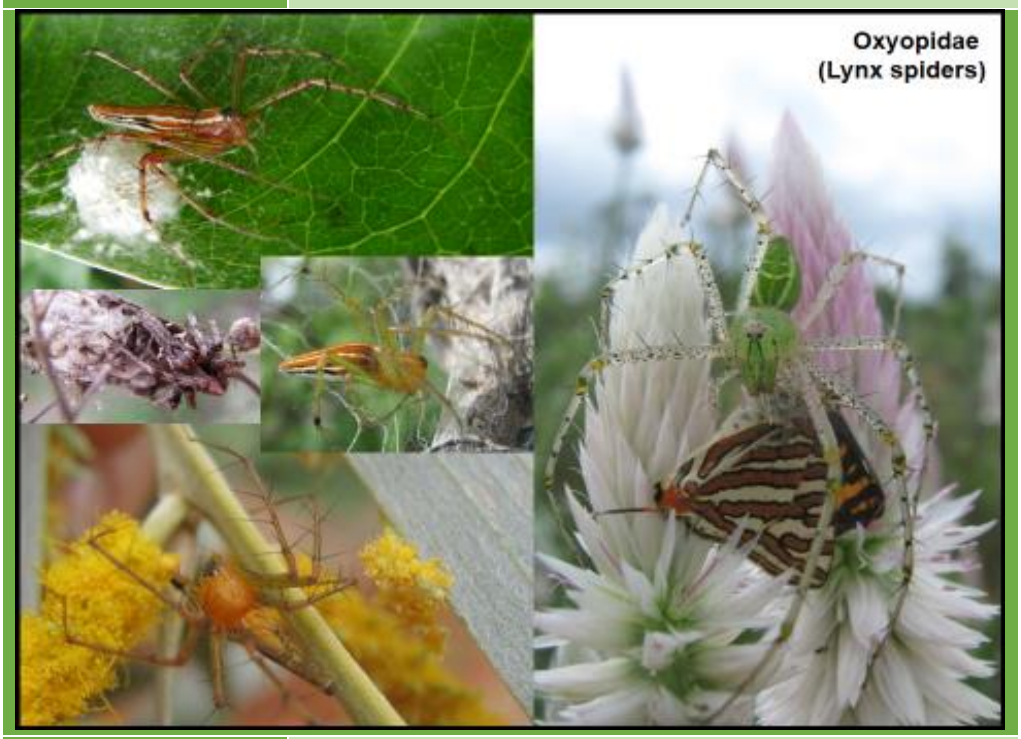
Suborder	Araneomorphae
Family	Agelenidae (FUNNEL WEB SPIDERS)
Genus	*Agelena* (2 genera have been reported from India)
Species	515 species worldwide, 10 are reported from India
	
Morphological characters:	8 eyes, hairy bodies and long legs, oval abdomens (rear part) with elongated last pair of spinnerets.
Habitat preference	grasslands, meadows, gardens and house walls.
Web	irregular and flat sheet-like web, with a tube extending from one edge to a retreat; the funnel in which the spider awaits for prey.
Prey preference:	walking and jumping insects.

Suborder	Araneomorphae
Family	Eresidae
Genus	*Stegodyphus* is the only genus reported from India
Species	100 species, 4 of which are reported from India

Morphological characters:	8-eyes, robust looking spiders with a square cephalothorax (head region), body covered with hair, giving a velvet appearance.
Habitat preference:	ground or bushes, shrubs and trees
Web:	sock-like silken retreat in the ground, or sheet webs on bushes, shrubs and trees connected to a small tubular or large irregular retreat
Prey preference:	insects

3 species are social, live in groups like ants, take care of common young, catch prey and feed together, and maintain the web together. Colonies of one of these species are easy to spot in bushes and trees around Agastya campus.

Suborder	Araneomorphae
Family	Araneidae (ORB WEAVERS)
Genus	Argiope, Araneus, Cyclosa, Cyrtophora, Gasteracantha and others (29 genera are reported from India)
Species	3000 species worldwide, 154 are reported from India
	
Morphological characters:	8-eyes with long hairy legs, very large abdomen (rear end of the body), that are brightly colored with various patterns, and sometimes irregularly shaped
Habitat preference:	grasslands, meadows, gardens, forests
Web:	an orb web is a circularly shaped web, constructed in a spiral way. The web is made of silk which spiders developed for the specific purpose of trapping flying insects, and it can reach great sizes. Spiders sometimes add decorations in form of denser silk in different patterns, or leaves, branches or stones
Prey preference:	flying insects

Suborder	Araneomorphae
Family	Oxyopidae (LYNX SPIDERS)
Genus	*Oxyopes*, *Peucetica* and others (4 genera are reported from India)
Species	430 species worldwide, 69 of which are reported from India
	
Morphological characters:	8-eyes with slender abdomens and extremely spiny legs.
Habitat preference:	plants, flowers and shrubs
Web:	these are actively hunting spiders without a catching web. They chase or ambush prey. Some hide in flowers and jump to catch flying insects.
Prey preference:	Lynx spiders are important in agricultural systems as biological control agents, as they feed on pest insects

Suborder	Araneomorphae
Family	Thomisidae (CRAB SPIDERS)
Genus	*Thomisus* and others (38 genera are reported in India)
Species	2120 species worldwide, 164 are reported in India
	
Morphological characters:	8-eyes, squat shaped spiders, which move sideways. The first 2 pairs of legs are larger, stouter and spinier than the last 2 pairs. Many species are pink, yellow or white and camouflage the flowers they occupy
Habitat preference:	Gardens and meadows, mainly on flowers, but sometimes on tree barks.
Web:	These spiders have no catching web as they ambush prey.
Prey preference:	Mainly pollinators (flying insects visiting flowers)

Suborder	Araneomorphae
Family	Sparassidae (GIANT CRAB SPIDERS)
Genus	*Heteropoda, Olios* and others (11 genera are reported from India)
Species	1093 species worldwide, 85 are reported from India
	
Morphological characters:	8-eyes, medium to large sized spiders with long legs and are often camouflaged. They run sideways and are active during the night.
Habitat preference:	ground litter or dry leaves and tree trunks
Web:	they build silken retreats, but do not spin webs
Prey preference:	Cockroaches

Suborder	Araneomorphae
Family	Salticidae (JUMPING SPIDERS)
Genus	*Carhotus*, *Salticus* and others (66 genera are reported from India)
Species	5300 species worldwide, 192 of which are reported in India
	
Morphological characters:	8 eyes in 2 rows (4+4) with an excellent eyesight, two of their eyes are conspicuously large; small to medium sized very hairy spiders of various colors They are active during the day.
Habitat preference:	Litter, grassland, bushes, trees, rocks and under stones
Web:	They make a silk safety line while jumping and moving around, but do not spin a web.
Prey preference:	They actively stalk and attack insects, like ants, or other spiders.

12.0 Frogs and toad of Agastya Foundation Campus, Kuppam

Amphibians (frogs, toads, salamander and caecilians) are divided into three groups:

- Gymnophiona (Gymno-naked, ophios-snake; caecilians and ichthyophis),
- Caudata (Cauda-tail; salamanders and newts) and
- Anura (an-absence, ura-tail; frogs and toads).

There are over 6,795 species of amphibians world over, of which India harbours 337 species. This includes one species of Caudata, 35 species of Gymnophiona and 301 species of Anura. Species belonging to all three extant orders are distributed in India though not uniform, due to the prevailing climate, phenology and topography (zoogeography) associated with habitat preferences of the species.

Table 1: Frogs and toad species

Species	Common name
Family: Bufonidae	
Duttaphrynus melanostictus	Common Indian Toad
Family:Dicroglossidae	
Euphlyctis cyanophlyctis	Skittering Frog
Hoplobatrachus tigerinus	Indian bull frog
Sphaerotheca breviceps	Indian Burrowing Frog
Family: Microhylidae	
Microhyla ornata	Ornate Narrow-mouthed Frog
Microhyla rubra	Red Narrow-mouthed Frog
Family: Rhacophoridae	
Polypedates maculatus	Chunam Frog

Frogs are a diverse and largely carnivorous group of short-bodied, tailless amphibians composing the order Anura. Frogs are widely distributed, ranging from the tropics to subarctic regions, but the greatest concentration of species diversity is found in tropical rainforests. There are approximately 4,800 recorded species, accounting for over 85% of extant amphibian species. The body plan of an adult frog is generally characterized by a stout body, protruding eyes, cleft tongue, limbs folded underneath and the absence of a tail in adults. Besides living in fresh water and on dry land, the adults of some species are adapted for living underground or in trees. The skin of the frog is glandular, with secretions ranging from distasteful to toxic. Warty species of frog tend to be called toads**.** Frogs' skins vary in colour from well-camouflaged dappled brown, grey and green to vivid patterns of bright red or yellow and black to advertise toxicity and warn off predators. Frogs typically lay their eggs in water. The eggs hatch into aquatic larvae called tadpoles that have tails and internal gills. They have highly specialized rasping mouth parts suitable for herbivorous, omnivorous or planktivorous diets. The life cycle is completed when they metamorphose into adults. A few species deposit eggs on land or bypass the tadpole stage. Frogs are a keystone group in the food web dynamics of many of the world's ecosystems. The skin is semi-permeable, making them susceptible to dehydration, so they either live in moist places or have special adaptations to deal with dry habitats. Frogs produce a wide range of vocalizations, particularly in their breeding season, and exhibit many different kinds of complex behaviours to attract mates, to fend off predators and to generally survive. Frog populations have declined significantly

since the 1950s. More than one third of species are considered to be threatened with extinction and over one hundred and twenty are believed to have become extinct since the 1980s. (Stuart, S. N.; Chanson, J. S.; Cox, N. A.; Young, B. E.; Rodrigues, A. S. L.; Fischman, D. L.; Waller, R. W. (2004). "Status and trends of amphibian declines and extinctions worldwide". *Science* **306** (5702): 1783–1786.). Kuppam campus harbours significant species of frogs and toad due to the favourable habitat present, though seasonal. The study area, though quite drier almost throughout the year, is with patchy water and moist locations during monsoon. The frogs are more active during monsoon, breeding efficiently. Eight species belonging to four families and seven genera were recorded from this region. Figure 1 depicts 7 species of frogs and 1 species of toad (Table 1).

Figure 1: Frogs and toad of Agastya Foundation Campus, Kuppam

<table>
<tr><td>  </td><td>  </td><td>  </td></tr>
<tr><td>Wrinkled Fejervarya Fejervarya sp., cricket frogs</td><td>Chunam frog, Polypedates maculatus (Gray, 1833): Indian tree frog</td><td>Red narrow mouthed frog, Microhyla rubra (Jerdon, 1854)</td></tr>
<tr><td>  </td><td>  </td><td>  </td></tr>
<tr><td>Ornate narrow mouthed frog, Microhyla ornata (Dumeril and Bibron, 1841)</td><td>Indian burrowing frog, Sphaerotheca breviceps (Schneider, 1799)</td><td>Indian Bull Frog, Hoplobatrachus tigerinus (Daudin, 1803)</td></tr>
<tr><td>  </td><td>  </td><td rowspan="2">References
Daniels, R.J.R. 2005. Amphibians of peninsular India. Universities Press, Hyderabad, pp. 268.
Gururaja KV. 2004. Sahyadri mandooka – Amphibians of Western Ghats. http://wgbis.ces.iisc.ernet.in/biodiversity/newsletter/issue6/article.html#wgbis
Gururaja K V, 2011. Anuran amphibians of Aghastya Foundation campus, Gubbi labs, Gubbi</td></tr>
<tr><td>Skittering Frog Euphlyctis cyanophlyctis (Schneider, 1799)</td><td>Common Indian toad, Duttaphrynus melanostictus (Schneider, 1799)</td></tr>
</table>

12.0 Reptiles of Agastya Foundation Campus, Kuppam

Kingdom	***Animalia***
Phylum	*Chordata*
Class	*Reptilia*
Sub-class	1. Snakes (Squamata) 2. Lizards (Squamata) 3. Crocodiles and Gharials (Crocodilia) *4.* Turtles, Terrapins and Tortoises (Testudines)

Reptiles are easily distinguishable as they

- lack hair on their body,
- possess scales,
- move along the ground,
- oldest living relatives of the dinosaurs,
- unique ability to survive on land, in water and are also arboreal
- found in all whether extremities like the hot tropical desert regions of Rajasthan, the highly humid conditions along the coast and even in severe cold climatic conditions
- Varying length of reptiles - lizards which are as small as 2 cm and crocodiles which are as big as 20 feet and weighing more than 1 tonne

Snake, Lizard, Crocodile..

Snakes	• Belong to the Squamata order, snakes are easily distinguishable due to their scaly skin, elongated body and lack of limbs • differentiated from legless lizards as they do not have eye lids or external ears • Fossil evidence reveal that snakes are evolved from burrowing lizards which lost the need for limbs • Ectothermic behaviour - cold blooded and depend on their surroundings to regulate their own body temperature. • Snakes vary in size – from few centimetres (Blind snakes) to 20 feet (Pythons) • Over 270 species of snakes are found in India • Snakes smell their surroundings using their forked tongue. Every time a snake flickers its tongue in the air, it picks up air particles which are then analyzed in the Jacobsons organ located at the top of the mouth and sense its environment. • follow an undulatory locomotion pattern where they move in an "S" shaped pattern • Are carnivorous - Small snakes such as blind snakes consume termites and other small insects. Medium sized snakes such as rat snakes and cobras are known to prey upon rats and frogs. King cobra is known to only consume other snakes. • Some snakes have very poor vision being able to distinguish only between light and dark whereas arboreal snakes have good vision allowing them to track relatively fast movements. The Green Vine snake is one of the only snakes found in India with horizontal pupil which gives it a binocular vision. • Most snakes are non-venomous and use methods of constriction to kill their prey. Venomous snakes are either Neurotoxin affecting s the nervous system of prey species (Cobras and Kraits) or Haemotoxic affecting the tissue and muscles of prey species (Vipers). • common venomous snakes are Spectacled Cobra (*Naja Naja*); Russell's Viper (*Daboia Russelii*); Saw Scaled Viper (*Echis Carinatus*); Common Indian Krait (*Bungarus Caeruleus*) • Skin is covered with scales and is dry and smooth. Snakes periodically undergo "moulting" - shed their entire outer skin to replace the worn out skin and also getting rid of latched parasites • Aquatic snakes have modified tails which act as oar pushing them forward. • Majority lay eggs to produce off springs. They abandon their eggs after laying them. King Cobra has been observed to build a nest, lay eggs and guard the nest ferociously until the birth of their off springs. • Some are ovoviviparous and retain their eggs inside their body until they are ready to hatch • Important role in the eco system - control the population of rodents, frogs and toads.

Lizards	• belong to the Squamata order in the Reptilia class • Over 3800 species of lizards all across the world. • They habit every known continent on earth except Antarctica • are cold blooded like all other reptiles • Easily distinguished from snakes due to the presence of external limbs, eyelids and visible external ear openings. • Unlike snakes, they have a highly developed sense of vision and are even known to be able to distinguish between colours. • vary in size - as tiny as 3 to 4 centimetres and 10 feet (Komodo dragon which grow up to 10 feet in length • exhibit the most peculiar and amazing behaviour known as "Autotomy", as a result of which they can completely detach their tail from their body to confuse and escape from predators • Exhibit a very interesting mode of communication using just the colours on their body, their posture and bodily gestures to attract mates, define territories or fight for mating rights against another rival male. • Known to have a bright flap of hidden skin underneath their lower jaw called a Dewlap, which is brought out during mating season to attract mates. Brighter the dewlap, higher is the chances of mating with a female. • Majority are insectivorous whereas some are known to be herbivorous as well. • Viviparous except for a very small number or lizards that are actually ovoviviparous. Lizards lay a small clutch of eggs which are known to have very hard shells and are often found buried in soil possibly as a mean to incubate the eggs.
Sub families of lizards	In India alone, there are 7 chief sub families of lizards that can be found: (a) Geckos: Largest sub-family of lizards and known for their very loud and unique vocalisation skills. Geckos have no eyelids and often use their tongue to clean their eyes. Geckos have suction pads on the underside of their digits which allow them to climb almost any surface. Geckos are nocturnal and they mainly feed on small insects, etc. (b) Agamid: Agamas very closely resemble iguanas in terms of looks. Arboreal agamas are flattened laterally and ground dwelling agamas are flattened ventrally. Most agamas have spines and appendages on their body. There is only one known species of herbivorous agama. The rest of them are insect eating lizards. (c) Chameleons: Only one species of chameleon, the Indian Chameleon is found in our sub-continent. They are mainly arboreal. They possess a unique extensile tongue that is used to ambush prey from a distance. They have eyes that can move independently of each other and their toes are opposed clasping ones as in many birds which give them the advantage to slowly creep up on their prey. The most remarkable ability of the chameleon is that they can change colours! (d) Skinks: Skinks look exactly like snakes with limbs! Their body is elongated and flattened ventrally with smooth shiny scales all along. Most skinks are ground dwellers. They feed mainly on insects and are diurnal by habit.

	(e) Lacertids: Lacertids are similar to snakes in the fact that their tongue is forked but only to a small extent. Lacertids have remarkably well developed limbs more than any other lizard. The pattern of the scales on the head of a lacertid can be used to identify it precisely. (f) Glass Snake: Not to be fooled by the name, glass snake is actually a species of legless lizard. Glass snake is the only legless lizard found in India. They look exactly like a snake except for the fact that they possess eyelids which happens to be the only distinguishing factor. They are known to feed on insects and earthworms. (g) Monitor Lizards: These specimens are the largest lizard species found in India. They can grow up to 5 feet in length! They are easily identifiable by their long, flattened body, equally long tail, elongated neck and perfectly forked tongue as in snakes. Re-curved teeth and strong well developed limbs make the monitor lizard fast runners and extremely agile hunters. They are known to eat small mammals such as wild hare, birds such as jungle fowl, etc.
Terrapins	• Terrapins are the most common of the Chelonians found throughout India. They are called Terrapins as they fall in between turtles and land tortoises in terms of their body modifications and evolutionary cycles. • Turtles have oar like flippers for limbs, tortoises have elephantine legs for walking on land, terrapins have webbed feet as they occupy both land and water. • They are found most often in fresh water bodies all across the country. They are widely adaptable and can hunt and eat both in water and on land. • Most of the terrapins are herbivores by nature. However there are a few exceptions such as the Indian Flap Shell which is insectivores. • These terrapins too lay eggs in the sand along the banks of river bodies. • Terrapins are known to have long necks due to which they can lie submerged inside water and just extend their nose beyond the water surface to take a gulp of air. This is especially useful for the carnivores terrapins helping them ambush their prey.

Reptiles of Agastya Foundation Campus, Kuppam

Spectacled Cobra

- Spectacled shaped marking on their hood.
- found commonly in Kuppam which can raise a hood.
- Highly venomous containing Neurotoxin venom which affects the central nervous system.
- Feeds primarily on rats and frogs
- Grows to a length of about 6 feet

Common Indian Krait

- Highly venomous, neurotoxin. Known to be the second most venomous only next to the King Cobra.
- Has black body with parallel white bands
- Grows to lengths over 6 feet.
- Feeds primarily on rats and frogs.
- Active during night.

Russells Viper

- Highly venomous. Contains haemotoxic venom which destroys tissues and muscles.
- Grows to almost 6 feet and heavier than other snakes.
- Has the longest fangs among the common venomous snakes of the campus
- Makes an extremely loud hissing noise when threatened or alarmed.
- Easy to identify from the triangular head and the diamond shaped pattern on the body.

Saw Scaled Viper

- Highly venomous. Contains haemotoxic venom
- Easily confused with the harmless Cat Snake due to similar body pattern and size.
- Grows to only two feet and is easily missed in heavily wooded areas as it can conveniently hide underneath rocks and boulders or even leaf cover.
- Feeds mainly on rats and frogs.
- Active during dark.

Common Indian Rat Snake

- most commonly found non venomous snake.
- Harmless, kills prey species only by constriction.
- Grows to lengths of over 12 feet.
- Very restless snake and can thrash around wildly when handled.
- Feeds mainly on rats and hence the name.
- Often mistaken with cobra but distinguished due to lack of hood.

Common Cat Snake

- This snake is known to possess rear fangs and considered semi venomous but not potent enough to kill human beings.
- Easily mistaken with the venomous saw scaled viper but distinguished due to the presence of a Y shaped mark on the head.
- Mainly arboreal. Often found hanging down from trees.
- Feeds on rats, small lizards and birds.

Green Vine Snake

- Considered s a non venomous snake,
- Possess rear fangs and is in fact semi venomous.
- The venom is not potent enough to kill human beings.
- When threatened, the snake opens its mouth to reveal the pink interiors and also expands its body to reveal the black and white scales underneath.
- This is the only snake found in Kuppam with horizontal pupils which provide the snake binocular vision.
- Grows to lengths of over 6 feet.
- Feeds mainly on lizards, frogs and small birds.

Common Kukri Snake

- Non venomous snake not seen very commonly.
- Grows to only little over 2 feet in length.
- Light brown back with regular black bands all across the body and an inverted V mark on the head typical of the Kukri family.
- Found mostly within termite mounds, tree holes etc.
- Feeds on small lizards, frogs and eggs of various animals.

Common Trinket Snake

- Non venomous species of snake.
- When alarmed, raises its body and poises in a S shape ready for a quick strike and return.
- Mostly olive brown throughout with two black stripes on neck and black streaks underneath the eye.
- Often found between loose rocks.
- Feeds mainly on rats, lizards, squirrels etc.
- Grows to lengths of about 5 feet.

Checkered Keelback Snake

- A very commonly seen non venomous species.
- Seen often in monsoon within water bodies as they prefer to stay in water.
- Easily identifiable due to the checkered pattern on their body.
- Very aggressive snake and will bite repeatedly when handled.
- Feeds on fishes, crabs and frogs.
- Grows to lengths of a little over 4 feet on an average.

Lizards

Brooks Gecko

- A very commonly seen gecko in dry regions.
- Just over 5 inches in length.
- Light brown throughout with dark brown spots on the body.
- Often found living under rocks, tree crevices and stones.
- Feeds mainly on small insects.

Termite Hill Gecko

- A very beautiful gecko found in scrub jungle habitats.
- Body light brown throughout with white edged crossbar pattern on the back.
- Found often within termite mounds and underneath rocks.
- Known to mainly feed on termites.
- Grows to about 6 inches in length.

Common Garden Lizard

- Found very commonly especially in south India.
- Excellent climber and often found on branches of small trees and shrubs.
- Spines on the body are typical of agamas.
- Fairly big lizard growing to almost 20 inches in length.
- Feeds mainly on insects.

Peninsular Rock Agama

- Brilliantly coloured agama found in dry regions.
- Males display a bright red colour during mating season.
- Tail often bigger than body in these agamas.
- They can grow up to 16 inches in length.
- Found usually underneath rocks and rubbles.
- Feeds on insects.

Indian Chameleon

- The most unique of all lizards
- Slow moving arboreal lizard.
- Known to have binocular vision.
- Long tongue combined with slow movement provides for the perfect weaponry to ambush prey species of insects.
- Bird like toes allow the lizard to grip branches well as they walk.
- Prehensile tail provides the additional balancing required.

Brahminy Skink

- Fairly commonly seen specimen on the skink family.
- Grows to about 11 inches in length.
- At first glance, looks like snake with legs.
- The upperside of the body is brown throughout with yellow lines flanking the sides. Very shiny scales on the body.
- Known to consume smaller lizards at times.

Snake Skink

- Very rarely seen and spends most of its time underground.
- Black upper body with fine yellow lines flanking the sides.
- In juveniles, the tail is completely red in colour.
- Grows to about 10 inches in length.
- Mainly feeds on insects.

Common Indian Monitor

- Biggest lizard found in Kuppam and India.
- Grows to almost 6 feet in length including tail.
- Olive coloured body throughout.
- Extremely strong claws and jaws.
- Mainly carnivores and hunts small mammals and birds.
- Extremely fast runner and very good climber.
- Found in burrows made by other animals

Terrapins

Indian Pond Terrapin

- Most commonly found terrapin in water bodies all across.
- Grows to almost a foot in length.
- Very easy to identify mainly due to its black shell and webbed feet.
- Feeds mainly on vegetable matter.
- Can be found both inside water bodies or basking on rocks.

Indian Flap Shell

- Quite commonly seen in water bodies around dry areas.
- Easily distinguishable due to its smooth olive coloured shell, webbed feet and a very elongated neck with extended nostrils.
- Species is an omnivore feeding on water plants and small animals such as crabs, fishes etc. found within water.
- A bulky terrapin, a fully grown adult can weigh more than 5 kilograms.
- Known to travel long distances on land in search of water during dry months.

14.0 Birds of Agastya Foundation Campus, Kuppam

Birds (class Aves) are feathered, winged, two-legged, warm-blooded, egg-laying vertebrates. Birds are characterised by feathers, a beak with no teeth, the laying of hard-shelled eggs, a high metabolic rate, a four-chambered heart, and a lightweight but strong skeleton. Birds also have digestive and respiratory systems that are uniquely adapted for flight. Many species annually migrate great distances. Birds are social, communicating with visual signals, calls, and songs, and participating in such social behaviours as cooperative breeding and hunting, flocking, and mobbing of predators. Eggs are usually laid in a nest and incubated by the parents. Most birds have an extended period of parental care after hatching. About 120–130 species have become extinct due to human activity since the 17th century, and hundreds more before then. There are about 8650 species of *birds* in the world, of which 1230 species are available in *India.* Agastya campus is located in terrain of Gudivanka, Andhra Pradesh, it is located at the intersection of three states Andhra Pradesh, Karnataka &Tamilnadu. There are around 137 species of birds recorded at the Agastya Campus (Table 1), 42 are migratory species. Among migratory species Harriers have chosen this place for roosting during night times.

Table 1: Birds of Agastya Foundation Campus

1)	Grey Francolin	*Francolinus pondicerianus*
2)	Rain Quail	*Coturnix coromandelica*
3)	Grey Junglefowl	*Gallus sonneratii*
4)	Indian Peafowl	*Pavo cristatus*
5)	Lesser Whistling-Duck	*Dendrocygna javanica*
6)	Bar-headed Goose	*Anser indicus*
7)	Spot-billed Duck	*Anas poecilorhyncha*
8)	Yellow-legged Buttonquail	*Turnix tanki*
9)	Lesser Golden-backed Woodpecker	*Dinopium benghalense*
10)	White-cheeked Barbet	*Megalaima viridis*
11)	Coppersmith Barbet	*Megalaima haemacephala*
12)	Common Hoopoe	*Upupa epops*
13)	Indian Roller	*Coracias benghalensis*
14)	Small Blue Kingfisher	*Alcedo atthis*
15)	White-breasted Kingfisher	*Halcyon smyrnensis*
16)	Small Bee-eater	*Merops orientalis*
17)	European Bee-eater	*Merops apiaster*
18)	Common Hawk Cuckoo	*Hierococcyx varius*
19)	Asian Koel	*Eudynamys scolopacea*
20)	Small Green-billed Malkoha	*Phaenicophaeus viridirostris*
21)	SirkeerMalkoha	*Phaenicophaeus leschenaultii*
22)	Rose-ringed Parakeet	*Psittacula krameri*
23)	Plum-headed Parakeet	*Psittacula cyanocephala*

24)	Asian Palm Swift	*Cypsiurus balasiensis*
25)	Barn Owl	*Tyto alba*
26)	Eurasian Scops Owl	*Otus scops*
27)	Eurasian Eagle Owl	*Bubo bubo*
28)	Spotted Owlet	*Athene brama*
29)	Short-eared Owl	*Asio flammeus*
30)	Common Indian Nightjar	*Caprimulgus asiaticus*
31)	Blue Rock Pigeon	*Columba livia*
32)	Little Brown Dove	*Streptopelia senegalensis*
33)	Spotted Dove	*Streptopelia chinensis*
34)	White-breasted Waterhen	*Amaurornis phoenicurus*
35)	Common Sandpiper	*Actitis hypoleucos*
36)	Black-winged Stilt	*Himantopus himantopus*
37)	Yellow-wattled Lapwing	*Vanellus malabaricus*
38)	Red-wattled Lapwing	*Vanellus indicus*
39)	Oriental Honey-buzzard	*Pernisptilo rhynchus*
40)	Black-shouldered Kite	*Elanu scaeruleus*
41)	Black Kite	*Milvus migrans*
42)	Brahminy Kite	*Halias turindus*
43)	Egyptian Vulture	*Neophron percnopterus*
44)	Short-toed Snake Eagle	*Circaetus gallicus*
45)	Crested Serpent Eagle	*Spilornis cheela*
46)	Western Marsh Harrier	*Circus aeruginosus*
47)	Pallid Harrier	*Circus macrourus*
48)	Pied Harrier	*Circus melanoleucos*
49)	Montagu's Harrier	*Circus pygargus*
50)	Shikra	*Accipiter badius*
51)	White-eyed Buzzard	*Butas turteesa*
52)	Lesser Spotted Eagle	*Aquila pomarina*
53)	Tawny Eagle	*Aquila rapax*
54)	Common Kestrel	*Falco tinnunculus*
55)	Red-headed Falcon	*Falco chicquera*
56)	Peregrine Falcon	*Falco peregrinus*
57)	Little Grebe	*Tachybaptus ruficollis*
58)	Little Cormorant	*Phalacrocorax niger*
59)	Great Cormorant	*Phalacrocorax carbo*
60)	Little Egret	*Egretta garzetta*
61)	Grey Heron	*Ardea cinerea*
62)	Purple Heron	*Ardea purpurea*
63)	Large Egret	*Casmerodius albus*
64)	Cattle Egret	*Bubulcus ibis*
65)	Indian Pond Heron	*Ardeola grayii*

66)	Glossy Ibis	*Plegadis falcinellus*
67)	Black-headed Ibis	*Threskiornis melanocephalus*
68)	Eurasian Spoonbill	*Platalea leucorodia*
69)	Painted Stork	*Mycteria leucocephala*
70)	Asian Openbill Stork	*Anastomus oscitans*
71)	Jerdon's Chloropsis	*Chloropsis cochinchinensis*
72)	Brown Shrike	*Lanius cristatus*
73)	Bay-backed Shrike	*Lanius vittatus*
74)	Rufous-backed Shrike	*Lanius schach*
75)	Indian Treepie	*Dendrocitta vagabunda*
76)	House Crow	*Corvus splendens*
77)	Jungle Crow	*Corvus macrorhynchos*
78)	Greater Coucal	*Centropus sinensis*
79)	Ashy Woodswallow	*Artamus fuscus*
80)	Eurasian Golden Oriole	*Oriolus oriolus*
81)	Large Cuckoo-Shrike	*Coracina macei*
82)	Small Minivet	*Pericrocotus cinnamomeus*
83)	Black Drongo	*Dicrurus macrocercus*
84)	White-bellied Drongo	*Dicrurus caerulescens*
85)	Asian Paradise-Flycatcher	*Terpsiphone paradisi*
86)	Common Iora	*Aegithina tiphia*
87)	Common Woodshrike	*Tephrodornis pondicerianus*
88)	Blue Rock Thrush	*Monticola solitarius*
89)	Tickell's Blue Flycatcher	*Cyornis tickelliae*
90)	Oriental Magpie Robin	*Copsychus saularis*
91)	Indian Robin	*Saxicoloides fulicatus*
92)	Common Stonechat	*Saxicola torquata*
93)	Pied Bushchat	*Saxicola caprata*
94)	Brahminy Starling	*Sturnus pagodarum*
95)	Rosy Starling	*Sturnus roseus*
96)	Common Myna	*Acridotheres tristis*
97)	Jungle Myna	*Acridotheres fuscus*
98)	Southern Hill Myna	*Gracula indica*
99)	Great Tit	*Parus major*
100)	Dusky Crag Martin	*Hirundo concolor*
101)	Common Swallow	*Hirundo rustica*
102)	Red-rumped Swallow	*Hirundo daurica*
103)	Red-whiskered Bulbul	*Pycnonotus jocosus*
104)	Red-vented Bulbul	*Pycnonotus cafer*
105)	White-browed Bulbul	*Pycnonotus luteolus*
106)	Streaked Fantail Warbler	*Cisticola juncidis*
107)	Jungle Prinia	*Prinia sylvatica*

108)	Ashy Prinia	*Prinia socialis*
109)	Plain Prinia	*Prinia inornata*
110)	Oriental White-eye	*Zosterops palpebrosus*
111)	Blyth's Reed-Warbler	*Acrocephalus dumetorum*
112)	Booted Warbler	*Hippolais caligata*
113)	Common Tailorbird	*Orthotomus sutorius*
114)	Greenish Leaf-Warbler	*Phylloscopus trochiloides*
115)	Rufous-bellied Babbler	*Dumetia hyperythra*
116)	Yellow-eyed Babbler	*Chrysomma sinense*
117)	Common Babbler	*Turdoides caudatus*
118)	Large Grey Babbler	*Turdoides malcolmi*
119)	Jungle Babbler	*Turdoides striatus*
120)	White-headed Babbler	*Turdoides affinis*
121)	Jerdon'sBushlark	*Mirafra affinis*
122)	Ashy-crowned Sparrow-Lark	*Eremopterix grisea*
123)	Rufous-tailed Finch-Lark	*Ammomanes phoenicurus*
124)	Eastern Skylark	*Alauda gulgula*
125)	Thick-billed Flowerpecker	*Dicaeum agile*
126)	Tickell'sFlowerpecker	*Dicaeumerythro rhynchos*
127)	Purple-rumped Sunbird	*Nectarinia zeylonica*
128)	Purple Sunbird	*Nectarinia asiatica*
129)	House Sparrow	*Passer domesticus*
130)	Large Pied Wagtail	*Motacilla maderaspatensis*
131)	Grey Wagtail	*Motacilla cinerea*
132)	Paddyfield Pipit	*Anthus rufulus*
133)	Oriental Tree Pipit	*Anthus hodgsoni*
134)	Baya Weaver	*Ploceu sphilippinus*
135)	Red Munia	*Amandava amandava*
136)	White-throated Munia	*Lonchura malabarica*
137)	Spotted Munia	*Lonchura punctulata*

Flying visitors of Agastya Foundation Campus

Laughing Dove

Spotted Dove

Coppersmith Barbet

		
Common Hoopoe	Paddy field Pipit	Black-shouldered Kite
		
Common Hoopoe	Cattle Egret	Indian Roller
		
Black Drongo	Great Tit	Common Tailorbird

Spotted Owlet

Golden Oriole

Red Whiskered Bulbul

Shikra

Common Hawk Cuckoo

White-browed Bulbul

Small Bee-eater

Indian Robin

Greater Coucal

Common Kestrel

Rufous-backed Shrike