"The earth is given as a common for men to labor and live in."

- Jefferson, Thomas
Profile of the Study area

Area and Population

Mysore is the southernmost district of Karnataka State. It is located at the convergence of Western and Eastern Ghats. It is 770 m above sea level and lies between 11° 30’N and 12° 50’N latitude and 75° 45’E and 77° 45’E longitude. Mysore taluk is one of the seven taluks of Mysore District. It is bounded by Mandya district to the north and northeast, T. Narasipura taluk to the east, Nanjangud taluk to the southeast, H.D. Kote taluk to the southwest, Hunsur taluk to the west and K.R. Nagar taluk to the northwest.

Mysore taluk has an area of 815 sq km with the distribution of 136 villages. According to census 2001, the population of Mysore taluk is 10.24 lakhs as against the total population of 26.25 lakhs in Mysore district. The total population recorded in rural areas is 2.38 lakhs, whereas in the urban areas it is 7.86 lakhs. The population density is 1,257 per sq km and the sex ratio is 964 females per 1000 males. Population growth rate in the past decade, 1991-2001 is 19.88%. In Mysore taluk, the total number of householders is 78,298. The total literacy rate in Mysore taluk is 50.30%. (GOI, Census, 2001).

Topography

Mysore taluk is a tableland of the southern Deccan Plateau with granite rocks protruding at odd intervals. It lies within the watershed of the Kaveri River, which flows through the northwestern and eastern parts of the Mysore taluk. The Krishna Raja Sagar Reservoir, which was formed by building a dam across the Kaveri lies on the northern edge of the taluk. Chamundi hill is situated at southeast direction 3 km from Mysore city.
Climatic condition

The climate of the taluk is moderate throughout the year and major rainfall is from the southwest monsoon. The average annual rainfall of the taluk is 761.9 mm. Temperature in this region ranges from a mean daily minimum of 21.4 °C to a mean daily maximum temperature of 34 °C. Relative humidity is generally high (70%) during southwest monsoon season.

Land use pattern in Mysore taluk

Of the 81,740 ha of total geographical area of Mysore taluk, the forest cover is 3,216 ha, land used for non-agricultural purpose is 11,260 ha, barren and uncultivable land is 6,770 ha, cultivable wasteland is 2,202 ha, permanent pastures are 2,919 ha and plantations and groves is 133 ha. About 737 ha of land area is categorized as fallow land. About 8,941 ha of land are irrigated with canals, tanks, wells, tube-wells etc. Red gravelly soil, red sandy soil and red loamy soils are the most common soil types found in this region.

Agricultural activities and animal husbandry

Important crops grown in this region are jowar, castor oil, cotton, sesame, paddy, sugarcane, ragi, vegetables, fruits, etc. Mysore taluk ranks fourth in the total livestock of the district. The total cattle population in Mysore taluk is 72,211.

Industries

Mysore district is industrially fast progressing district in Karnataka. Mysore taluk has the highest number of industries.
Field survey

Investigations were carried out in the selected 15 villages of Mysore taluk around Mysore city, within a distance of 12 km from the heart of the city are shown in Map - 1. Village proximity to main roads and railway stations were taken into consideration while selecting the area for investigation. This has been made with a view to assess the fuel transportation and availability of fuelwood along the avenues. Other important parameters considered while selecting the villages was the village history, such as geographical location, geographical area, human population, number of households, literacy rate, land use, etc.

In each village all the households were surveyed to evaluate and assess the village history, energy utilization pattern, which include types of fuel used, purpose of utilization - domestic, industries or others, quantity of fuel utilized, type of tree species used as fuel, methods of fuelwood utilization and related health hazards.

The data pertinent to the history of each village are collected from Directorate of Census Operations, Karnataka; Zilla Panchayat; Gram Panchayat; Taluk Office, and other Governmental and Non-governmental Departments. However, the data collected from the above sources do not disseminate any information or work related to the type of natural fuels used for cooking by different income groups among the rural households, sources of fuel, availability of the energy, stake holder’s desire to switch to clean fuel, and related health hazards on utilization of fuel resources.

A field survey is conducted in the villages selected for investigation to gather necessary information. Survey is conducted at different levels, namely, individual, household, village and nearby health-care facility (primary health centers, public
health centers, government hospitals), which the villagers generally use. Village-
level and health centre (HC) survey were conducted to validate data acquired at
household and individual levels, and also to get an overview of the village.

Households were interviewed, for which a standardized questionnaire was used
(Annexure - 1). Taking into account the tools used by the past researchers in the
field, the investigator selected questionnaire to evaluate and assess the natural fuel
resources and related health hazards among the rural folk. A number of standard
books, journals were also carefully studied for the selection of the questions.
Experts in the field were consulted. Questionnaire was designed both in English
and also in Kannada, which is the local language of the study area. The first draft
of the questionnaire was then reviewed, criticized and revised after thorough
discussion with the guiding professor and other experts for content validity.
Survey was carried out for the period of one year and resurveyed in the second
year to check and verify the data.

The study detail was described to the respondent, especially the women folk
and obtained informed consent.

The individual health data were collected on various characteristics of the
individual, i.e., physiological, behavioral and health characteristics. Physiological
characteristics of an individual include sex and age. Behavioral data include
information on literacy and occupation. Involvement of men, women and children
in biomass energy cycle, such as collection, transportation, processing and
combustion is studied. Persons less than 14 yrs of age are considered as children.
According to the definition given u/s 2 (ii) of the Child Labour (Prohibition and
Regulation) Act, 1986, a child means a person who has not completed his
fourteenth year of age. Responses from the all the respondents were collected
pertinent to the risks and health hazards associated with the different activities in
biomass energy cycle. Information were collected on cooking behaviour, including the individuals involved in cooking and their age, number of meals cooked per day, time spent for cooking per day, etc.

Biomass fuels are all the organic fuels from biological origin used for energy purposes are referred as biomass fuels. It includes all terrestrial and aquatic vegetation, its residues such as fuelwood, twigs, dead leaves, shell; cultivated crops and their residues like cereal straw, seed-husks, bagasse; livestock products and their residues (e.g., dung). Biomass energy is the energy derived from the combustion of biomass fuels. Fuelwood is the wood in rough produced from forests as well as non-forests and used solely for fuel purposes.

Individual’s opinion regarding the reasons for using biomass fuel for domestic cooking energy sources, reasons for not using LPG and kerosene and reasons for opting improved biomass cookstoves (Astra stove) are sought. Their awareness pertinent to risks and health hazards and environmental damage (indoor and outdoor air pollution and deforestation) caused due to biomass consumption. People’s willingness to reduce the impact of indoor air pollution and information on people’s desire to participate in social forestry programmes for firewood production in the area are studied.

Respondents were questioned for the possible risks and health hazards associated with biomass energy cycle. Health risks such as snake bites, thorn pricks, cuts and health hazards such as allergy, body ache, headache, burns, irritation of nostrils and throat, cough etc., were part of health related question. For health-related issues the queries were put directly to all adult individuals present during the survey. For the children proxy answers were recorded from the main respondents or their mothers. Proxy answers are considered valid assuming that
the children narrate the incidence of risks and common health hazards to their mother.

The data at household level were collected to get a comprehensive insight of the demographic pattern, socio-economic conditions, domestic cooking energy utilization pattern, quantity of energy source utilized per day, month, and year, housing characteristics, biomass cookstove used, location of the cookstove in the house, ventilation in the house, etc. The demographic character of each household, number of individuals in the household including men, women and children and the household size is noted. Annual income of the family expresses their socio-economic condition, which is essential to categorize the households into low, middle and high income groups. Families earning less than rupees 20,000 per annum are grouped under low income, those earning between rupees 20,000 to 50,000 per annum are grouped under middle income and those earning more than rupees 50,000 to 1,30,000 per annum are grouped under high income.

Energy utilization pattern included information on utilization of types natural fuel resources, such as Liquefied Petroleum Gas (LPG), kerosene, coal, biomass, solar energy, electricity and biogas. Utilization pattern of biomass fuel such as firewood, agricultural residues, saw dust and cow dung cakes are also assessed. Purpose of utilization - domestic and industry, sources of biomass fuel procurement, time and effort involved in procurement, persons (men, women and children) involved in procuring fuel in the household, quantity of fuel required per day per household and in different seasons of the year, fuel used earlier for cooking, etc. Biomass fuel procurement from sources, such as Common Property Resources (CPRs), Private Property Resources (PPRs) and wood depot were studied. Natural forests, village forests and avenues are classified under CPRs.
Housing characteristics included information on the type of house, number of rooms, type of kitchen, location of kitchen, and number of doors and windows in the kitchen. Since indoor air pollution due to fuel combustion depends on the presence of chimney and adequate ventilation, the kitchen with or without chimney and ventilation for each household has been noted. The type of cooking device most commonly prevailing in the study area and its location in the house is also considered in the present study.

The total quantity of biomass utilized in the village is evaluated. Types of biomass such as wild, avenue, horticulture tree species, agricultural residues and cow dung, which are commonly utilized as the cooking energy source in the 15 villages around Mysore city have been identified. These tree species are graded with ranks based on their abundance in the locality and rate of utilization. About 10 wild tree species, 6 avenue tree species, 4 horticultural trees and 4 agricultural residues and cow dung cake (Plates - 1 to 21) are considered to assess the abundance and utilization pattern of biomass fuel. Parts of the tree or plant utilized as fuel are also assessed. The different parts of each tree species have been photographed and their description, ecology and fuelwood values were written based on the available literature (Randhawa, 1983; Hocking, D., 1993; Saldanha, 1996; Blatter and Millard, 1997; Pandey and Chadha, 1997 and Sahni, 1998) and our own observations. The different tree species were identified based on existing herbarium, literature and on consulting experts in plant taxonomy. The key features considered for identifying the firewood species are detailed as below.

**Taxonomic name:** *Acacia nilotica* (L.) Del. (Plate – 1)

**Family:** Mimosaceae

**Common name:** English: Indian Gum Arabic Tree; Hindi: Babul, Kikar; Kannada: Gobbli, Kari Jaali
**Description:** Moderate-sized, evergreen tree, 15-30 m height, 3 m girth. Short trunk, dark brown to black bark, longitudinally fissured or deeply cracked. Leaves 2.5-5.0 cm long, bipinnate, with spinescent stipules, pinnules oblong. Leaflets 7-25 pairs, 1.5-7 mm long, 0.5-1.5 mm wide, glabrous or pubescent, apex obtuse, panicles clustered at nodes of leafy and leafless branchlets. Flowers during October-December, golden-yellow, fragrant, crowded in long-stalked globose heads, 6-15 mm in diameter, forming axillary clusters of 2-5 heads. Fruits during March-June. Pods linear, flat, indehiscent, 8-17 cm long, 1.3-2.2 cm broad, straight or curved, glabrous or grey-velvety, turgid, blackish, 10-15 seeded. Seeds deep blackish-brown, smooth, sub-circular, compressed, areole 6-7 mm long and 4.5-5 mm wide.

**Ecology:** *Acacia nilotica* is indigenous to plains of Andra Pradesh and Maharastra in India. Grows at 10-1340 m in altitude, tolerates 250-2280 mm mean annual rainfall, temperature of -1 to 50 °C, on variety of soils-alluvial soils, black cotton soils, heavy clay soils and porous soils with pH ranging 5.0-8.0. Grown as windbreak, to fixes nitrogen, for land rehabilitation on degraded saline or alkaline soils and also flooded areas.

**Fuelwood:** Wood is heavy (specific gravity - 0.67) and is an excellent firewood and charcoal. The calorific value of the sapwood is 4,800 kcal/kg and that of heartwood is 4,950 kcal/kg.

**Taxonomic name:** *Azadirachta indica* A. Juss. *(Plate – 2)*

**Family:** Meliaceae

**Common name:** English: Neem, Indian Cedar, Margosa tree; Hindi: Balnimb, Nim, Nind; Kannada: Bevu.

**Description:** Small to medium sized evergreen tree, but becomes deciduous in drier areas, 12-18 m in height and 1.8-2.4 m in girth with large crown. Bark rough, moderately thick with deep longitudinal or oblique fissures on the outer surface and flaking in older trees, dark-grey outside and reddish inside and contains small-
scattered tubercles. Leaves alternate, imparipinnate, 20-40 cm long, contain 8-19 leaflets with very short petiole, alternate proximally and more or less opposite distally, ovate to lanceolate, sometimes falcate (min 2) 3.5-10 x 1.2-4 cm, glossy, serrate; apex acuminate base unequal. Flowers are white or pale yellow, small, bisexual; is borne on axillary inflorescence, many flowered thyrsus, and 30 cm long. Flowering is observed during the month of March-May. Fruits are greenish yellow when ripe with single seeded drupe, which is ovoid or spherical in shape measuring 1.3-1.8 cm long. Fruits ripen during June-August.

**Ecology:** *A. indica* is believed to have originated in the Myanmar region. The tree grows wild in the dry forests of the Deccan and in the open scrub forests of the dry zone of Burma. It is cultivated all over India in mixed forest with *Acacia* sps. and *Dalbergia* sps, but best thrives in the drier climate of the northwestern parts where normal rainfall varies from 400-1200 mm, altitude ranging from 0-1500 m and mean annual temperature up to 40°C. It grows in all kinds of soils, but does well on water drained black cotton soil. It is very useful roadside and avenue tree in dry and moderately dry climate, an excellent shade tree during the hot season when other trees are bare and is a suitable plant for afforestation in dry region. It is grown where wood is used in furniture, construction materials, carts, axles, yokes, naves and felloes, boat making, oars, helves, carving, toys, drums and agricultural implements.

**Fuelwood:** Wood is moderately heavy with a specific gravity of 0.68 and is used as firewood as it produced charcoal of excellent quality.

**Taxonomic name:** *Ficus bengalensis* L. (Plates – 3)

**Family:** Moraceae

**Synonyms:** *F. indica* Roxb.; *Urostigma bengalense* Gosp.

**Common names:** English: Banyan, Hindi: Bargad, Kannada: Ala

**Description:** Very large, fast growing evergreen tree, briefly leafless in dry localities, 20-30 m height, 2.5-3.0 m in diameter, leafy crown is 304.8-609.6 m in
circumference. Aerial roots are many, some develop into accessory trunks. Bark smooth, 1.5 cm thick, green when young, grayish white when mature, turning pink when cut, exfoliating in sheets. Leaves ovate to elliptic, coriaceous with scale-stipules, 10.16 - 20.32 cm long. Fruit during February-April, sessile, in pairs, 1.27 cm to 1.905 cm in diameter, subglobose, red in colour when ripe.

**Ecology:** The tree occurs in monsoon and rain forests of India, both in the sub-Himalayan region and in deciduous forests of Deccan and S. India. The tree is extensively grown along road-sides and gardens for shade. Altitude up to 1300 m in the sub-Himalayan region and in peninsular India. Banyan trees grown on a wide variety of soils including shallow and stony sites or even rocky crevices and grows well on deep well-drained loams and saline soils. Tolerates temperatures of -1 to 46° C; rainfall of 500-4000 mm, drought resistant and frost hardy. It is epiphytic when young, propagates through seed and from cuttings.

**Fuelwood:** If felled, the yield of fuel would be 300-400 kg.

**Taxonomic name:** *Albizzia amara* Boivin (Plate – 4)

**Family:** Leguminosae

**Common names:** Kannada: Chugali, Chigare

**Description:** Small to moderate sized, unarmed, much branched deciduous tree. Bole crooked, 3.0 m in height and 0.6-0.9 m in girth, branchlets densely pubescent, smooth, dark green, scaly bark. Leaves are pinnately compound, with 15-30 pairs of small linear leaflets (1-2 cm × 2-6 mm), on 6-15 pairs of pinnae, membranous with a gland between the lowest pair. The clusters of fragrant yellow globose flowers develop in April-May, when the tree is almost leafless. The pods are thin, flat, large (12-20 × 2-3 cm), grayish-brown, veined with undulating edges, pubescent, about 10-15 × 2-3 cm, 6-8 seeded; ripen and fall to the ground in November-December. Seeds are small, ovoid, flattened.

**Ecology:** Found in all parts of south India, often in hilly areas, and on the Deccan Plateau up to 900 m altitude, in dry deciduous and thorny forests types.
Grows on wide range of soils; very shallow poor soils and in soils between rocky outcrops. Tolerates temperatures up to about 47 °C; mean daily minimum not lower than about 10 °C, rainfall range of 500-1000 mm. It is a strong light demander, intolerant of shade, drought and fire-hardy when mature, cannot stand frost. The tree is used for shelter-belts, wind-breaks and for afforestation.

**Fuelwood:** Wood is hard and heavy (sp gr, 0.84; wt, 865 kg/m³), its most important use is as fuelwood, for which it is repeatedly coppiced. Calorific value of sapwood is 5,049 kcal/kg; heartwood 5,306 kcal/g.

**Taxonomic name:** *Acacia ferruginea* (DC.) Roxb. *(Plate – 5)*

**Family:** Leguminosae; Mimosaceae

**Synonym:** *Mimosa ferruginea* (DC.) Roxb.

**Common names:** Hindi: Son-khair, Kaiger; Kannada: Bannimara

**Description:** Moderate sized deciduous tree, 12 m height and 35-50 cm in diameter with rarely straight bole. Branches slender armed with conical prickles, spines persist on bole until it reaches about 15 cm in diameter. Twigs are zigzag at nodes, wiry, glabrous, green or reddish. Bark is 2.5 cm thick, grey, rough with longitudinal furrows and transverse cracks. Leaves alternate; prickles twin, infrastipulae, slightly curved. Common petiole 7-15 cm long; pinnae four to six pairs; leaflets 15-30 pairs, grey to glaucous, linear, 0.6-1.25 cm long. The foliage is ready for lopping at the end of the cold season. Flowers pale yellow in numerous lax axillary spikes about 14 cm long, which are often panicked at the end of branches. Corolla white, glabrous, two to three times as long as calyx. Flowers appear from March to May when the tree foliage is very scanty. Pods are glabrous, flat, thin, straight, 7-18 × 2-15 cm, contain a dry sweetish pulp, dark brown, ripen from November to February and are finally dehiscent; three to seven seeded. Seeds are 0.5-0.7 × 0.35-0.5 cm, flat, ovate, oblong, distinctly stalked (a diagnostic feature); greenish to brown; collected from December to April and remain viable for one year.
Ecology: Found distributed in Peninsular India, from Gujarat in the west to Ganjam (Orissa) in the east; Central and Southwest India, occasional in scrub in southern interior Karnataka, to the eastern slopes of the Western Ghats, more common in Kolar district. It occurs also in dry forests of Sri Lanka. Altitude limits are from about 150-1500 m. Soil types suited are preferably loose and friable, as of cultivated fields, ranging from heavy black vertisols to light, gravelly alfisols. Also survives in shallow stony soils around bouldery outcrops. Temperatures tolerated are up to 40° C; it is frost tender and dies back in severe winters at higher altitude. Rainfall in its natural range averages 350-750 mm annually, but it also does well in moister zones up to 1500 mm annual rainfall.

Fuelwood: The wood is very hard, heavy (1120-1168 kg/m³); straight grained and very coarse-textured. Owing to its religious significance, this tree is seldom felled for firewood. However, it is exploited where other fuelwood sources are scarce.

Taxonomic name: *Acacia leucophloea* (Roxb.)Willd (Plate – 6)

Family: Leguminosae; Mimosaceae

Common names: English: White barked Acacia; Hindi: Safed kikar; Kannada: Bilijali

Description: It is a moderate size to large deciduous thorny tree, with clear bole, attaining heights of 35 m and diameters at breast height of 100 cm with spreading umbrella like crown. In harsh environments and on poor soils this species remains a shrub or small malformed tree. Trunk is stout, dividing into several large diameter branches; bark is white to yellowish-grey and smooth on young stems, dark brown to blackish and rough on old branches, smooth and exfoliates in long strips, leaving pale white patches on the trunk. In India, the trunk is often crooked and gnarled, especially when subjected to browsing pressure when young. Young branches are armed with stout 3.5 cm long, mauve-red (rarely white) straight stipular spines in pairs at the base of leaves. New leaves
appear about March-April, dark green, alternate bipinnately compound having 5-15 pairs, 5 × 1 mm, 12-30 pairs of leaflets, crowded. Rachis pubescent, usually with a cup-shaped gland between each pair of pinnae. Flowers appear during July to November, rainy season, creamy white, in large terminal tomentose panicles of globose head 6-9 mm, sweet scented which is pronounced at dusk. Pods appear in winter, are green when young and turn persistent dense brown in colour, flat and up to 20 seeded. Heavy pods contain 10-20 smooth oblong seeds of dark brown colour and 6 × 4 mm in size.

**Ecology:** The tree is native of South and Southeast Asia. Widespread over all of the Indian sub-continent, especially in dry tracts; in dry deciduous scrub, dry deciduous, southern thorn, and desert thorn forest types from sea level to elevations of 800 m. The temperature range in its zone of occurrence is – 4 to 49 °C. The average rainfall is 450 to 1500 mm per annum and dry season may persist for 9-10 months. It is high drought resistant and most frost-tolerant trees in this habitat. The young seedlings, however, are sensitive to frost, fire and weed competition, are light demanding. It grows in variety of soils from shallow and gravelly in hill slopes to deep alluvial. It grows best on loose deep soil; on stiff clay and shallow dry soils and it is rather stunted. It avoids sand dunes saline soils. *A. leucophloea* is a good reforestation species for poor soils in low rainfall areas.

**Fuelwood:** The wood is used for making agricultural implements, carts and for turnery. The tree yields good fire-wood; 4,886 kcal/kg.

**Taxonomic name:** *Ficus infectoria* Roxb. (Plate – 7)

**Family:** Moraceae

**Synonym:** *Ficus infectoria* Buch.

**Common names:** Hindi: Pilkhan; Kahimal, Keol, Kaim; Kannada: Basari, Juvvi

**Description:** Large deciduous, profusely branched, spreading tree, growing up to 40 – 60 m height and 1.5 – 2.5 m in girth. Bole is short, irregular with deep curves. Bark smooth, greenish to grey. It is epiphytic in early stages, sometimes
sending down a few aerial roots. Leaves are membraneous, 10.16 - 12.7 cm long, 3.81 - 6.35 cm wide, ovate or ovate-oblong, shortly acuminate with entire or subundulate margins. Fruits in axillary pairs, usually sessile, sub-globose, green and turn white when ripe or flushed with red and dotted.

**Ecology:** Found nearly throughout India and is commonly planted as an avenue and ornamental tree. Found growing on variety of soil types, including sandy soils, gravelly soil and heavy clay soils. Grows at an altitude of 800 m, temperature up to 40 °C and tolerate 250-2000 mm mean annual rainfall, dry seasons. In south India, it is considered a good shade tree for coffee, the fallen leaves supplying heavy mulch.

**Fuelwood:** The wood (wt., 35 lb./cu.ft) is grey and moderately hard. It is used for charcoal.

**Taxonomic name:** *Prosopis juliflora* (Swartz) DC. (Plate – 8)

**Family:** Leguminosae; Mimosae

**Synonyms:** *P. chilensis* (Mol.) Stuntz; *Mimosa juliflora* Swartz

**Common names:** English: Algaroba, Mesquite; Hindi: Vilayati babool, Kabuli Kikar; Kannada: Jali

**Description:** Small to medium-sized, perennial deciduous thorny shrub or small tree, generally evergreen, and distinguished by the wavy, drooping and zig-zag appearance of its new shoots extending above the crown, grows 9-12 m height and 1.2 m in diameter. Appears as multi-stemmed shrub, attaining 3-4 m height when repeatedly coppiced from ground level. Bark is 2-3 cm thick, dark brown or blackish, divided by shallow, vertically-oriented fissures. Twigs are zig-zag, mostly well-armed with stout thorns up to 5 cm long. Vigorous shoots extend above the canopy, then droop, and the tip rising again gives a typical wavy appearance to the top of the tree or shrub, capping off a generally tough and aggressive appearance. Leaves compound, pinnate, alternate, 3-16 cm long, dark green. There are 8-50 pairs of leaflets, 5-50 × 3-6 mm, linear-oblong, glabrous,
often hairy, commonly rounded at the apex. Most forms are evergreen, but on poor and dry sites the foliage becomes progressively thinner and it is almost leafless in the winter. New leaves emerge by February-April. Flowers are creamy white in axillary spikes, 4-10 cm long, cattail-like, becoming greenish as the ovules develop after pollination. Stipular spikes may be solitary, or in groups of 3-4, yellowish, often stout. Flowering takes place at almost any time of the year except during hot summer and monsoon. Plants begin flowering within one or two years, and every year produce plenty of seeds. Pods develop in bunches of 8-10; linear, compressed and green when young; becoming twisted, constricted between the seeds, and yellowish when mature; 12-25 × 0.7-2.0 cm in size. The mesocarp is pithy, surrounds each seed and is difficult to remove. Each pod contains 12-35 seeds; light-brown, hard and shiny, ovate, flattened, 8-14 mm long.

**Ecology:** Native to tropical America and was introduced to south Asia in Sindh Province of Pakistan in 1878 and to Rajasthan State in India in 1912 and later through much of tropical Africa. It is now found almost everywhere in the arid and semi-arid tropics, mostly on plains and valleys but also on hillsides and rocky hillocks up to 1,500 m elevation. Tree grows on almost any type of soil, highly saline and alkaline sites and even with its roots in tidal brackish water. Tolerates temperatures up to 48 °C and 150-750 mm range of annual rainfall. Resistance to low temperatures is variable; some varieties are killed by frost, others can tolerate - 4 °C. Once established, all varieties survive frost. Its fast-growing, drought resistance and tenacity make it a good species for reclamation of mining spoil, wastelands, and sand dunes. Its nitrogen-fixing ability helps to improve the sites for later colonization of productive undergrowth for grazing.

**Fuelwood:** Wood is hard and dense (about 800 kg/m³) and is valued mainly as a firewood crop. Calorific value of sapwood is about 4,700 kcal/kg. It also makes excellent charcoal, which is sold to urban areas by villagers. Productivity of fuelwood plantations ranges about 5-15 t/ha/yr, depending on site and rainfall.
Taxonomic name: *Albizia lebbek* (L.) Benth. (Plate – 9)

**Family:** Leguminosae; Mimosae

**Common names:** English: East Indian Walnut; Hindi: Siris; Kannada: Bagemara

**Description:** Moderate sized to large deciduous tree, erect, deciduous, growing up to 18 m height and girth of 1.8 m, much branched with a broad crown. It is easily distinguished by its numerous large, pale pods that remain on the tree almost year round. Bark is dark brown to greenish black, rough, with longitudinal and transverse fissures on outer surface. Inner surface of bark is whitish with fine longitudinal striations. Leaves bipinnate, 10-40 cm long with a greenish main axis bearing 3-4 pairs of lateral axes, each having 8-18 pairs of leaflets. The leaflets are unequal at the base, rounded at both ends, 2-5 × 1-2 cm. The tree is usually leafless from November to March/April. The new flush of leaves and flowers appear at almost the same time in April-May, when the tree is gloriously covered by masses of greenish-white, globose flowers in clusters. The flowers have many thread-like, spreading, white to yellow stamens tipped with light green. The pods are flat, thin, linear-oblong, strap shaped, yellowish brown coloured, about 20-30 × 3-5 cm. Each pod contains 6-12 light brown, smooth, oblong, compressed seeds with hard testa, about 8 × 10 mm. The outline of the seeds is prominent on the outside of the pod. The fruits dehisce only after falling to the ground.

**Ecology:** This tree has a very wide range of natural occurrence, from the sub-Himalayan region up to an altitude of 1100 m in Northern India to Tamilnad in the south; occurring in forest types from wet evergreen to tropical dry deciduous. Now cultivated all over the tropics. It grows on a wide variety of soils, preferring well-drained loam. It grows well on laterite and on clay or black cotton soils and can tolerate soils with high salt content. It occurs in very wide rainfall zones of 600-2500 mm, and survives when planted in very dry tracts with annual rainfall of 300 mm. It can tolerate high temperatures up to 49 °C and also frost down to – 5 °C in some parts of its native habitat, but in other areas is sensitive to frost.
Fuelwood: The wood is light with specific gravity of 0.61; weight, 624.78 kg/m³. The calorific value of the sapwood and the heartwood is 5,163 and 5,166 kcal/kg respectively and is used as fuelwood.

**Taxonomic name:** *Morinda tinctoria* Roxb. (Plate – 10)

**Family:** Rubiaceae

**Common names:** English: Togariwood of Madras, Aal, Indian mulberry; Hindi: Al; Kannada: Muddy mara

**Description:** Evergreen shrub or small to medium-sized tree growing to 5 - 10 m tall with a straight cylindrical stem, 3.6 - 4.2 m in length and 90 cm in girth. Bark corky, pale brown with long fissured. Leaves are 15 – 25 cm long, oblong to lanceolate. Flowers are tubular in dense ovoid heads, white, scented, about 2 cm long. Fruit a drupe, green syncarp, globose or ovoid, 2 – 2.5 cm in diameter, edible.

**Ecology:** Native to southern Asia. Found in dry forests throughout the greater part of India; extensively cultivated in some places.

Fuelwood: Wood is moderately hard to hard and light (sp. Gr., 0.52; wt. 34 lb/cu ft).

**Taxonomic name:** *Delonix regia* (Bojer ex Hook) Raf (Plate – 11)

**Family:** Leguminosae

**Synonym:** *Caesalpinia regia*.

**Common name:** English: Royal Poinciana, Flamboyant, Peacock flower, Flame tree; Hindi: Gulmohar; Kannada: Kathi kai mara

**Description:** Flamboyan C *Delonix regia* (Bojer ex Hook), is small to medium-sized, fast growing semi-deciduous tree, 7 to 16 m height and 60 cm in diameter, with broad, flat crown. Dwarf forms rarely grow above 2.5-3 m. Flowers during summer season when tree is almost leafless. Red flowers are common, white, yellow or orange in some cases and are 8-25 cm across. Calyx is
5-pointed, hairy and borne on racemes 15-25 cm long. Fruit is a legume, hard, 35-50 cm long, 6 cm wide, 5 mm thick, assumes dark brown to black from green colour when mature, split lengthwise into two parts and they hang tenuously on trees year around.

**Ecology:** *Delonix regia* is native of Madagascar, planted nearly in every tropical country as flowering ornamental tree. Grows well in most soil derived from limestone and tolerate drought conditions and need full sun. *Delonix regia* is a beautiful flowering, shady tree and is often planted along roadside on either side as shade tree and also to add beauty to the avenue.

**Fuelwood:** Wood is yellow-brown, weak, brittle and soft, with specific gravity of 0.3 and is widely used as firewood.

**Taxonomic name:** *Enterolobium saman* (Jacq.) Merr. *(Plate – 12)*

**Family:** Mimosaceae

**Synonyms:** *Mimosa saman* Jacq.

**Common names:** English: Rain Tree; Hindi: Vilaiti Siris; Kannada: Bagae mara

**Description:** Large deciduous tree, 60 m tall, low spreading 80 m crown, stout trunk of 1.5 m in diameter. Bark brownish-grey and rough furrowed. Leaves alternate, bipinnate, 25-40 cm long, with 2-6 pairs of pinnae, each bearing 6-16 paired stalkless leaflets, with a glandular dot between each pair. Inflorescence one or two together on 5 to 9 cm long peduncles, flower heads are clustered near the end of twigs, each cluster on a 7-10 cm long green hairy stalk, with many small tubular pinkish-green flowers, calyx and corolla 5-toothed. Many stamens united to form a tube near their bases. Pods fleshy, 20 – 30 cm long, oblong, more or less flat, arcuate with raised border and is black when ripe. Each pod has one cm long 16 – 20 seeds, 10 to 11 x 5 to 6 mm, oblong reddish-brown, truncate at one end, pointed at the other, dark reddish brown with a paler ring at each side.

**Ecology:** Native to Latin America, from the Yucatan Peninsular and Guatemala to Peru. Ranging from subtropical very dry to moist through tropical
dry to moist forest life zones. It tolerates annual precipitation of 60-250 cm, annual temperature of 21.6-28.5° C and pH of 6-7. It is an admirable avenue tree, also valuable as a shade tree in pastures, stimulating grass growth.

**Fuelwood:** There are reports the branches and trunk are used as firewood.

**Taxonomic name:** *Peltophorum pterocarpum* (Plate – 13)

**Family:** Leguminosae

**Common name:** English: Copperpod, Golden flamboyant, Yellow Poinciana; Kannada: Haladi gulmohr

**Description:** Tree is upright, handsome, semi-evergreen tree, 8-15 m high and rounded canopy with spreading crown of 6 to 11 m. Leaf is alternate, bipinnately or pinnately compound, entire and oblong, have 4-15 pairs of pinnae, each with 8-20 pairs of 8-30 x 3.5-10 mm leaflets, dark green, delicate, feathery, rounded or emarginate at apex. From May through September, the entire tree's canopy is covered with a yellow blanket of flowers, appearing in showy, terminal panicles and exuding a delicious, grape-like perfume. The fragrant flowers have canary-yellow petals 1-2 cm long, with frilly margins. Fruit is elongated, 5-11.5 cm long and 2-2.7 cm broad, the valves at length splitting lengthwise through the middle", ripen to a brilliant, dark, wine-red colour.

**Ecology:** Native of this tree range from southeastern Asia through Malaysia to northern Australia widely cultivated in tropical areas". Grows in full sun, grows on clay, sand and loam soil, high dry tolerance, but requires protection from frost. Grown for buffer strips around parking lots or for median strip plantings in the highway; reclamation plant; shade tree; specimen; no proven urban tolerance.

**Fuelwood:** Although the species is not a good source of timber, the wood is widely used as firewood.
Taxonomic name: *Pongamia pinnata* (L) Pierre (Plate – 14)

**Family:** Leguminosae/Faboideae; **Subfamily:** Fabaceae

**Synonym:** *Pongamia glabra* Vent.

**Common names:** English: Pongam Oil Tree, Indian Beech; Hindi: Karanj, Karanja; Kannada: Honge

**Description:** Medium sized fast growing, glabrous tree, with short bole, 18 m in height and 1.5 m in girth and spreading crown. Bark grayish green or brown, smooth or covered with tubercles. Leaves are imparipinnate, glossy. Leaflets 5-9, ovate or elliptic, terminal leaflet larger than the others. Flowers during April-June, white tinged with pink or violet in axillary, pendent, long racemes or panicles and fragrant. Pod vary in size and shape oblique-oblong, 3.8-5.0 cm, long and 1.8-2.5 cm broad, short stalked, flat, smooth, short curved beak, thickly leathery to subwoody, yellowish grey when ripe, indehiscent, one reddish brown seed; seed thick, reniform.

**Ecology:** Native of Western Ghats, distributed throughout India. It is not exacting in its soil and climatic requirements. Grows at an altitude of 1,200 m and in most soil types, sandy and rocky soils, including oolitic limestone, even with its roots in salt water. It is high drought resistant, moderately frost-hardy and highly tolerant of salinity. Often grown as avenue tree in nearly all over India. Used for afforestation, especially in watersheds, in dry lands.

**Fuelwood:** The wood has the calorific value of 4,600-4,840 kcal/kg, is burned for cooking fuel.

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Taxonomic name: *Eucalyptus globulus* Labill. (Plate – 15)

**Family:** Myrtaceae

**Common names:** English: Blue gum eucalyptus, Tasmanian blue gum; Kannada: Nilgiri mara

**Description:** Large evergreen tree, 40-70 m tall with straight trunk 0.6-2 m in girth, narrow irregular crown of large branches and drooping aromatic
camphoraceous foliage. Bark deciduous smooth, mottled grey, brown, and greenish or bluish, peel off in long strips, at base becoming gray, rough and shaggy, thick, and finely furrowed; inner bark light yellow within thin green layer. Leaves in juvenile shoots opposite, sessile, cordate-ovate, covered with a bluish white bloom; adult leaves alternate, drooping on flattened yellowish petioles 1.5-4 cm long, narrowly lanceolate, 10-30 cm long, 2.5-5 cm wide, mostly curved, acuminate at tip, acute at base, entire, glabrous, thick, leathery, with fine straight veins and vein inside marlin, shiny dark green on both surfaces. Flowers 1 (rarely 2-3), at leaf base, more than 5 cm across. Capsules single at leaf base, broadly top-shaped or rounded, 1-1.5 cm long, 2-2.5 cm wide, 4-angled warty. Seeds many, irregularly elliptical, 2-3 mm long, dull black.

Ecology: Blue gum eucalyptus is native to Tasmania and southeastern Australia. *E. globulus* was introduced into India as a fuel tree in 1843. It grows well at a height of 1,219 – 2,591m. It is unsuitable for cultivation at altitude below 1,219m or at altitude where snowfall is heavy. Most widely planted in subtropical regions. A cool, moist, equitable climate and deep fertile soil, which is not calcareous or saline, are favourable for the growth of *E. globulus*. Blue gum eucalyptus is used for windbreaks, shelterbelts and sight and sound barriers along highways.

Fuelwood: *E. globulus* grown for firewood in India. It is also grown in other countries as popular firewood species. It burns freely, leaves little ash, produces good charcoal. Plantations can be harvested for firewood every 7 years. It yields good fuelwood (calorific value, 4,932 kcal/kg).

Taxonomic name: *Acacia auriculiformis* A. Cunn. ex Benth. (Plate – 16)
Family: Fabaceae
Common name: English: Papuan Wattle, Australian Wattle, earleaf acacia, northern black wattle; Kannada: Jali
**Description:** Small to medium sized tree, grows straight up to 16 m in height with slightly angular branchlets. Bark is white, smooth and somewhat fissured or furrowed. Leaves pinnate, rachis modified into a phyllode measuring 12-20 cm in length and 3-5 cm width, glaucous, glabrous, falcate and oblong-curved. Flower heads are slender rod-like, white to bright yellow in colour forming axillary racemose spike. Pods are hard, woody, nearly flat, oblong and coiled at maturity.

**Ecology:** *A. auriculaeformis* is native to Australia and introduced into the semi-arid regions of India. It is a commonly planted forestry tree and can become naturalized where planted. It is a quick-growing tree with a high germinative capacity. It is a good substitute for species of *Eucalyptus* in some specific semi-arid sites and is a useful sand binder and is also grown as an ornamental tree.

**Fuelwood:** Good firewood with a high specific gravity (0.6-0.75) and a calorific value of 4,800-4,900 kcal/kg.

**Taxonomic name:** *Tamarindus indica* (Plate – 17)

**Family:** Leguminosae

**Synonym:** *T. occidentalis* Gaertn.; *T. officinalis* Hook.

**Common name:** English: Tamarind; Hindi: Emli; Kannada: Hunase

**Description:** Frost-tender, tropical, evergreen tree, reaches 24 – 30 m in height and spread 15 m, growing upright and dome-shaped. Massive, short, stocky trunk, 7.5 m in circumference; drooping branches, has rough fissures, down and across; bark is dark-grey. It is densely foliated with pale to bright green, compound, feathery leaflets which give a broad, spreading crown a light, airy effect. Leaf arrangement is alternate, pinnately compound, entire and elliptical, oblong leaf shape measuring 7.5 - 15 cm long with 10-20 pairs of 2.5 cm oblong leaflets. Flowers are small red and yellow appearing on short racemes; 2.5 cm across, pale yellow with purple or red veins. Fruits are elongated, pod or pod-like in shape, measuring 5.08 to 17.78 cm in length, have five unequal lobes and borne in small drooping clusters; cover is dry or hard brown in colour, contains the 8 – 10 seeds;
black, shiny squares surrounded by pulp. The pulp is light brownish-red; sweetish acidic and edible.

Ecology: Perennial tree, native to tropical Africa, the tree grows wild throughout the Sudan. *Tamarindus indica* is indigenous to India. It has long been naturalized in the East Indies and the islands of the Pacific, Hawaii, tropical America, Bermuda, the Bahamas, West Indies and many other countries around the world. The tree requires full sun for growth. The growth rate is slow to moderate. Very young trees should be protected from cold but older trees are surprisingly hardy. It tolerates great diversity of soil types - clay, sand, loam, alkaline, acidic, well-drained soil and tolerance for drought is high. It withstands salt spray and can be planted fairly close to the seashore. Propagation is by seeds which germinate readily or by cuttings. Dry weather is important during the period of fruit development. The tamarind tree is a beautiful, fine textured tree and it makes an excellent shade tree in large landscapes. It often is planted in public parks and as an avenue tree in tropical cities.

Fuelwood: Tamarind wood burns well as fuel and make a high-grade charcoal for cooking and brick kilns, for it gives off an intense heat. In Malaysia, even though the trees are seldom felled, they are frequently topped to obtain firewood.

Taxonomic name: *Artocarpus heterophyllus* Lam. (Plate – 18)

Family: Moraceae

Common name: English: Jackfruit; Hindi: Kanthal, Panasa; Kannada: Halasu

Description: Large, handsome and stately evergreen tree, 10-15 m in height. Stem straight, cylindrical, covered with smooth or slightly rough bark, which is green or black in colour. Leaves are alternate, glossy, broad, 5-25 x 3.5-12 cm, obovate-elliptic to elliptic, decurrent, glabrous, entire and deep green in colour on mature wood, sometimes oblong or deeply lobed on young shoots. Tree is monoecious, inflorescence is solitary axillary, cauliflorous and ramiflorous, measuring 5-10 cm in length, borne on short leafy shoots. Male heads sessile or on
short peduncled receptacles, sometimes borne on the ultimate twigs, female heads on oblong ovoid receptacle with simple spathulate style exserted to 1.5 mm. Jackfruit is largest of all tree-borne fruits, measuring 20-90 cm long, 15-50 cm wide and weighing 4.5-50 kg. The exterior of the compound fruit is green or yellow when ripe and composed of numerous hard, cone-like points attached to a thick and rubbery, pale yellow or whitish wall. There may be 100-500 seeds in a single fruit, each seed measuring 2-4 cm long and 1.25-2 cm thick, oblong-ellipsoid in shape.

**Ecology:** Tree is adapted to humid tropical and near-tropical climates. It is indigenous to the evergreen forests of the Western Ghats at altitudes of 450-1,500 m and cultivated throughout the hotter parts of India. Government horticulturists promote the planting of jackfruit trees along highways, waterways and railroads to add to the country's food supply. The jackfruit tree flourishes in rich, deep soil of medium or loose texture, sometimes on deep gravelly or laterite soil and in shallow limestone regions. Soil drainage is of great importance as under proper conditions of drainage is of great importance as under proper conditions of drainage, it is tolerant to a wide variety of soil.

**Fuelwood:** The wood is moderately hard; sapwood pale, heartwood bright yellow, darkening on exposure.

**Taxonomic name:** *Mangifera indica* L. (Plate – 19)

**Family:** Anacardiaceae

**Common name:** English: Mango; Hindi: Am, Amb; Kannada: Mavu

**Description:** Large evergreen tropical tree growing up to 10-45 m in height, with dense, heavy, dome-shaped crown. Bark dark grey in colour, thick, rough and flaking off when old. Leaves, dark green above and pale below, usually red while young; linear-oblong or elliptic-lanceolate, measuring 10-30 cm long and 2-9 cm wide. Inflorescence is large panicle at branch terminals, containing 2,000-3,000 flowers. Flowers, tiny, reddish white or yellowish green, pungently odourous and
melliferous. Fruit is large drupe, varying in size and shape, may be kidney shaped, ovate or rounded (rarely), turns pale green or yellowish or red when ripe. Seed solitary, ovoid-oblique, encased in a hard fibrous, stony endocarp.

**Ecology:** Mango is native to southern Asia, especially Burma and eastern India. Occur wild or semi-wild in tropical and sub-tropical hilly forests, subtropical Himalayas, hills of Western and Eastern Ghats and forests of Central India, Bihar, Orissa, Assam and Andaman Islands. Cultivated in plantations and orchards and often in roadside avenues. Mango flourishes in tropical climates with temperature of 26.6 °C, rainfall of 75-250 cm and abundant atmospheric moisture, wide variety of soils; alluvial and clayey loams, sandy and gravelly, well drained soil.

**Fuelwood:** A hard charcoal of high calorific value is obtained from mango wood.

**Taxonomic name:** *Cocos nucifera* L. (Plate – 20)

**Family:** Arecaceae, Palmae

**Common name:** English: Coconut; Hindi: Nariyal; Kannada: Tengu

**Description:** Palm grow up to 20-30 m or more tall, bearing crown of large pinnate leaves; trunk stout, 30-45 cm in diameter, straight or gently curved, rising from a swollen base surrounded by mass of roots, rarely branched, bark is smooth and grey, marked with rings of leaf scars. Leaves 2-6 m long, pinnatisect, they consist of linear-lanceolate, more or less recurved, rigid, bright green leaflets of 0.6-1 m long, narrow, tapering. Inflorescence in axil of each leaf as spathe enclosing a spadix 1.3-2 m long, stout, straw or orange coloured, simply branched; female flowers numerous, small, sweet-scented, borne towards top of panicle. Fruit is a drupe, ovoid, 3-angled, 15-30 cm long, containing single seed; exocarp a thick fibrous, husk, enclosing a hard, bony endocarp or shell. Adhering inside wall of endocarp is testa with thick albuminous endosperm, the coconut meat; embryo below one of the three pores at end of fruit, cavity of endosperm filled in unripe
fruit with watery fluid, the coconut water, and only partially filled when ripe. Flower and fruits are found year round in tropics.

**Ecology:** Ranging from Subtropical dry or wet through tropical very dry to wet forest life zones. The major coconut areas lie between 20 °N and 20 °S on both sides of the equator. The coconut palm thrives on sandy, saline soils; it requires abundant sunlight and regular rainfalls over the year. Coconut has been reported from stations with an annual precipitation of 700-4,200 mm, annual temperature of 21-30 °C with 4-12 consecutive frost free months, each with at least 60 mm rainfall, and pH of 4.3-8.0.

The most important coconut producing countries in the world are India, Ceylon, Malaya, Indonesia, Philippines and the South Sea Islands in the Pacific. It is cultivated to a small extent in East Africa, West Indies and Central America. In India, the bulk of the acreage under coconut is concentrated in the coastal and deltaic regions of south India. Cultivation is by no means rare, and large estates are situated far inland and up to an elevation of 609.6 - 914.4 m above Mean Sea Level.

**Fuelwood:** Dried non-edible products of this tree are used as fuelwood.

**Taxonomic name:** *Ricinus communis* L. (Plate – 21 A)

**Family:** Euphorbiaceae

**Common name:** English: Castor oil plant; Hindi: Arandi; Kannada: Haralu geda

**Description:** Plant is small tree or tall shrub, 10-13 m tall in tropical and 1–3 m tall in temperate regions and succulent stem is 7.5–15 cm in diameter. Leaves alternate, orbicular, palmately compound, 10–60 cm broad, with 6–11 toothed lobes, glabrous; flowers numerous in long inflorescences; fruit a globose capsule 2.5 cm in diameter, on an elongated pedicel, usually spiny, green turning brown on ripening, usually containing 3 seeds; seeds ovoid, tick-like, shiny, 0.5–1.5 cm long, carunculate, varying colour with base color white, gray, brownish, yellow,
brown, red, or black, with the outer pattern gray or brown to black, the pattern varying from fine to coarse, veined or finely dotted to large splotches.

**Ecology:** Probably native to Africa, Castor bean has been introduced and is cultivated in many tropical and subtropical areas of the world. In India it is cultivated singly or as a mixed crop along with jowar, bajra, groundnut etc., chiefly in Andhra Pradesh, Karnataka, Maharashtra and Orissa. Reported to tolerate annual precipitation of 20 to 429 cm and annual temperature of 7.0 to 27.8 °C and pH of 4.5 to 8.3. Plant requires 140–180 day growing season and is readily killed by frost. Grows best where temperatures are rather high throughout the season, but seed may fail to set if it is above 38°C for an extended period. Plants do best on fertile, well-drained soils which are neither alkaline nor saline; sandy and clayey loam being best.

**Taxonomic name:** *Gossypium ssp.* *(Plate – 21 B)*

**Family:** Malvaceae

**Common name:** English: Cotton; Hindi: Kapas; Kannada: Hatti

**Description:** *Gossypium ssp.* Is a perennial shrub or small tree, 4-6 feet height. Much branched stem bears palmately lobed leaves and single flowers in axillary position. The fruit is a capsule known as boll having 3-5 locules known as 'locks'. Each locule has about nine seeds, as such about 25 to 50 seeds are present per boll. The ovoid, more or less pointed, dark brown, curved seeds bear two types of tubular outgrowths or hairs – the long, thick and white or creamy coloured hairs called lint and the white, very short hairs called fuzz. The lint staple is the cotton fibre of commercial importance. The mature lint hair has a long, tubular cell with very thick wall, made up of superimposed bands of cellulose. The hair is twisted at specific points, the average being 150 twists per inch.

**Ecology:** Cotton is a tropical crop, believed to have multiple origin, West Indies, Peru, Mexico and India being probable centres of origin. It is a shrub cultivated mainly in Southern India. Grows best in hot and moist climate. Requires
sufficient moisture during seedling stage, dry climate during flowering and absolutely no rainfall during ‘boll’ formation. Tolerate temperature as high as 43 90 °C to 46 90 °C and rainfall ranging from 40 to 100 cm. Grows on variety of soils such as red soils, black soils, alluvial soil, best in sandy and moist soils.

**Taxanomic name:** *Sorghum vulgare* Pers. (Plate – 21 C)

**Family:** Graminae

**Common name:** English: Sorghum; Hindi: Jowar; Kannada: Jola

**Description:** Primarily dryland crop, annual grass, 4-15 feet height, exhibit morphological adaptations such as wiry and fibrous well developed root system, reduced leaf surface and ability to roll up in dry weather. Inflorescence is a panicle, commonly known as head, differing in size, shape, form and colour. Each panicle, consists of numerous spikelets arranged in pairs, of which one is sessile and other pedicillate. Sessile spikelet is fertile, bears two flowers – one fertile and the other sterile and pedicillate spikelet is staminate only. Seed is round, 2 mm in diameter, creamy white to yellow in colour.

**Ecology:** Important crop in Egypt back as far as 2200 B.C, native of Africa and Asia. Crop is extreme resistance to dry and drought conditions, moderate rainfall of 12 inches, temperature of 80 to 90 °F and grows best on plains and at height of 3000 feet. Cultivated on all types of soil – sandy, heavy and light, alluvial, red loamy and clay loamy soils. It is grown as Kharif and Rabi crops.

**Fuelwood:** After harvest stalks, are chopped into pieces and used as fodder for cattle. The remains of the fodder are used as fuel.

**Taxanomic name:** *Sesamum indicum* L. (Plate – 21 D)

**Family:** Pedaliaceae

**Common name:** English: Sesame; Hindi: Til; Kannada: Hellu

**Description:** An annual herb with pubescent, grows erect, branched stem, 1-2 m in height. Leaves 3-foliolate or pinnatisect, upper ones simple, ovate-oblong to
lanceolate, 4-20 cm long, to 15 cm wide, on petioles 2-15 cm long; Flowers, single (sometimes paired) in axils, very shortly pedicellate; calyx pubescent, green, about 6 mm long, lobes sharply acute; corolla pinkish-purple (rarely white), about 3.6 cm long; stamens included; capsule erect, oblong, rounded, 4-grooved, pubescent, about 2.5 cm long, 2-valved; seeds black, brown or white, 2.5-3 mm long, smooth or minutely reticulate".

Ecology: Native to tropics and naturalized in southern areas of the United States. The herb is cultivated extensively in many regions of the world, including the People's Republic of China, India, Ethiopia, El Salvador, Nicaragua, Sudan, Mexico, Guatemala, and the United States. In India it is mainly cultivated in Uttar Pradesh, Rajasthan, Andhra Pradesh, Tamil Nadu, Maharastra and some parts of Karnataka. Tolerate temperature range from 11 to 29 °C with an annual precipitation of 0.2 to 0.4 meters and a soil pH of 4.3 to 8.7 (4.1-31). The crop does best in a warm temperature with a long growing season. Grows in all habitats from plains up to an altitude of 4000 feet. It is cultivated both as Rabi and Kharif crop. It prefers light to sandy soils or moisture-containing, medium, heavy, alluvial or black soils.

This survey also looked into various issues such as estimates for energy needs in rural areas around Mysore city, factors under-lying fuel preferences, review of existing policy initiatives, opinions and attitude of the rural population regarding currently available forms of energy and potential alternatives.

Wood smoke related health hazards have been assessed in the 15 villages around Mysore city. All the 15,885 individuals (5% men, 85% women and 10% children) involved in the cooking activity have been screened to chest x-ray to diagnose health hazards, such as pneumonia, bronchitis, asthma, cor pulmonale, tuberculosis (TB) and cancer. About 795 men, 13,502 women and 1,588 children were radio-diagnosed by Radiologists at the hospitals. The representative samples
of different types of health hazards among the people during exposure to smoke have been photographed. Different age groups, literacy, household’s income, tobacco smoking habit, time spent for cooking, cookstoves used, cooking place and housing pattern are considered for the assessment of health hazards among the biomass users.

**Estimation of calorific values**

**Preparation of the sample**

Fuel value of wood is greatly dependent on its calorific content and is generally believed to be one of the parameters to compare one fuel with another. The wood samples of the tree species utilized by the rural folk were collected. The different wood samples were oven dried at 105°C, until the samples are dried to permanent weight. Oven dry samples were ground to – 40 + 60 mesh powders. About one gram of powdered material was pressed to prepare pellets or capsule.

**Preparation of fuel briquettes**

High-pressure binderless compaction of biomass waste materials, such as saw dust, cotton stalk, jowar stalk, sesame stalk, castor oil stalk, cattle dung and pods of *Delonix regia* and their calorific values were studied. Coal dust is use in some briquettes to increase the calorific values of the briquette. These different biomass waste materials were used to prepare six types of briquettes in different combination.

Waste materials are tested for their chemical composition to decide on their suitability and to select a proper mix. The materials were sun dried to remove moisture content in it. Sun dried material containing approximately 10 – 15%
moisture is suitable for briquetting. The little moisture content in the raw material is essential because if the material becomes too dry it will become too dusty and particles will not adhere to each other to form the briquette. Also, if the materials are too wet, they will fall apart as they dry after briquetting. However, if material has higher moisture content it needs to be dried.

The waste materials in case large in size, they are chopped to small pieces. When using more than one type of waste material, the finely ground material is well mixed. The mixed material is then screened for size quality, which will remove large sized particles. The screened large sized particles are returned to the grinder for regrinding before adding it to production line again.

The waste material is conveyed and fed by a hopper on to the machine or the compressor. The flow is regulated manually where it is compressed in specially designed dies. A piston-and-mold (punch-and-die) process was used to produce briquette logs under room temperature and at pressures ranging from 34 to 138 MPa (Li and Liu, 2000). The compression raised the temperature of the material, softening some of the inherit binders in it, which comes to the surface and binds the material together. Briquettes formed are in the shape of logs, which are forced through tracks for proper shaping, by cooling them under pressure. No binder is required in the process.

The calorific value of the prepared sample capsule was determined using Adiabatic Calorimeter at the Institute of Wood Science and Technology. The powdered material was burned in an Oxygen Bomb Calorimeter (LECO Corporation; Calorimeter with Model Number AC 350) for determination of calorific value on dry weight bases.
Benzoic acid was used for the calibration of the calorimeter. This Bomb Calorimeter is a microprocessor based instrument, which utilizes the isothermal method for measuring the calorific value. The analysis period (time) for a sample is around 15 minutes.

The briquette manufacturing unit with the briquette sample as inside picture and the Bomb Calorimeters is shown in Plate - 22.

Study encompasses a series of broad, thematic recommendations addressing the problems of domestic cooking energy and human health and environment identified by technical studies and interaction with rural inhabitants around Mysore city.

A set of underlying principles are utilized which incorporate the energy approach, collaboration and cooperation, sustainability, a balance between energy quantity and quality, equity and public involvement.
*Acacia nilotica* (L.) Del. A - Tree; B - Leaves; C - Flowers; D - Spines; E - Fruit; F - Trunk
Azadirachta indica A. Juss. A - Tree; B - Flowers; C - Fruits; D - Leaves
E - Trunk
PLATE – 3

*Ficus bengalensis* L. A - Tree; B - Fruit; C - Leaves; D - Trunk
*Albizzia amara* Boivin. A - Tree; B - Fruits; C - Flower; D - Leaves; E - Trunk
Acacia ferruginea (DC.) Roxb. A - Tree; B - Fruits; C - Leaves; D - Flowers; E - Spines; F - Trunk
Acacia leucophloea (Roxb.) Willd

A - Tree; B - Thorns; C - Leaves; D - Flowers; E - Fruits; F - Trunk
*Ficus infectoria* Buch. A - Tree; B - Fruits; C - Leaves; D - Trunk
Prosopis juliflora (Swartz) DC. A - Tree; B - Spines; C - Leaves; D - Fruit; E - Flowers; F - Trunk
*Albizia lebbeck* Boivin. A - Tree; B - Flower; C - Leaves; D - Fruits; E - Trunk
Morinda tinctoria Roxb. A - Tree; B - Flowers; C - Trunk; D - Leaves; E - Fruits
Delonix regia (Bojer ex Hook) Raf. A - Tree; B - Leaves; C - Inflorescence; D - Fruits; E - Trunk
Enterolobium saman (Jacq.) Merr. A - Tree; B - Leaves; C - Inflorescence; D - Fruits; E - Trunk
*Peltophorum pterocarpum* A - Tree; B - Inflorescence; C - Fruits; D - Leaves; E - Trunk
Pongamia pinnata (L) Pierre. A - Tree; B - Inflorescence; C - Leaves; D - Fruits; E - Trunk
PLATE - 15

_Eucalyptus globulus_ Labill. A - Tree; B - Fruits; C - Trunk; D - Flower; E - Leaves
Acacia auriculiformis A. Cunn. Ex Benth. A - Tree; B - Inflorescence; C - Fruits; D - Leaves; E - Trunk
Tamarindus indica. A - Tree; B - Inflorescence; C - Leaves; D - Fruits; E. Trunk
Artocarpus heterophyllus Lam. A - Tree; B - Inflorescence; C - Fruits; D - leaves; E - Trunk
Mangifera indica L. A - Tree; B - Leaves; C - Inflorescence; D - Fruit; E - Trunk
Cocos nucifera L. A - Tree; B - Inflorescence; C - Trunk; D - Fruits; E - Leaf
Agricultural residues: A - *Ricinus communis*; B - *Gossypium sps.*; C - *Sorghum Vulgare*; D - *Sesamum indicum*; E - Cattle dung cake being prepared; F - Dung cake
A - Biomass fuel briquette processing work in progress; Inset – Prepared briquettes for use
B - Bomb Calorimeter (Model: AC-350)