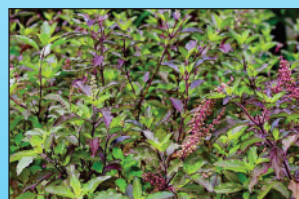
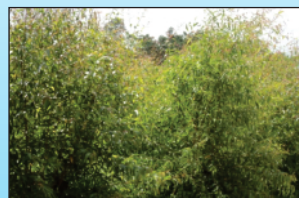


Land Use Planning for Important Medicinal and Aromatic Plants in Karnataka



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LAND USE PLANNING FOR IMPORTANT MEDICINAL AND AROMATIC PLANTS IN KARNATAKA

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ABOUT THE NBSS&LUP

The National Bureau of Soil Survey and Land Use planning (NBSS & LUP), Nagpur, a premiere institute of the Indian Council of Agricultural Research (ICAR), was established in 1976. Bureau is mandated for preparing soil resource maps at village, watershed, taluk, district, state and national level and to provide research inputs in soil resource mapping, soil correlation and classification, soil genesis, remote sensing applications, land evaluation, land use planning. It has grown significantly in its size and stature by building up adequate research infrastructure and well qualified human resources. NBSS&LUP is consistently carrying out resource inventorying for suggesting alternate land uses towards optimizing agricultural production. The Bureau's multidisciplinary approach comprising soil survey, establishment of databank, documentation, correlation, assessment of land for different land uses has won the recognition as a premier institute in India as well as in the world.

The Bureau is implementing its mandate through five Regional centers and three divisions, all of which are well equipped with scientific capabilities. The Regional centers at Bangalore, Delhi, Kolkata, Jorhat and Udaipur are involved in soil resource mapping, soil correlation and classification, and undertaking research in land use planning. The divisions namely, Soil Resource Studies, Remote Sensing Applications and Land Use Planning are undertaking fundamental and applied research in National Agricultural Research System and provides needed support to the regional centers.

The publication on “**Land Use Planning for Important Medicinal and Aromatic Plants in Karnataka**” is the significant outcome of rigorous work. It will guide the readers to broaden their understanding about Medicinal and Aromatic Plants (MAPs) in different agro climatic regions of Karnataka. The study helps in rational use of available resources of land, water and other environmental conditions. The efforts has significance in translating science to societal benefit. Hence, present study was initiated to identify agro climatically most suitable zones for some medicinal & aromatic plants using GIS technologies in Karnataka.

The study also shows the way to produce sizeable quantities of MAPs with required quality parameters which will greatly help in maximizing yields of MAPs thus providing immense economic benefits to farmers as well as availability of raw materials for drug and fragrance industries. Also, such information provides basis for developing clusters of farmers / villages in different regions of Karnataka who can cultivate profitably, process and market specific MAPs thus creating value chains.

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LAND USE PLANNING FOR IMPORTANT MEDICINAL AND AROMATIC PLANTS IN KARNATAKA

THE safety and affordability of natural products as medicines, food, cosmetics and pesticides has led to a resurgence of interest in medicinal plants. Globally, wild or natural products meet 70 to 90 Per cent of the market demand for medicinal and aromatic plants (MAPs), also ensuring the livelihoods of millions of rural people. However, the recent increment in commercial demand is a threat to natural MAP resources if they are not managed to safeguard their regeneration. The threat is further intensified by forest degradation, land conversion, anthropogenic disturbances and other factors. Cultivation and domestication of wild plants is often suggested as a way to meet the growing market demand and also to create a balance between the use and conservation of MAPs, but for many species knowledge and practices are not yet advanced enough to bridge the gap between demand and supply.

India, with its diversity of agro-ecology and socio-cultural conditions, is considered the storehouse of medicinal and aromatic plants of the world and is endowed with rich diversity of flora of 47000 different plant species, of which and 15000 medicinal plants that include 7000 plants are used in Ayurveda, 700 in Unani medicine, 600 in Sidhha medicine, 450 in Homeopathy and 30 in modern medicine. This makes India one among 12 mega bio-diverse country of the world despite having only 2.5% of total area, the country accounts for more than 8% of the recorded species of the world.

The Indian system of Medicine has identified 1500 medicinal plants, of which 500 species are commonly used in preparation of Indian System of Medicine Drugs. Medicinal plants appear to have excellent source of bioactive compounds that have the ability to cure some of the diseases, hence worldwide interest has developed rapidly for cultivation of medicinal plants.

Global market for all categories of herbal products is estimated at \$ 62 billion. Over 8000 manufacturing units of herbal drugs with a turnover of Rs. 4200 crores/year operates in India. India is the second highest producer of essential oils at 16000-17000 tons / year.

India is bestowed with wide range of medicinal plants. In the early seventies, two-third of our exports in the field of plant based raw materials and derived chemicals were from forests. However, with rapidly rising demand, there is a danger of extinction of many valuable species due to indiscriminate harvesting and hence, there is a need to develop modern agro-techniques to increase the productivity. According to one estimate, about 46 native medicinal plant species in India are under continuous pressure of large scale collection rendering them rare, and endangered. Therefore, there is a need for conservation and sustainable use of medicinal plants. Cultivation of medicinal plants is clearly a sustainable alternative to present collection of medicinal plants from wild resources. This can be a potential source of returns to the farmers.

Medicinal Plants play an important role in the subsistence economy of the rural people. The collection, simple processing such as drying and grading and trading contribute appreciably to their cash income and livelihood. The country offers great potential of cultivation of medicinal and aromatic plants. In recent past, there has been renewed interest for plants as a source of medicines, perfumes and cosmetics as they are harmless. This may be due to no side effects, relatively cheaper, readily available in rural areas, eco-friendly and creates job/livelihood opportunities in rural areas.

The occurrence of essential oils or volatile oils is very widespread in the plant kingdom. They are accumulated in oil cells, in secretion ducts or cavities or in glandular hairs of plants. Plants bearing essential oils were known or even utilized in religious ceremonies or for personal use, adornment and flavouring agents in food products long before recorded history. In India hundreds of aromatic substances including cinnamon, ginger and sandalwood were recorded in Vedic literature around 200BC. The production and consumption of essential oils, because of their multipurpose application is increasing continuously: essential oils are used in perfumery, food industry, households, condiments, making sweets, beverages as well as pharmaceutical and aroma therapeutic products of plant origin.

Asia is well known throughout the world as 'the Land of Aromatic Plants' because it possesses favorable climatic conditions suitable for the growth and development of aromatic plants. Other names like 'the Land of Spices', 'the Land of Traditional Perfumes', also indicate the popularity of aromatic plants in Asia. Such plants have been used commercially as spices and as sources of raw material for essential-oil industry from the dawn of history. In India, for example, old literature mentions numerous uses of essences obtained from plants in performing religious rites since prehistoric times. India is regarded as the traditional home of oriental perfumes.

International market studies predicted the consumption of flavors and fragrances to be about 8 billion US \$ at the beginning of the twentieth century. India is the second highest producer of essential oils at 16000-17000tons/ year.

Karnataka state is also endowed with a variety of agroclimatic regions which can support production of wide range of variety of MAPs. MAPs are increasingly emerging as alternative crops for diversification in Karnataka and also in sustaining farmers' livelihoods. In recent years, contract farming of medicinal and aromatic plants is encouraged in Karnataka with buy back arrangement from the pharmaceuticals and perfumery industries.

So far, MAPs are being grown in isolated patches in small areas and needs to be evaluated for their suitability to integrate in different land use plans for different soils and agro-ecological zones. If, suitable MAPs are identified with less variability in yield and quality over large soil units or areas, this can help in an integration of these plants in the existing farming / cropping systems. Moreover cultivable wastelands and marginal lands can be brought under these plants in big way to conserve and minimize soil erosion.

Scientific delineation of potential areas for Medicinal and Aromatic Plants (MAPs) in different agro climatic regions of Karnataka helps in rational use of available resources of land, water and other environmental conditions. This study shows the way to produce sizeable quantities of MAPs with required quality parameters which will greatly help in maximizing yields of MAPs thus providing immense economic benefits to farmers as well as availability of raw materials for drug and fragrance industries. Also, such information provides basis for developing clusters of farmers/ villages in different regions of Karnataka who can cultivate profitably, process and market specific MAPs thus creating value chains. This effort has significance in translating science to societal benefit. Hence, present study was initiated to identify agro climatically most suitable zones for some medicinal & aromatic plants (Table -1) using GIS technologies in Karnataka.

Table 1 : List of important medicinal & aromatic plants under study

Medicinal Plants	Aromatic Plants
Ashwagandha (<i>Withania somnifera</i>)	Eucalyptus (<i>Eucalyptus citriodora</i> Hook.)
Senna (<i>Cassia aungustifolia</i>)	Davana (<i>Artemisia pallens</i>)
Sweet Flag (<i>Acorus calamus</i>)	Geranium (<i>Pelargonium graveolens</i>)
Amla (<i>Emblica officinalis</i>)	Vetiver [<i>Vetiveria zizanioides</i> (Linn.) Nash
Tulsi (Basil) (<i>Ocimum</i> spp.)	Rosemary (<i>Rosmarinus officinalis</i> L.)

MEDICINAL PLANTS

Ashwagandha



Ashwagandha crop

Ashwagandha or Asgand (*Withania somnifera*), also known as Indian ginseng is a native medicinal plant grown all over north-western and central India. The local name ashwagandha seems to be derived from the Sanskrit name ashwandha which means smelling like a horse. The medicinal properties of the root are attributed to the presence of several alkaloids, Withanolide group being the prominent. Ashwagandhan has got a wide range of applications in the treatment of various physiological disorders. It is a recognized folk remedy for a numbers of diseases viz. arthritis, asthma, bronchiitis, adenopathy, anthrax, cancer, candidiasis, cold, cough, cystitis, debilify, diarroehea, dropsy, dyspepsia, erysipelas, fever, furuncle, gynecopathy, hiccups, hypertension, inflammations, lumbago, marasmus, nausea, piles, psoriasis, ringworm, scabies, senility, smallpox, sores, syphilis, tunberculosis, tumors, typhoid, uterosis and wounds. In Ayurveda it is mainly recommended in the treatment of shosha (malnutrition), shuka dosa (defects of semen), vata- Vyadhi (nervine diseases), unmade (mental diseases) and apasmara (epilepsy). Ashwaghandha and its extracts are a component of many invigorating herbal teas, powders, tablets and syrups that are manufactured by a number of pharmaceutical companies, especially those that specialize in Ayurvedic and Unani formulations. Ashwagandha is an important item of export.

The plant is a shrubby bush which grows in dry arid soils of subtropical regions. In India, the plant grows well throughout the drier parts and in the subtropical and semi temperate regions including the states of Maharashtra, Gujarat, Madhya Pradesh, Rajasthan, Uttar Pradesh, Haryana and Punjab extending to Himachal Pradesh and Jammu and Kashmir, from plains to the elevations of 1700 meters. Ashwagandha grows well in sandy loam or light red soil with good drainage having pH in the range of 7.5 to 8.0.

In Karnataka, it is mainly grown in medium deep to deep black soils in Koppal, Bellary and Gadag districts (AEZ-1, 2 & 3). The texture of the soil is sandy clay having alkaline pH and low nitrogen and phosphorous and high potash. Organic carbon of these soils are medium to high.

Based on crop performance and quality of plant products soil and climatic parameters that are significantly affecting the productivity of ashwagandha crop were identified and soil-site suitability criteria for ashwagandha were developed. The results depicted that Gadag district is found to be highly suitable followed by Bangalore rural and urban, Chikkaballapur, Kolar, Yadgiri and Uttar Kannada districts Whereas, Mysore, Haveri, Mandya, Davangere, Chamrajnagar, Bijapur, Ramanagaram, Dharwad and Belagum districts are moderately suitable area for ashwagandha cultivation.

SENNA

Senna (*Cassia aungustifolia*) is commonly known as Sonamukhi. Senna leaves and pod-shell contain the laxative principle (sennoside A & B) which are extensively used as bulk laxative in medicine. Senna is a small branched shrub remaining in fields for 5-7 months. It is a drought tolerant crop and can be grown either as pure crop or mixed with other agricultural crops. Senna is grown in red loams including coarse gravelly and alluvial loams. It has capacity to tolerate salinity and performs well in heavy soils also. It can also be grown on poor and marginal soils. It requires warm and dry weather year round and sensitive to heavy rains. In Bellary district (AEZ-1), Senna is grown in deep black soils, alkaline in nature with poor soil fertility status of nitrogen and phosphorus.



Based on yield and plant quality correlation studies, soil and climatic parameters influencing the productivity of cassia crop were identified and soil-site suitability criteria were developed. The results showed that Gulbarga district is highly suitable followed by Bangalore rural, Bijapur, Ramanagara, Hassan, Mysore, Chikkaballapur, Chithradurga, Bellary, Chamarajangar, Tumkur and Yadgir districts Whereas Haveri district (39%) is moderately suitable area available for Cassia cultivation.

SWEET FLAG (BAJE)

Baje (*Acorus calamus*) belonging to Acoraceae family is a tall perennial wetland monocot. The scented rhizomes have traditionally been used medicinally and to make fragrances. The dried and powdered rhizome were been used as a substitute for ginger, cinnamon and nutmeg. The rhizomes of Baje are mainly used for improving the digestion and also for gastric problems. The powdered rhizome and essential oil can be used as a safe insecticide. It grows wild in marshy and semi aquatic places as a perennial aromatic herb with creeping rhizome. It produces an essential oil. The essential oil contains β -asarone (82%). β -asarone acts on Central nervous system.



Baje is grown fairly well in moist, clay loams and light alluvial soils. It is cultivated almost in submerged conditions like wet land paddy. It is a hardy plant and grows in tropical and sub-tropical climate. The optimum temperature range is 10-38°C and rainfall from 70-250 cm. Baje is mainly grown in Tumkur and Ramanagara districts, where soils are deep, clay loam in texture, strongly alkaline with high amounts of phosphorus and potash.

Based on crop yield and plant quality correlation studies, soil and climatic parameters that are significantly affecting the productivity of Baje crop were identified and soil-site suitability criteria was also developed. The crop performance results showed that Gulbarga district is highly suitable followed by Bijapur, Haveri, Bidar, Mandya, Bellary and Chitradurga whereas, Gadag, Davangere, Dharwad, Mysore, Bagalkot, Hassan, Raichur, Koppal, Chikballapur, Dakshina Kannada, Chikmagalur and Bellary districts are moderately suitable for cassia cultivation.

AMLA

Amla (*Emblica officinalis*) belonging to the family *Euphorbiaceae*. It is a small to medium sized deciduous tree, 8-18 m in height with crooked trunk and spreading branches. It is very hardy, prolific bearer and highly remunerative even without much after care. Amla is the richest known natural source of vitamin C. Its juice



contains 20 times as much vitamin C as orange juice. Amla is known for its pharmaceutical properties. The use of amla in ayurvedic preparations as Chyavanprash, Triphala and Ashokrishta is age-old. It boosts immune-system, good live tonic, refrigerant, cooling, blood purifier and anti-diabetic; useful in jaundice, anemia, heart complaints, dyspepsia and indigestion; seeds used to treat diabetes, asthma, bronchitis and stomach disorders. The fruits can be made into preserves, sauce, dried chips, tablets, jellies, pickles, toffee, powder etc. It is also used in pharmaceutical and cosmetic products such as hair oil, shampoos, chavanprash, etc. The ascorbic acid and other constituents are well retained even in dried form of amla fruits.

It is largely cultivated in Uttar Pradesh (Azamgarh, Pratapgarh, Varanasi and Bareilly districts), Gujarat, Maharashtra and Karnataka. In Karnataka, it is grown in Tumkur, Shimoga, Chitradurga, Gadag and Bagalkote districts.

Amla is grown in tropical climate on marginal lands of light (sandy loam) to heavy soils (clayey soils) and is capable of withstanding adverse conditions. However, well drained fertile soils are preferred. The plants are well adapted to dry regions and can also tolerant to moderately alkaline conditions. It is sub-tropical fruit but can be cultivated successfully in tropical climate as well. The plant is not very much influenced either by hot wind or frost. The mature trees can tolerate temperature as high as 46°C. A matured tree of about 10 years yields 50-70kg of fruits.

Based on fruit yield and quality, soil and climatic parameters, which are favourable for amla crop were identified and soil-site suitability criteria was developed. The soil and crop adoptability studies showed that Mysore district is highly suitable followed by Bangalore rural and urban, Kolar, Haveri, Ramanagaram, Bidar and Chikkaballapur Whereas, Shimoga, Mandya and Chamarajnagar districts are moderately suitable amla cultivation.

TULSI (BASIL)

Basil (*Ocimum* spp.) belonging to *Lamiaceae* family and plant with medicinal and aromatic properties belonging to the genus *Ocimum*. Different species of the genus *Ocimum*, based on their chemical and/or aroma characteristics are known by different names viz. mint smelling linalool rich *O. canum* as Mint basil, the boroneol smelling *O.canum* as Hoary basil, the camphor rich *O. kilimandschancum* as Camphor basil, the shrubby eugenol rich *O.gratissimum* as Shrubby basil or Spice basil and *O. sanctum*, the species worshiped by the Hindus as the Sacred basil or Holy basil. *O.basilicum* also known as Sweet basil, French basil or common basil has assumed greater importance for its essential oil in perfumery and flavouring industry. It is widely cultivated in France, UK,



Tulsi Crop

Reunion and to a certain extent in India. Besides, mint (*Mentha arvensis*), India has of late, become the largest producer of basil (*ocimum basilicum*) oil in the world since 1996 and holding this position since then. The sweet basil (*O.basilicum*) is a native of central Asia, North-East Africa and North-west India. It is believed to have been introduced in Europe from India during 15th or 16th century by Arabs. In India, Basil is cultivated in the states of Uttar Pradesh, Haryana and Punjab, now a days extended in southern and western parts of India as monsoon crop. At present, in India about 3000 ha area is under Basil cultivation and it account for an annual production of about 300-350 tons of oil. Oil of *Ocimum basilicum* is rich in highly valuable compounds like methyl chavicol and linalool.

The plant is widely used as an herbal spice, perfume, cosmetic, fly repellents, medicine, snuff and also an ornamental. The plant also finds it uses in bakery for making special breads, breadsticks, cocktail crackers and beverages for cordials and liquors, gravies and sauces, as mouth fresheners and dental preparations. It is found to possess anti-microbial and antifungal properties The plant also possesses insecticidal, larvicidal, wormicidal and insect repellent properties. The basil oil possess vermifungal, febrifuge, anti-malarial, anti-tubercular and anti-ulcerogenic activities.

Sweet basil possesses adaptability to a wide range of habitats and can be grown in variety of environments. It thrives well on a variety of soils ranging from rich loam to poor lateritic soil. However, moderately fertile, well-drained loam or sandy loam soils rich in organic matter are best suited for its cultivation. It flourishes well under fairly high rainfall and humid conditions. Long days and high temperature have been found favorable for plant growth and oil production. The plant is moderately tolerant to drought and frost. The crop can be grown both as *kharif* and *rabi* crop in the plains and solely as *kharif* crop in the hilly regions of northern India as the plants are susceptible to extremely low freezing temperature.

In Karnataka, two types of tulsi are being grown. In Bellary district (AEZ 1) linalool rich tulsi is grown on deep black to alluvial soils for seed purpose and Ramanagaram (AEZ-8), Sirsi and Shimoga districts (AEZ-13), Eugenol rich tulsi is grown. In Ramanagaram district, it is grown for ornamental and garland purpose whereas in Shimoga and Sirsi, it is grown mainly for medicinal purpose.

Based on crop performance and quality studies, soil and climatic parameters responsible for higher productivity were identified and soil-site suitability criteria were developed. These studies showed that Dakshina Kannada district is highly suitable followed by Kodagu, Bangalore rural, Bangalore urban, Chikkamagalore, Hassan, Kolar and Chikkaballapur. Whereas, Dharwad, Haveri, Chamarajnar and Gadag districts are found moderately suitable for tulsi cultivation.

AROMATIC PLANTS

Eucalyptus citriodora

Eucalyptus L'Herit (Myrtaceae), a native plant of Australia, is a unique genus of tall trees and shrubs comprising of around 800 species widely cultivated in various parts of the world. These are commonly called gum trees as these exude a gum and are known world over for insect-repellant properties. The eucalyptus trees are characterized by evergreen foliage that is variably fragrant due to presence of volatile essential oils. They are used extensively in perfumery and pharmaceutical industry and their amount and fragrance varies with the species. In India, eucalyptus was first introduced in 1792 and is now one of the major plant species grown over 32.6 M ha area under the forest plantations. Besides, these are also cultivated along roadsides, parks, and gardens mainly for aesthetic value and along agricultural fields as windbreaks and shelterbelts. Some of the species commonly grown in India are red gum (*E. camaldulensis*), lemon-scented gum (*E. citriodora*), Tasmanian blue gum (*E. globulus*) and Cider gum (*E. tereticornis*). Among these, *E. citriodora* is a large, quick-growing tree with smooth and white bark and lemon-scented leaves. It is extensively planted and coppiced for the extraction of essential oil that is rich in citronellal and used in perfumery and as flavouring agent. The oil is known to possess a wide spectrum of biological activities including fungicidal, insecticidal, nematocidal and allelopathic properties. The essential oil is also used in the preparation of cosmetics, hair oil and soap and forms a raw material for menthol manufacture.



For various industrial uses the oil is generally extracted from the juvenile and adult foliage. India's demand for this oil is mainly met with by imports since a very a little quantity is produced indigenously. Over Rs. 2 million worth oil and its chief constituents are annually imported into India. Because of the extensive demand for citronellol, the main constituent of *E.citriodora* oil, there is considerable scope for extensive cultivation. In addition, the wood obtained can be used for paper pulp. *Eucalyptus citriodora* can also be grown as a hedge plant (vegetative barrier) in slopy areas to control the erosion.

Climatic conditions play an important role for making *E.citriodora* plantation economically viable. *E.citriodora* thrives well in tropical and sub-tropical climate. High humidity and plenty of rainfall are conducive to its luxuriant growth. It can be grown in varied types of soils i.e., acidic to mildly alkaline soil. Adequate amounts of nitrogen and moisture are essential for luxuriant growth of *E. citriodora*. A moderate atmospheric temperature coupled with reasonable humidity is extremely essential for development of these plants in early stages of growth.

In Karnataka, *E. citriodora* is mainly grown in Bangalore rural, Kolar and Chikkaballapur districts (AEZ 7) and to some extent in Dharwad district (AEZ 10). It is grown on shallow and marginal soils in Kolar and Chikkaballapur districts where as in Bangalore rural and Dharwad district, deep soils have been put to cultivate this crop. Soils are acidic to slightly alkaline in Bangalore and Dharwad district and neutral to slightly alkaline in Kolar and Chikkaballapur districts. Crop is harvested 3 to 4 times in a year for oil extraction.

Based on leaf yield and oil quality studies, soil and climatic parameters responsible for higher productivity of Eucalyptus crop were identified and soil-site suitability criteria were developed. The results of these studies showed that highly suitable area is maximum in Dakshina Kannada and Udupi districts followed by Uttar Kannada, Kodagu, Bangalore rural, Hassan, Bangalore urban, Kolar, Chikkamagalur, Chikkaballapur, Shimoga, Chamaraajnagar, Tumkur and Ramanagaram Whereas, moderately suitable area is maximum in Gulbarga followed by Mysore, Bidar, Mandya, Bijapur, Yadgir, Belagum, Bellary, Raichur, Koppal and Bagalkot districts.

DAVANA

Davana (*Artemisia pallerns*) belonging to family *Asteraceae* is an annual erect branched herb that grows upto 45-60cm tall. It is a traditional herb in south India, prized for its fruity fragrance. It forms an important component in garlands and bouquets, where sprigs of davana lend an element of freshness

and a rich sumptuousness of odour. The leaves and flowers emit a delicate, persistent fruity fragrance and are used in floral decorations. Davana oil is used in preparation of high grade perfumes. The oil has been reported to possess antimicrobial activity. The oil of davana contains hydrocarbons (20%), esters (65%) and oxygenated compounds (15%). Esters are the major compounds responsible for the characteristic smell of davana.



Davana crop

The essential oil of davana has not attained wide popularity in India, since it is hardly known to the perfumer and the flavourist perhaps, the high price of the oil has also hindered its popularity. The oil is a brown viscous liquid with deep mellow, Persistent rich fruity odour. USA, Japan and European countries are showing increasing interest for the oil and it is understood that it is being used for flavoring of cakes, pastries, tobacco and beverages.

Davana fresh herbage yields about 12 tonnes per hectare, which on shade drying and distillation yields about 7.5 kg of Davana oil. Oil content in Davana is maximum in the flower-head and is much less in the leaf and stem.

Davana can be grown on various types of soils ranging from sandy loam to medium black. However, it grows luxuriantly in fertile, well-drained sandy loamy soils. In south India, davana is mostly cultivated in the red soil. A few light showers with moderate winter conditions with no frost are conducive for the good growth of the plant. Season is very important when the crop is grown for production of oil. Hence, it is planted during the first week of November. Usually this crop is grown under irrigated conditions during October – February. The crop is allowed to grow until it flowers, which takes about 4 months from sowing. It is grown as a short term crop from November to February/ March and as a ratoon crop extending up to April/May. Season is not an important criterion when davana is grown for use in garlands and bouquets, where the crop is harvested for every two months.

In Karnataka, davana is being grown extensively in Bangalore rural, Chikkaballapur and Kolar districts (AEZ-7 and 8). Davana is grown in medium deep to deep soils under irrigated conditions. Soil texture varies from sandy loam to sandy clay loam and at few locations it is clay loam. Soil reaction is slightly acidic to neutral or slightly alkaline. Fertility of these soils are low to medium in nitrogen, medium to high in phosphorous and potash.

Based on crop herbage and oil quality studies, soil and climatic parameters influencing herbage and quality were identified and soil-site suitability criteria were developed. The results showed that Bangalore urban are highly suitable followed by Kolar, Bangalore rural, Mysore, Chikkaballapur, Chamaraajnar, Ramanagaram, Tumkur, Shimoga and Bellary Whereas, Gadag Belagum, Bagalkot, Dharwad, Davanagere, Bijapur, Gulbarga, Bidar, Chitradurga and Chikkamagalur districts are moderately suitable for davana cultivation. However, temperature decides the quality and quantity of davan oil content. Therefore in northern Karnataka Davana may be planted in such a way that harvesting should be completed by end of February (before temperature rises to more than 30°C).

GERANIUM

Pelargonium graveolens L. belonging to family Geraniaceae is popularly known as rose-scented geranium. Rose-scented geranium on distillation yields an essential oil, which is commercially known as the 'Geranium oil'. It is one of the important essential oils widely used in perfumery, soap and cosmetic industries. Current trends show that geranium oil may also have tremendous value in aromatherapy and anti-stress formulations.



Geranium is a native of Cape Colony (South Africa). Currently, it is commercially cultivated mainly in China, Egypt, Morocco, Reunion, Algeria and to some extent in India and Israel for production of essential oil. Geranium was first introduced into India at Yercaud (Shevroy hills), during the early past 20th century and to Nilgiris in 1953. Presently the total annual production of geranium oil in India is around 5 tonnes. This production is inadequate to meet the growing demand of the Indian perfumery industry. Consequently more than 150 tonnes of geranium oil is being imported annually. The imports during the last ten years have shown sharp increase from a level of 8 tonnes to the present level of about 150 tonnes. Hence, there is a large scope for commercial cultivation of geranium to meet the demand-supply gap in India

It is a perennial, drought resistant herbaceous plant. The chief constituents of essential oil of geranium are geraniol and 1-citronellol. There are three types, Algerian and Bourbon and Egyptian types in India; the Bourbon type is largely cultivated. Bourbon has 27.5% citronellol and 22.7% geraniol. The geranium is cultivated for oil, which has a pleasing rose like odour and blends well with

a wide range of floral and oriental perfumes. It is used for scenting ointments, pharmaceutical and tobacco products, in the manufacture of high grade soaps and cosmetic products.

Geranium thrives best in well drained porous soils. It is successfully cultivated on the hill slopes of Niligiris along contours and on the terrains of hills. Geranium requires well drained red sandy loams with slightly acidic soil (pH 5.5-6.5). They can grow in climatic conditions viz. temperate, sub-tropical and tropical regions. It has been successfully cultivated at wide range of altitudes ranges from 300m to 2400m and in the areas with rainfall ranging from 75cm of the plains upto 275cm. Areas with dry weather with good irrigation sources are also preferred.

In Karnataka, it is being grown in Chikkaballapur and Chitradurga districts (AEZ 7) in large areas for extraction of oil. However, in other parts of the state it is being grown in less area for garland purpose. Geranium is grown on deep to very deep, red sandy loam to sandy clay soils under irrigated conditions with good crop management practices. The soils in this region are neutral to slightly alkaline pH with low in available nitrogen and available potash and high in available phosphorus.

Based on soil and crop adaptation studies, soil and climatic parameters affecting the productivity of geranium crop were identified and soil-site suitability criteria was developed. The results showed that Bangalore rural district is highly suitable area followed by Bangalore urban, Mysore, Chikkaballapur, Chamarnajagar, Kolar, Tumkur, Ramanagaram, Chitradurga and Koppal whereas Haveri is having maximum area under moderately suitable followed by Bijapur, Gulbarga, Yadgir, Davanagere, Mandya, Bidar, Dharwad, Bagalkot, Bellary, Belagum, Gadag, Hassan and Chikkamagalur districts are suitable for geranium cultivation.

VETIVER

Vetiveria zizanioides (Linn.) Nash is having several vernacular names such as Usirah, Vira and Sugandhaimulah in Sanskrit, khus-khus in Hindi, vetiveru and lavancha in Kannada, Vettiveru in Telugu, Illamichamber in Tamil and vetiver in English. Vetiver is indigenous to India, Pakistan, Bangladesh, Sri Lanka and Malaysia. Out of the species occurring in India, *Vetiveria zizanioides* and *V. lawsoni*, only the former one has commercial significance because of high class perfumery value of its oil, known since ancient times. In India, vetiver grows luxuriantly in Uttar Pradesh,



Rajasthan, Southern and peninsular India. Major vetiver producing countries are Haiti, Indonesia, India, China, Guatemala and Brazil. World production of vetiver essential oil is around 250-300 tonnes/annum. Haiti and Indonesia account for 80 per cent of total vetiver oil production in the world.

Vetiver is a major aromatic plant grown exclusively for extraction of aromatic oil from the roots. Root is the most economical part of plant. Vetiver roots contain fragrant oil considered as one of the finest aromatic oil. Aroma chemicals such as vetiverol, vetivone and vetiveryl acetate are prepared from this volatile oil. Vetiver oil is extracted through hydro or steam distillation. Vetiver oil is a light to dark brown, olive, or amber viscous oil and is having a deep smoky, earthy-woody odour with a sweet persistent undertone. It is high grade fixative and blends well with sandal wood, lavender, patchouli and rose oil. It is high-priced oil and is used extensively in fine perfumery and cosmetic products. In dilute state, it smells like sandalwood oil. It is used exclusively in the preparation of compound perfumes in which the oil on account of its low volatility is normally used as a base to fix other high-value volatile oil like rose, lavender and jasmine oil. Vetiver oil has been utilized as a major raw material in various fragrant products (cosmetics, perfumes, deodorants, lotions and soaps). It is used to flavor sherbet and as food preservatives.

In addition, vetiver oil plays an important role in aromatherapy. The main action of vetiver oil is on the nervous system and has both sedating and strengthening effect. It is excellent in the treatment of depression, nervous tension, debility, insomnia and many stress related diseases, and also act as an aphrodisiac where there is a clear connection between impotence or frigidity and stress. It stimulates the circulatory system and makes useful massage oil for elderly or debilitated people with poor circulation. It helps to stimulate the production of red blood cells and is thus beneficial for anemia. It makes a useful warming and pain-relieving rubbing oil, suitable for deep massage of muscular aches and pains, sprains, stiffness, rheumatism and arthritis. It may be massaged on muscles before and after sports. Vetiver root is also having effects like cooling, bitter, alexitive, stomachic, calmative astringent and stimulates immune system.

Vetiver has fibrous roots and is useful in both soil and water conservation. It helps in maintaining soil moisture, absorbs toxic substances in chemical fertilizer/pesticides and improves physical characteristics of soil. Dry roots are used for making mats, screens, pillows, baskets, incense sticks and sachet bags. Roots after extraction are used as raw material for making cardboard, paper etc. Young leaves are used as fodder and dry leaves are used for thatching as well as for making brooms. Leaves made into pulp are suitable for making straw boards. Above ground portion is used in various ways such as making paper, mats, ropes, hats and baskets.

In India, vetiver is cultivated in the states of Rajasthan, Uttar Pradesh, Karnataka, Tamilnadu, Kerala and Andhra Pradesh. About 20-25 tonnes oil is produced in India annually which is much below its demand. Uttar Pradesh produces the highest quantity of oil mainly from wild plants. Vetiver oil produced from Northern India is the best and costliest in the world. Though, the major global demand is met by Indonesia and Haiti, the quality of oil produced is inferior due to iron contamination besides poor and crude extraction and processing ability. On the contrary, most of the distilled oil in India is processed in quality stainless steel vessel which makes the oil superior and high coloured. The opinion of perfumers worldwide substantiate that the Indian vetiver oil has an excellent odour profile and free from iron contamination making it acceptable even for fine fragrance manufacturing. Commercial cultivation of vetiver has been increasing in coastal Karnataka.

Vetiver is mainly cultivated on hill slopes as a rainfed crop. It grows well on a variety of soil types because of its adaptability to a wide range of soil and climatic conditions. A rich and fairly well drained sandy loam soil is considered suitable for its cultivation. However vetiver plant can be grown on marginal soils, including saline and sodic soils, sandy, water logged and sloppy lands, with the use of appropriate conservation practices. Vetiver can withstand soil salinity to as high as EC 10 dsm-1 and sodicity as high as 55 ESP. It grows well without significant reduction in root yield, upto soil pH of 9.5. It prefers a warm climate and grows in areas up to 600 m elevation. An annual rainfall of about 100 to 200 cm, temperature ranging from 25 to 40°C and moderate humidity are ideal for its growth.

In Karnataka, vetiver is being grown extensively in coastal districts viz. Udupi, Bhatkal (AEZ 16). However, it is also being grown in Mysore (AEZ 11) and Bangalore (AEZ 8) districts in lesser extent. Vetiver growing areas have deep red sandy clay loam to sandy loam soils with extreme acidic to slightly acidic reaction. Soil fertility of vetiver growing soils varied from low to medium in nitrogen, medium to high in phosphorous and potash.

Based on soil and crop adaptability correlation studies, soil and climatic parameters, significantly affecting the productivity of vetiver crop were identified and soil-site suitability criteria were developed. The results revealed that Bangalore rural district is highly suitable area followed by Udupi, Bangalore urban, Kodagu, Dakshina Kannada, Uttara Kannada, Hassan, Kolar, Mysore, Chikkamagalur, Chikkaballapur, Ramangaram, Tumkur, Shimoga and Mandya. Whereas, Yadgir, Chamarajnagar, Raichur and Gadag districts are moderately suitable area for vetiver cultivation.

ROSEMARY

Rosemary (*Rosmarinus officinalis* L.) is an evergreen, woody aromatic herb with a characteristic aroma and lavender-like leaves. The plant is native to the Mediterranean region where it grows wild along the seacoast. Rosemary is cultivated on a large scale in Spain, Italy, France, Algeria and Portugal for its essential oil. Rosemary is regarded as a symbol of fidelity and is still used in religious ceremonies in southern Spain. In the middle ages, Hungarian queen used rosemary alcoholic water for body care, which later became popular as 'Hungarian water'. Even in 13th century it was popular as a perfume in Europe. The essential use of rosemary is mainly used in the production of soaps, detergents, household sprays and other such products. Rosemary extract is also used as an antioxidant to improve stability of preserved foods. It is employed as fixative and blends well with several other oils. The oil shows antimicrobial and insecticidal properties. The oil is reported to have a direct vascular smooth muscle relaxant effect. Its use as a flavouring agent in edibles and in distilled water for eyewash are also reported. Dried leaves and tops of the rosemary crop are a priced culinary item.



Rosemary crop – Field view

Rosemary requires Mediterranean type of climate with frost free cool winters and mild summer below 30°C. In India rosemary is cultivated as a garden crop in cooler climate of Nilgiris in south India. It grows well on the well drained red sandy loam soils in the plains of Karnataka. The southern and northern hills of Tamil Nadu with elevation ranging from 1000-1500 m MSL, are good locations for this crop. The cooler months of December/January are suitable for planting.

The crop can also be cultivated in the lower regions of Himalayas (1000 meters altitude) in the states of Jammu and Kashmir, Himachal Pradesh, Uttar Pradesh, Sikkim, West Bengal and Arunachal Pradesh. In these areas crop can be planted in the months of March & April.

It is a very hardy plant and found growing on the rocky terrain in the temperate parts of the world. In India, the plant comes up well on light loamy soils of Nilgiris and sandy loam soils of Bangalore. The crop requires a soil pH ranging from 6.5-7.0 for its successful growth.

Rosemary on harvesting, yields about 12 to 15 tonnes of fresh herbage per hectare per year. The fresh leaves on distillation yields 1% of oil and that of shade dried leaves yield 3% oil.

In Karnataka, rosemary is being grown in Chamarajnagar (AEZ 6) and Bangalore (AEZ 7) districts. They are grown on deep red sandy clay loam soils with neutral to slightly alkaline in nature. Soil fertility of these soils is low in nitrogen, medium to high in phosphorus and potash.

Based on soil and crop adaptability correlation studies of soil and climatic parameters significantly affecting the productivity of Rosemary crop were identified and soil-site suitability criteria were developed. The results revealed that Bangalore rural district has highly suitable area followed by Bangalore urban, Kolar, Kodagu, Chikkaballapur, Ramangaram, Mysore, Tumkur, Mandya, Chitradurga and Koppal Whereas, Yadgir district is moderately suitable area followed by Bellary, Dakshina Kannada, Haveri, Uttar Kannada, Gadag , Davengere, Raichur and Shimoga are suitable for rosemary cultivation.

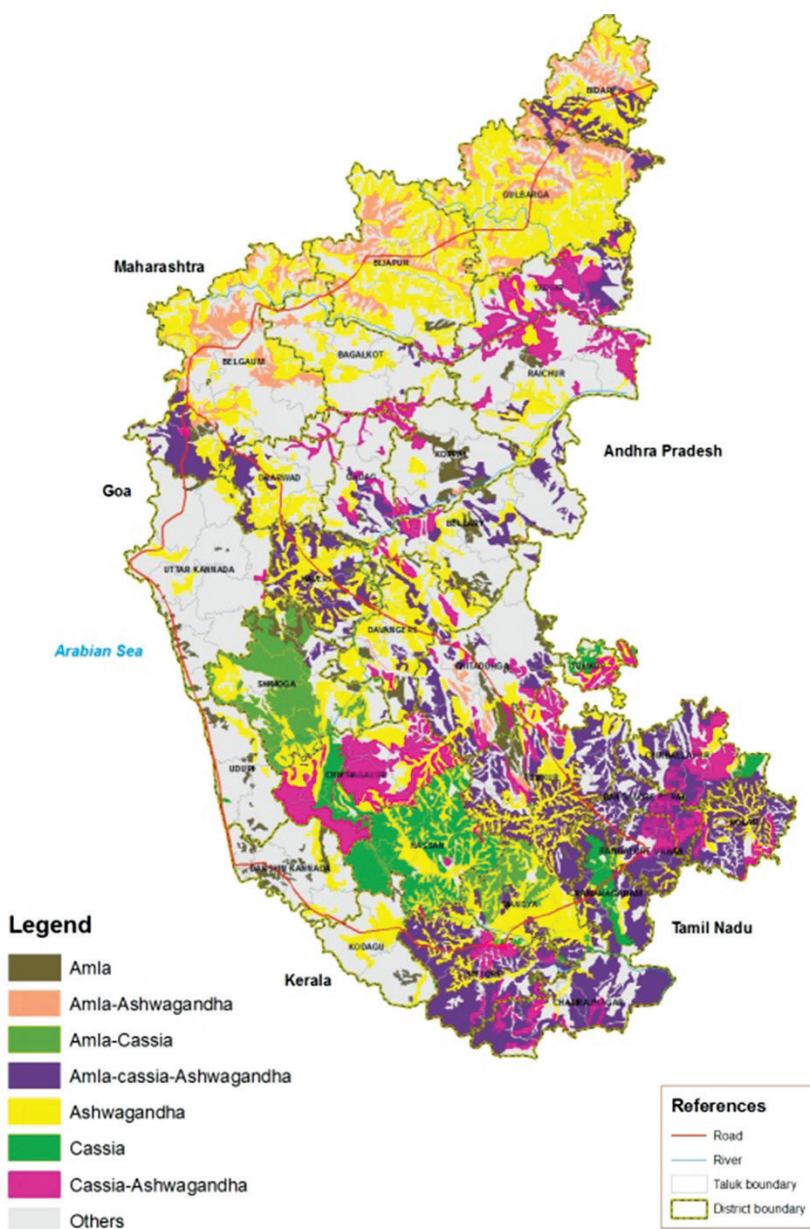
CONCLUSION

Karnataka state is also endowed with a variety of agro climatic situations, which can support inclusion of variety of MAPs in developing land use plans for the state. MAPs are increasingly emerging as alternative crops for diversification in Karnataka and also in sustaining farmers' livelihoods.

Potential areas were delineated based on land suitability assessment for medicinal and aromatic crops. The crop requirements of each crop have been established by studying different crop growing environments in relation to productivity and quality. Crop growing tracts of MAPs were grouped into highly, moderately, marginally and unsuitable considering soil site and climatic criteria developed. Highly suitable and moderately suitable areas have been considered as potential areas under each crop and by over laying district boundaries on suitability map in GIS, and thus potential districts were identified.

Thus, the above study helps to identify suitable medicinal & aromatic plants for cultivation in an existing cropping system or integrated cropping system with less variability in yield and quality over large soil units or area. The study has also helped in identifying cultivable wastelands and marginal lands for expansion of MAPs cultivation. The large scale area adoption under these crops would offer both producers and traders to choose different potential species suitable in different biophysical set up of the region so that viable agro-industries can be set up at village level. In turn, this would help in generation of additional employment and improves rural economy.

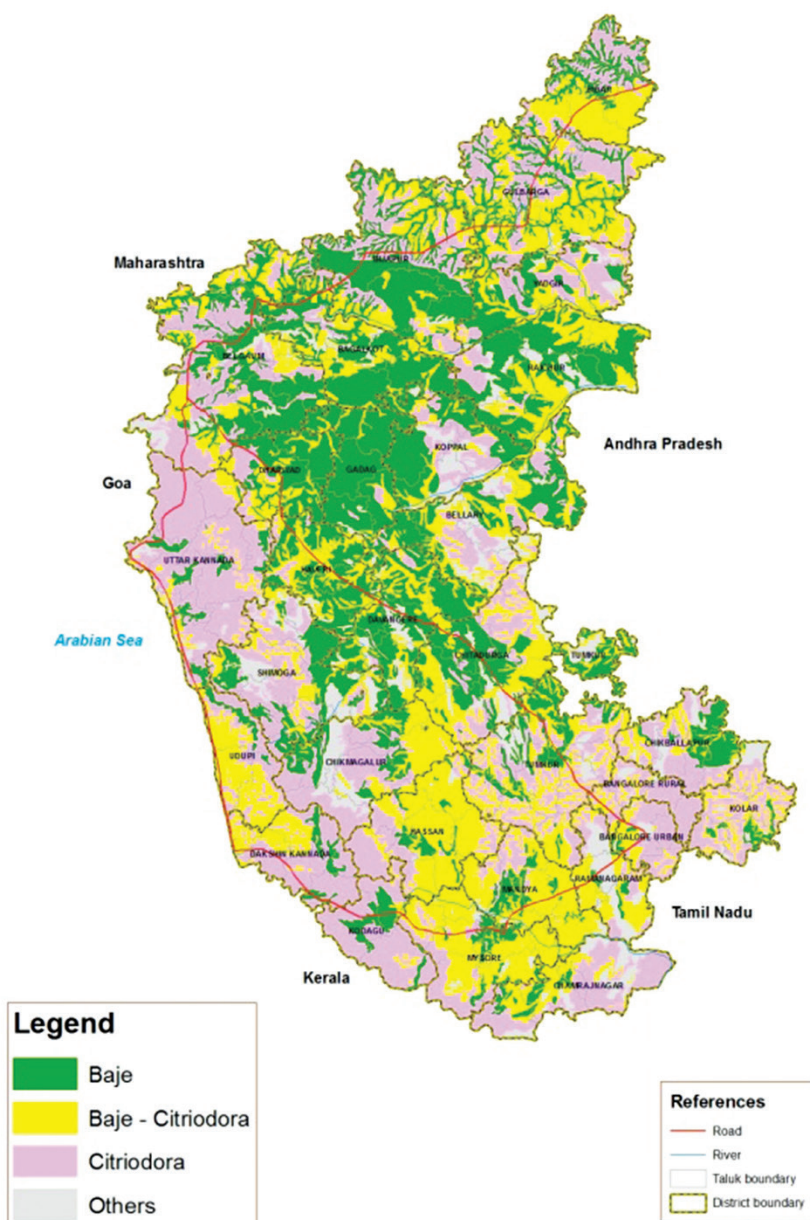
Potential Area for Amla-Cassia-Ashwagandha
KARNATAKA



Potential areas for amla-cassia-ashwagandha

Potential Area for baje and citriodora

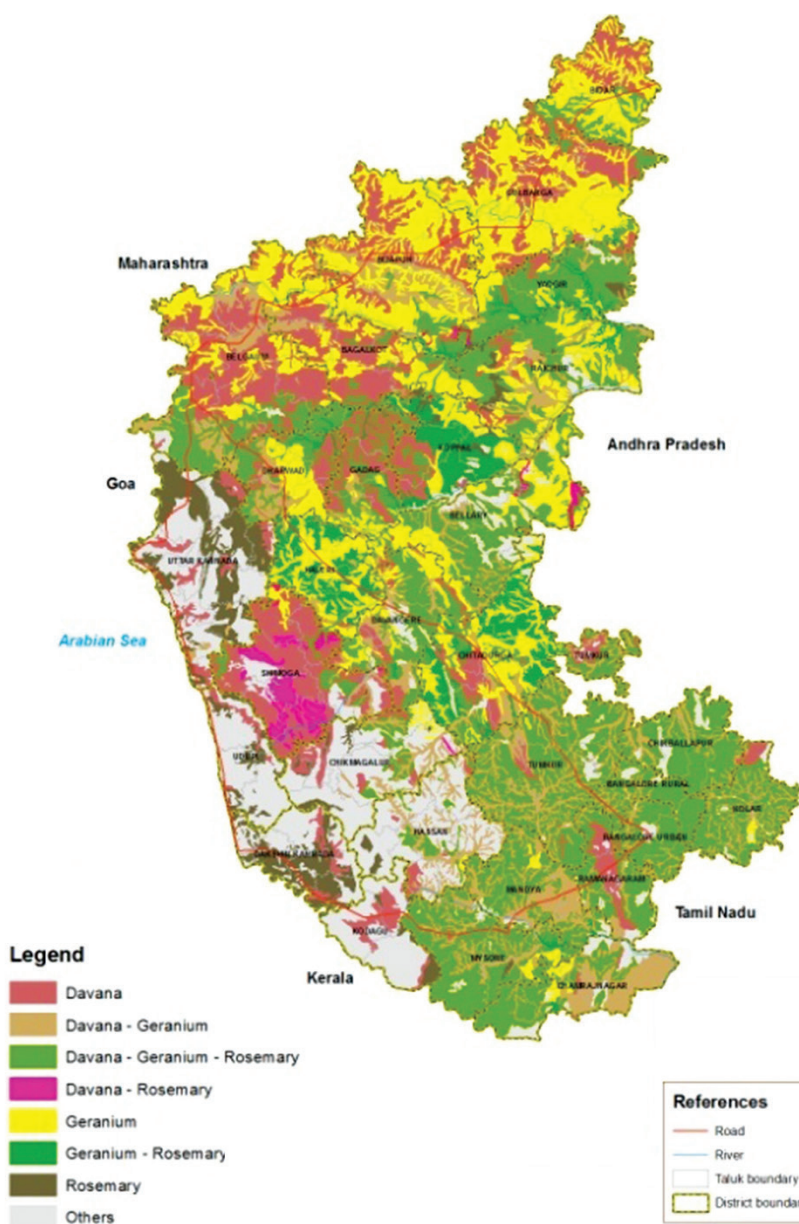
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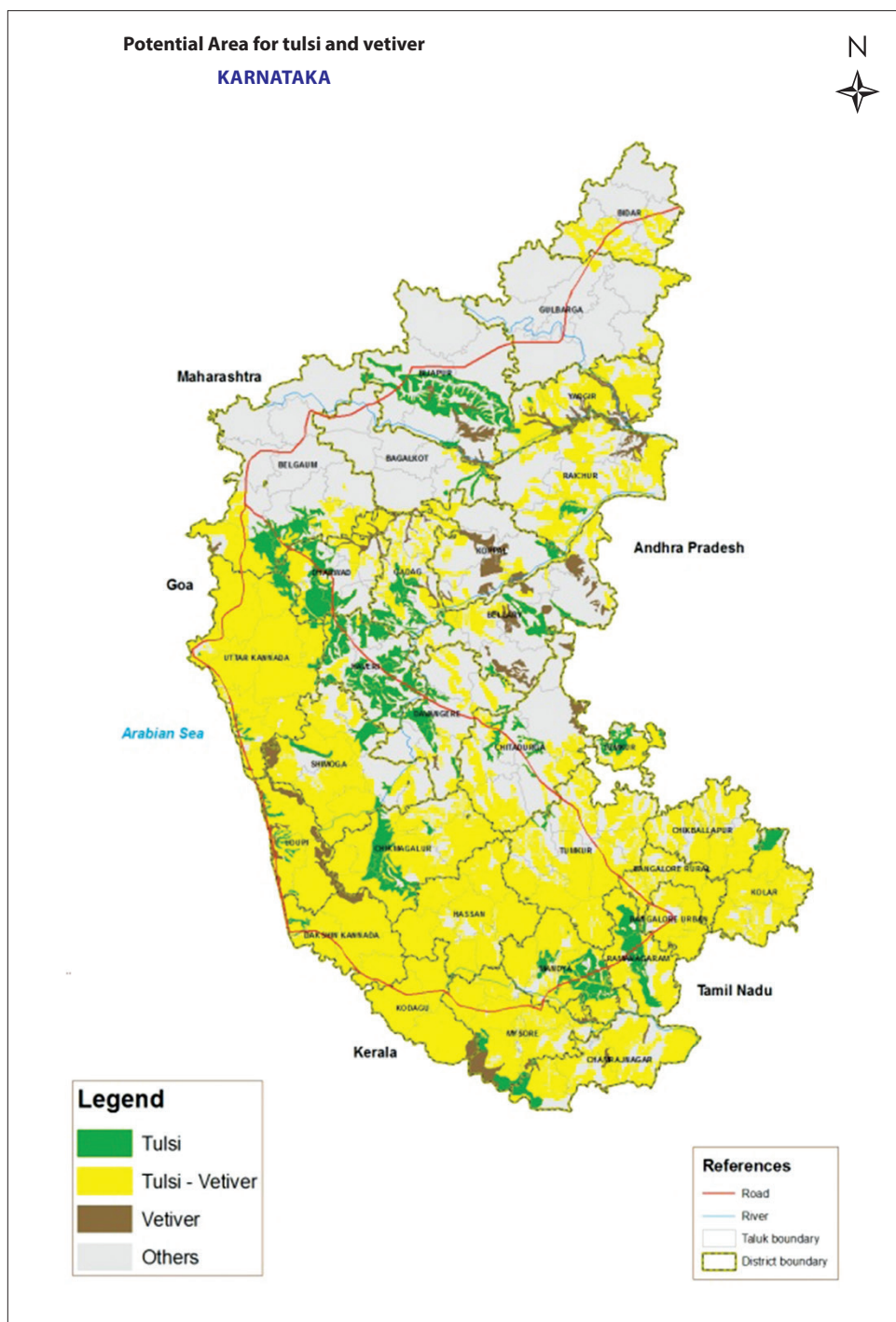
Potential areas for baje and citriodora

Potential Area for davana-geranium & rosemary

KARNATAKA



Potential area for davana-geranium & rosemary



Potential areas for tulsi and vetiver