Full Research Article

Characterisation of Major Forests in Tamil Nadu based on Climate and Soil-site Characteristics for Identifying Potential Areas for Afforestation

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Abstract

Global climate change may have an impact on forest cover. Comprehensive knowledge on soils and climatic resources helps to identify the potential areas for afforestation. The present study was aimed to assess the impact of soil and climatic resources on different existing forest types to identify the problems and potentials of forest pockets for afforestation in Tamil Nadu. The soil resource information developed by ICAR-National Bureau of Soil Survey and Land Use Planning (ICAR-NBSS and LUP), Length of Growing Period (LGP) and forest cover map of Tamil Nadu was used to evaluate the soil site characters supporting various forest types by *Overlay* analysis in the GIS environment. Soil site characters and climatic parameters which supporting dense, open and scrub forest were quantified and verified in the ground. The results show that soil depth and length of growing period were found to be two significant key factors influencing the forest type. Moderately deep (75 to 100 cm) to very deep (>150 cm) soils with moist period of 5 to 9 months are found suitable for dense forest cover whereas shallow depth, presence of higher proportion of gravels in sub soil and prolonged dry period are identified as major constraints in open and scrub forest. By using overlay technique, potential forest areas were identified based on soils and site characteristics for afforestation and suitable soil and water conservation measures were suggested to develop sustainable forest cover.

1. Introduction

India ranks 10th amongst the most forested nations of the world (FAO, 2010) with 23.81% (78.29 mha) of its geographical area under forest and tree cover (FSI, 2011). The per capita availability of forest land is 0.08 ha which is lowest in the world as against an average of 0.5 ha for developing countries and 0.64 ha for the world (FAO, 2002). Total forest area in Tamil Nadu state is 22,877 km^2 which constitutes 17.59% of the geographical area of the state. Reserve forests comprise 84.75%, protected forests 9.54% and unclassified forest constitutes 5.71% (FSI, 2011). According to Champion and Seth (1968) classification, the state has been divided into nine forest types viz., tropical wet evergreen (3.30%) tropical semi ever green (3.66%), tropical moist deciduous (8.12%), littoral and swamp (0.4%), tropical dry deciduous (46.98%), tropical thorn (12.91%), tropical dry evergreen (1.61%), sub-tropical broadleaved hill (1.01%) and mountain wet temperate forests (1.04 %).

Forest ecosystems have a major influence on the global climate as major contributors to the terrestrial carbon sink and large reservoir of carbon. Besides, storage of carbon in the soil, forests stores large amount of carbon as biomass (Freibauer et al., 2004; Brown et al., 2009; Kristofer et al., 2011). Beneficial effects of forest ecosystem like positive changes in water transpiration, water balance and impact of hydrological cycle (Lal, 1981), changes soil structure and physiochemical properties by increasing the water holding capacity of soil, reducing run off and eliminating the effects of water and wind erosion are reported by many researchers across the world (Zalamea et al., 2007; Porto et al., 2009; Wani et al., 2010).

The growth and reproduction of forest cannot be understood without the knowledge of climate and soil (Sharma et al., 2010). Climate is one of the most significant factor influences the distribution, structure, ecology and type of forests (Kirschbaum et al., 1996). Rising temperature increases the forest cover for a short period in tropical forests (Feeley et al., 2007) and most forest ecosystems will be impacted through changes in species composition, productivity and biodiversity (Leemans and Eickhout, 2004). Soil and forest are highly interrelated

and none of them can live without each other and thus soil help to secure renew the forest. Forest trees depend directly upon the soil for physical support, temperature moderation, and nutrition. The effects of the textural properties of soil are frequently reflected in the composition and the rate of growth of forest vegetation and forest types can change soil properties and flora (Gol et al., 2010; Schrumpf et al., 2013). Tree species can differ significantly in their influence on soil properties as well as soil fertility (Augusto et al., 2002). Integrated forest management requires comprehensive database on soil and climatic resources for sustainable management as they strongly influence the forest type, distribution and productivity. The present study attempts to characterize soil and climatic constraints of the diverse forest types in Tamil Nadu and identify the potential forest areas for afforestation.

2. Materials and Methods

2.1. Climate

The climate is semiarid tropical monsoons with the annual rainfall ranging from 550 mm in the plains to 2400 mm in the hills. The south-west monsoon season extends from June to September and mean temperature during this period varies from 22.7 °C to 36 °C in the coastal plains and uplands whereas in the hilly areas it ranges between 10 and 18 °C. Mean temperature during the North-East monsoon season varies between 20 and 31 °C in the uplands and coastal plains, whereas in the hills it ranges between 8 and 19 °C. The summer season starts from March and ends by May and mean temperature varies from 23 °C to 37 °C in the coastal plains and uplands and from 10 °C to 22 °C in the hills. The coldest and hottest months in Tamil Nadu are January and May, respectively. Rainfall is received in three distinct seasons, i.e., pre-monsoon (Jan-May), southwest monsoon (June-Sept) and north-east monsoon (Oct-Dec). Pre-monsoon showers contribute 12% of annual rainfall, 37% during South-West monsoon, and 51% during North-East monsoon (IMD, 2012).

2.2. Soil

The hilly tracts (Nilgiris, South Sahyathri and Eastern Ghats) have deep or very deep, well drained clayey soils with high organic matter, strongly acidic. Low hills have deep or very deep well drained gravelly clay soils classified under great group Haplohumults, Paleudalfs and Humitropepts. In Eastern Ghats the major soils are very shallow to moderately shallow, red gravelly loam to gravelly clay soils (Ustropepts/ Ustorthents/Haplustalfs). In Tamil Nadu uplands dominant soils are moderately shallow, gravelly loam or clayey soils (Rhodulstalfs/Ustropepts/Paleustalfs/Haplustalfs). Deep calcareous black soils (Chromusterts/Ustropepts) occur near Coimbatore in patches. Tamil Nadu plains are having three types of soils are deep to very deep, imperfectly or poorly drained clayey with vertic features (Vertic ustropepts) in northern parts, highly weathered, moderately deep to very deep, well drained, clayey soils with iron or manganese pebbles (Ustropepts/Haplustalfs/Paleustalfs/Rhodustalfs) in laterite tracts of Tiruvallur, Kanchipuram, Cuddalore, Thanjavur, Pudukottai and Sivagangai districts. Deep or very deep, moderately well drained or imperfectly drained calcareous black clayey and gravelly clay soils (Chromusterts/Pellusterts/ Ustropepts) in southern places. All along the coast, the soils are very deep excessively drained, sand and sandy loam textures (Ustipsamments) and coastal swamps and marshes found in patches, deep, poorly drained clayey soils (Haloaquepts) are predominant (Natarajan et al., 1997).

2.3. Data and methodology used

The soil resource data (1:250,000) and soil map (Figure 1). Generated for Tamil Nadu (Natarajan et al., 1997) was used as a base information. The length of crop growing period (LGP) assessed for the state to know the duration of moisture availability for forest growth. Long term weekly rainfall data of 120 locations representing different parts of the state for 30 years were collected from IMD, Pune. Water balance for each station was calculated using Thornthwaite and Mather (1955). For assessing the Length of Growing Period (LGP) FAO model was used (Higgins and Kassam, 1981) based on weekly rainfall, PET and soil available water capacity. LGP is the duration in days or months when precipitation exceeds 0.5 PET and ends with utilisation of stored moisture till it reaches 0.25 PET. The LGP for all locations was worked out and digitised using SPANS GIS (Naidu et al., 2012). LGP is the duration in days or months when precipitation exceeds 0.5 PET and ends with utilisation of stored moisture till it reaches 0.25 PET. The LGP for all locations was worked out and digitised using SPANS GIS (Naidu et al., 2012). The forest types viz., dense, open and scrub classified by Forest survey of India (FSI, 2011) formed base for delineating the forest cover and types (Figure 2). Soil site characteristics and length of moist period for the forest sites were abstracted by integrating three layer of maps viz. Soil, length of moist period and forest types by overlay analysis method in the GIS environment. The field verification was carried out in the month of November 2013 and March- April 2014. In the selected places, profiles were studied in detail for their physical and morphological characteristics (Soil Survey Staff, 2003) and verified along with type of forests with the existing soil map of Tamil Nadu and FSI map. Using GIS overlay technique the soil/climate parameters responsible for maintenance good/poor forest types were correlated to identify the potential areas for *afforestation*

and higher biomass productivity.

3. Results and Discussion

All lands, more than one hectare in area, with a tree canopy density of more than 10% has been classified as dense and moderately dense forest which constitutes 58%, open forest constitutes 45.2%. Forest lands having canopy density less than 10% are classified as scrub forest which constitutes 5.8% of forest area. The ground truth data's pertaining to type of forest and soil site characteristics were collected in Nilgiris (Gudalur), Thirunelveli (Kalakadu, Therkuviravanallur and Courtallam slopes), Kanyakumari (Thadagamalai), Salem (Yercadu), Viluppuram (Pakkamalai) and Dharmapuri (Toppur and Chitteri hills) districts representing the different forest pockets and the relationship between soil, climate and type of forest were established. The soil characteristics and length of moist period for the major forest tracts in different physiographic regions of Tamil Nadu were presented below (Table 1).

3.1. Nilgiris

The major reserved forests in Nilgiri regions are Gudalur, Mudumalai, Nilgiri eastern slope, Melur slope, Goppanari and Thadagam which comes under dense forest whereas Kothagiri reserved forest belonging to open forest type. The major soil and site factors responsible for the dense forest are favorable climate (LGP 210-270 days) and deep soil (>100 cm). The soils are mainly clayey in texture, non gravelly occurring on hills and hill ranges with 5-30% slope.

3.2. South Sahyathri

The moist period in South Sahyathri region is more than 9 months. Hilly tracts of Coimbatore, Dindugul, Kanyakumari, Madurai, Theni, Thirunelveli and Virudunagar districts are coming under this region. The district wise different forests and their soil and site characteristics were presented below.

3.2.1. Coimbatore

Amaravati, Manjampatti, Anaimalai, Kudirarar/Kookal are the major reserved forests in Coimbatore district. The soil conditions in Amaravati and Manjampatti reserved forests are deep soil (100-150 cm), clayey texture, non gravelly with slope ranges from 15-30%. The soils found in Anaimalai and kudirarar/Kookal forest are moderately shallow (50-75 cm), clayey texture occurring on high hills with slope ranges from 15-30%. The favorable moist period (9 months) supports dense forest irrespective of soil.

3.2.2. Dindugal

Palani hills and Perumal malai are the two dominant reserved forests in Dindugal district. The soils found in these forests are moderately shallow (50-75 cm), loamy to clayey texture occurring on high hills with slope ranges from 8-30%. Though soils are shallow, longer moist period (9 months) supports dense forests.

3.2.3. Kanyakumari

Thadagamalai, Veerapuli and Kilamalai reserved forests are dominant in south Sahyathri zone of Kanyakumari district. The area has deep non gravelly clayey soils (100-150 cm) occurring on high hills with the slope ranges from 15-30%. Deep soils associated with moist climate are responsible for developing dense forest.

3.2.4. Madurai

Saptur, Elumalai and Andipatti are major dominant reserved forests in Madurai district. The area has deep (100-150 cm), gravelly (>35%) clayey soils occurring on low hills with the slope ranges from 8-15%. Deep soils associated with moist climatic conditions (9 months) are responsible for developing dense forest.

3.2.5. Theni

Suruli and Koduvilarpatty are the two major dominant reserved forests in Theni district. The soils of Suruli forest are very deep (>150 cm), non gravelly, loamy soils supporting dense forest whereas Koduvilarpatty reserved forest classified under scrub which has moderately deep (75-100 cm) non gravelly, loamy soils.

3.2.6. Thirunelveli

Vellakalathur, Vairavankulam, Krishnapuram, Sivagiri, Singampatti zamindar, Papanasam, Puliyarai, Kalakadu, Therkuviravanallur and Courtallam slopes are the dominant reserved forests found in south Sahyathri zone of Tirunelveli district. Soils encountered in this forests are deep (100-150 cm) to very deep (>150 cm), non-gravelly clayey to loamy soils. These forests are dense forest except Krishnapuram which comes under scrub category. Deep soils and longer moist period are responsible for dense forest in this zone.

3.2.7. Virudunagar

Settur reserved forest in Virudunagar district is dense forest. It has moderately deep (75-100 cm), non gravelly, loamy soils on hills with slope range from 3-8% with prolonged moist period (9 months) supporting good forest cover.

3.3. Eastern Ghats

This zone covers hilly tracts of Dharmapuri, Erode and Vellore districts. The moist period in these regions is 5-6 months. The district wise forests and their soil and site characteristics were given below

Table 1: Soil characteristics and length of moist period for major reserved forests of Tamil Nadu

District	Reserved Forest	LGP	Depth	Texture	Gravel	Slope	Land form	District	Reserved Forest	LGP	Depth	Texture	Gravel	Slope	Land form
Coimbatore	Amaravati	>270	100-150	clayey	-	15-30	HR	Dharmapuri	Ajjampatty	150-180	25-50	loamy	>35	30-50	SHS
	Manjampatti	>270	100-150	clayey	-	15-30	HR		Boonthikkal	150-180	75-100	cracking clay	-	0-1	NL
	Anaimalai	>270	50-75	clayey	-	15-30	HH		Pennagaram	150-180	50-75	loamy	>35	15-30	HS
	Kudirarar/ Kookal	>270	50-75	clayey	-	15-30	HH		Badanavadi	150-180	50-75	loamy	>35	15-30	HS
	Nilgiri eastern slope	240-270	50-75	loamy	>35	>50	EFS		Thoppur	150-180	25-50	loamy	-	15-30	LH
	Melur slope	240-270	50-75	loamy	>35	>50	EFS		Palani hills	>270	50-75	loamy	-	3-8	HR
	Goppanari	240-270	50-75	loamy	>35	>50	EFS	Dindugul	Pillayarmattam	90-120	25-50	loamy	>35	8-15	LH
Cuddalore	Thadagam	240-270	>150	clay	-	30-50	Hills		Mudumalai	90-120	25-50	loamy	>35	8-15	LH
	Pitchavaram	150-180	marshy lands	-					Panchamthangi	90-120	25-50	loamy	>35	8-15	LH
	Killai	180-210	marshy lands	-					Thoppasamimalai	90-120	25-50	loamy	>35	8-15	LH
Dharmapuri	Chitteri hills	150-180	50-75	loam	>35	3-8	GSSS		Karanthaalai	150-180	75-100	clayey	-	8-15	HH
	Sittilingi	150-180	75-100	clay	>35	8-15	HH		Erakkalamalai	150-180	25-50	clay	>35	>50	HS
	Tambal ext	150-180	75-100	clay	>35	8-15	HH		Perumalai	150-180	25-50	clay	>35	>50	HS
	Nachikutti	150-180	75-100	clay	>35	8-15	HH		Perumalamalai	>270	50-75	clayey	-	15-30	HH
	Ammapalayam	150-180	75-100	clay	>35	8-15	HH	Erode	Ullepalayam	150-180	<25	loamy	-	>50	Hills
	Kottapatty	150-180	75-100	clay	>35	8-15	HH		Thamaraikkarai	150-180	<25	loamy	-	>50	Hills
	Tarisal	150-180	75-100	clay	>35	8-15	HH		Palamalli	150-180	<25	loamy	-	>50	Hills
	Woddapatti	150-180	50-75	clayey	-	15-30	Hills		Nagalur	150-180	50-75	clayey		30-50	HHE
	Gurthirayan	150-180	50-75	clayey	-	15-30	Hills		Thalamalai	150-180	50-75	clayey	-	30-50	HHE

HR: Hills and ridges; HH: High Hils; EFS: Escarpments and foot slopes; GSSS: Gently sloping side slopes; SHS: Steep hills slopes; HS: Hill slopes; LH: Low hills; HHE: High hills and escarpments; GSL: Gently sloping lands

District	Reserved Forest	LGP	Depth	Texture	Gravel	Slope	Land form
Kanchipuram	Nanmangalam	150-180	100-150	clay	>35	3-8	GSL
Kanyakumari	Poigaimalai	<90	100-150	clayey	-	15-30	HH
Kanyakumari	Mahendragiri	<90	100-150	clayey	-	15-30	HH
	Thadagamalai	<90	100-150	clayey	-	15-30	HH
	Veerapuli	>270	100-150	clayey	-	15-30	HH
	Kilamalai	>270	100-150	clayey	-	15-30	HH
	Asambu	>270	rock out crops				
	Therkumalai	<90	rock out crops				
Krishnagiri	Biligundulu	150-180	50-75	clayey	-	15-30	Hills
Madurai	Veguthumalai	150-180	25-50	loamy	>35	8-15	LH
	Karumalai	150-180	25-50	loamy	>35	8-15	LH
	Saptur	>270	100-150	clay	>35	8-15	LH
	Elumalai	>270	100-150	clay	>35	8-15	LH
	Nalladevanpatti	90-120	100-150	clay	>35	8-15	LH
	Andipatti	>270	100-150	loamy	-	3-8	GSS
Madurai	Alagar hills	150-180	75-100	clayey	-	8-15	HH
	Sirumalai	150-180	75-100	clayey	-	8-15	HH
Nagapattinam	Kodiyakarai	150-180	>150	sandy	-	3-8	SR
Namakkal	Mavar	150-180	25-50	clay	>35	3-8	GSS
	Bailnadu	150-180	25-50	loamy	>35	30-50	SHS
	Karavallicombai	150-180	25-50	loamy	>35	30-50	SHS
	Kollihills	150-180	25-50	loamy	>35	30-50	SHS

District	Reserved Forest	LGP	Depth	Texture	Gravel	Slope	Land form
Nilgiris	Gudalur	210-240	>150	clay	-	5-8	LH
	Kothagiri	240-270	100-150	clayey	-	30-50	HH
	Mudumalai	210-240	100-150	clay	>35	15-30	LH
Perambalur	Manmalai	150-180	75-100	clay	>35	8-15	HH
	Nagoor	150-180	75-100	clay	>35	8-15	HH
	Ayyur	150-180	>150	clayey	-	3-8	GSL
	Sunderesapuram	150-180	>150	clayey	-	3-8	GSL
Pudhukottai	Pudukkotai	150-180	50-75	clay	>35	3-8	GSL
	Belur	150-180	75-100	clay	>35	8-15	HH
	Gangavalli	150-180	75-100	clay	>35	8-15	HH
	Udambium	150-180	75-100	clay	>35	8-15	HH
Salem	Arasankadu	240-270	<25	loamy	-	3-8	SHH
	Godumalai	150-180	25-50	loamy	>35	>50	LH
	Jalluttu	150-180	25-50	loamy	>35	>50	LH
	Kuttur	150-180	25-50	loamy	>35	30-50	SHS
	Nanthanchedu	240-270	25-50	loamy	>35	30-50	SHS
	Yercadu	240-270	100-150	clayey	-	30-50	HH
Theni	Lokkur	150-180	>150	loamy	-	15-30	LH
	Koduvilarpatti	>270	75-100	loamy	-	3-8	Hills
	Suruli	>270	>150	loamy	-	15-30	HHE
Thirunelveli	Singampattizamindar	>270	100-150	clayey	-	15-30	HR
	Papanasam	>270	100-150	clayey	-	15-30	HR
	Kuliyarai	>270	100-150	clayey	-	15-30	HR
	Kolundhamadai	90-120	rock out crops			-	
	Vellakalathur	>270	>150	loamy	-	15-30	HHE

HH: High Hills; LH: Low hills; GSS: Gently sloping slopes; SR: Sand ridges; SHS: Steep hills slopes; GSL: Gently sloping lands; SHS: Steep hills slopes; HHE: High hills and escarpments

District	Reserved Forest	LGP	Depth	Texture	Gravel	Slope	Land form
Thirunelveli	Vairavankulam	>270	>150	loamy	-	15-30	HHE
	Krishnapuram	>270	>150	loamy	-	15-30	HHE
	Sivagiri	>270	>150	loamy	-	15-30	HHE
	Kalakkadu	>270	100-150	loamy	-	5-8	LH
	Therkuveeravanallur	>270	100-150	loamy	-	5-8	LH
	Courtallam slopes	>270	100-150	loamy	-	5-8	LH
	Uthumalai	90-120	>150	clayey	-	3-8	GSL
	Kothamalai	90-120	100-150	clay	>35	3-8	GSL
Thiruvallur	Allikuzhi	150-180	<25		stony	5-8	Hills
Thiruvannamalai	Ponnaiyur	150-180	75-100	clay	>35	8-15	HH
	Nattampalli	150-180	75-100	clay	>35	8-15	HH
	Moolakaddu	150-180	75-100	clay	>35	8-15	HH
Thoothukudi	Vallanadu	<90	100-150	clayey		5-8	UR
Trichy	Veeramalai	150-180	25-50	loamy	>35	8-15	LH
	Arasadiyavettu	150-180	25-50	loamy	>35	30-50	SHS
Vellore	Ambur	150-180	75-100	clay	>35	8-15	HH
	Mambakkam	150-180	75-100	clay	>35	8-15	HH

District	Reserved Forest	LGP	Depth	Texture	Gravel	Slope	Land form
Vellore	Vellakutta	150-180	75-100	clay	>35	8-15	HH
	Athiyur	150-180	75-100	clay	>35	8-15	HH
	Arasampattu	150-180	75-100	clay	>35	8-15	HH
	Thellai	150-180	75-100	clay	>35	8-15	HH
	Mambakkam	150-180	75-100	clay	>35	8-15	HH
	Mangalam	150-180	75-100	clay	>35	8-15	HH
	Kunjanur	150-180	75-100	loam	>35	3-8	GSH
	Mahimandalam	150-180	75-100	loam	-	5-8	UL
	Ammur	150-180	75-100	loam	-	5-8	UL
	Palamadai	150-180	<25	loamy	>35	15-30	LH
	Punganur	150-180	<25	loamy	>35	15-30	LH
	Yelagiri	150-180	75-100	loamy	>35	8-15	HH
	Nayakkaneri	150-180	75-100	clayey		15-30	HS
Villupuram	Parigan	150-180	25-50	loamy	>35	30-50	SHS
	Karai	150-180	75-100	clayey	-	5-8	UL
	Milkondai	150-180	100-150	clayey	-	0-1	Lowlands
	Pakkamalai	150-180	Rock lands				
	Muttakadu	150-180	Rock lands				
	Siruvadi	150-180	Rock lands				
Virudunagar	Settu	>270	75-100	loamy	-	3-8	Hills

HHE: High hills and escarpments; LH: Low Hills; GSL: Gently sloping lands; HH: High Hills; UR: Undulating ridges; SHS: Steep hills slopes; GSH: Gently sloping hills; UL: Undulating lands; LH: Low hills

3.3.1. Dharmapuri

The major reserved forest in the eastern ghat portion of Dharmapuri district is Woddapatti, Gurthirayan, Pennagaram and Badanavadi. Woddapatti and Gurthirayan are dense forest whereas Pennagaram and Badanavadi are classified under open forest. The soils of dense forest are moderately shallow (50-75 cm) non-gravely clayey soils occurring on hills with the slope of 15-30%. Even though soil depth is shallow, non gravelly clay soil with high water holding capacity supports dense forest cover in this region(Naidu et al., 2009). The soils of open forest

are rock lands associated with moderately shallow (50-75 cm), gravely loamy soils.

3.3.2. Erode

Ullepalayam, Thamarakkarai, Palamalli, Nagalur and Talamalai are the major reserved forests located in Erode district. The soils of Ullepalayam, Thamarakkarai and Palamalli are very shallow (<25 cm), non gravelly loamy soils occurring on hills with slope of more than 50%. The soils of Nagalur and Talamalai are moderately shallow (50-75 cm), non gravelly clayey soils on high hills and escarpment with the slope ranged from 30-50%. Though these forests tracts have moist period (5-6 months), shallow soils associated with steep slopes and severe erosion are the main causes for the poor forest cover.

3.3.3. Vellore

Palamadai, Punganur, Ambur, Kunjanur, Mahimandalam, Ammur, and Nayakkaneri are the major reserved forests in Vellore district. Except Ambur and Nayakkaneri, all the forest pockets are classified as scrub forest. Ambur comes under open forest and Nayakkaneri classified under dense forest. The soils are moderately shallow (75-100 cm), gravelly to non gravelly loamy soils except Palamadai and Punganur having soil depth of less than 25 cm.

3.4. Tamil Nadu Uplands

Tamil Nadu uplands regions having four different length of moist period viz., LMP of <3 months, 3-4 months, 5-6 months and 8-9 months. The soil characteristics of different forests of these regions are described below.

3.4.1. Moist period: <3 months

Poigaimalai, Mahendragiri, Therkumalai in Kanyakumari and Vallanadu in Toothukudi are the major reserved forests in this zone. Poigaimalai and Vallanadu reserved forests are classified under open forest whereas Mahendragiri and Therkumalai come under scrub category. The soils of this zone are deep, non gravelly clayey soils occurring on high hills of 15-30% slope. Prolonged dry period along with frequent drought are responsible for poor scrub forest (Sharma et al., 2009).

3.4.2. Moist period: 3-4 months

Reserved forests of Pillayarmattam, Mudumalai, Panchamthangi, Thoppasamimalai, Erakkalamalai, Perumalai and Karanthamalai in Dindugul, Nalladevanpatti in Madurai and Uthumalai, Kothamalai and Kolundhamadai in Tirunelveli are belonging to this zone. The soils in Dindugul reserved forest are shallow, gravelly loam soil occurring on low hills with a slope of 8-15%. The soils under Madurai and Tirunelveli reserved forest are deep (100-150 cm), gravelly clayey soils occurring on gently sloping lands. These forest are classified under scrub category.

Even though it has favorable soil condition shorter moist period leads poor forest growth.

3.4.3. Moist period: 5-6 months

3.4.3.1. Dharmapuri

Toppur, Chitteri hills, Sittilingi, Tambal, Nachikutti, Ammapalayam, Kottapatti, Taraisel and Boonthikkal are the major reserved forests located in upland zone of Dharmapuri district. Except Toppur forest, all the forests are classified under dense forest having moderately shallow (75-100 cm), gravelly clay soils occurring on high hills with slope of 8-15 %. Toppur forest has been classified under scrub forest which has shallow (< 50 cm) loamy soils.

3.4.3.2. Salem and Namakkal

Bailnadu, Karavallicombai, Kolli hills, Ajjampatti, Kuttur, Belur, Gangavalli and Udambium are the major dense forest pockets and Mavar, Lokkur, Jalluttu, Godumalai are scrub forests in this region. The soils of scrub forests are shallow (25-50 cm), gravelly loamy soils occurring on steep hills slope (30-50%) except Lokkur R.F having very deep soils. The soils of dense forest are moderately deep (75-100 cm), gravelly clay soils occurring on high hills with a slope of 8-15% except Bailnadu, Karavallicombai, Kolli hills which have shallow soils.

3.4.3.3. Vellore and Thiruvannamalai

The forests of upland zone of Vellore and Thiruvannamalai districts are dense forests. Moderately deep (75-100 cm), gravelly clay soils on 8-15% slope high hills responsible for dense forest cover.

3.4.3.4. Trichy, Villupuram and Madurai

The dense forest of Manmalai and Nagoor of Perambalur district having Moderately deep (75-100 cm), gravelly clay soils. The scrub forest namely Veeramalai and Arasadiyavettu in Trichy district has shallow (25-50) gravelly loamy soils. Veguthumalai, Karumalai, Alagar hills and Sirumalai are the major reserved forests in Madurai districts. The scrub forests (Veguthumalai, Karumalai) having shallow (25-50 cm) gravelly loam soils occurring on low hills (8-15% slope) whereas dense forests (Alagar hills and Sirumalai) are moderately deep non gravelly clayey soils.

3.4.8. Moist period 8-9 months

Nanthanchedu and Yercadu forest of Salem district are grouped under dense forest. The soils of Yercadu forest are deep (100-150 cm) non gravelly clayey soils supporting for dense forest whereas soils of Nanthanchedu reserved forest are shallow (25-50 cm) gravelly loamy occurring on steep hills (30-50% slope)

Even though the soils had depth constraint good dense forest have developed because of longer moist period (8-9 months).

3.5. Inland plains

Nanmangalamin Kanchipuram, Ayyur and Sunderesapuram in Perambalur, Pudukkotai R.F in Pudukottai, Milkondai, Pakkamalai, Muttakadu and Siruvadi reserved forests in Villupuram districts are the major reserved forests belongs to this region. The soils of dense forest in Perambalur and Kanchipuram are deep (100-150 cm), gravelly clay occurring on gently sloping lands (3-8% slope). Deep soils associated with favorable moist conditions (5-6 months) are responsible for developing dense forest in this zone. The soils of Pudukottai and Villupuram are moderately shallow (50-75 cm), gravelly loam soils.

3.6. Coastal plains

Kodiyakkarai in Nagapattinam and Pitchavaram and Killai reserved forest pockets in Cuddalore are the dominant forest in coastal plains. The soils of Kodiyakkarai forest are very deep (>150 cm), non gravelly sandy soils occurring on sand ridges with a slope of 3-8%. These forests are classified under open forest. The length of moist period is 8-9 months. Pitchavaram and Killai reserved forests are marshy lanwds comes under Mangrove forest.

3.7. Potential areas for afforestationand management strategies

Evaluation of soils and duration of moist period in the state showed that moderately deep (75 to 100 cm) to very deep soils (more than 150 cm), gravelly/non gravelly soils with moist period of 5 to 9 months are found suitable for dense forest cover. Currently in some pockets of open/scrub forests are found even underfavourable soil and climatic conditions.They are Thadagam in Coimbatore, Sittilingi, Ammapalayam and Bothakkadu in Dharmapuri, Nanmangalam in Kanchipuram, Saptur and Elumalai in Madurai, Kodiyakarai in Nagapattinam, Kothagiri in Nilgiris, Ayyur and Sunderesapuram in Perambalur, Lokkur in Salem, Andipatti and Koduvilarpatti in Theni, Krishnapuram in Tirunelveli, Moolakaddu in Thiruvannamalai, Ambur, Mahimandalam and Ammur in Vellore and Pakkamalai reserved forest in Villupuram district (Table 2).

▷ Selection of suitable tree species adapted to drier conditions with shallow root system will help in developing good forest cover in the regions where the unfavourable soil and climatic conditions exists (shallow soil depth and minimum length of moist period).

▷ Inclusion of mixed multi-purpose tree species, management of biophysical degradation (forest fire/overgrazing) through afforestation improve present scrub forest in places where favourable soil and climatic conditions exists.

▷ Appropriate technical backstopping with location specific soil and water conservation practices like continuous contour trenches, water adsorption trenches, other water harvesting structures to arrest the soil erosion and conserve the soil moisture.

▷ Natural resource conservation could be achieved in these areas by development and restoration of degraded forest areas with appropriate resource conservation and green caping/land cover strategies along with fodder/forage production measures for livestock.

Table 2: Potential reserved forests for Afforestation

District	Reserved forest	Length of moist period	Soil depth	Land form
Coimbatore	Thadagam	240-270	>150	Hills
Dharma-puri	Sittilingi	150-180	75-100	HH
	Ammapa-layam	150-180	75-100	HH
	Bothakkadu	150-180	75-100	NL
Kanchi-puram	Nanman-galam	150-180	100-150	GSL
Madurai	Saptu	>270	100-150	LH
	Elumalai	>270	100-150	LH
Nagapat-tinam	Kodiyakarai	150-180	>150	SR
Nilgiris	Kothagiri	240-270	100-150	HH
Perambalur	Ayyur	150-180	>150	GSL
	Sundere-sapuram	150-180	>150	GSL
Salem	Lokkur	150-180	>150	LH
Theni	Andipatti	>270	100-150	GSS
	Koduvilar-patti	>270	75-100	Hills
Thiru-nelveli	Krish-napuram	>270	>150	HHE
Thiruvan-namalai	Moolakaddu	150-180	75-100	HH
Vellore	Ambur	150-180	75-100	HH
	Mahimanda-lam	150-180	75-100	UL
	Ammur	150-180	75-100	UL

HH: High hills; NL: Nearly level; GSL: Gently sloping lands; LH: Low hills; SR: Sand ridges; GSS: Gently sloping slopes; HHE: High hills and escarpments; UL: Undulating lands
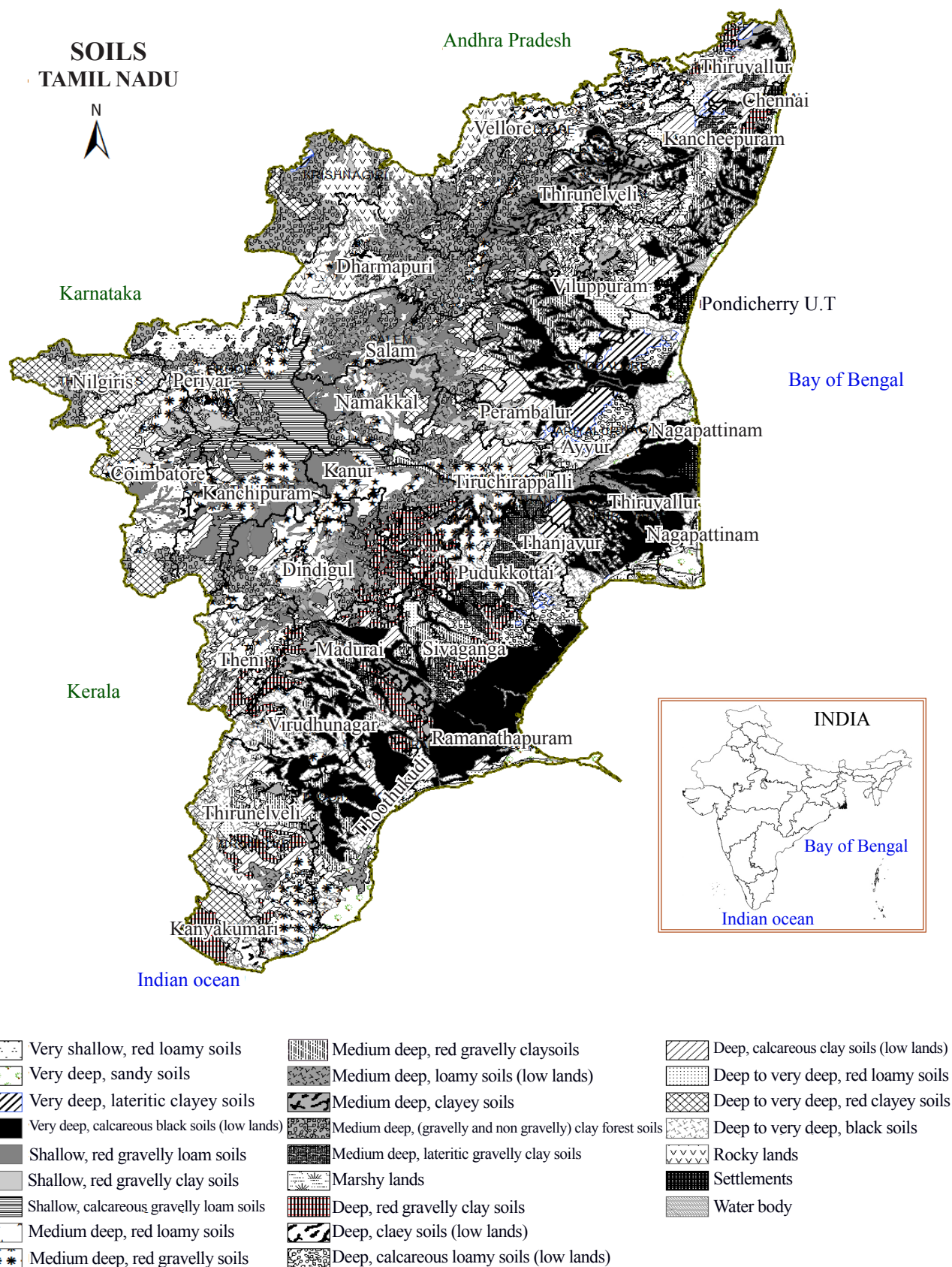
SOILS
TAMIL NADU

Very shallow, red loamy soils
Very deep, sandy soils
Very deep, lateritic clayey soils
Very deep, calcareous black soils (low lands)
Shallow, red gravelly loam soils
Shallow, red gravelly clay soils
Shallow, calcareous gravelly loam soils
Medium deep, red loamy soils
Medium deep, red gravelly soils

Medium deep, red gravelly claysoils
Medium deep, loamy soils (low lands)
Medium deep, clayey soils
Medium deep, (gravelly and non gravelly) clay forest soils
Medium deep, lateritic gravelly clay soils
Marshy lands
Deep, red gravelly clay soils
Deep, claey soils (low lands)
Deep, calcareous loamy soils (low lands)

Deep, calcareous clay soils (low lands)
Deep to very deep, red loamy soils
Deep to very deep, red clayey soils
Deep to very deep, black soils
Rocky lands
Settlements
Water body

Figure 1: Soil map of Tamil Nadu

Forest Types and Length of Moist Period Tamilnadu

Figure 2: Forest types and Length of growing period of Tamil Nadu

4. Conclusion

Dense forests are found in place where the soils are moderately deep (75-100 cm) to very deep (>150 cm) associated with favourable 5-9 months moist period. Shallow depth, presence of higher proportion of gravels in sub soil and prolonged dry period are major constraints in open and scrub forests. The potential forest areas were identified based on soils and site characteristics and suitable soil and water conservation measures were suggested to develop sustainable forest cover.

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