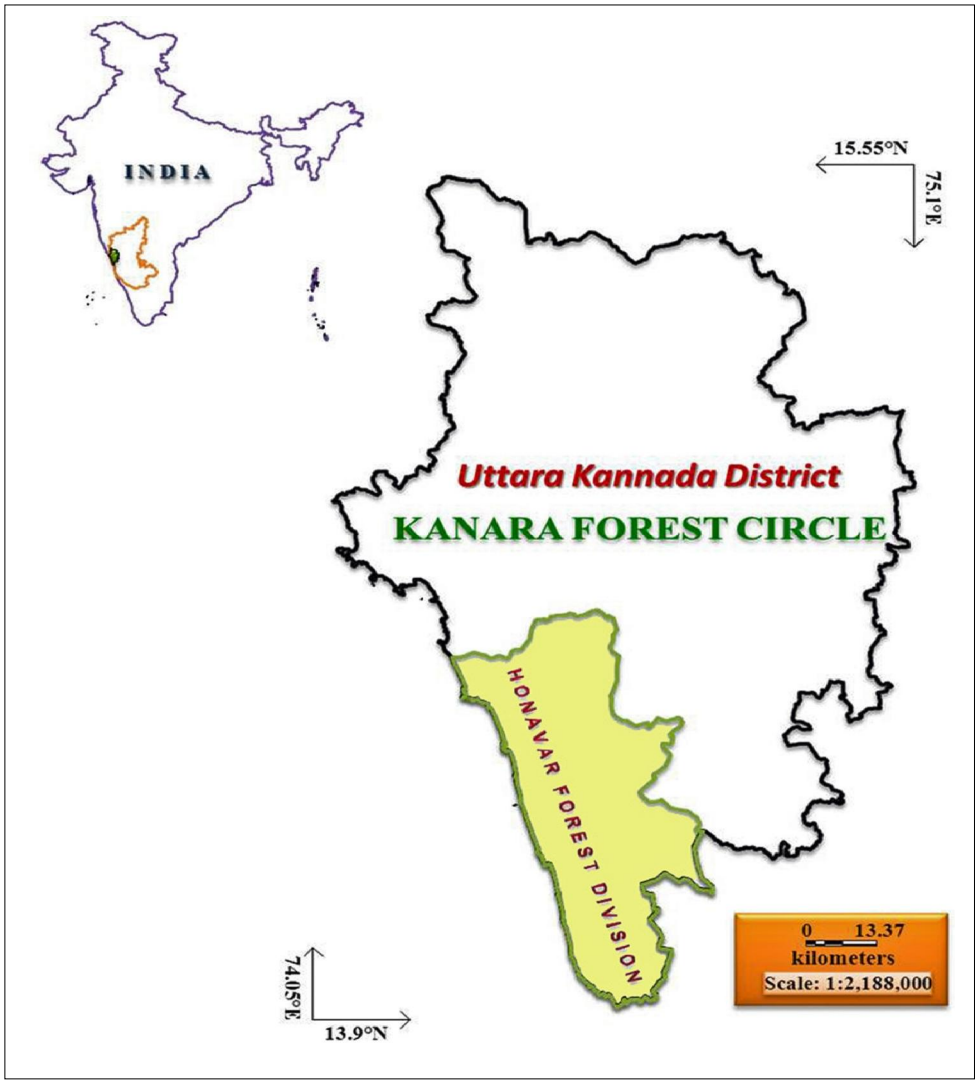
MANGROVES IN HONAVAR FOREST DIVISION, UTTARA KANNADA

The Uttara Kannada District Sea Board lies between 74° 9' to 75°10' east longitude and 13° 55' to 15° 31' north latitude and extends over an area of 10,327 Sq. km. The district has three main and distinctive regions: the Coastlands, the Sahyadri range and Eastern margin where the tableland begins. The coastlines are the best-developed area with a high degree of economic development and a high density of population. It is in this region, Karwar, Ankola, Kumta, Honavar and Bhatkal taluks are located. The five important rivers of Uttara Kannada are Kalinadi, Gangavali, Aghanashini Sharavathi and Venktapur. The mangrove zone towards the river mouth, having higher salinity, is known as 'euhaline'. Along the coast of Uttara Kannada, the river mouths are rocky and with strong wave action, and not suitable for mangroves. This is unlike the deltaic river mouths of the east coast, where mangroves can grow luxuriantly. The euhaline zone has salinity range from 30 ppt to 40 ppt. The zone behind is called 'polyhaline' where the wave action is less and salinity ranges from 18 ppt to 30 ppt. The substratum is sandy clay. This region is ideal for mangroves like *Sonneratia alba, Rhizophora* spp., *Avicennia* spp., *Bruguiera* spp., *Acanthus ilicifolius* etc. The third zone, still behind is 'mesohaline' where salinity ranges from 5 ppt to 18 ppt. It has silty clay bottom and feeble wave action. The mangroves of this zone are *Kandelia candel*, *A. ilicifolius, Rhi*zophora spp., *Aegiceras corniculatum, S. alba* etc. (Rao and Suresh, 2001).

The Honavar forest division in Uttara Kannada is one of the five forest divisions of Kanara forest circle and comprises of the forest areas of Kumta, Honavar and Bhatkal taluks and part of Ankola taluk along the coastal Uttara Kannada. It is bounded by forest divisions of Kundapur to the south,, Sirsi and Sagar toward east, Karwar to the north and the Arabian Sea on the western side. There are four notable west flowing rivers with their respective estuaries that merge with the Arabian Sea, viz. Gangavali, Aghanashini, Sharavathi and Venkatapur. The division receives heavy rains from the South-west Monsoon averaging nearly 4000 mm per year. The mean maximum & minimum temperature of the region lies in 27.33 (±5.86)ºC and % of relative humidity is 87.5(±7.5). The division has three sub divisions at Kumta, Honavar and Bhatkal six forest ranges namely Hiregutti, Katgal, Kumta, Honavar, Manki, Gersoppa and Bhatkal. It covers 134082 ha. Figure 1 depicts the Honavar forest division in Uttara Kannada.

Figure 1: Location of Honavar Forest Division



MATERIALS AND METHOD

Estuarine area with mangrove areas and potential areas available for planting in four river estuaries and several minor creeks in the Honavar Forest Division were digitized using open source GIS software (QGIS). Google Earth & Bing Earth Tile images were used for depicting the estuaries, mangrove areas and potential areas for planting. Mangrove areas were identified and mapped in the field using GPS readings and their areas estimated in ha. The mangrove areas and potential areas for planting are depicted on the administrative maps of the forest division to the smallest unit, the beat, for the convenience of the beat guard. The estuaries were gridded and

sample surveys were made in selected grids for mangrove species composition and tree density. Estuarine water post monsoon salinity was measured and depicted on maps as high (>15 ppt), medium (5-15 ppt) and low (<5 ppt). Mangrove species composition in any specific grid was correlated to salinity status of the grid. In general mangrove species of the study region were brought under three categories namely high, medium and low salinity mangroves. The GPS readings of mangrove tree species which covers minimum 5X5 meter canopy area were recorded and species-wise area under tree mangrove distribution was estimated with the help of the RS data 2010 IRS p6 L4 MX 5M having resolution of 5 m, using remote sensing software (GRASS). Using images of estuaries during low tides and with the help of bathymetric maps areas suitable for mangrove planting was also estimated.

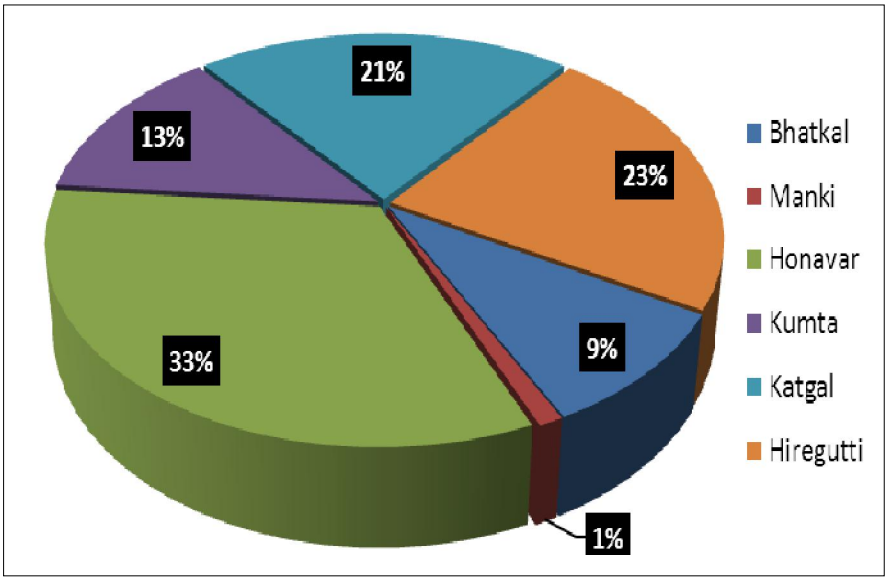
RANGE-WISE MANGROVE COVER IN HONAVAR FOREST DIVISION

The range-wise mangrove cover was estimated for all the six ranges of Honavar forest division (Table 1, Figure 1). A total of 1549 mangrove forest patches were recorded in the entire forest division which cover an area of 391 ha (0.28%) of the total forest area in the district. Despite their small coverage area, mangroves are highly integral to coastal ecology and productivity, fisheries and bird conservation as well as carbon sequestration and needs to be protected and enhanced with great care. The range wise mangrove cover analysis shows that the Honavar range leads in the area covered by mangroves (127.8 ha) followed by Hiregutti, Katgal, Kumta, Bhatkal and Manki ranges.

Table 1: Range wise estimates of area under mangrove plantations and the suitable area for mangrove plantation in various ranges of Honavar Forest Division

Sn.	Range	Mangrove area (ha)	Suitable area for planting (ha)	No. of mangrove patches	No. of potential areas for planting
1	Bhatkal	36.4	22.8	231	40
2	Manki	4.0	0.5	22	3
3	Honavar	127.8	161.1	449	136
4	Kumta	50.4	90.7	468	82
5	Katgal	84.1	35.7	133	19
6	Hiregutti	88.2	708.4	246	50
	Total Div	**390.74**	**1019.10**	**1549.00**	**330.00**

Figure 2: Relative share of mangrove areas in the forest ranges of Honavar Division



ESTUARY-WISE MANGROVE COVER

The mangrove vegetation in Honavar forest division is found associated with the estuaries and creeks. Before the agricultural interventions by the humans these were areas pristine intact patches of mangroves. However, after introduction of agriculture, good portions of shallow estuarine areas were reclaimed by preparing earthen embankments for raising of salt tolerant rice varieties like 'Kagga'. Devoid of mangroves, such estuarine areas (also known as 'gaznis') are cultivated with Kagga rice varieties, especially during the rainy season when the fields get flooded and salinity levels decline substantially. The farmers also plant rows of mangrove trees just outside these bunds to fortify them from collapse. This traditional system of estuarine cultivation with mangrove planting was a sustainable system. Maintenance of some patches of mangrove forests as sacred, as in the Masurkurve Island in the Aghanashini estuary, dedicated the deity Babrudevaru, is a notable example of traditional conservation. However, this traditional system suffered a severe setback with the replacement of earthen embankments for gazni fields with permanent stone bunds, beginning in 1960's. As these bunds are stronger the farmers felt no need to fortify them further with planting of mangroves alongside. A realization on the importance of mangrove vegetation dawned during the late 1980's, and the Government, some institutes like the Indian Institute of Science and NGO's like Snehakunja, Kasarkod, entered the arena for spreading awareness on mangroves and attempting planting in sample plots, especially in Aghanashini estuary. But it was through systematic programmes of mangrove planting by the Forest Department, beginning in late 1990's, that estuaries started turning greener with mangroves. The formation of village forest committees in estuarine villages promoted peoples' involvement and better protection was afforded to the mangroves.

The field surveys using GPS and the analysis of remote sensing images was carried out to record the mangrove areas in different estuaries and creeks of this forest division. The total current mangrove area and the potential are for mangrove plantations in each estuary and creek was found out (Table 2). It was clearly observed in the study that the Aghanashini river estuary had highest area under mangrove plantation (169.40 ha) followed by Sharavathi-Badgani estuarine complex (136.20 ha), Gangavali estuary (45.93 ha) and Venkatpur estuary (20.54 ha). The existing mangrove covered areas and the potential areas for mangrove plantations for three estuaries and one creek are represented in Figures 3 to 6.

Table 2: Estuary-wise area under mangroves and potential area suitable for mangrove afforestation in the estuaries and creeks of Honavar Division

Sn	Estuary name	Mangrove area(ha)	Potential area (ha)	Total water spread Area (ha)
1	Gangavali estuary,	45.93	95.29	817.10
2	Aghanashini estuary	169.40	711.00	5236.00
3	Kumta creek	14.23	42.42	238.10
4	Dhareshwar creek	1.43	2.57	4.02
5	Sharavathi-Badgani estuarine complex	136.20	184.40	3415.00
6	Apsarkonda creek	0.14	0.00	1.30
7	Manki creek	0.62	0.47	21.63
8	Mavalli creek	3.06	0.00	17.80
9	Murudeshwar creek	0.37	0.00	35.37
10	Venkatapur estuary	20.54	22.77	219.20
11	Jali creek	0.02	0.00	5.40
12	Bhatkal creek	1.69	0.00	53.22
13	Huvilmadi creek (Hadeen Creek)	0.10	0.00	13.71
14	Belke creek	0.12	0.00	5.97

Figure 3: Mangrove areas and potential areas for afforestation in Aghanashini estuary

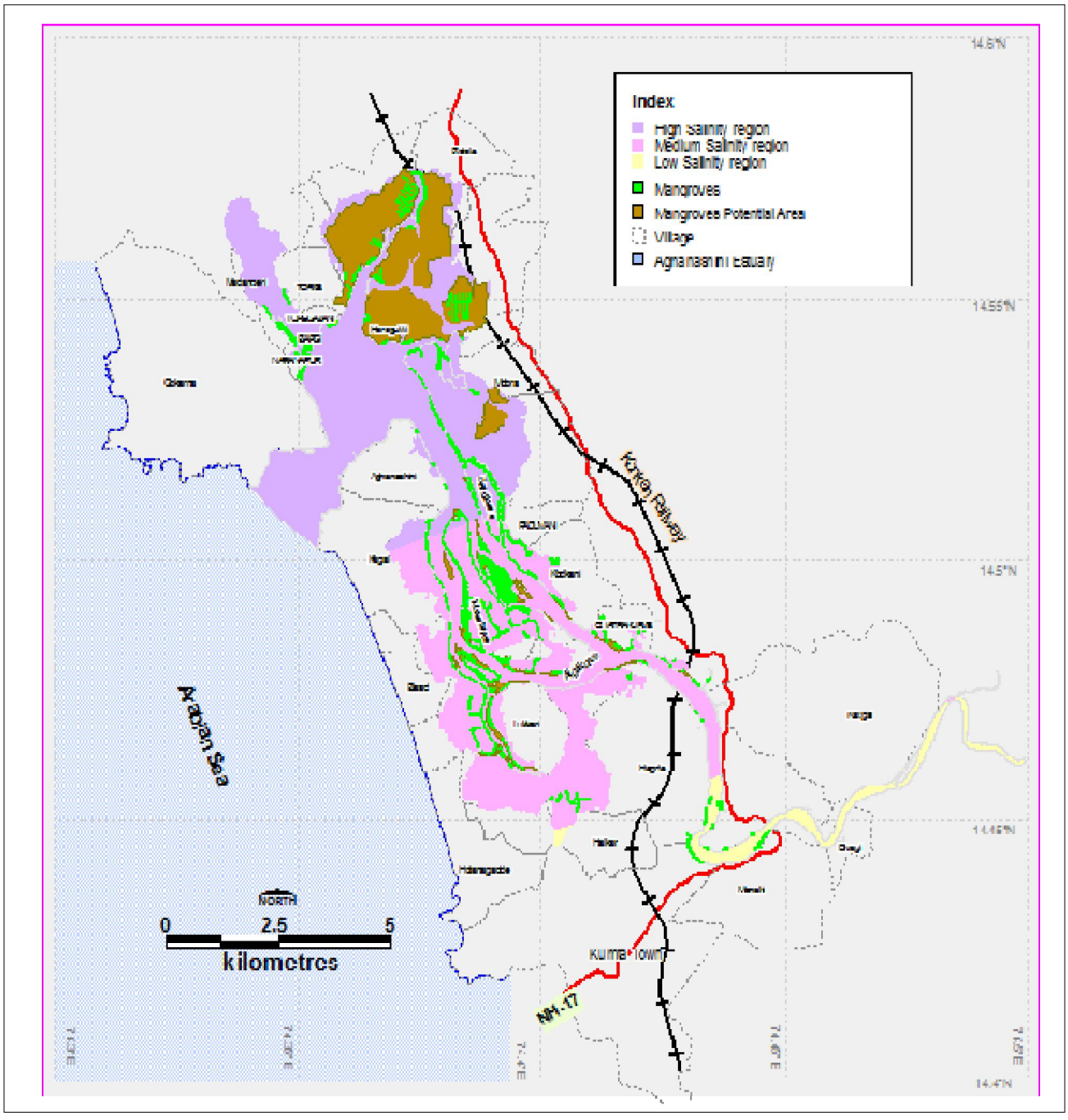


Figure 4: Mangrove areas and potential areas for afforestation in Gangavali estuary

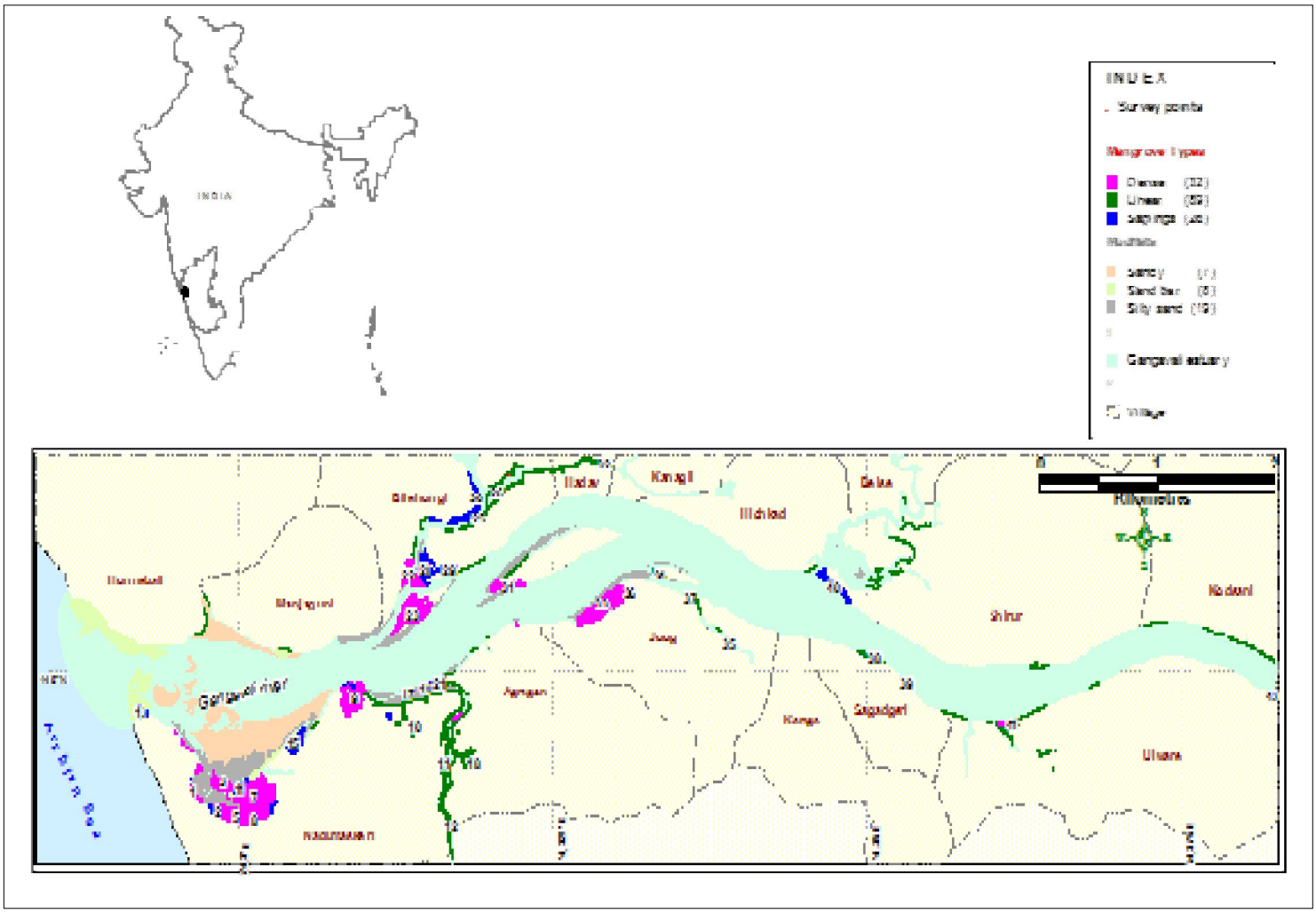


Figure 5: Mangrove areas and potential areas for afforestation in Sharavathi estuary

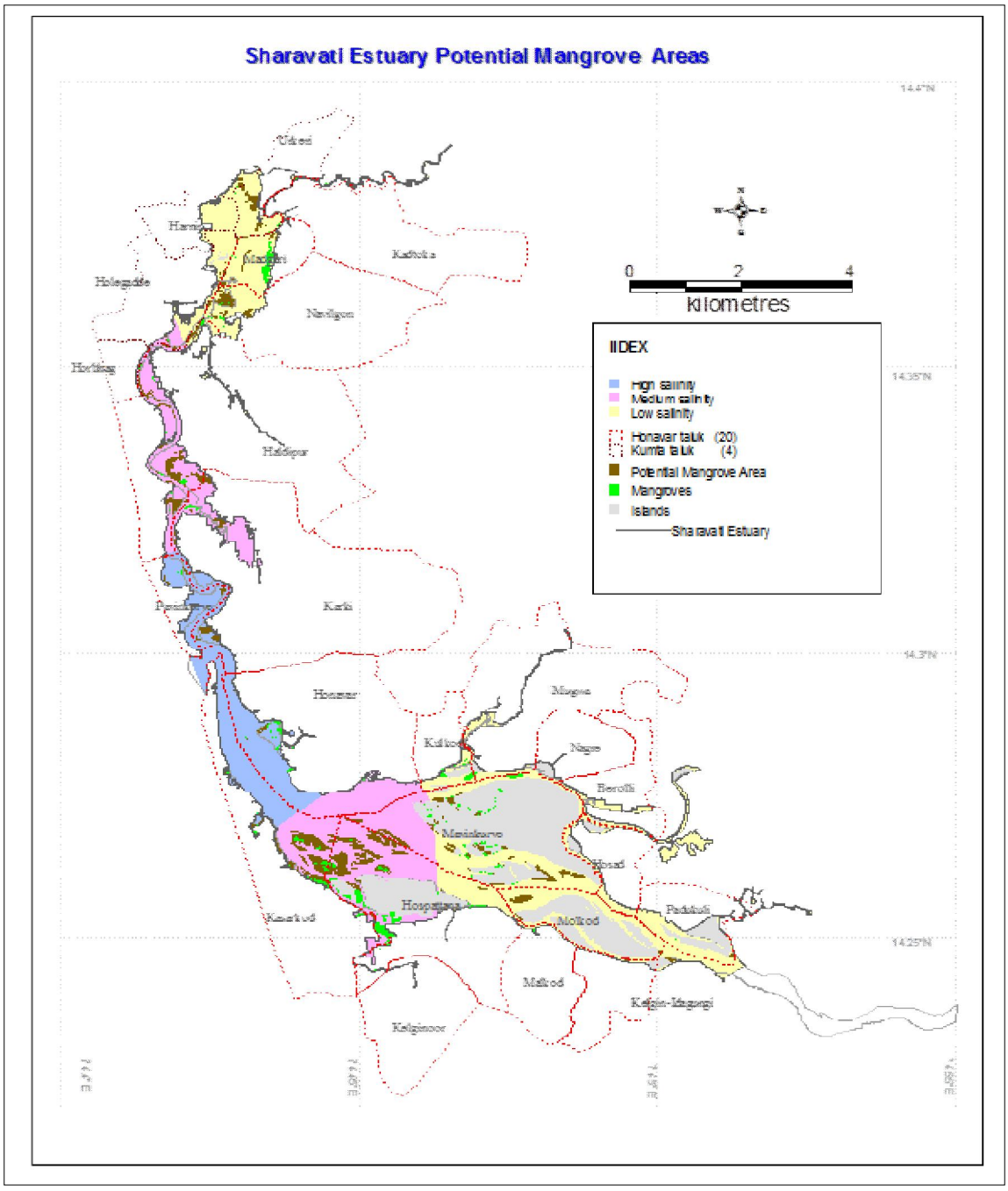
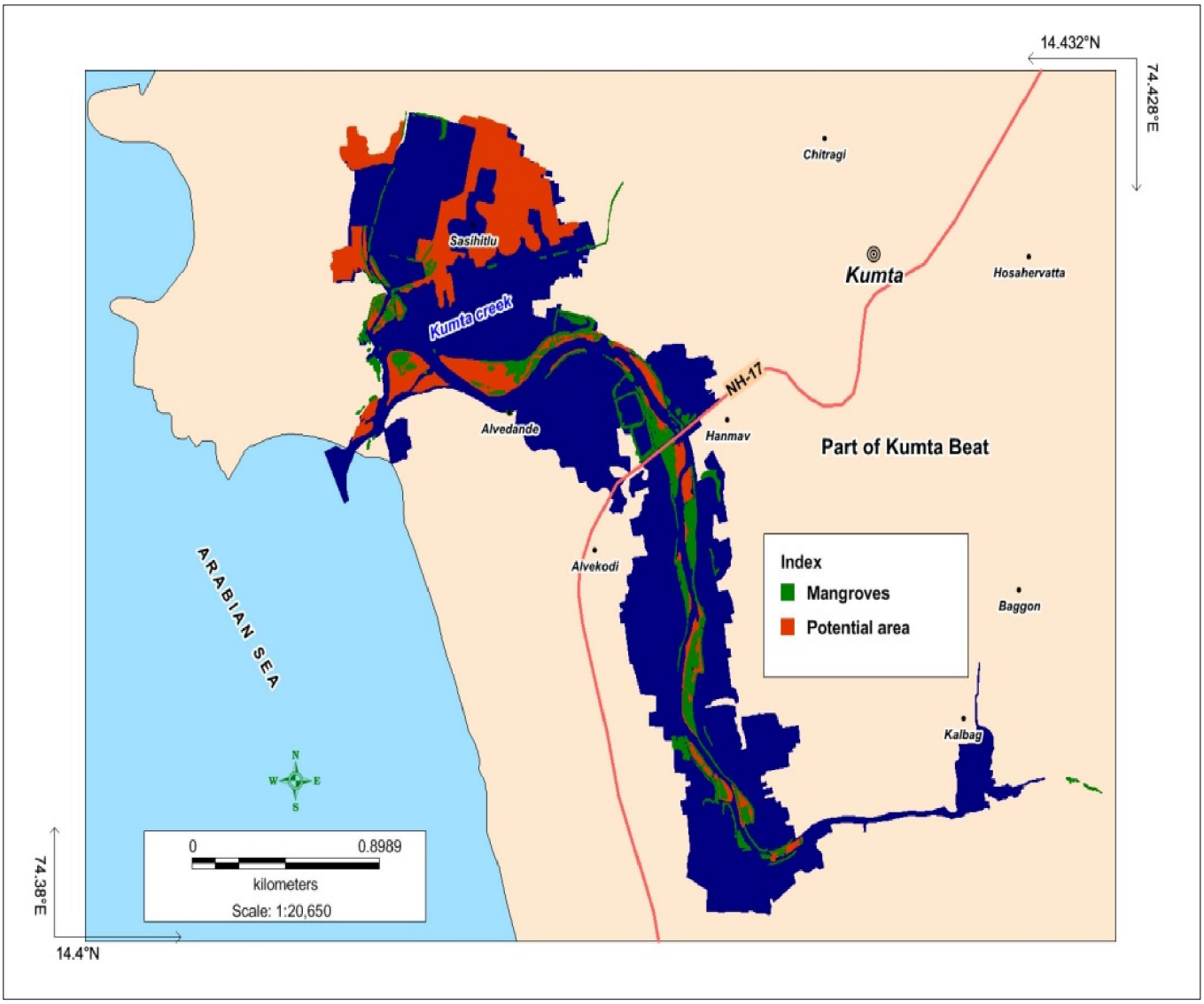


Figure 6: Mangrove areas and potential areas for afforestation in Kumta creek



IDENTIFICATION AND DISTRIBUTION OF MANGROVES

Most mangroves are woody plants, shrubs and trees. There are also few herbs, mainly some grasses and sedges. Among the woody plants one is a lower plant- a fern namely *Acrostichum aureum* (Plate 2.1); this fern grows in colonies in swampy and marshy places where the tidal force is low and salinity is not that high. The important mangrove families and their members found in Honavar Forest Division are described here.

I. TRUE MANGROVES

Family: Rhizophoraceae

This is the most important family of mangroves. The members are woody plants, usually trees. The family has spectacular development of aerial stilt roots. These roots spring from the main stem and also the branches; they branch repeatedly and grow downwards and give additional support to the tree in the soft mud. The aerial roots, studded with tiny air passing windows known as lenticels, visible to the naked eye, also help in aeration.

The trees have opposite, simple, dark green leathery leaves. The terminal bud is protected by a long cover made up of stipules. These stipules fall off when new leaves emerge. The members of the family produce from the fruits long, green, cylindrical propagules. These on maturity detach from the fruit and fall vertically into the mud, where they strike roots and become daughter plants. If the propagules happen to fall when the substratum is flooded during high tides they may be carried away by water currents; Onreaching suitable swampy places they develop into new plants. This interesting phenomenon of reproduction is called ‘vivipary’. Here apparently the mother plant is giving birth to daughter plants.

Members of Rhizophoraceae can be identified using the following key:

Calyx 8-16 lobed; petals 2 lobed : 1. ***Bruguiera***

Calyx 4-6 lobed; petals not lobed:

Calyx 4 lobed; petals without apical outgrowths : 2. ***Rhizophora***

Calyx 5-lobed; petals with apical outgrowths;
Stamens more than 12 : 3. ***Kandelia***

1. **Bruguiera**

We have only one species in the Honnavar Forest Division, namely ***B. gymnorrhiza***. It is a tree with rough corky bark; stem base may be flattened into buttresses. Leaves elliptic to oblong elliptic with a narrow tip; but not ending in a narrow long point as in *Rhizophora.* Leaf size 7-14 cm by 4 to 6 cm. Leaf stalks and midrib red coloured. Flowers in singles, reddish coloured; calyx 10-16 lobed, red to pinkish; petals bilobed, outer margin with silky hairs. The fruit produces a propagule of 10-15 cm. The propagule is slightly angled [Figure 9(d)].

Note: A small single tree was found at Hegle in Venktapur river of Bhatkal. In Andamans it grows to 36 m, and is buttressed.

2. ***Rhizophora***

R. mucronata*:* Trees reaching maximum height of 10 m in the Division. Numerous branched stilt roots arise from the base of the stem. Some arise from the branches also. Leaves 10-18 cm X 4-10 cm, broad and elliptic; the leaf tip is produced into a narrow outgrowth called mucro; leaf base blunt to obtuse. Flowers are produced in long clusters, each cluster having 4-8 flowers. Petals are hairy and stamens 8. The propagule, a long green, smooth cylindrical structure, reaches a maximum length of 65 cm [Figure 8(a)].

Note: Both *Rhizophora mucronata* and *R. apiculata* are found in the Division. The former is the commoner and widely used for afforestation.

***R. apiculata**:* A smaller tree, reaching 4-5 m in the Division. Stilt roots arising from main stem as well as from branches form impenetrable barrier beneath the canopy. Leaves elliptic lanceolate with a smaller narrow bristle like point towards the narrow tip. Size 10-20 cm X 5-8 cm. Leaf base conical; leaf middle vein reddish. Flowers in pairs in upper leaf axils, without stalks; petals not hairy; stamens 12. Propagules 30-50 cm long [Figure 9(b)].

Note: Found mainly in Aghanshini. Small single tree, seen in Kalsanmotte of Sharavathi appears to be planted.

3. Kandelia candel

Small trees reaching 5-6 m high. Leaves narrower than *Rhizophora*, oblong shaped. Flowers white, in dichotomously branched inflorescence axis. Calyx 5 lobed, reflexed; petals 5, divided into numerous fine branches. Stamens numerous. Propagule cylindrical, green, narrowed towards the tip, 30-40 cm long. The trees have flesh coloured base flattened into buttresses; stilt roots closely adpressed to the stem base. Bark reddish brown, peeling off into flakes.
Note: Found commonly in all the rivers [Figure 9(a)].

Family: Sonneratiaceae

Buttresses absent; pneumatophores (breathing roots) corky and soft, rising vertically into the air from the mud. Leaves opposite, simple; flowers large with numerous free stamens.

Sonneratia alba: Small trees reaching maximum of 5 m. Many corky pneumatophores stick out of the mud from all around the tree. Leaves opposite, elliptic, oblong, blunt at apex, narrowed at base; Flowers 2-3 together; calyx has a cup shaped part and 6-8 lobes which are distinct in fruit. Petals white, small; stamens numerous, free, white; ovary depressed globose. Fruit somewhat spherical, many seeded with calyx remaining in the fruit. Natural regeneration is plentiful especially in shallow places with low tidal effects [Figure 8(b)].

Note: Found in all rivers; rare in Sharavathi.

Sonneratia caseolaris: Trees up to 12 m height; Soft corky pneumatophores longer than *S. alba*, reaching up to 1 m. Young stem 4-angled. Leaves almost without stalk, much narrowed at base, opposite. Leaf tip has a pore known as hydathode through which excess salt is secreted. Flowers reddish purple, in singles at the tip of branches; stamens numerous, reddish. Fruits depressed globose [Figure 9 (c)].

Note: Most common mangrove tree in Sharavati; Rare in other rivers; not found in Gnagavali, although Rao & Suresh (2001) present it as a cpmmon species there. It prefers places with low salinity; the Sharavathi river, where fresh water from the dams is constantly released appears to be ideal for it.

Family: Avicenniaceae

Shrubs or trees without buttresses. Breathing roots (pneumatophores) numerous and protruding from the mud all around the tree. Leaves opposite, without stipules; flowers yellow. Fruit one seeded, dry when mature.

Avicennia marina: Shrubs or small trees upto 4 m high. Bark smooth yellowish brown. Leaves 3-6 X 2.2.5 cm, elliptic oblong or ovate, narrowing to an acute tip; leaf base rounded or narrowing. Flowers small, stalkless, yellowish clustered towards tips of floral axis; stamens not projecting out from the corolla. Fruit at maturity ovoid with a pointed tip, slightly flattened [Figure 8(c)].

Note: Very common in Gangavali, rare in Aghanashini, common in Alvekodi creek, absent in Sharavathi and Badgani, moderate in Venktapur.

Avicennia officinalis: Larger trees, reaches 8-10 meters in Honavar Forest Division; exceptional individuals of 12 m are found in the sacred grove of Masurkurve in Aghanashini. Smooth whitish gray bark; pneuatophores seen all around the tree. In addition masses of branching stilt roots hang from the upper part of the trunk and base of large branches. Leaves 5-7.5 cm X 2.5- 3.25

cm, ovate, oblong with more or less rounded leaf tip. Small, yellow stalkless flowers seen in clusters towards the tip of floral axis. Flowers distinguished from *A. marina* by stamens seen projecting outside the corolla [Figure 8(d)].

Note: Found in all the rivers of the Division.

Family: Myrsinaceae

Plants without pneumatophores; flowers with 4 sepals and 4 petals; and superior ovary.

Aegiceras corniculatum: Shrubs or small trees with slender stilt roots. Leaves 4-8 cm X 2-4 cm, alternate, ovate-oblong or obovate, may have a small notch at the blunt tip; leaf base cone like. Flowers small, white, fragrant in umbellate bunches. Propagules which come out of the fruits are 3-4 cm long and curved with pointed tips.

Notes: Found in all estuaries; prefers edges and banks away from strong tidal effects; notable for fragrant white flowers

Euphorbiaceae

Plants with latex. Male and female flowers in separate clusters

Excoecaria agallocha: Large shrubs or small trees occurring along the edges of the swamp, on bunds and on wet soils. Acrid, blister causing latex present. Numerous serpentine roots produced from base of stem. Leaves alternate, margins entire or mostly minutely toothed; leaves turn red before shedding [Figure 7(d)].

Acanthaceae

Family of herbs and shrubs. Flowers not regular in shape.

Acanthus ilicifolius: A shrubby plant growing in colonies in shallow parts of the swamp. Leaves opposite, stiff, wavy and with sharp spines along the margin. Flowers large, blue [Figure 7(a)].

Poaceae

The members are grasses. In the estuaries these grasses are found often forming meadows submerged during high tides and exposed during low tides. *Porterisia coarctata* is the only grass confined to the estuarine areas of Uttara Kannada.

Porteresia coarctata: A stiff erect grass growing in meadows in open shallow parts of the estuaries [Figure 7(b)].

MANGROVE ASSOCIATES

Numerous species of plants occur in association with the mangroves. These are not obligate mangroves and higher salinity is not often a prerequisite for their growth. They may also be often associated with inland habitats. These plants have certain degree of salinity tolerance. They often grow along the margins of swamps, or on estuarine bunds. Details of notable mangrove associates are found in Table 3.

The distribution of the mangrove plant species in the Honavar forest division is shown in Figures 10 to 21.

Table 3: Details of notable mangrove associate species in Honavar forest division

Sn	Name	Family	Remarks
1	*Cerbera manghas* (Kan: Cande)	Apocynaceae	Shrub or small tree with white latex and white flowers and mango sized green fruits; old fruits fibrous
2	*Barringtonia racemosa* (Kan: Samudraphala)	Barringtoniaceae	Small to medium tree with 15-30 cm long leaves, and pink flowers in long hanging inflorescences.
3	*Dolichandron spathacea*	Biganoniaceae	Tree close to coastal swamps with white fragrant flowers, and long bean like compressed cylindrical pods
4	*Capparis* spp.	Capparidaceae	Spiny climber on bunds
5	*Crateva magna*	Capparidaceae	Small trees on the bank of Aghanashini near NH bridge; leaves 3 foliate; yellowish flowers with hard fruit.
6	*Calophyllum inophyllum* (Kan: Honne)	Clusiaceae	Large evergreen tree; white fragrant flowers and greenish yellow ripe fruits with a single seed.
7	*Cyperus malaccensis*	Cyperaceae	Grass; abundant in Sharavathi backwaters.
8	*Diospyros embryopteris*	Ebenaceae	Small evergreen tree with guava sized gummy fruits.
9	*Bridelia scandens*	Euphorbiaceae	Climbing shrub with greenish yellow flowers small bluish-black fruits.
10	*Acacia farnesiana* (Kan: Kasturijali)	Fabaceae	Thorny bush or small tree; leaves with minute leaflets; flowers yellow, fragrant.; pod dull brown & inflated.

11	*Acacia nilotica*	Fabaceae	Small trees, rare on the coast; leaflets small; flowers golden yellow in globose heads.
12	*Caesalpinia bonducella* (Kan: Gajagakai)	Fabaceae	Climber with curved sharp prickles; compound leaves; yellow fragrant flowers; dark brown dry pod 1-2 seeded.
13	*Caesalpinia crista*	Fabaceae	Large woody climber climber; stem and leaves with sharp curved prickles; flowers fragrant, yellow; pod one seeded.
14	*Derris scandens* (Kan: Handiballi)	Fabaceae	Woody climber with rosy flowers
15	*Derris trifoliate*	Fabaceae	Woody climber common on the coast
16	*Erythrina variegata* (Indian coral tree; Kan: Varjipe)	Fabaceae	Soft & light wooded tree, branches covered with small black prickles; leaves with 3 foliage; coral coloured flowers.
17	*Pongamia pinnata* (Kan: Honge)	Fabaceae	Medium sized tree with compressed pods, growing often near water courses, sea beaches and rarely on estuarine banks.
18	*Prosopis juliflora*	Fabaceae	Shrub or small trees with drought resistance.
19	*Hibiscus tiliaceous*	Malvaceae	Shrub or small tree with yellow flowers changing to pink in the evening.
20	*Thespesia populnea* (Kan: Hoovarase)	Malvaceae	A medium sized coastal tree with heart shaped leaves on long stalks and yellow flowers resembling cotton flowers.
21	*Ficus racemosa* (Kan: Atti)	Moraceae	Tree with milky latex and hollow, edible, fleshy false fruits.
22	*Morinda citrifolia* (Kan: Ainshe, Tagase)	Rubiaceae	Small tree with large leaves, dense heads of white flowers and glossy green fruit, white when ripe.

23	*Pandanus fascicularis* (Kan: Ketaki)	Pandanaceae	A palm-like, but branched shrub with narrow very long spinous leaves with small flowers on dense axis covered with white or light yellow, very fragrant bracts
24	*Cynodon dactylon*	Poaceae	Karki grass forming meadows in open shallow part of estuaries
25	*Sporobolus virginicus*	Poaceae	Grass; perennial grass with good sand-binding properties.
26	*Salvadora persica* (Tooth-brush tree; Kan: Gonimara)	Salvadoraceae	Much branched shrub or small tree; rare along the bunds of Aghanashini; small round fruits dark red when ripe.
27	*Clerodendrum inerme*	Verbenaceae	Shrub with white flowers
28	*Odina wodier* (Kan: Gojal)	Verbenaceae	Medium sized deciduous tree with minute flowers in panicles and small, reddish, compressed fruits with one seed.
29	*Premna corymbosa*	Verbenaceae	Shrub
30	*Vitex negundo* (Kan: Lakkigida; Nokki)	Verbenaceae	Shrubs, young stem 4-angled; aromatic; leaves 3-5 foliate; terminal leaflet longer
32	*Vitex trifolia*	Verbenaceae	Shrubs, young stem 4-angled; leaves 3-foliate; leaflest without stalks

Figure 7: (a) *Acanthus ilicifolius*; (b) *Porteresia coarctata* – a mangrove grass; (c) *Acrostichum aureum* – a mangrove fern; (d) *Excoecaria agallocha*

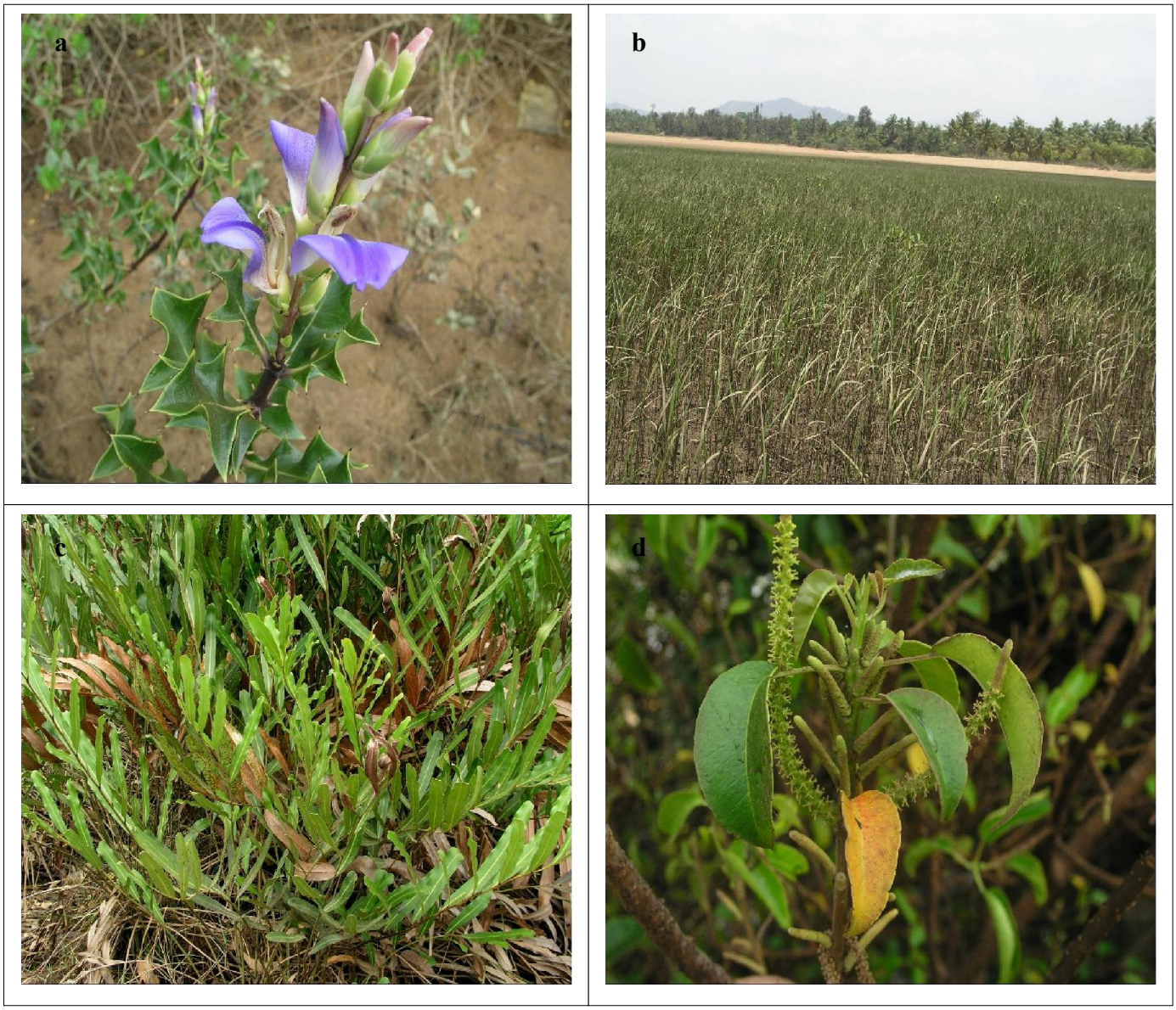


Figure 8: (a) *Rhizophora mucronata*; (b) *Sonneratia alba*; (c) *Avicennia marina*; (d) *Avicennia officinalis*

Figure 9: (a) *Kandelia candel*; (b) *Rhizophora apiculata*; (c) *Sonneratia caseolaris*; (d) *Bruguiera gymnorrhiza*

Figure 10: Distribution of *Acrostichum aureum* in Honavar Forest Division

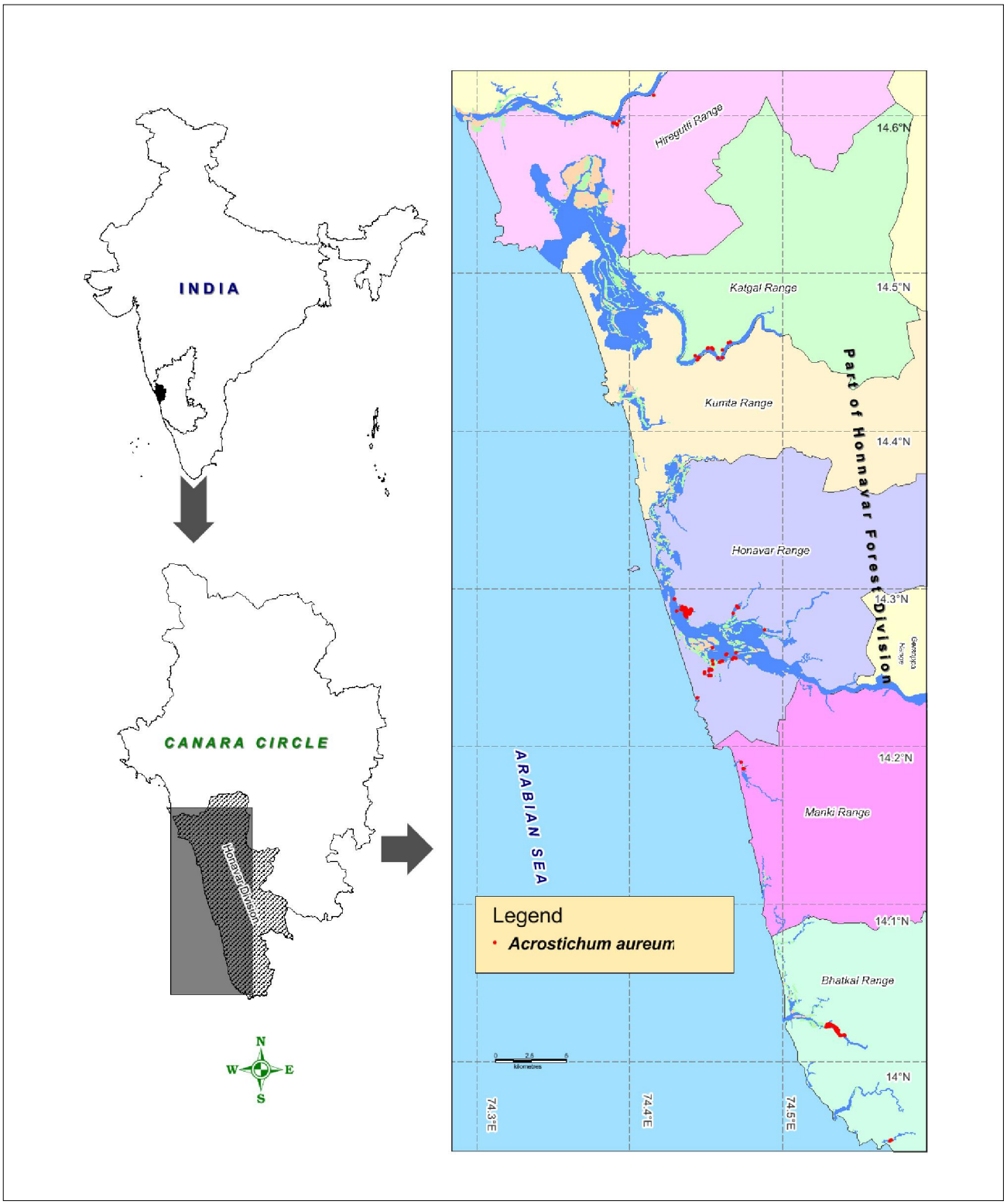


Figure 11: Distribution of *Aegiceras corniculatum* in Honavar Forest Division

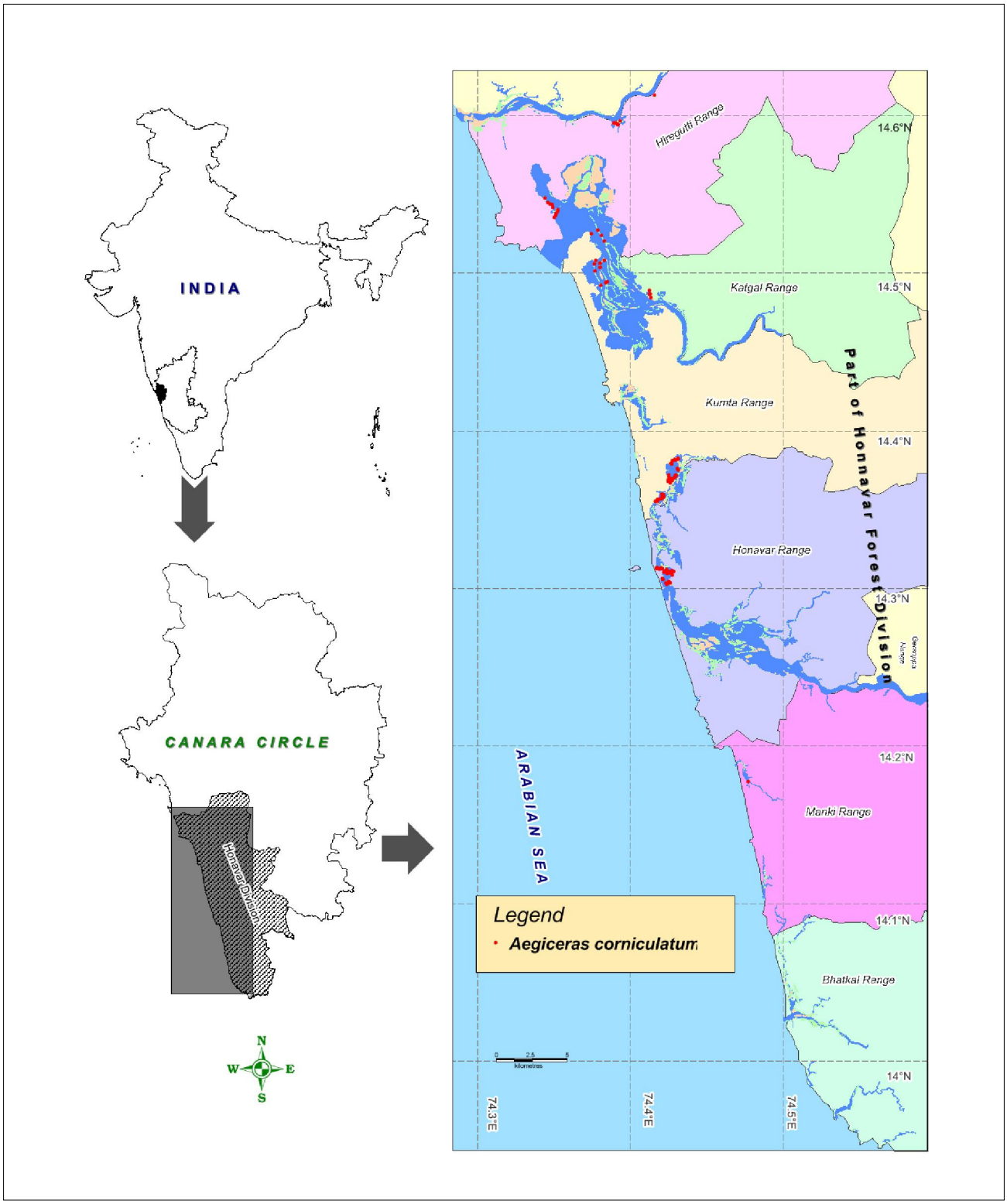


Figure 12: Distribution of *Acanthus ilicifolius* in Honavar Forest Division

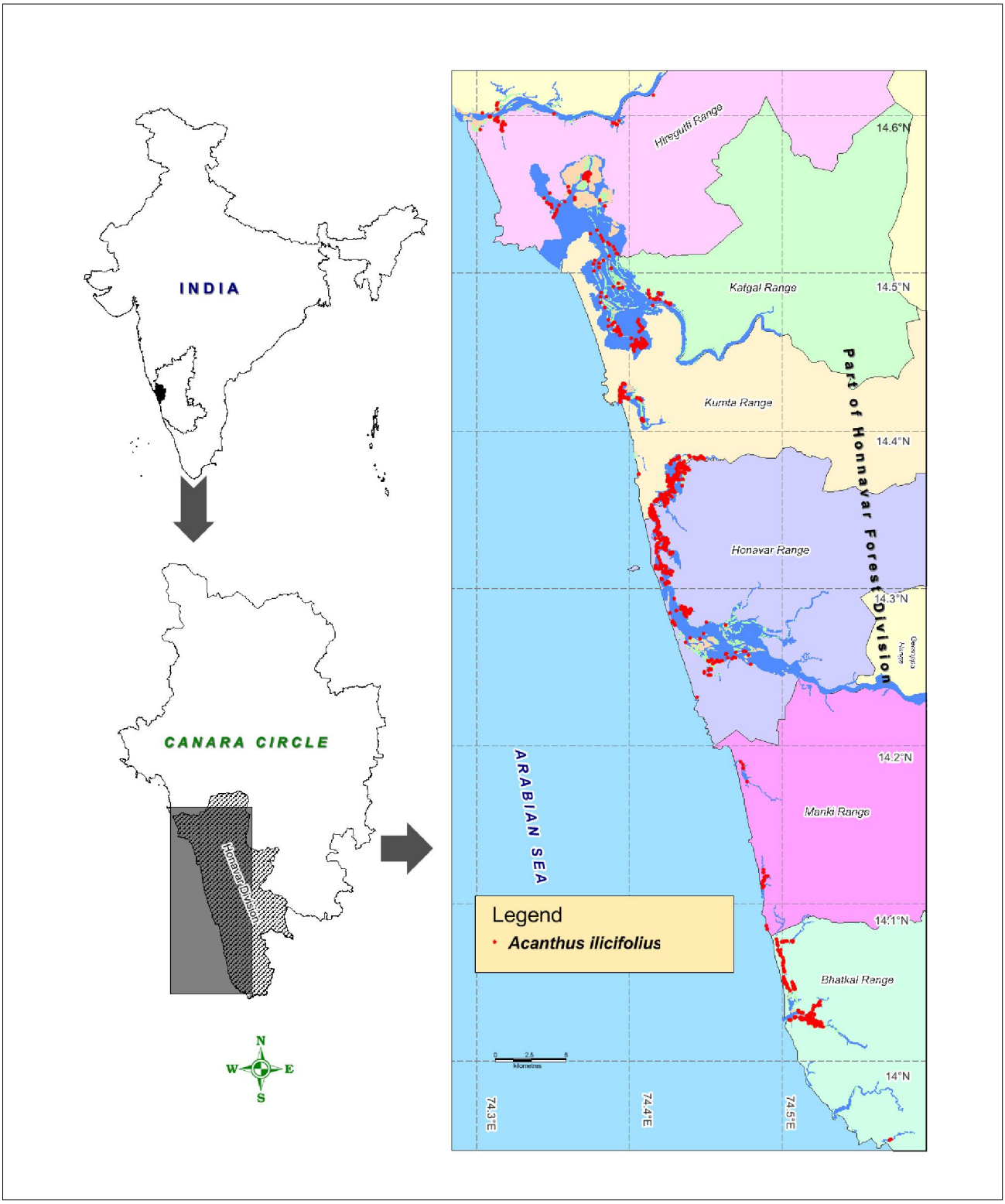


Figure 13: Distribution of *Avicennia marina* in Honavar Forest Division

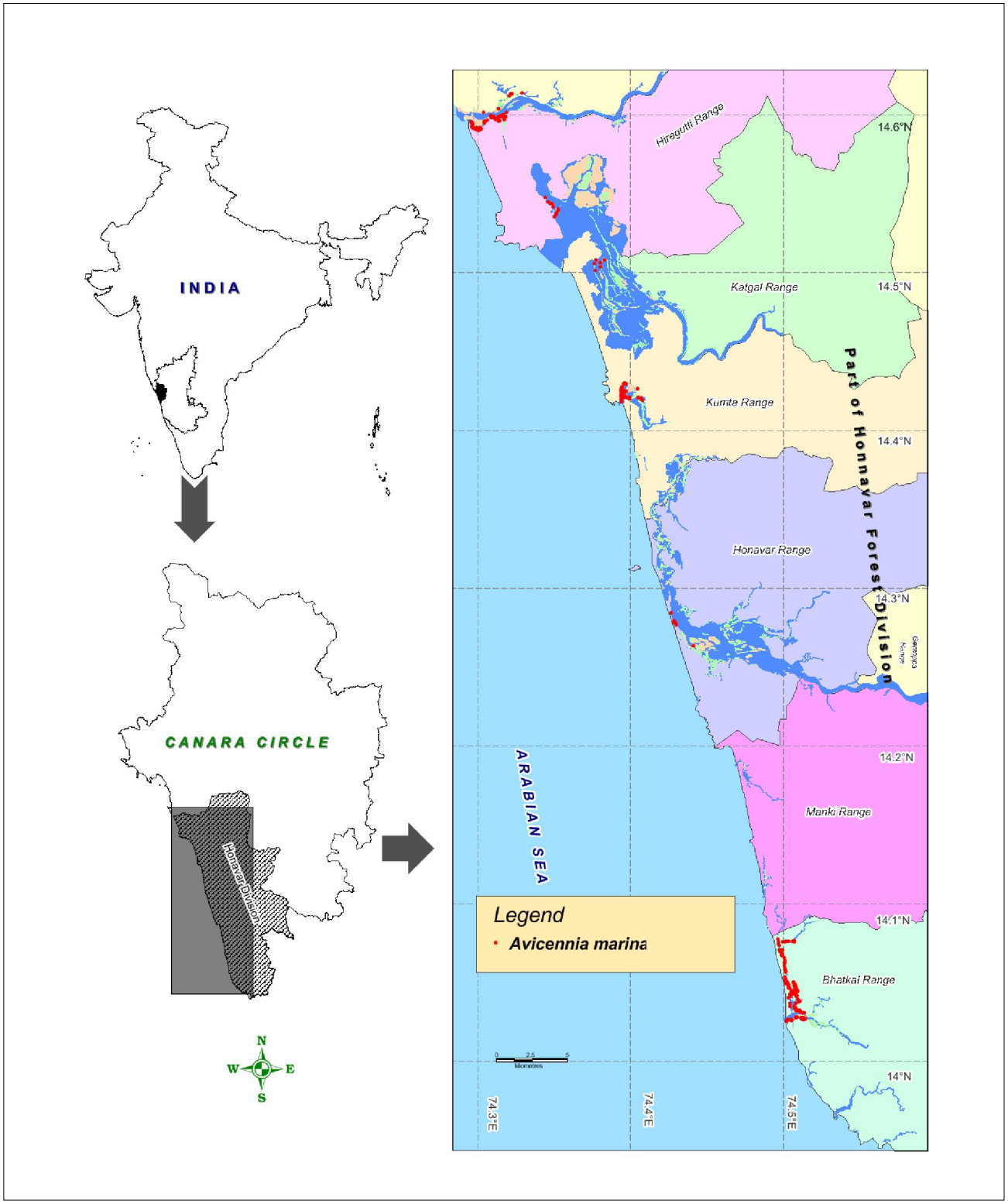


Figure 14: Distribution of *Avicennia officinalis* in Honavar Forest Division

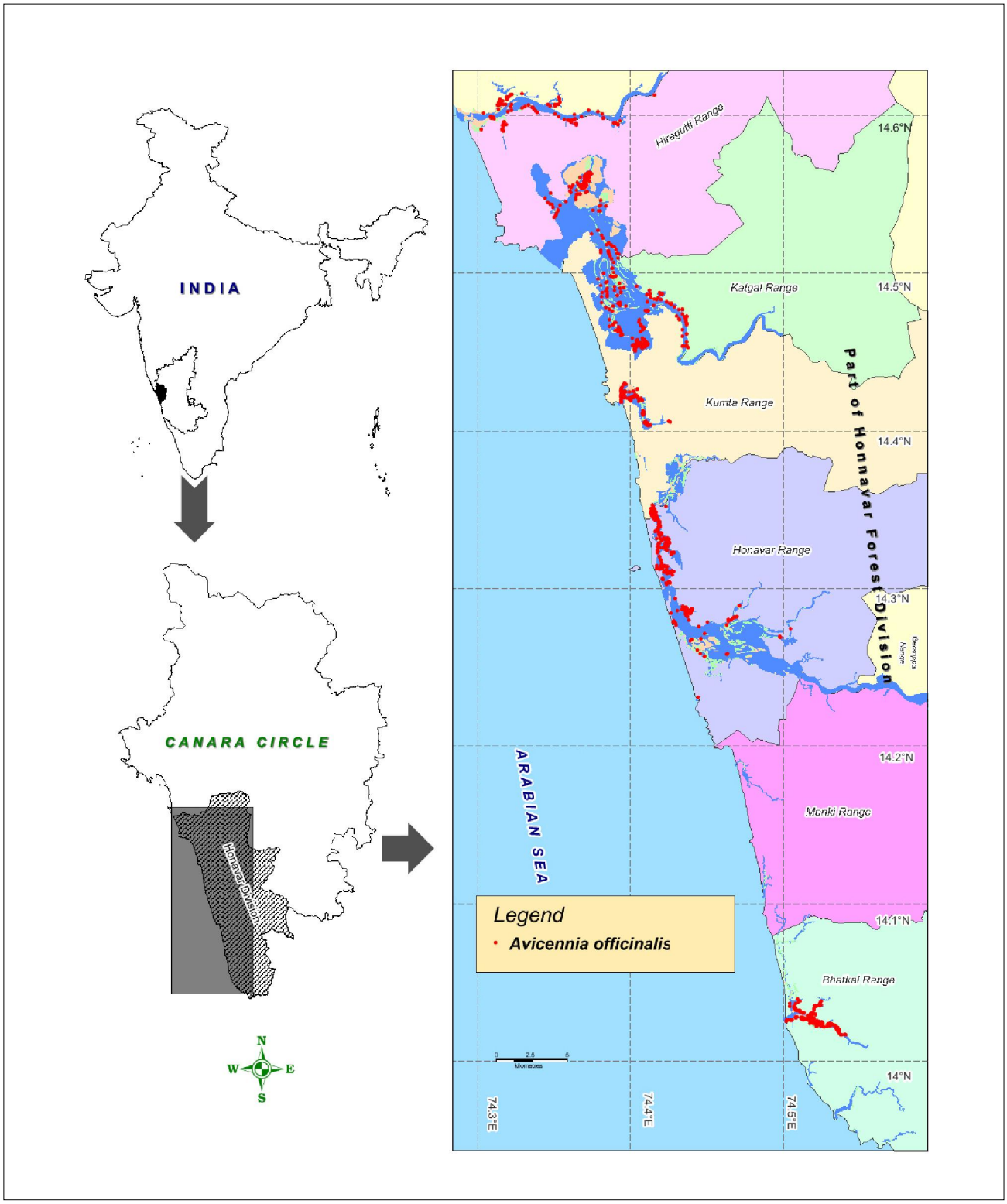


Figure 15: Distribution of *Excoecaria agallocha* in Honavar Forest Division

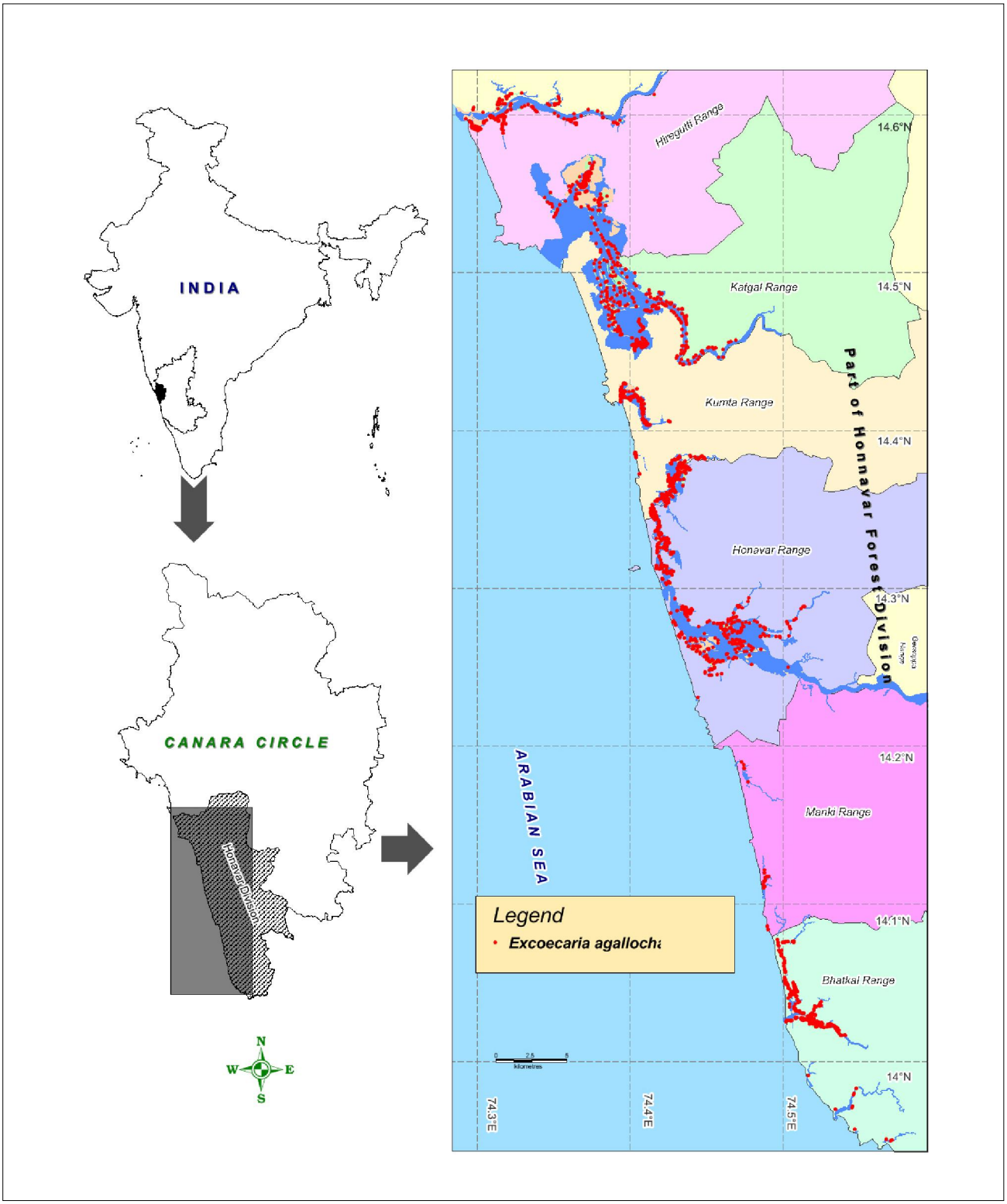


Figure 16: Distribution of *Kandelia candel* in Honavar Forest Division

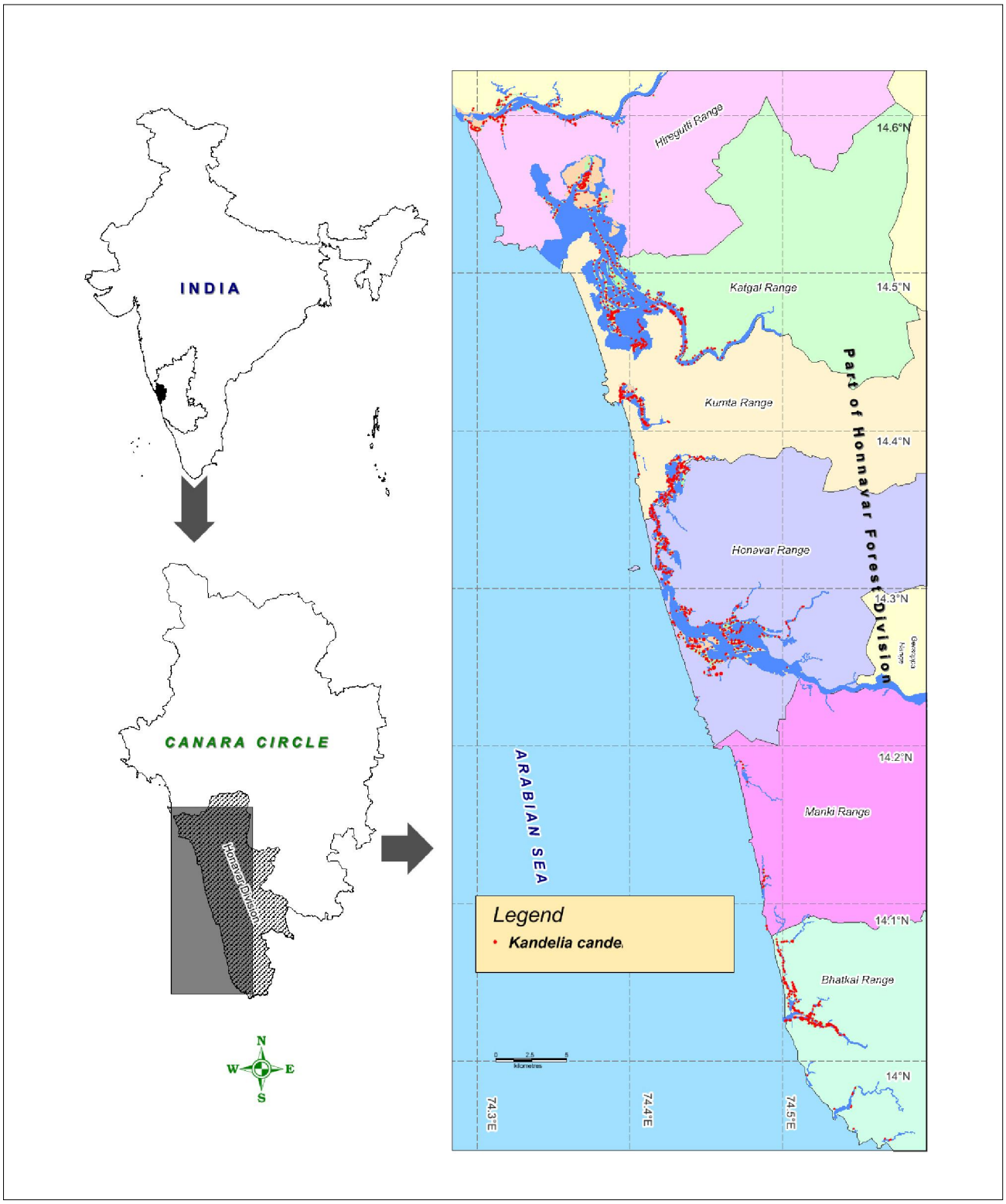


Figure 17: Distribution of *Rhizophora apiculata* in Honavar Forest Division

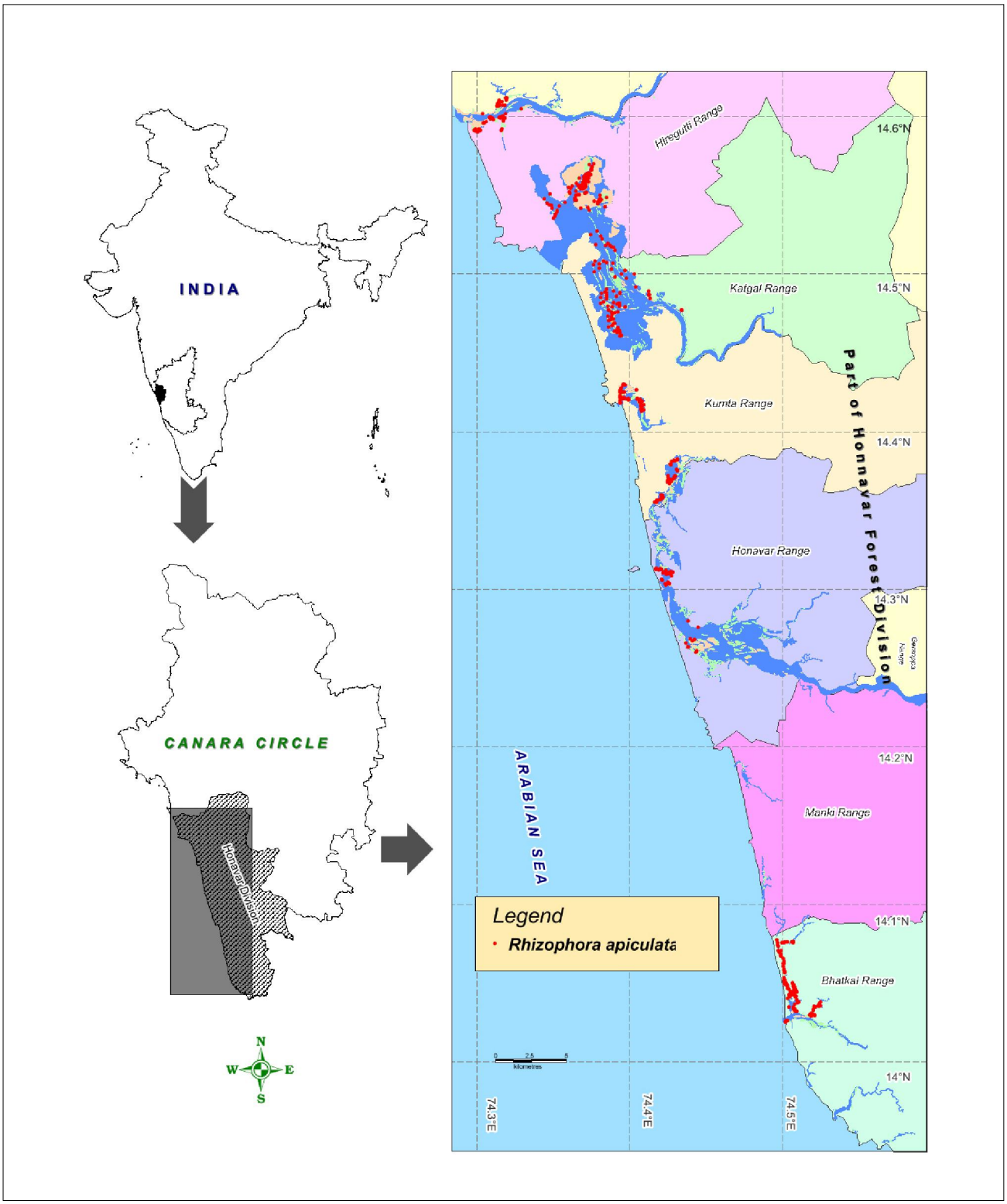


Figure 18: Distribution of *Rhizophora mucronata* in Honavar Forest Division

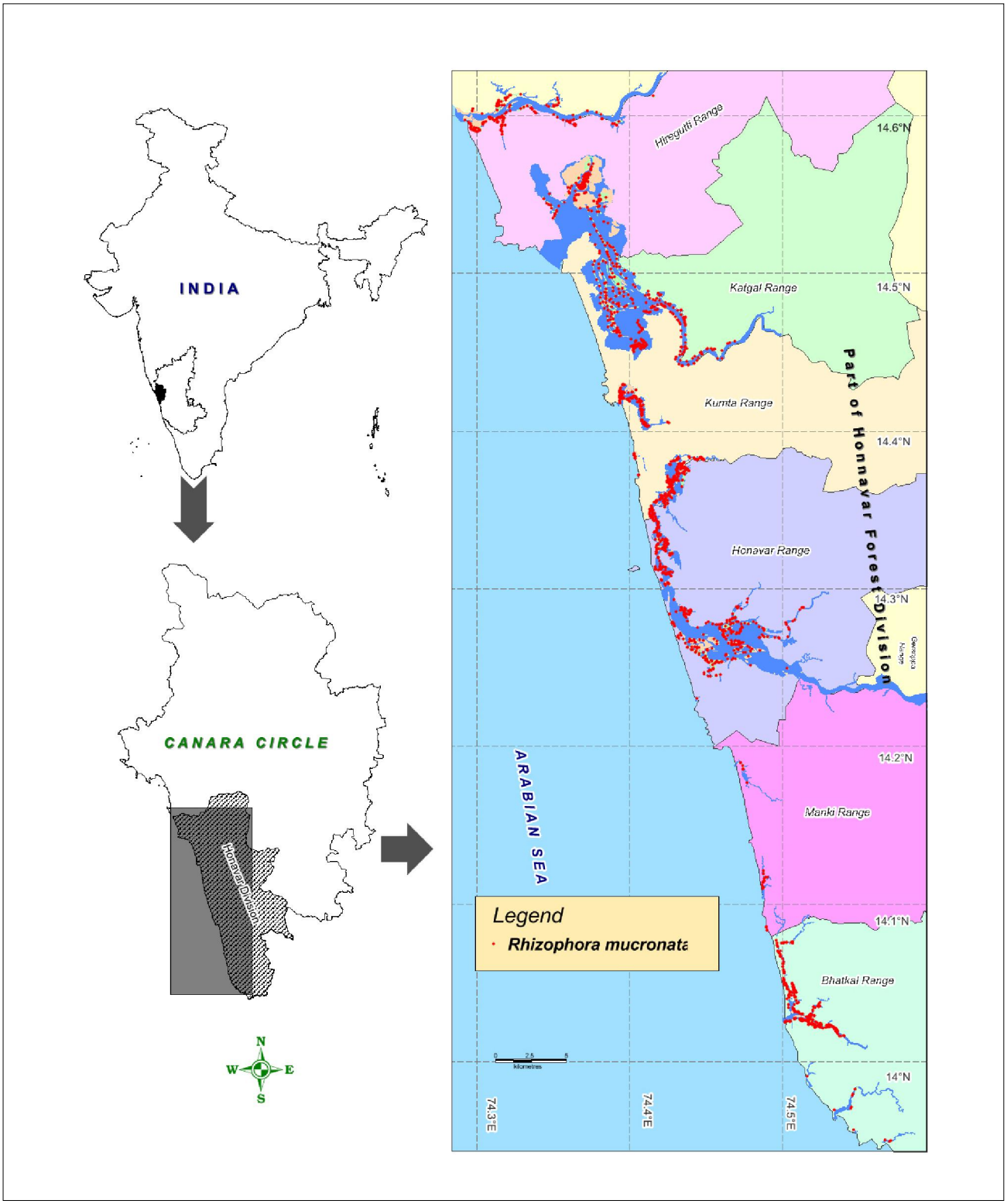


Figure 19: Distribution of *Sonneratia alba* in Honavar Forest Division

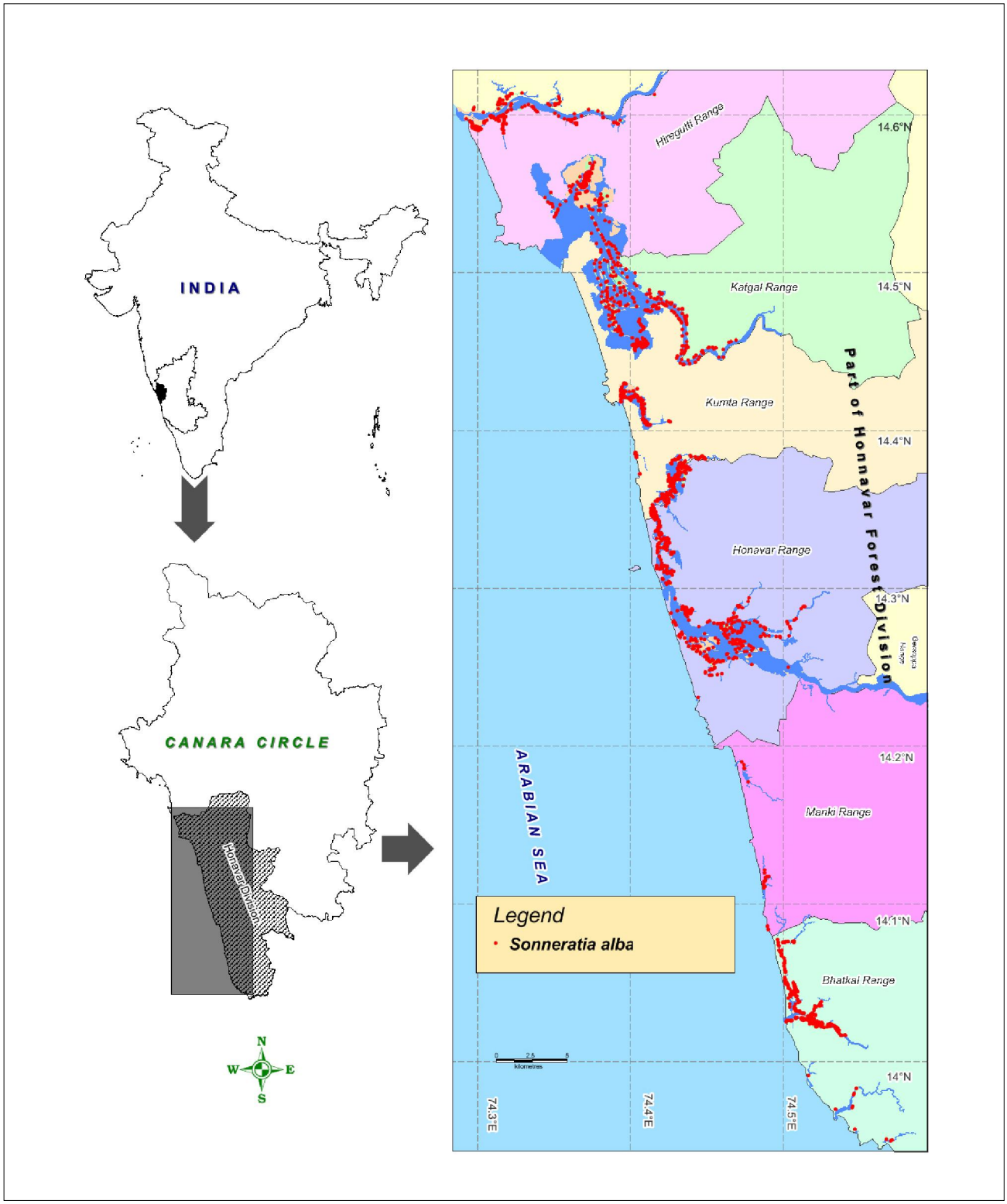


Figure 20: Distribution of *Sonneratia caseolaris* in Honavar Forest Division

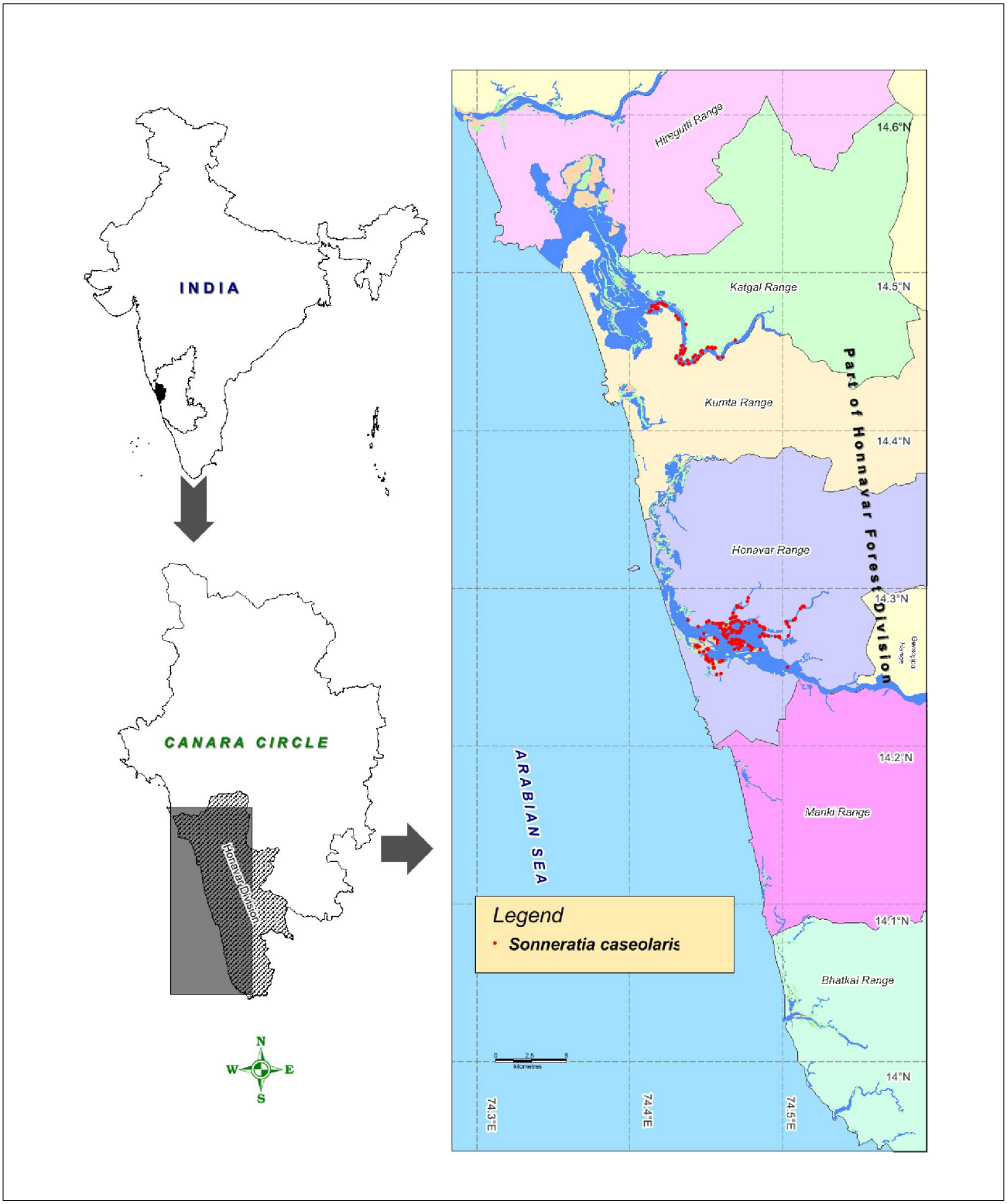


Figure 21: Distribution of *Porteresia coarctata* in Honavar Forest Division