Final report of the Conservation and sustainability fellowship

Resource assessment of high biodiversity value species with a biofuel potential in Northern Western Ghats of India.

Submitted by

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Introduction

The amount of discussion about and attention to the pressing environmental issue of climate change seem to have undermined the seriousness of biodiversity loss. The persistent efforts by the conservation organisations to garner wider support for biodiversity conservation by devising market based strategies such as Payments for Ecosystem Services (PES) in order to make it more popular and investment friendly are receiving lukewarm response. The complexities involved in conducting ecosystem services valuation and the trouble with arriving at a universally accepted formula for this purpose might be some of the reasons for this state of affairs.

Nevertheless, it is a widely accepted fact that one of the major drivers of climate change is the carbon intensive nature of energy upon which the global economies are based. Thus the replacement of carbon intensive energy options through low carbon and sustainable energy alternatives (Wind, Solar and Bioenergy) has been adopted as a most favoured strategy for mitigating the impacts of climate change. Out of these alternatives, biofuels, though debated widely for causing more damage to the native ecosystems and being carbon positive i.e. requiring more energy for production than it actually delivers , offer no of avenues for establishing synergetic relationship and sustainable links with biodiversity and ecosystem conservation. More importantly, the biofuel sector has been attracting huge investments in recent years and thus presents an opportunity for diverting investments for biodiversity friendly biofuel production. Integrating high conservation value and native species having potential to produce biofuel into the supply chain of mainstream biofuel/biodiesel production could be one of the strategies for creating a healthy balance between these cross-cutting issues.

There are over 300 different species of trees which produce oil bearing seeds (Subramanian et al), thus there is significant potential for promoting different species and increasing feedstock choices for biodiesel production. The research carried out through Alcoa Foundation's conservation and sustainability fellowship focussed exactly on assessing the potential of two underutilised and high conservation value species– *Calophyllum innophyllum* and *Caesalpinia crista* – for biofuel production.

A resource assessment of these species was carried out in two blocks- Rajapur and Vengurla of Ratnagiri and Sindhudurg district of Maharashtra, India for this purpose. A detailed account of the distribution, density and dispersal of these species as well as information about traditional methods of oil extraction, different uses of the oil and future prospects of the oil use for biofuel industry has been provided in this report. Moreover, brief information has been given about the policy relevance of resource assessment of high conservation value species in the context of biodiversity conservation and the need for according due priority to native biofuel potential species for large scale cultivation for biodiesel production while formulating biofuel policies of mega diverse countries.

Resource assessment - definitions

The terms assessment and inventory are used interchangeably most of the times . Thus it is important to make a clear distinction between the two. Kleinn (2000) describes the inventory as a process of quantitative and qualitative identification of a resource, whereas assessment consists of situating the data thus obtained and attributing values to the specific resource. Lund (1998) stresses that once an object is assessed we can begin to estimate or weigh its significance, importance and value.

As we look at these two processes, they are clearly interwoven, especially for Trees outside forests. The term `inventory' is better applied to statistical methods, techniques and calculations for the ostentation of `neutral' and `representative' numerical data, whereas assessment ties in with a more global, subtler and in the end more realistic approach, given the myriad local situations typical of this resource. **Natural resource assessment** is based as much as possible on inventory data, where available and reliable. But it also taps data from other sources --- maps, ecological data, sectoral or territorial analyses, economic, socioeconomic, ethno botanical or other data, so that a relative or contextual value can be assigned to the resource. (Ronald Bellefontaine et al , 2002)

Resource assessment – a needs analysis

Tree species are important for the well-being of people in all countries, particularly in the humid tropics and arid landscapes around the world. Many tree species are of major economic importance as the source of products such as timber, fruits, nuts, resins and

gums. Worldwide, 2 billion people depend on wood for cooking and fuel; millions of others depend on trees for food and medicines. Trees are also the structural components of forests, providing a habitat for many other species and defining the characteristics of forest ecosystems. Information is limited on the distribution and conservation status of tree species. Preliminary surveys undertaken to date suggest that approximately 8,000 tree species are threatened with extinction worldwide. The potential loss of nearly 10 per cent of all tree species is a major conservation issue, requiring international attention and widespread action. Importantly, information about tree species reinforces the information needed to conserve habitats and ecosystems. Various initiatives (SBSTTA, 1996; Lammerts van Bueren and Duivenvoorden, 1996) have suggested that tree species diversity can be used as a surrogate for overall species diversity in forest ecosystems. Moreover, information on the distribution of restricted range species can be used to determine patterns of biodiversity and define priority areas for conservation. Tree species information also provides a crucial link with information on patterns of genetic resources within forest ecosystems.(Newton A. et al 2003).

Policy context

The objective of international biodiversity and forestry policy is to prevent the loss of ecosystem functioning, component species and genetic resources whilst at the same time supporting the rights and development aspirations of people. The Global Strategy for Plant Conservation (GSPC) was agreed by the Parties to CBD in April 2002. The ambitious Strategy has 16 targets for delivery by 2010. Implementation of activities to meet key targets will be dependent on baseline information. Assessments of the conservation status and distribution of tree species will be particularly valuable to support Targets 2, 5, 6, 7, 11 and 14 as shown in Box 2 below.

<table>
<tr><td colspan="2">Box 2 The value of tree species assessments in implementation of the CBD Global Strategy for Plant Conservation (Targets to be reached by 2010)</td></tr>
<tr><td>Target No. 2
Preliminary assessment of the conservation status of all known plant species at national, regional and international levels.
Value of tree species assessments: Assessment of tree species will be a key component of this target. A proposed milestone is the reassessment of all</td><td>Target No. 7
60 per cent of the world’s threatened species conserved in situ.
Value of tree species assessments: Important for protected area planning to ensure adequate representation of threatened tree species.
Target No. 11
No species of wild plant endangered by international trade.</td></tr>
</table>

species in The World List of Threatened Trees by 2006. **Target No.5** Protection of 50 per cent of the most important areas for plant diversity assured. **Value of tree species assessments**: Presence of globally threatened species is one of the three criteria for selection of Important Plant Areas, therefore species assessment is important as an aid to site selection. **Target No. 6** At least 30 per cent of production lands managed consistent with the conservation of plant diversity. **Value of tree species assessments:** Spatial data on trees is particularly important for resource management in areas of production forest.	**Value of tree species assessments:** An estimated 1,000 globally threatened trees are threatened at least in part by unsustainable levels of felling for international trade. Information is required for the selection and management of species for international trade control mechanisms such as CITES. **Target No. 14** The importance of plant diversity and the need for its conservation incorporated into communication, education and public awareness programmes. **Value of tree species assessments:** The concept of developing illustrated profiles of tree species, supported by maps, will have high educational value.

(Newton A. et al 2003)

One of the most important goals of resource assessment is make **the resource** known to policy- and decision-makers, planners and managers, who need "objective" data before embarking on an action. (Ronald Bellefontaine et al , 2002). This is absolutely crucial for countries like **India** which is one of the **17 mega diversity** countries and has **20 agro-ecoregions and 60 agro-ecosubregions** for developing long term land use strategies.(Gajbhiye K.S. et al). An utter negligence of the Indian Government towards the biodiversity and agro-ecosystems of the country is reflected in the National Mission on Biofuels launched in 2002 for achieving a target of 20% blending of biodiesel by 2012 (GoI, 2003). One of the key aspects of this policy is that the biodiesel is to be derived from vegetable oil produced from the seeds of the perennial shrub, *Jatropha curcas* which is to be planted on about 13.4 million ha of marginal land across all states of India. (Rajagopal D. 2008). *Jatropha curcas* is an exotic species with toxic properties and unsuitable for cultivation in many agro-climatic zones. Thus it is imperative to generate comprehensive baseline information about potential feedstock species which a) are native in nature b) are suitable for cultivation on large scale in a particular agro-ecosystem c) are not land use and water intensive d) produce non-edible oil and most importantly e) contribute to other ecosystem functions besides producing oil.

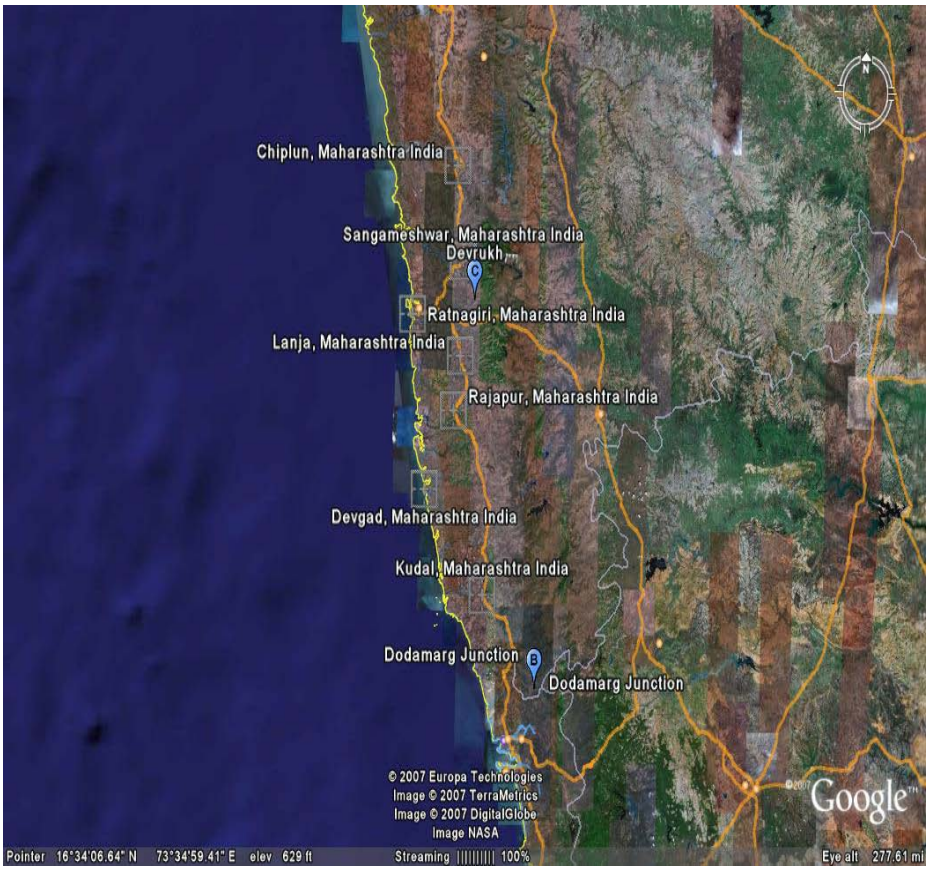
It will not only create necessary impact on future biofuels policies but also give biodiversity the necessary opportunity for proving its vital role in satisfying energy needs of human beings in a sustainable manner. This study carried out to understand potential of the selected high conservation value species in large scale biofuel production at regional level is the first step in this direction.

Study Area

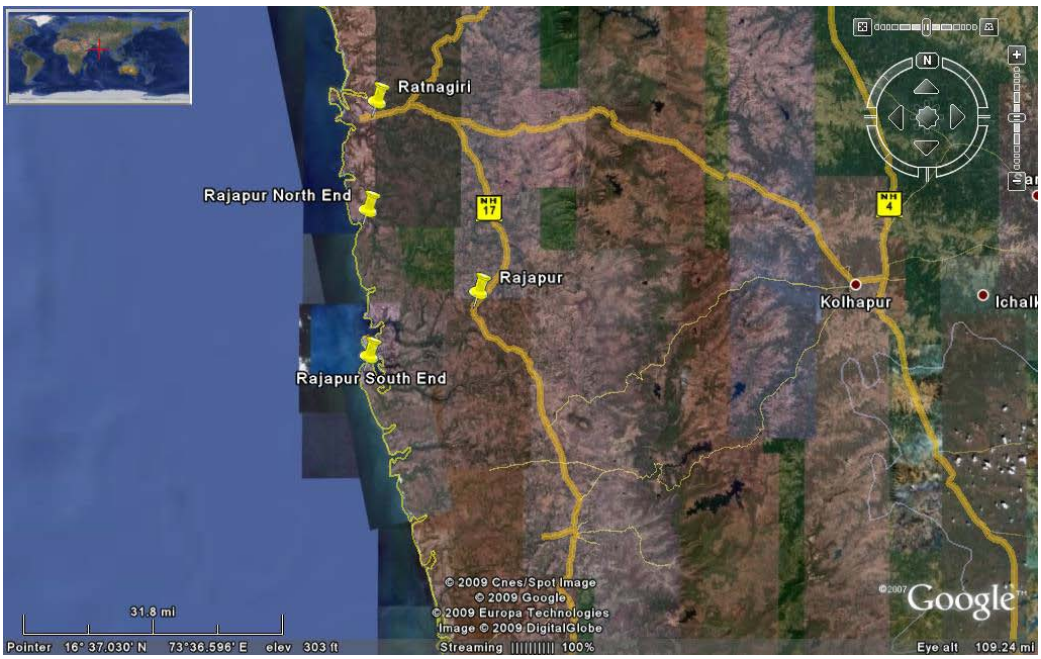
The study was carried out in Rajapur and Vengurla blocks from coastal districts – Ratnagiri and Sindhudurg respectively of Maharashtra state of India. Maharashtra is one of the coastal states situated on west coast of India and has about 720 km long indented coastline, which is marked by the presence of major estuaries and narrow creeks. The five districts situated on west coast of Maharashtra are : Thane, Raigad, Greater Bombay, Ratnagiri and Sindhudurg.

Rajapur administrative block is situated in south of Ratnagiri district (Map 1 and 2). The south boundary of the district is adjoining with Sindhudurg district while the northern boundary is attached with Ratnagiri block of Ratnagiri district. Rajapur block has the coastline of 30 km from Nanar – Sagave in South end to Purnagad in north. Three rivers flow through the Rajapur block. River Wagothan and Muchkundi mark the geographical boundary of the block on either direction South and North respectively. Wagothan river is about 42 km long while Muchkundi river is 20 km long. River Arjuna is flowing through the central region of the block and 29 km in length. Wagothan River enters in to sea at Nanar, Arjuna River at Jaitapur while Muchkundi River enters the Sea at Purnagad (Map 3 and 4). Thus, these three rivers form three major estuaries in the Rajapur block. Nanar and Jaitapur estuaries are close to each other and thus form a network of estuaries in this area. Total nine estuaries (3 large and 6 small) were assessed for estimating the population of *Calophyllum innophyllum and Caesalpinia crista* in this block. In all 95 sampling points were recorded in 72 villages (Appendix 1)

Map1 : Location Map of Maharashtra



Google earth image of Ratnagiri and Sindhudurg districts of Maharashtra



Map 2 : Location Map of Rajapur in Ratnagiri District and sampling area.

Profile of species –

Calophyllum innophyllum Linn.

Botanical name- *Calophyllum innophyllum*

Family- Clusiaceae (Mangosteen family)

Conservation status- IUCN Redlist (LRLC) – **needs to be updated**.

Common names - Alexander Laurel (English), Undi (Marathi – Maharashtra),

Distribution Widely dispersed throughout the tropical Asia (India, Sri Lanka, Thailand, Indonesia, Malaysia, Philippines), including the Hawaiian and other Pacific islands.

Size -Typically 8–20 m (25–65 ft) tall at maturity.

Habitat : Strand or low-elevation riverine, 0–200 m (660 ft) in Hawai'i, up to 800 m (2000 ft) at the equator; mean annual temperatures 18–33°C (64–91°F); annual rainfall 1000–5000 mm (40–200 in).
Vegetation Occurs on beach and in coastal forests on west and east coast of India.
Soils Grows best in sandy, well drained soils.
Growth rate May initially grow up to 1 m (3.3 ft) in height
per year on good sites, although usually much more slowly.
Main agro-forestry uses Mixed-species woodlot, windbreak, home garden.
Main products Timber, seed oil.

Yields No timber yield data available; 100 kg (220 lb) nuts/tree/yr yielding 5 kg (11 lb) oil.
Intercropping Casts a heavy shade, so not suitable as an over story tree; has been grown successfully in mixed-species timber stands.

Ecosystem functions : Shoreline protection, important mangrove associate, preferred food plant of bats , good source of honey.

Invasive potential : Low potential to become invasive.

Caesalpinia crista L.

Botanical name: ***Caesalpinia crista*** **L.**
Common name: Teri pods, Fever nut
Hindi name: Kanchak
Sanskrit name: Putrakaranj
Marathi name: Sagargotta, Gajra

Distribution (in Maharashtra): It is distributed in river bank near coastal part of Maharashtra i.e. Raigarh, Sindhudurg and Ratnagiri; in Raigarh infrequently distributed in Dasgaon and Mahad; and also distributed in Deogad, Kudal, Kochra, Malvan, Kalaval of Sindhudurg district.

Description: *Caesalpinia crista* L. is an extensive armed climber. Stem spiny, rough bark. Leaves pinnate, 15- 18cm. leaflets 2.5-4.5 x 1.5-2.5 cm. long, glabrous above, glaucous beneath. Flowers (1.5-2cm long) yellow in terminal, long peduncle axillary racemes, 25-35cm. long, pods ovoid to oblong, 3x5 cm.

Flowering & Fruiting time: October to February

Use: Seed, flowers and leaves are used in medicinal purposes like diarrhoea, fever. Piles leaf decoction to bathe infants.

Approach

During this study an effort was made to explore the coastal areas in Rajapur block of Ratnagiri district for assessing the population density of the *Calophyllum inophyllum* trees as well as fruit estimation. Besides recording of total count of *Calophyllum* in study area related but crucial information was also gathered about extent of its distribution from seashore, its seed dispersal mechanism, present status of oil extraction, the no of extraction units present in the area , issues related to oil extraction, existing problems for collection of the fruits, competitive uses of the timber and oil. As regards, *Caesalpinia crista*, it is widely distributed on banks of estuaries and in vicinity of mangroves in the

study area . Its population density and fruit estimation was difficult due to its habit- a climbing shrub and its expanse in form of thickets. Nevertheless notes were taken about its presence and absence as well as peculiarity of its habitat throughout the sampled area.

Materials and Methods

Line Transect Method

- Line transect method was used for sampling the *Calophyllum innophyllum* present in the selected villages along the coast of Ratnagiri and Sindhudurg district.
- One km transect is consider along the seashore with the interval of 2-3 km.
- Number of each *Calophyllum* tree present in and around the village was physically counted.
- GPS waypoint recorded at every sampling spot or village.
- In case of riverbank assessment, sampling was carried out from upstream of the river and continued up to mouth of the river.
- GBH (in m) and Height of each tree (in m) was measured and noted down
- Counting of primary branches number, average secondary branches, average tertiary branches and average quaternary branches was done for estimation of the fruit number.
- Fruits present only on quaternary branch were counted.
- Status of the each tree recorded with respect to lopping or coppicing or in normal state.

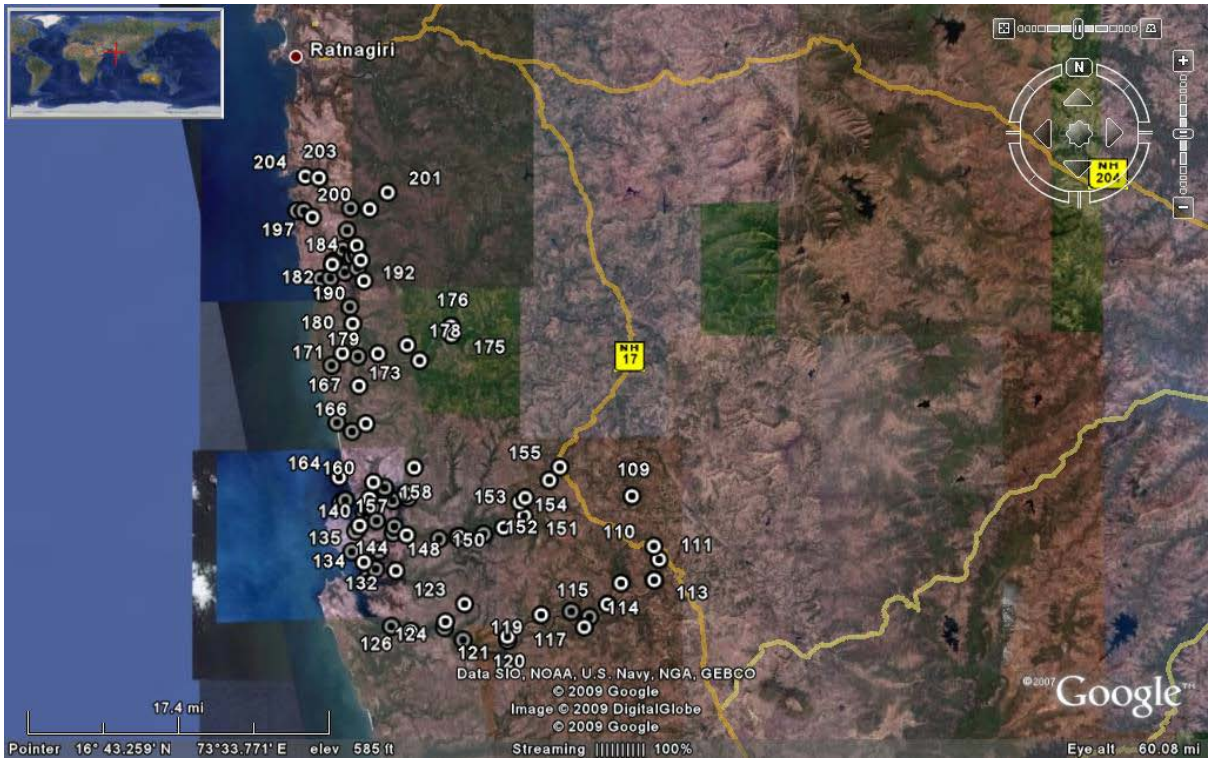
GPS waypoint recording

- Garmin - Ultra Handled GPS was used to record the waypoints.
- Garmin - MapSource software and Google Earth software used to upload the GPS data on map.
- Map images stored in .jpg format of each estuary and river.
- Images used for distribution pattern analysis.

Data compilation and analysis

- Habitat of *C. inophyllum*, associate members, mangrove distribution, presence of *Caesalpinia crista* and other relative ecological observations noted down at each sampling point.

- Collected the information about the presence of *C. inophyllum* upto last decade, in that area.
- Associate members of *Calophyllum* recorded at each sampling point.
- Recorded the status of *C. crista* and mangroves present at each sampling point.
- Data recorded in MS – Excel and prepared the database.
- Analyzed the data using standard statistical techniques.



Map 3 : Sampling points along the river, estuary and sea coast in Rajapur block

Map 4 : Sampling points along the Vagothan River, estuary and tributaries

The investigator during the fieldwork

Observations

In all 95 sampling points recorded in 72 villages for presence of *Calophyllum* and recorded 2182 trees from Rajapur block.

- The upstream of Vagothan river sampled at Pangari, Panhale, Gunjavani, Shejavali, Walye, Bandiwade, Prindavan, Tatekhajan, Upale Taral and Kumbhawade.
- In these villages, there is no presence of the *C. inophyllum.*
- Estuary starts at Walye where the banks of estuary are protected by the *Vitex negundo* and *Thespesia populeana*.
- *Caesalpinia crista* has been frequently observed in swampy saline areas is definite candidate for the non-edible oil. The seed of *C. crista* contains oil but presently no use of its seeds was known for any reason.

Photo Plate 1

Inflorescence of *C. crista*

Fruits of *C. crista*

Associate members of *C. crista*

Thespesia populeana & *Vitex negundo* protecting banks of the estuary

Abundant population of *C. crista* at Kumbhavade

Inflorescence of *Derris trifoliata*

- In Taral, before some years *C. inophyllum* was present in good number, but today not a single tree is present in this area.
- Kumbhawade is nearer to seashore from where mangroves start to appear.
- In mangroves *Acanthus illicifolius* and *Rhizophora, mucronata* was predominant.
- *Caesalpinia crista* was observed in association with *Pongamia pinnata* and *Derris trifoliata.*
- At Kumbhawade good population of *C. crista* observed in the swampy area of the estuary. It is intermixed with mangrove species.
- In Paley and Nanar , presence of *Calophyllum* inophyllum was observed along the edges of estuary and paddy field which get filled with saline water during high tide.
- Total 24 trees were recorded from these two villages with average GBH of 0.80 m and height of 10.88 m.
- Estimated number of fruits from these trees is 34940.
- Most of the trees were in normal state except three, which were lopped.
- In Sagave and Sagave Katil, there is no report of any *Calophyllum inophyllum.* According to the villagers *C. inophyllum* was present before some years in this area.
- Madban village is rich in *C. inophyllum* population. There are 305 trees recorded with average GBH of 0.80 m and average height of 8.77 m. Ten percent of total trees found lopped.
- Most of the trees observed on seashore. Estimated fruit number is 565740.

- In Ansure and Danda villages, healthy population of the *C. inophyllum* was observed. Both villages have swampy area. The edges of swampy areas are densely populated with *C. crista*.
- Danda village is famous for the oil expeller community called as 'Teli Community' (Oil producers)
- There are about 40 households form a pada 'Teliwadi' in Danda.
- We took the interview of people from teli community and tried to understand the problems and status of their business in present days.
- In Bakale there is no presence of any *Calophyllum* tree. Bakale village is located at considerable elevation from the seashore.

Photo Plate 2

Seashore at Madban

C. inophyllum at Madban Sea shore

Fruits of *C. inophyllum* at Madban

Mangrove status in Madban estuary

Seashore at Dhaniware showing *Acacia* sp. On shore

Nature of bank at Dhaniware – no swampy area

- Tulsunde village having rocky seashore where *C. inophyllum* is completely absent from this area (Photo Plate 4).
- Tulsunde is famous for the construction of the fishing boats.
- On the way to Holi, some population of *C. inophyllum* is present at Kuveshi. This village is closed to seashore and having lot of swampy area. On the way from Kuveshi to Holi most of *Calophyllum* population is present. This road is just pathway passing along the seashore.
- *Caesalpinia crista* formed a thicket patch along the edges of estuary in association with *Clerodendron inermi.*
- Total 113 trees recorded from this area with average GBH of 78 cm and average height of 7.5 M. More than 50 % or the trees are in lopped condition.

Photo Plate 4

Rocky beach at Tulsunde

C .inophyllum population on way to Kuveshi - Holi

Thickets of *C. crista* at Kuveshi – Holi Road

C. inophyllum population at Jaitapur

Status of seashore and *Acacia auriculiformis*

Mangrove status at Jaitapur

- Jaitapur is relatively large village in this area. Jaitapur bridge over the Jaitapur estuary will connect to Pawas in Ratnagiri block. Presently bridge is under construction. On the east of the Jaitapur Bridge, healthy population of mangrove is present.
- Total 216 trees were recorded from Jaitapur having average GBH of 62 cm and height of 7.5 m. Twenty percent lopping observed in this area.
- Jaitapur is closed to seashore whereas Wagran, Jambhalwadi (khalachi), Chavan Wadi, Bane Wadi, Vilaye, Kaneri, Shede and Kondetad are situated along the banks of estuary.
- Even though the Jaitapur estuary is rich with mangrove diversity and swampy area, in other villages population of *Calophyllum* could not be observed
- According to the villagers, *Calophyllum* population was present up to last decade in that area.
- *Caesalpinia crista* is playing key role of protection of the estuary banks from soil erosion.
- At the up stream of the estuary, there is no swampy area.
- At up stream at Vilaye, mangroves disappear and along the bank of estuary *Vitex negundo* observed. Presence of *Caesalpinia crista* recorded in association with *Fluggea sp.*, *Derris trifoliata* and *Clerodendron inermis.*
- On the bank of one of the tributary of Jaitapur estuary, Devache Gothane, Ghadiwadi, Marbeet, Dhaulwadi and Nate these villages are present. Irrespective of large swampy area, there is no presence of *C. inophyllum* in this area.
- Patches of Calophyllum population observed at Musakaji, Ambolgad and Vetye (Photo plate 7).
- In Musakaji total 116 trees were recorded with average GBH of 138 cm and average height of 8.7 m. Lopping percentage was 16 %.
- Trees at Musakaji were much close to seashore and their habitat was very specific. Most of the trees were present at the base of large plateau.
- Ambolgad area is rich in *C. inophyllum*. Total 299 trees were recorded and average GBH size was 95.3 cm with height of 8.4 m. Regeneration status of Calophyllum inophyllum is good in this area.

- The seashore at Vetye is quiet dangerous. Mangrove population is intermixed with *Calophyllum* population on either bank of the estuary. Total 99 trees recorded in this area with average GBH of 155 cm and height of 9.18 m.
- There is no record of *C. inophyllum* at Kasheli and Kondasar area.

Photo Plate 5

Mangrove population at Waghran

Swampy area along the estuary at Jambhalwadi

Malabar Pied Hornbill at Jambhalwadi

Bank of estuary protected by *C. crista* at Vilaye

Unprotected Bank of estuary at Kondsar

C. crista at Vilaye

Photo Plate 6

Swampy area at Devache Gothane

Bank of estuary at Nate showing *C. crista*

Calophyllum presence at the base of rocky plateau - Musakaji

Photo Plate 7

Large sized C. inophyllum trees on the way to Ambolgad

Patchy population of *C. inophyllum* at Vetye

Mangrove ecosystem and *C. inophyllum* at Vetye

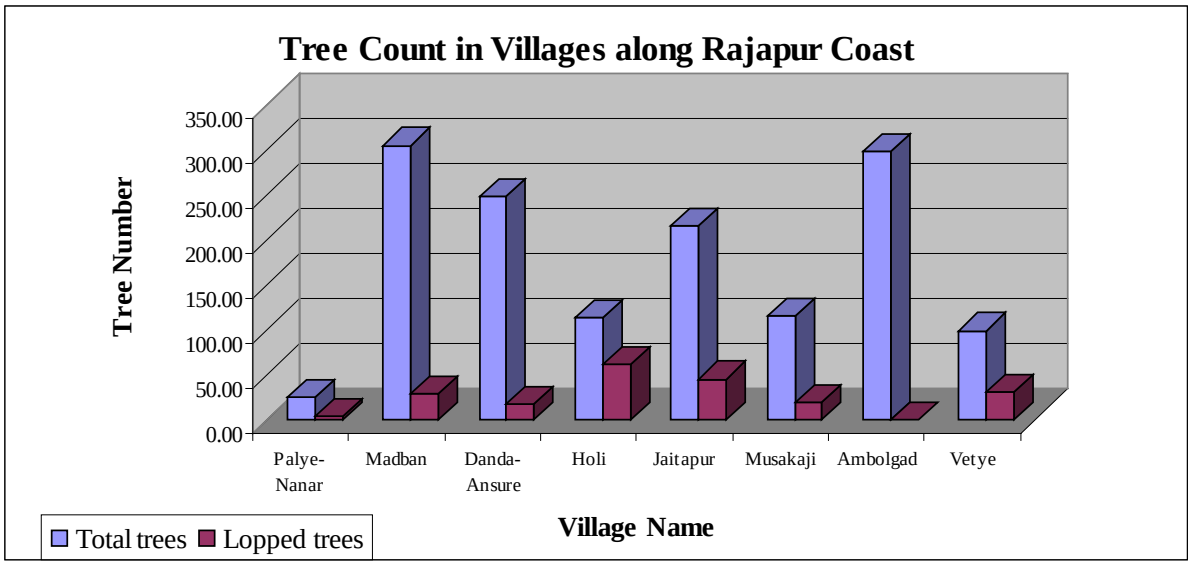
Results and findings

From the observations of all villages for *C. inophyllum* distribution, comparative account is prepared as follows

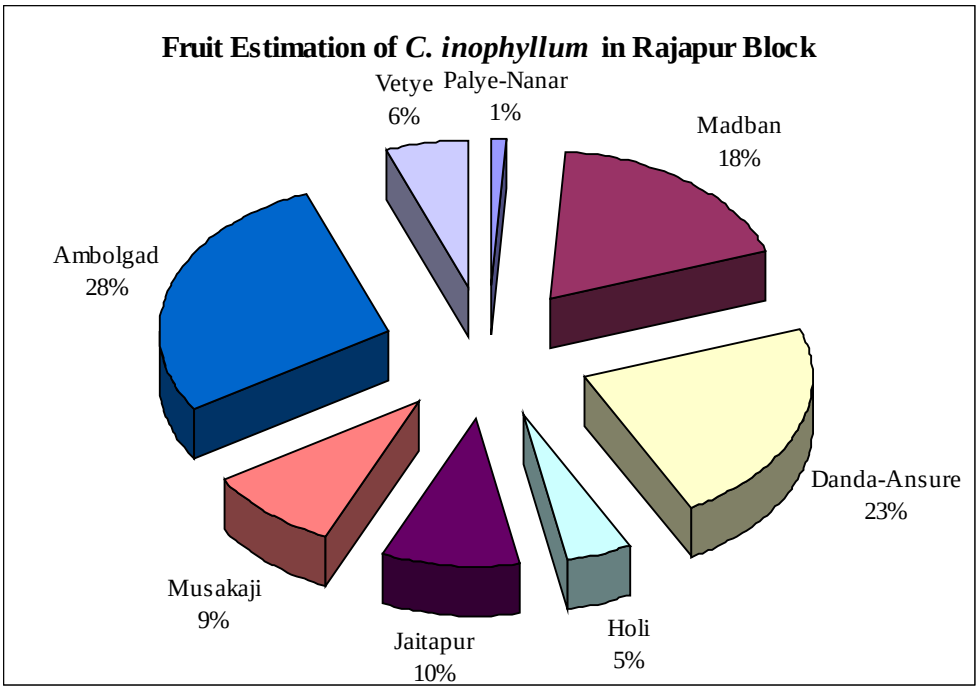
Table 1 : Comparative account of C. inophyllum distribution in different villages in Rajapur block

	Village Name	Way point	Tree Count	Lopped Tree no.	GBH in cm	Height in m	Fruit No.	Percent Lopping
1	Palye-Nanar	124	24.00	3.00	79.67	10.88	34940	12.50
2	Madban	128	305.00	29.00	75.53	8.77	565740	9.51
3	Danda-Ansure	133	248.00	17.00	99.97	9.28	690738	6.85
4	Holi	138	113.00	61.00	78.06	7.61	140360	53.98
5	Jaitapur	139	216.00	45.00	61.44	7.59	302680	20.83
6	Musakaji	161	116.00	19.00	138.57	8.79	287930	16.38
7	Ambolgad	164	299.00	0.00	95.33	8.40	856000	0.00
8	Vetye	168	99.00	30.00	155.00	9.18	180560	30.30
	Total		1420.00	204.00	97.95	8.81	3058948	

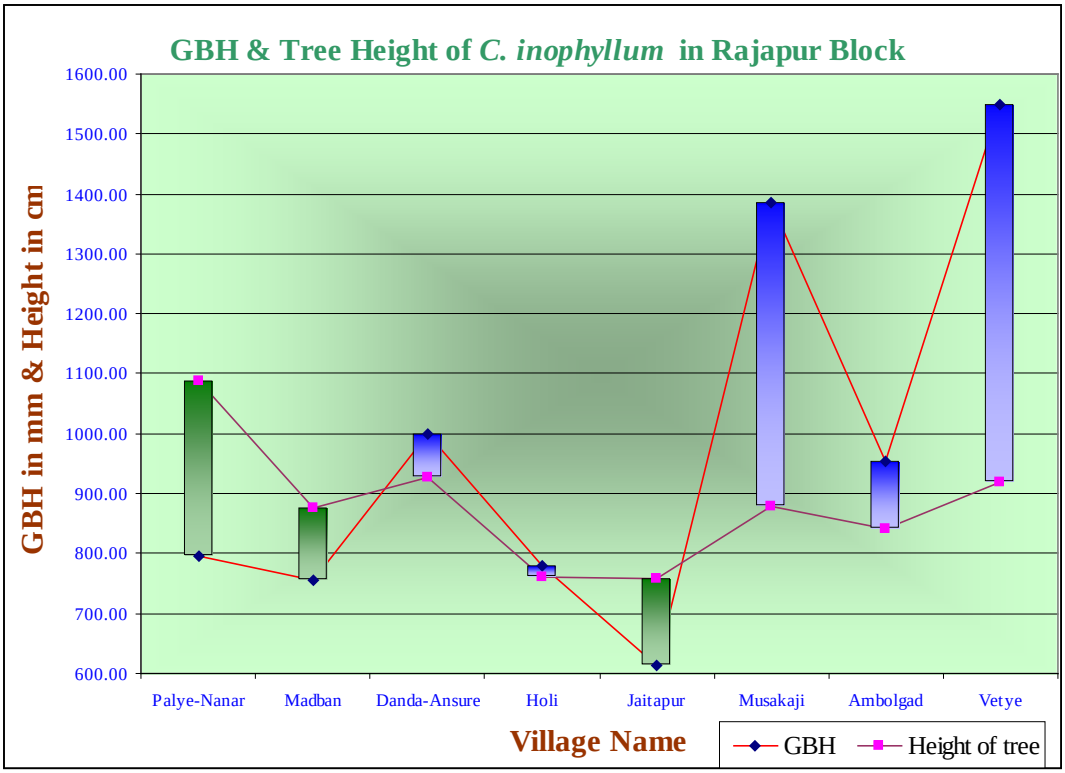
Graph 1 : Comparative status of tree number and lopped trees in different villages along the coast of Rajapur block



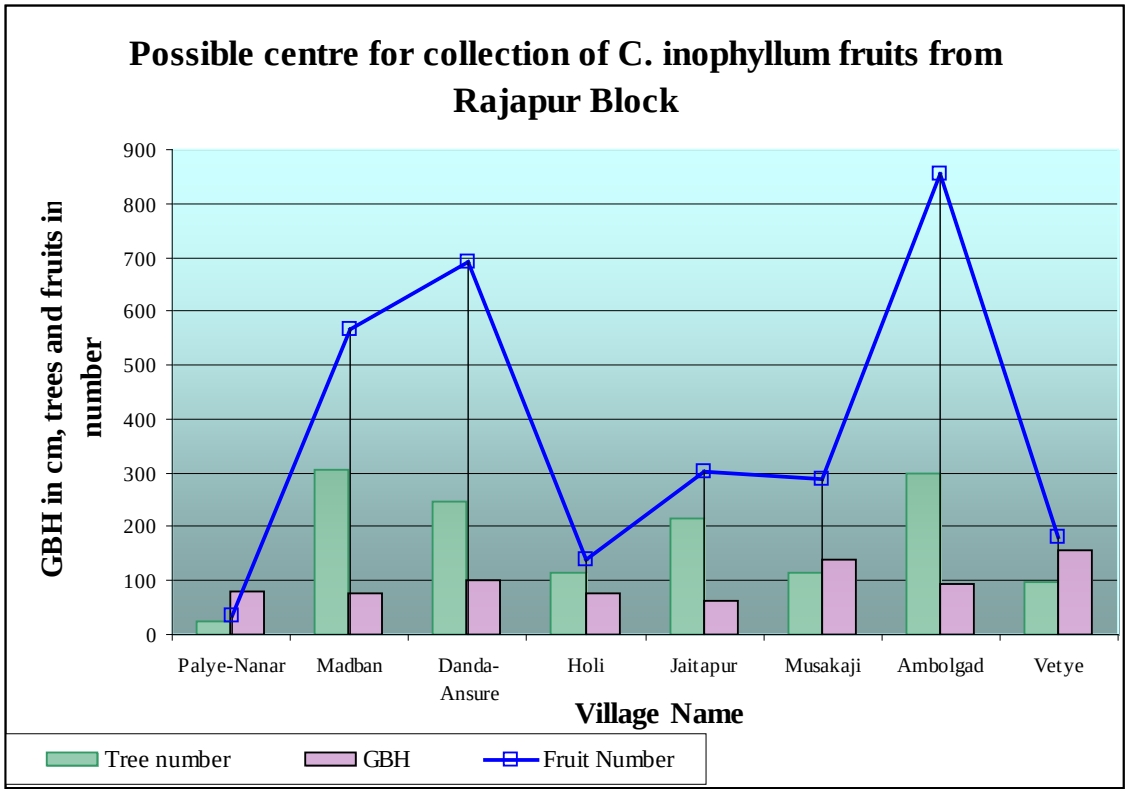
Graph 2: Estimated number of fruits from different villages along coast of Rajapur block



Graph 3: Relationship in between the GBH and tree height of *C. inophyllum* in Rajapur block



Graph 4 : Possible centres for collection of *C. inophyllum* fruits in Rajapur block



Traditional uses of *Calophyllum innophyllum* :

Calophyllum oil extraction is a traditional business of 'Teli'(Oil producers) community in study area(it is also known as Konkan) . People from this community live in groups . Such villages are well famous for the oil extraction. The *Calophyllum* oil is mainly utilised for coating the fishing boats and small sized ships. Every year these boats are coated with *Calophyllum* oil to prevent the deterioration of basal wooden or metal part, which always remain in touch with the seawater. Therefore, collection of the *Calophyllum* fruits for extraction of oil is a seasonal livelihood activity for the villagers. Up to last decade, the traditional business of oil extraction and fruit collection was very much active but there after declination in this business took place due to number of reasons. The ultimate and cumulative effect of this decline is traditional business of oil extraction is on the brink of death. The wood of *Calophyllum* is very useful for the construction of the ships and fishing boats. *Calophyllum* wood remains intact in saline water due to its inherent properties . When business of oil extraction came to halt, Calophyllum trees were cut down increasingly for purpose of timber. Villagers got good returns from sale of old and comparatively tall trees. Disruption in seed collection mechanism was one of the major

reasons for falling of the trees. At present in large coastal area at many places, population of the *Calophyllum* has thus reduced beyond the considerable limit. Most of the traditional oil extraction units are already shut down except one or two. However, oil demand has not reduced till date. Fishermen now have switched over to *Pongamia pinnata* oil as an alternative to *Calophyllum* oil.

It seems that in the time to come, the existing population of the *Calophyllum* will lower down to its threshold value and will get concentrated in few areas only. The switch over to *Pongamia* oil increases the threats to *Calophyllum* population in Konkan area. Understanding these issues is key for AERF to formulate the long term strategies for conservation of *Calophyllum innophyllum.*

Use of Calophyllum oil as anti-corrosive for fishing boats

Participatory resource assessment – a strategy to understand people and plants relationship

A series of informal discussions and interviews were conducted for collecting information about the traditional oil mills, its owners and the current status of *Calophyllum innophyllum* oil use. In the following excerpt are provided from interviews with the local community.

Mr. Jayant Sarnaik in discussion with local people at village Ansure

Interview with the people in Danda, Anasure

Name of the participants : Mr. B. R. Rasal and family

Oil extraction is their traditional business since many generations. Presently there are 8 - 9 wooden oil extraction machines are present in Danda – Teli Wada (Photo plate 3). Out of which two or three are in working conditions. Rest of all the people from this community changed their livelihood business from oil extraction to other. Most of them working on daily wages or working in quarry. The future is very unclear as next generation is not ready to do anything in this business.

Opportunities and issues associated with seed collection and processing of *Calophyllum inophyllum*

- Calophyllum seeds are rich in oil and yield at least 50% oil .
- The traditional use of Calophyllum seed oil is quite established.

- Collection of the fruits from other villages is very problematic as local transport up to Teli Wada (place of oil extraction) is not available. Everything needs to be carried on head.
- Crushing and drying of the fruits takes lot of time.
- Traditional method of oil extraction requires lot of energy e.g. to lift the rocky bricks and to put it on wooden loft manually.
- Yield is lower than expected.
- Selling cost is fixed maximum Rs. 50.00 per kg
- There are opportunities for enhanced seed collection and processing if advanced and mechanical extraction process is established.

Peculiar features and limitations of the traditional oil extraction mill.

- Per day, maximum 3-5 kg seeds could be extracted .
- It is run using a single bull.
- Mill is completely made out of wood.
- Is labour intensive.

Population density of *Calophyllum innophyllum* near the Oil extraction mills

Healthy population of the trees was recorded in this area. Total 248 trees with GBH of 1 m (approx) and average height of 10 m have been recorded. Just 7 % trees are lopped. Lopping has been done as these trees are used in construction of the launch. Very old trees are present in Danda and surrounding area. Cash crops like Mango, Cashew nut and some times Coconut trees plantation are replacing existing *Calophyllum* habitats. On seashore *Casurina* plantation has been done on private land by the social forestry department instead of *Calophyllum* to protect the seashore, where as in 70 % of this area *Calophyllum* is naturally present. It has been observed that these trees are present mostly on edges of swampy area and therefore most of the trees are very nearer to seashore.

Photo Plate 3


Traditional wooden machine of oil extraction


The owner of the machine with his unit.


Seashore at Danda Ansure Swampy area of Anasure

Even on elevation of 10 to 15 m from seashore they could not be observed. Presently the regeneration of the seedlings in this area is very good but sustainability is low due to the human interference.

Threats

In case where seashores are constructed artificially, no space left for the swampy area resulted into total loss of *Calophyllum* in the vicinity.

Mr. Dasharath Advilkar

Another community of Teli is in Mithgavane. They were also famous for the oil extraction. Presently they are not in a position to continue this business. Low income is the major reason behind this. Mr. Advilkar closed down his business 2 years ago . On daily wages a person gets salary of Rs. 80 to Rs. 100 per day. Even that much money could not be earned from oil extraction business. In our observations, most of the *Calophyllum* population observed in swampy area but according to the villagers up to last decade there were some trees also present along the banks of the river. Today not a single tree is present along the bank of the river. It might have happened that the older trees cut down after which no regeneration observed due to the loss of mother plant from that area.

Findings :

- From Table 1 and Graph 1, it becomes clear that the maximum number of trees are present in Madban and Danda – Anasure followed by Ambolgad and Musakaji.
- The lopping percentage in Ambolgad area is lower as compare to Madban area (Graph 2).
- Graph 2 shows the maximum possible number of fruits available in each village. According to the calculation, Ambolgad area sustains highest number of fruits followed by the Danda Anasure. However, cumulative collection at Danda – Anasure and Madban shows more number of fruits than the Ambolgad and Musakaji.
- Graph 3 indicates the relationship in between the GBH and Height of the trees at each collection point. For convenience the scale for GBH is consider in mm and scale for height of trees is consider in cm. From the graph, it can be concluded that the deviation in GBH at different collection point is higher than the Height of the tree. There is certain consistency in the height of the trees. It strongly suggests that the number of pods is more dependent on GBH of the trees than the height of the trees (Graph 4).

- Graph 4 represent the overall relationship among the number of trees, estimated number of fruits and GBH of the trees at each collection point. It strongly suggest that Madban - Danda Ansure and Musakaji - Ambolgad are the two possible centres from the Rajapur block from where maximum seed collection can take place.

Threats to population of *C. inophyllum* in Rajapur

- Decline in the oil extraction business has been the main cause of logging of these trees for timber purpose .
- According to the oil extractor, transport cost is increased and suitable transport is not available.
- Local government promoting the plantation of *Casurina* sp. instead of *C. inophyllum*, as *Casurina* is fast growing species.
- At some places, non-indigenous species like *Acacia auriculiformis* (exotic) has been planted.
- It was strongly observed that wherever banks of the river or estuary are constructed artificially, absolute loss of *Calophyllum* species observed.

Analysis of the distribution pattern of the *C. inophyllum* in Rajapur and Vengurla block

As part of the study, survey was also carried out in Sindhudurg district of Maharashtra to assess the distribution and density of *Calophyllum inophyllum.* It was realised that the distribution pattern of this species is not same in these two districts. A comparative analysis of distribution data has been provided here for creating a better understanding about the geographic differences and its impact on distribution

Methodology

For sampling purpose continuous Belt transect method was used. Each transect was of 2 x 2 km size in Sindhudurg. In Rajapur block two belts of different length having breadth of 4 km was laid down. In each transect count of every individuals were recorded along with parameters like GBH, Height and total number of the fruits on each tree.In case of trees not in fruiting stage, fruit numbers were estimated with the help of average number of fruits present on each tree in respective transect. Comparison of both the blocks were done on the basis of distribution pattern, tree number, fruit density per sq km etc.

Rajapur Block, Ratnagiri district

In Rajapur block five transect were taken along the coast and estimates were done for calculating the total number of fruit available, its density and distribution pattern. A summary of observations for the Rajapur block is provided below

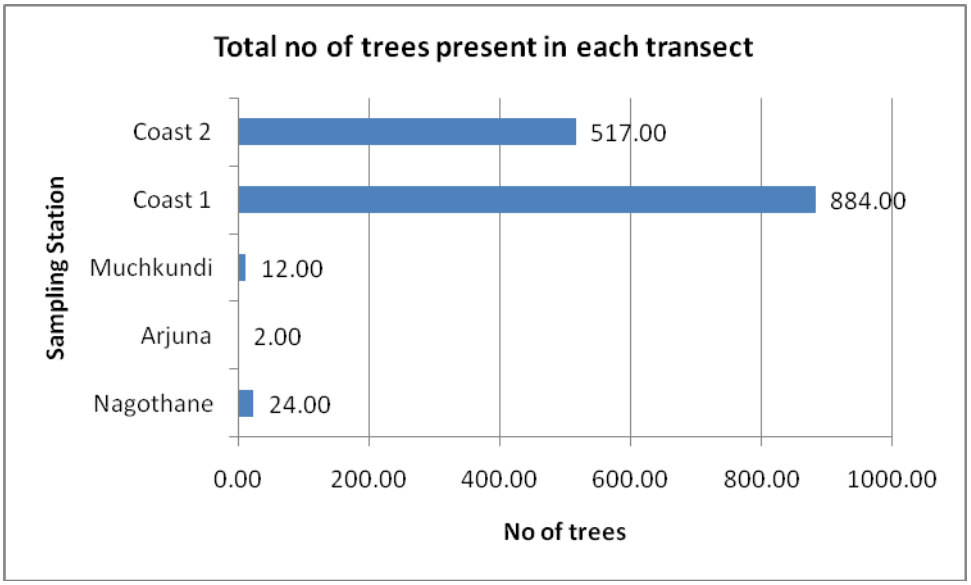
Table 1:

Transect Name	Nagothane	Arjuna	Muchkundi	Coast 1	Coast 2	Total
Transect No	1.00	2.00	3.00	4.00	5.00	
Length in km	32.00	20.00	13.00	9.00	16.00	
Width in km	2.00	2.00	2.00	4.00	4.00	
Area covered in sq km	64.00	40.00	26.00	36.00	64.00	230.00
No of Samp Pt	19.00	14.00	7.00	15.00	16.00	71.00
Tot trees	24.00	2.00	12.00	884.00	517.00	1439.00
Avg trees per plot	1.26	0.14	1.71	58.93	32.31	
Avg branc per tree	24.33	20.00	16.00	24.96	29.81	
Avg fr per branch	47.29	75.00	45.00	68.24	70.56	
Avg GBH	0.80	0.75	0.90	0.84	1.28	
Avg Height	10.88	8.00	8.50	8.85	8.69	
Total lopped	3.00	0.00	0.00	152.00	49.00	
Total Fruit	27614.39	3000.00	8640.00	1505986.87	1087482.01	
Fruit density / Sq km	431.47	75.00	332.31	41832.97	16991.91	

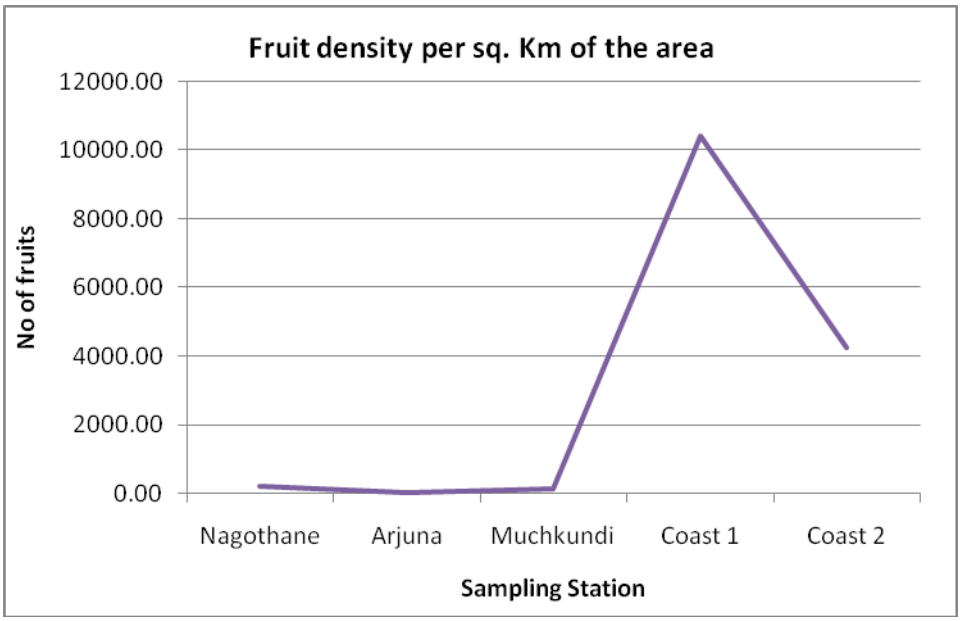
Total 230 sq km area was scanned to find out the distribution of every individual of *C. inophyllum inophyllum.* The three transect were taken along the estuaries in Rajapur. The transect length for each transect was different but width was kept constant. Along the coast, two transects were taken. One was of 9 km while second was of 16 km. Width of each transect along the coast was 4 km. Entire coast of Rajapur block is covering a distance of 28 km. Initially a belt of 4 x 28 km along the sea coast was proposed for area under study but as we got the extended distribution along the edge of estuaries, we sampled estuaries separately. Out of 112 sq km study area, 100 sq km area was actually sampled which is almost 90 % of the proposed area. Therefore estimates about the fruit and tree densities are actual one. There was no need of extrapolation of the data.

Observations

From the data (Table 1) it becomes clear that the maximum density of the *C. inophyllum* fruit is present near the coast only. The fruits density reduces absolutely about 10 km east from the sea coast. Highest density of the fruits observed 41832.97 per sq km just within the distance of 4 km from the coast. In Rajapur block there are three estuaries and each one having three to four tributaries near the sea coast. Most of the *C. inophyllum* trees are distributed within the network of these estuaries and their tributaries near sea coast. *C. inophyllum* trees are heavily concentrated (58.9 trees per plot) in Jaitapur, Madban, Danda, Ansure and nearby areas. From graph 1 & 2, it is clear that *C. inophyllum* trees are more concentrated near the coast and also producing highest number of the fruits. As far as the GBH is concerned we could see the average GBH of the *C. inophyllum* trees in transects taken along the coast were higher (1.06) than that of GBH recorded in other transects (0.82).



Graph 1 : Distribution pattern of the *C. inophyllum* trees along the coast and along estuary in Rajapur block



Graph 2 : Estimated fruit density at each sampling station in Rajapur block

Vengurla block, Sindhudurg district

In Vengurla block of the Sindhudurg district the distribution pattern for the *C. inophyllum* is different than that of the Rajapur block in Ratnagiri district. The main difference due to absence of network of the estuaries in Vengurla block. Therefore the maximum distribution of the *C. inophyllum* trees was observed within the belt of 2 km from sea coast. Each sample was taken over 2 x 2 km length and collected data were used for the further calculation. Total 38 km distance covered in the 7 samples. Eighteen square kilometre area was physically sampled. i.e. 47.4 % percent of the total area under study.

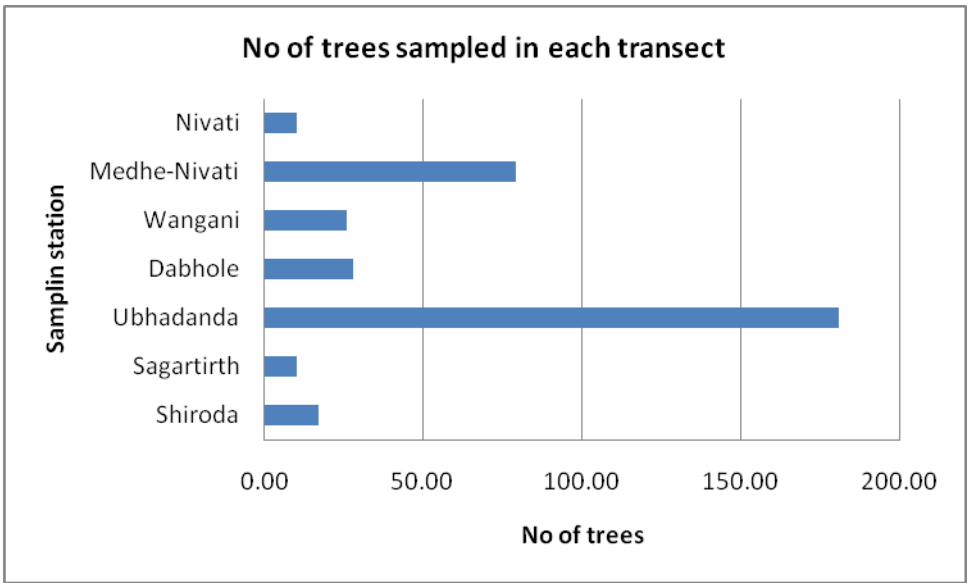
Observations

During the survey of the *C. inophyllum* in Vengurla block, all the trees were not in fruiting stage. Hence fruit number was estimated based on the average fruits observed on the trees. The average fruit no was further extrapolated over the entire study area of the Vengurla block.

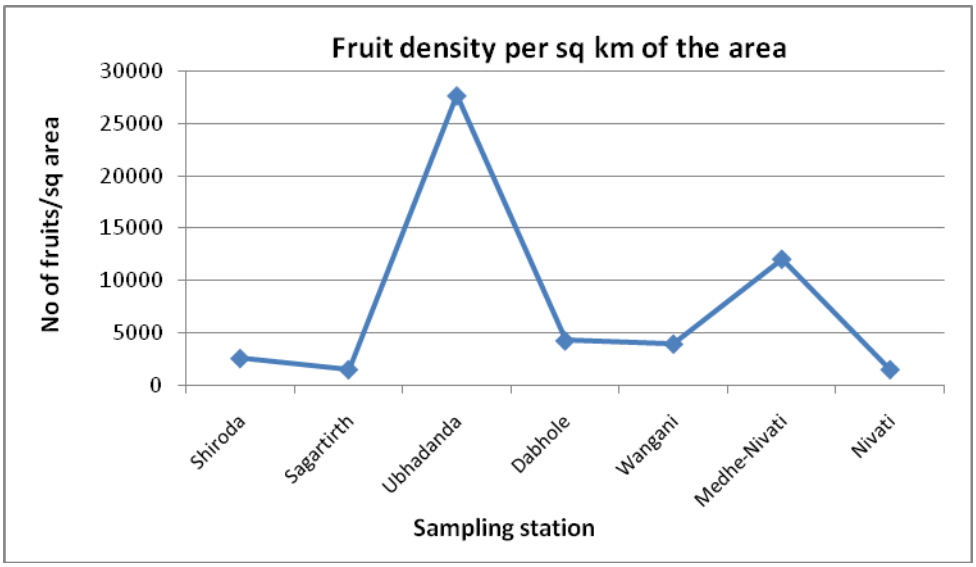
Table 2: Observations for Vengurla block in Sindhudurg district

Transect Name	Shiroda	Sagar tirth	Ubha danda	Dabhole	Wangani	Medhe-Nivati	Nivati	**Total**
Transect No	1.00	2.00	3.00	4.00	5.00	6.00	7.00	
Length in km	2.00	2.00	2.00	2.00	2.00	2.00	2.00	
Width in km	2.00	2.00	2.00	2.00	2.00	2.00	2.00	
Area covered in sq km	4.00	4.00	4.00	4.00	4.00	4.00	4.00	28.00
No of Samp Pt	6.00	3.00	15.00	6.00	6.00	12.00	2.00	50.00
Tot trees	5.00	10.00	181.00	28.00	26.00	79.00	10.00	339.00
Avg GBH	68.82	44.80	76.23	44.39	94.60	61.18	115.00	
Avg Height	7.74	5.20	9.88	8.71	10.20	7.47	13.50	
Total lopped	5.00	0.00	9.00	2.00	0.00	1.00	0.00	17.00
Total Fruit	10385.79	6109.288	110578.1	17106.01	15884.15	48263.37	6109.288	
Fruit density / Sq km	2596.447	1527.322	27644.53	4276.501	3971.037	12065.84	1527.322	
							7658.429	

Total sampling was done at seven places covering an area of 28 sq. Km area. Overall 339 trees were recorded and estimated fruit density was 1527.32 fruits per sq km area. Lopping percentage was low, just 5 % of the total trees. As there is no network of the estuaries in Vengrula block, we could not observe any *C. inophyllum* trees about 10 km away from the seashore. Maximum number of trees was observed near Ubhadanda beach. In this area regeneration of the trees was also well observed whereas in other areas regeneration was less frequent. Even though GBH variation was observed at each sampling station, it did not show any relationship with the total fruit number.



Graph 3: Tree distribution patter along the coast of Vengurla block



Graph 4: Estimated fruit density at each sampling station in Vengurla block

Comparative *C. inophyllum* inophyllum status of Rajapur block in Ratnagiri and Vengurla block in Sindhudurg district

1. Distribution pattern of the *C. inophyllum* trees along coast is more consistent in Rajapur block that that of the Vengurla.
2. In Rajapur block trees are distributed about 4 km belt from the seashore whereas in Vengurla it is just 2km belt.
3. In Rajapur we could record the maximum distribution of *C. inophyllum* about 12 km from the seashore along the estuaries, whereas in Vengurla maximum distribution was observed up to 6 km from sea shore.
4. Tree lopping percentage is higher in Rajapur block (14.17%) than the Vengurla block (5.01%)
5. Average GBH of trees in both the blocks are different. In Rajapur it is 1.06 m while in Vengurla it is 0.72 m.
6. In Vengurla 610 fruits were observed per tree whereas in Rajapur the fruit number is quite high. It is 1848 per tree.
7. As far as the overall estimation for the fruits is concerned, Rajapur has a potential of 3798652 fruits production per year while Vengurla has a potential of 582040 fruits per year.

   According to the local people fruits are harvested twice in a year. First season is during the summer and second season is at the end of November. The estimated figures of fruits number is for single season. It is based on the observation in summer season. During winter season (i.e. end of November) fruits production is comparatively low. People are not collecting much fruits during winter season.
8. Average fruit density in Rajapur was calculated as 33916.5/sqkm and in Vengurla it is 7658.4/sqkm

Seed dispersal and propagation of *Calophyllum inophyllum*

This tree is also important for many bird species. They continuously feed on the fruits of this tree. *C. inophyllum* thus plays a role of keystone species in coastal ecosystem. Frugivorous bats mainly short nosed fruit bats (*Cynopterus sphinx*) mainly feed on the *C. inophyllum* fruits(Elangovan V. 1999). They are also the crucial agent for the dispersal of the fruits along the coast and away from the coast. On the other hand, fruit availability from Calophyllum trees through out it the year is also equally responsible for

maintenance of healthy population of bats in India as well as other countries. Our discussions with oil producers revealed an interesting fact- eating of fruits in harvesting season by bats eases the job of shell removal for the seed collectors and it also helps faster processing of seeds in oil production. In both the blocks it has been observed that there are very limited intact habitats for the frugivorous bats. Poaching is major threat to survival of bats in this region.

Bat dispersed seeds of *C.inophyllum*

Healthy regeneration of *C.innophyllum* near a roosting tree of bats

Propagation trials of *C. innophyllum* were conducted using bat dispersed seeds and normal seeds. It was found that germination of bat dispersed fruits was faster (20 days earlier) than in case of normal fruits. In any case it takes about 40 days for germination of fruits of this tree.Other issues such as pests , growth rate are being studied.

Seedlings of C. innophyllum at AERF nursery

Discussion

One could never have thought that the challenges of biodiversity conservation and the need to adopt cleaner energy options would offer us some exciting opportunities to achieve both the goals in single effort. Native species based biofuel productions definitely provide a ray of hope among all the debate and controversies about climate change and biofuels as a mitigation strategy. The sustainable use as strategy for conservation would also make lot more sense in the field of biofuels. Lastly, one must look at brighter side of problems and learn to rely on biodiversity for all our needs as our wiser ancestors used to do if we are to survive the next ice age. Linking biofuels production with high conservation value species is an attempt for making this hypothesis a reality.

Appendix 1 : Summary of villages covered for survey in Rajapur

Sr. No.	Area of sampling	No of Villages visited
1	Rajapur – Pangari – Panahle – Gunjavani – Shejavali – Walye – Bandiwade – Prindavan – Tate Khajan – Upale – Taral – Kumbhawade – Nanar – Palye Phata – Palye – Nanar 2 – Sagave Katli – Sagave – Rajapur	18
2	Rajapur – Madban Khalachi Wadi – Dhaniware – Mithgavane – Anasure – Adiwadi Ansure – Danda – Bakale – Rajapur	07
3	Rajapur – Tulsunde – Kuveshi – Holi – Jaitapur – Jaitapur 2 – Waghran – Jambhalwadi khalachi – Chavan Wadi – Bane Wadi – Vilaye Kondawadi – Vilaye – Vilaye 2 – Kaneri – Shede – Kondetad – Rajapur	15
4	Rajapur – Devache Gothane – Ghadiwadi – Marbeet – Dhaulwadi – Nate bridge – Nate – Musakaji – Musakaji plateau – Ambolgad – Tivare – Rajwadi – Adivare – Vetye – Kondasar – Kashale Bandh – Kashale – Rajapur	16
7	Rajapur – Pawas – Gaonkhadi – Devi Hasole – Muchkundi – Dasur – Beni Bu. – Sadarwadi Beni – Harche – Shelakewadi Harche – Dorle – Pawas	11
8	Pawas – Purnagad – Lokarewadi – Gavade Ambore – Kelkarwadi – Mavlange – Natunde – Gazanewadi Natunde – Hanumanwadi – Dabhil Ambore – Shivar Ambore – Pangekarwadi – Mavlange Natunde – Gaonkhadi sea shore – Kardhe – Ganeshghule – Pawas	17
9	Pawas – Nakhare phata – Nakhare – Golap Khadi – Ranpar - Pawas – Ratnagiri – Sangmeshwar – Devrukh – Sakharpa – Kolhapur	07

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