Commercial agriculture inside reserve forests – the case of natural rubber cultivation in Kanyakumari district, Tamil Nadu, India

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Satellite-based remote sensing data was used in conjunction with toposheets of forest maps to estimate the extent of natural rubber cultivation existing inside reserve forests and their immediate peripheries in Kanyakumari district. The study revealed that nearly 15% of the total natural rubber cultivated area in the district was inside reserve forests and another 14% was within a radius of 500 m from the forest boundary. Ironically the entire natural rubber cultivated inside the forests and bulk of that existed adjacent to the forests were owned by a public sector undertaking (PSU) of the state government. This PSU was formed in 1984 with the objective of rehabilitating the Sri Lankan Tamil repatriates. There are more such PSU plantations inside and adjacent to forest periphery in Tamil Nadu, Kerala and Karnataka that were established with equally noble causes, but they put severe pressure on the forests, fragmenting them and blocking wildlife corridors. Incidents of man–wildlife conflicts are not uncommon in these plantations. A serious scientific introspection is needed about the ecological, economic and social sustainability of these commercial PSU plantations developed inside and close to forests and whether they should be now reverted to forests and set a new and bold example for conservation. The current generation of plantation workers who are descendants of Sri Lankan Tamil repatriates should be trained for better jobs elsewhere.

Keywords: Ecological conservation, GIS, reserve forests, rubber plantations, satellite data, Western Ghats.

THERE exist large extents of natural rubber and other commercial plantations inside and adjacent to reserve forests in many parts of India, particularly along the Western Ghats and the North East Region[1–3]. Expansion of plantation agriculture in the country in the past is a classic example of developmental and conservation imperatives coming into direct conflict with each other. The case of natural rubber cultivation in Kanyakumari district, Tamil Nadu, India, where the present study was undertaken on a pilot basis, is a typical example. While acknowledging that it will be extremely difficult to arrive at a universally acceptable definition for sustainability in such conflicting scenarios, there is growing consensus that environmental impacts of developmental activities should be at an acceptable low level.

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Historically, plantation agriculture such as rubber, tea and coffee was practised in biodiversity hotspots like the Western Ghats after deforestation of large forest areas[2,4,5]. Obviously these commodities are always needed by man and there are few environmentally less harmful substitutes for them. For example, natural rubber is an indispensable industrial raw material even as synthetic rubbers constitute a significant share of the total usage. Synthetic rubbers, manufactured entirely from petroleum stocks have much larger ecological, social and carbon footprints than natural rubber[6–8].

Kanyakumari district, the only region where natural rubber can be grown in Tamil Nadu, has the best agro-climatic conditions in India to cultivate this crop[9]. This is also one of the earliest rubber-growing regions in the country. In the present study, using satellite-based remote sensing data and forest boundary maps, we estimated the extent of natural rubber cultivation inside reserve forests and along the forest periphery in this district. We present a case for starting a national dialogue on whether public-sector commercial plantations established inside and along reserve forest fringes should be reverted to natural forests.

Spatial distribution of natural rubber plantations in Kanyakumari district was mapped using satellite-based remote sensing data. Multi-spectral satellite data were used for the work (Resourcesat 1, L-3, 101/68, 23.5 m, 25 March 2012). Satellite data pre-processing such as orthorectification, normalized differential vegetation index (NDVI) generation, image classification and ground truth were carried out to estimate the natural rubber cultivated area. Preliminary satellite data was interpreted using visual elements such as colour, tone, texture, pattern and terrain conditions. Spectral signature of rubber trees was standardized (young and mature trees) prior to mapping and analysis. Major spectral changes of natural rubber trees occur during December to March when they undergo wintering and refoliation. This could be observed by generating NDVI of the plantations and analysing other dominant land uses/vegetations present in the district. Using these spectral signature variations, natural rubber area (age three years and above) was delineated and corroborated with ground-truth information.

Forest boundary maps obtained from the Survey of India toposheets were used in conjunction with the natural rubber distribution map for spatial analyses. Buffer distances of 500 and 1000 m were created from the periphery of the reserve forest in the GIS platform and distribution of natural rubber plantations was spatially analysed. Identification of natural rubber plantations physically sharing boundary with forests (i.e. contiguous with forests) was not always possible due to the less-than-sufficient resolution of the satellite data used in this analysis. Buffer analysis tool in ArcGIS platform was employed for this and the spatial extent of natural rubber plantations falling inside the reserve forest, and 500 and 1000 m from the forest boundary was estimated.

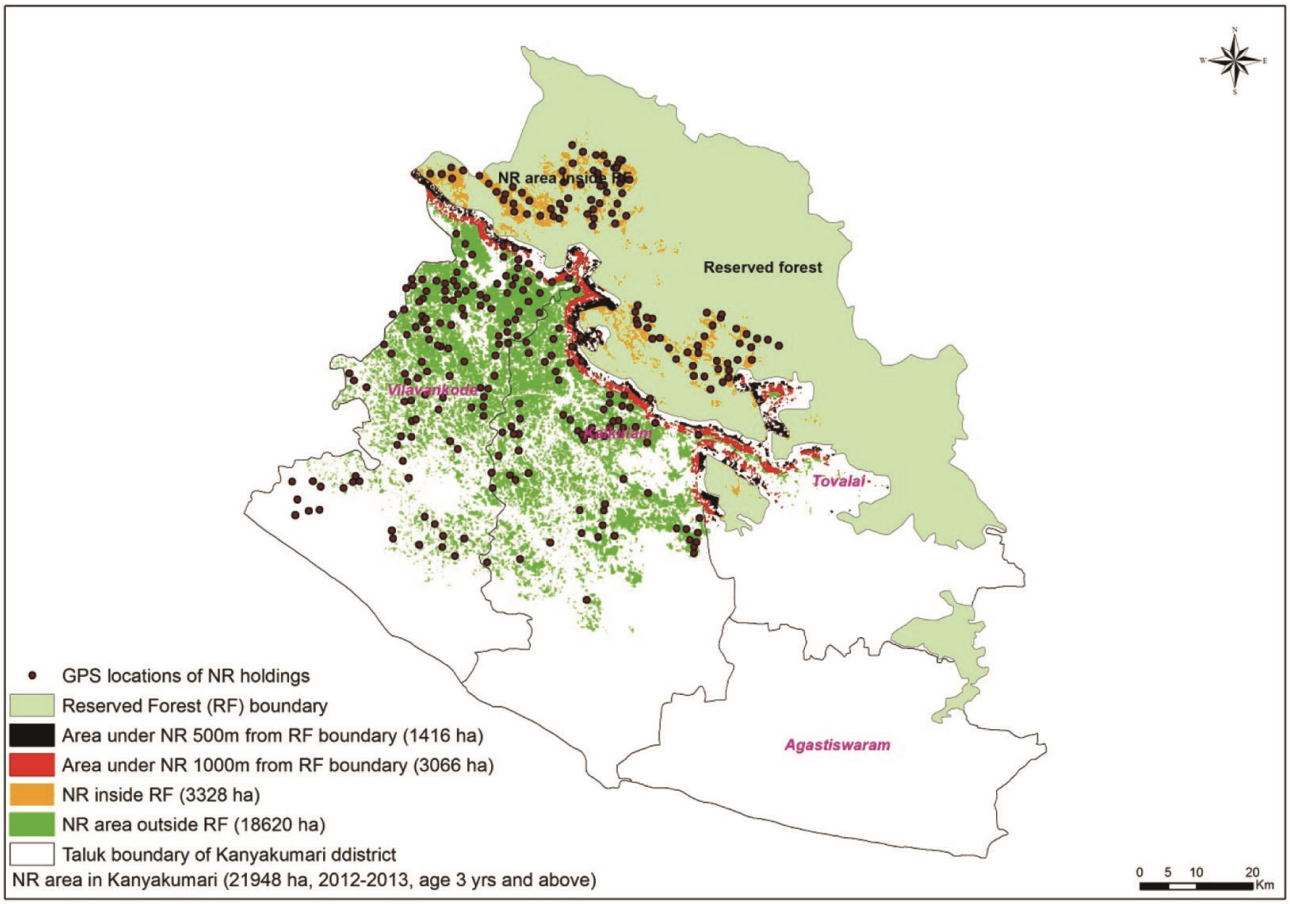

Figure 1. Geospatial distribution of forests and natural rubber plantations inside and close to forests (500 and 1000 m) in Kanyakumari district, Tamil Nadu, India.

With 22,000 ha which is roughly 30% of the net sown area of the district, natural rubber cultivation is a significant land-use activity in Kanyakumari district. Nearly 93% of these plantations is distributed in Kalkulam and Vilavancode taluks, and these are concentrated largely towards the Western Ghats in the east (Figure 1). Almost the entire reserve forest (50,486 ha) in the district is also concentrated in the same area[10] and 3328 ha of natural rubber plantations could be seen inside the forest (Figure 1). Another 3066 ha of the plantations fell within 1000 m from the forest boundary and half of that was within 500 m from the boundary. Thus almost 29% of the total area under natural rubber cultivation in the state is either inside or close to reserve forests, which is a startling finding.

Based on ground-truth visits (Figure 1) it was confirmed that the entire natural rubber plantations found inside the reserve forest and a large share of the plantations in their close proximity were owned by a public sector undertaking (PSU) under the Department of Environment and Forests, Government of Tamil Nadu. In 1984 with the primary objective of rehabilitation of Sri Lankan Tamil repatriates, this PSU developed nearly 4200 ha of natural rubber plantations, which it planted after clearing forests. The entire natural rubber plantation of this PSU is either inside the reserve forest or within 500 m from the forest boundary. This leaves only about 540 ha of plantations under the ownership of private citizens within a distance of 500 m from the forest boundary.

Encroaching forests by private individuals for cultivating crops, including natural rubber was not uncommon in the Western Ghats states until as recently as the middle of the second half of the 20th century[2,11]. Natural rubber-growers are accused by environmentalists and conservationists, and often rightly so, of land grabbing and deforestation for expanding their rubber cultivation. However, in Kanyakumari district, private rubber planters who are mostly small and subsistence farmers with a mean rubber-holding size of just 0.5 ha have much less culpability for deforestation.

Even as late as the 1980s, large-scale conversion of forest into natural rubber plantations occurred in Tamil Nadu under the supervision of the state government, despite efforts by conservationists to prevent it through legal interventions. The decades of the 1970s and 1980s saw some of the stringent wildlife and conservation Acts enacted and laws laid down in India. This was also the

time when environmental awareness and conservation movements were strong in the country after the historic success of the iconic Silent Valley Movement. In the contemporary enlightened society which gives nature and conservation a prime place, forest conversions like that in Kanyakumari or other places for natural rubber and other plantation crops by the state governments would be politically suicidal. There are allegations that several developmental projects inside forests and other protected areas are being given approval, diluting wildlife and conservation laws in different parts of the country.

The present analysis in Kanyakumari district on a pilot basis can be extended to other states and plantation crops, including North East India, where natural rubber cultivation is fast expanding. Citing instances of rubber cultivation inside reserve forests, open forests and degraded forests in parts of North East India, research has revealed serious concerns of monoculture rubber plantations becoming a major threat for forests and biodiversity in the region[1]. Presently, the Government of India is in the process of implementing a major programme for accelerated expansion of natural rubber cultivation in the North East with financial assistance from the Automotive Tyre Manufacturers' Association. The Indian rubber industry in general and the automotive tyre industry in particular are concerned about the rising deficit in the domestic supply of natural rubber, even as its industrial demand is steadily on the rise[12,13]. According to provisions of the Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006, tens of thousands of forest land will be available to forest-dwelling native communities to take up plantation agriculture, including natural rubber cultivation in the North East. Globally, natural rubber farming has recently attracted much negative publicity even as a boom in expansion of rubber cultivation triggered by the historic rise in rubber price in the last decade led to considerable loss of forests and biodiversity in countries such as China, Laos, Cambodia, Myanmar, Thailand, Indonesia and Vietnam[14–16]. Environmental concerns of rubber monoculture in a biodiversity hotspot like North East India raised by several researchers also need to be considered[17,18]. The present study acts as a pointer towards balancing expansion of natural rubber plantation and conservation in the fragile sub-Himalayan region in North East India.

The state-of-the-art technique adopted in the present study could be extended to more states in the country and other plantation crops such as coffee and tea, which may reveal more inconvenient truths about large-scale forest conversions that have taken place in the past for establishing commercial plantations under the public sector and possibly also by private planters.

There are serious concerns about the ecological sustainability of commercial PSU plantations that have caused large-scale loss of biodiversity, fragmentation of forests and obstruction of wildlife corridors[19,20]. Patches of natural rubber plantations belonging to the PSU plantation in Kanyakumari district which used to be well-established elephant corridors, have been abandoned and returned to the State Forest Department. Some of these commercial PSU plantations have accrued huge financial losses. The PSU rubber plantation in Kanyakumari district has the lowest rubber productivity in the country.

There are also concerns about the long-term social sustainability of the commercial PSU rubber plantations. While this plantation under study provided the much needed succour to Sri Lankan Tamil repatriates at a crucial and tragic time in their past, the situation is different today. The present generation of descendants of the Sri Lankan repatriates should be encouraged to find better livelihood opportunities outside the rubber plantations.

Rising anthropogenic pressure leading to forest degradation and fragmentation, decline in food and water inside the forests as a result of prolonged drought, forest fires, etc. due to climate change can increase man–wildlife conflicts in the future in plantations existing in close proximity to forests. Maps of commercial plantations and forests made using satellite-based remote sensing data of much higher resolution than what is used in the present study can give more precise information, such as the exact locations and length of natural rubber plantations or other crops sharing a common boundary with the forests, whether these plantations block any wildlife corridors, etc. However, the present findings are sufficient to start a national dialogue on the future of commercial PSU plantations situated inside reserve forests in different parts of the country.

It will be unfair to sit in judgement over past conversions of forests into plantation agriculture when environment, biodiversity and forest conservation issues were not major concerns as they are now. But today's more enlightened society can take corrective actions for the past damages done to forests and biodiversity in the name of expansion of commercial plantation agriculture in ecologically sensitive areas and biodiversity hotspots in India.

Studies have shown that weeding is not essential and the natural flora can be allowed to grow inside a mature natural rubber plantation without adversely affecting the growth and yield of rubber trees[21]. This will improve biodiversity inside natural rubber plantations; a welcome step of symbolic atonement for the past mistakes of deforestation and biodiversity loss caused by natural rubber cultivation. However, the undergrowth may provide a safe heaven for wild animals lurking in the rubber plantations close to forests.

Perhaps the time is now ripe to start a national dialogue among conservationists, policy makers, academia and the general public on whether these PSU plantations have already outlived their intended purposes, assess the ecological, economic and social sustainability of these agricultural enterprises established inside and bordering the forests, and whether these should be reverted to forests. A

new and more sustainable alternative strategy to rehabilitate the plantation workforce is also urgently needed.

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Potential of native forest leaves to modulate *in vitro* rumen fermentation and mitigate methane emission

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Tree foliages rich in phytochemicals can be used as sustainable fodder for livestock to modulate rumen fermentation for cleaner and improved production. Samples of nine different forest tree leaves were collected from hilly regions of Arunachal Pradesh, India to study their effect on *in vitro* rumen fermentation and methane production. After 24 h of incubation, highest ($P < 0.05$) gas production (ml/g DM/24 h) was observed in *Symplocos racemosa* among the leaves. Methane production (ml/g DDM/24 h) was lowest ($P < 0.05$) in *Symplocos crataegoides* followed by *Berberis aristata* leaves, while *in vitro* true dry matter digestibility was highest ($P < 0.05$) for *Berberis aristata* leaves. In case of rumen fermentation attributes, *B. aristata* and *S. crataegoides* produced maximum volatile fatty acid and microbial biomass amongst other screened leaves. Therefore, these leaves can be used as a fodder supplement to address feed scarcity and reduce methanogenesis in ruminants of the North East hilly regions of India.

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