

# Forest degradation in the Western Ghats biodiversity hotspot: Resource collection, livelihood concerns and sustainability

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**We assessed collection intensity of forest products in three regions of the Western Ghats: Kogar, Sigur and KMTR with differing population densities and levels of forest protection. Fuel-wood was intensively collected in all three regions; fodder and green leaves in predominantly agricultural regions and cattle manure in Sigur. Agriculture, wage labour and local and regional markets were associated with resource harvesting. Collection intensity decreased with increasing levels of protection, regardless of human density. Extensive forest degradation in these regions suggests that the intensive use of forests for sustenance and consumption is no longer viable.**

**Keywords:** Deforestation, India, local communities, protected areas, sustainability, Western Ghats.

LAND use changes in the Western Ghats over the last century caused by agricultural expansion, conversion to plantations and infrastructural projects have resulted in loss of forests and grasslands<sup>1-3</sup>. While land use change remains the major threat to Western Ghats biodiversity, the intensive harvesting of non timber forest products (NTFPs) such as fuel-wood, bark, leaves, fruits, exudates, etc., has also contributed to loss of biodiversity and forest cover<sup>4-11</sup> as in other Southeast Asian forests<sup>12,14</sup>. NTFP extraction contributes significantly to local household income in tropical regions<sup>15,16</sup> and has been viewed as preferable to conversion to other land uses<sup>17</sup> when it is sustainable. However, non-sustainable resource extraction can have deleterious consequences for biodiversity and affect the livelihoods of the users.

Definitions of sustainability differ<sup>18,19</sup> but in strictly ecological terms, sustainability must be measured and monitored on a target plant or animal population over time<sup>10,19</sup>. Sustainable extraction can be achieved only under particular conditions of low population density, simple technology, localized resources and limited possibilities of expansion<sup>20-23</sup>.

Rural populations in the Indian subcontinent depend heavily on forest resources<sup>24</sup> and resource collection continues in most protected areas despite prohibition<sup>25,26</sup>. Collection for subsistence livelihoods could be a major driver of deforestation although the relationship between deforestation and wealth is not straightforward<sup>27,28</sup>. Deforestation has multiple scalable causes that differ geographically<sup>29,30</sup>, suggesting that policy might have to be site and case-centric to be effective.

We reviewed three studies conducted in different regions of the Western Ghats, where impact of resource collection on the vegetation had been directly measured and found to be unsustainable<sup>4,5,9,31,32</sup>. We identified major forest products collected in each region, estimated collection intensity and assessed socio-economic correlates of resource collection. We tested the hypotheses that dependence on forest resources would increase with human density and decrease with levels of protection.

## Study regions

The northernmost study site was Kogar in the Shimoga Division, Karnataka State (latitude 14°00'N, longitude 74°45'E) in the Central Western Ghats with an economy predominantly based on agriculture (Figure 1). Forest resource dependence by three agrarian systems: pioneering stage of agriculture by immigrants, mixed farming and intensive cash cropping was examined<sup>5,9</sup>. A land use/land cover analysis revealed that this region has a mosaic of forest in different stages of degradation and cultivated land<sup>9</sup>. These forests come under the Reserve Forest and Wildlife Sanctuary categories. Reserve Forests permit collection of forest products and livestock grazing, whereas Wildlife Sanctuaries, at a higher level of protection, prohibit collection but allow livestock grazing (Wildlife Protection Act, 1972). Resource extraction in the adjoining forests has resulted in loss of biodiversity and forest cover<sup>5,9</sup>.

The Sigur region, which lies between latitude 11°28'N–11°32'N and longitude 76°37'–76°48'E at around 900 m elevation (Figure 1), connects the Reserve Forests of the

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Sigur plateau with the protected areas of Mudumalai, Bandipur, Nagarhole and Wynaad towards the north and west, and with the forests of Sathyamangalam towards the east. This region covers a forested area of over 3300 km<sup>2</sup> and supports a population of 1800–2300 elephants (based on Forest Department census figures). It has been identified as one of the four most important zones for long-term conservation of the Asian elephant due to its relatively intact habitat<sup>33,34</sup>. Sigur's forests provide critical migration corridors and habitat for elephants<sup>33</sup>, however, the expansion and near contiguity of settlements that were historically established along rivers have left only narrow corridors for elephant movement<sup>31,33</sup>. The need for protection of these corridors was identified decades ago<sup>34</sup> and has since been repeated in several studies<sup>31–33,35,36</sup>. The grazing pressure exerted by the 12,000–15,000 livestock maintained in this region has resulted in low tree densities, poor recruitment and more open cover (24–

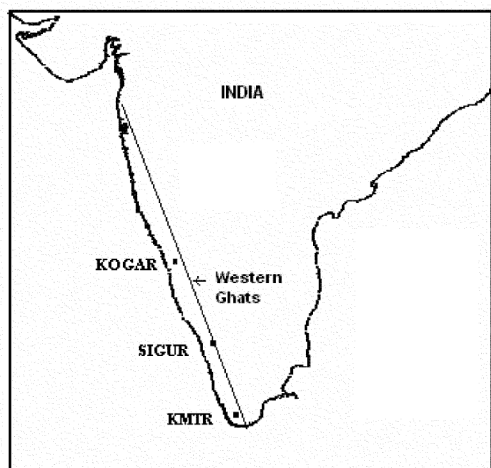
31%) compared with forests with low levels of grazing pressure<sup>31</sup> (Figure 2).

The Kalakad–Mundanthurai Tiger Reserve (KMTR), situated in the Southern Western Ghats region (8°25'–8°53'N latitude and 77°10'–77°35'E longitude) was established in 1988 (Figure 1). A Tiger Reserve has the highest level of protection and resource collection and livestock grazing are not permitted in the core zone. The eastern boundary of KMTR is adjacent to rich agricultural land consisting of 145 villages/hamlets with about 30,000 households located within 5 km from the reserve boundary<sup>37</sup>. The dry forest adjoining the reserve has been extensively degraded due to resource extraction pressure and livestock grazing<sup>4,38,39</sup> (Figure 3).

## Methods

We assessed forest resource use in these three sites using published and University theses. Information pertaining to the Kogar region was obtained from Garrigues<sup>5</sup> and Puyravaud and Garrigues<sup>9</sup>, who conducted a study between 1992 and 1994 on the relationship among agrarian systems, use of forest products and collection intensity.

Data pertaining to the Sigur study was obtained from Roessingh<sup>32</sup> and Mammen<sup>40</sup>. Roessingh<sup>32</sup> employed remote sensing analysis to map land use/land cover changes from 1973 to 1999, while Mammen<sup>40</sup> conducted a survey among 78 randomly selected households in four major villages: Bokkapuram, Masinagudi, Mavinahalla and Singara, which adjoin Mudumalai Wildlife Sanctuary. Mammen assessed dependence on forest products by households, household income, occupation and sources of energy. He estimated collection intensity of fuel-wood from January to March 2007 for a total of seven days, along four major paths connecting Masinagudi village to Mudumalai Wildlife Sanctuary. The area covered by the fuel-wood collectors was approximately 20 km<sup>2</sup>. He assessed population



**Figure 1.** Map of the Indian peninsula indicating location of the study regions.



**Figure 2.** Livestock grazing and degraded dry forests in the Sigur region.



**Figure 3.** Degraded dry forests adjacent to settlements along the eastern boundary of the Kalakad–Mundanthurai Tiger Reserve.

**Table 1.** Collection intensity and use value of forest products collected in the three regions

	Human density ( $\approx \text{km}^2$ )	Major products	Economic activity	Collection intensity (tonnes/ha/year)*	Use value	Impact on forest
Kogar	50	Fuel-wood	High income cash cropping ( $N = 1493$ )	$2.2 \pm 0.5$	Consumptive	Negative
			Middle income mixed agriculture ( $N = 5242$ )	$1.5 \pm 0.3$	Consumptive	Moderate
			Pioneering subsistence agriculture ( $N = 476$ )	$0.9 \pm 0.2$	Consumptive	Moderate
Sigur	80	Fuel-wood	Tourism	0.70	Consumptive/ local market	Negative
KMTR	350	Cattle manure	Organic coffee plantation	0.13	Regional market	Negative
		Fuel-wood	Agriculture	0.13	Consumptive/ local market	Negative
		Fodder		0.002	Consumptive	Moderate

\*Wet weight.

**Table 2.** Types of energy used by households in Sigur and KMTR. The types of domestic energy used by households in the two regions differed significantly ( $\chi^2 = 18.56$ ,  $df = 2$ ,  $p = 0.0001$ )

Fuel source	Number of households (%)	
	Sigur	KMTR
Fuel-wood from forest	42 (54)	169 (22)
Other biomass*	—	376 (48)
Fuel-wood, biomass + non-renewable	28 (36)	99 (13)
Non renewable (kerosene, LPG)	8 (10)	142 (18)
Total households	78	786

\*Value excluded for  $\chi^2$  test.

density of the region bounded by Singara, Masinagudi, and Moyar in the West to Vallathottam eastwards, using 2001 census data<sup>41</sup>.

The study in KMTR was conducted between 2000 and 2002 by Arjunan<sup>38</sup>, who assessed collection and use of forest products such as fuel-wood, fodder and green manure by 786 households in 31 villages located within 3.5 km from the forest boundary (Table 1). Type of energy used by each household was recorded. The quantity of forest products collected along eight major footpaths connecting 12 villages to the forest was estimated by 12-hour daily observations over a seven-day period. These observations were replicated every three months over a two-year period for a total of eight sample periods. From these observations the average fuel-wood and fodder collected and collection intensity over an approximate area of 100 km<sup>2</sup> were estimated.

To facilitate analysis, forests were coded with from the lowest to the highest levels of protection: Reserve Forests were (1), Wildlife Sanctuaries (2) and Tiger Reserve (3). A Spearman's Rank Correlation was used to test whether human density and levels of protection were associated with collection intensity.

The domestic energy sources of households in Sigur and KMTR were compared using a  $\chi^2$  test. To see whether re-

source dependent households were from certain occupational classes, the numbers under different occupational categories were analysed using a contingency table of observed versus expected values. Categories with values <5 were not included in the analysis.

## Results

### General patterns

Fuel-wood collection was common to all three regions; fodder and green leaves were collected in the predominantly agricultural regions of Kogar and KMTR<sup>5,38</sup>, whereas cattle manure was collected in the Sigur region<sup>40</sup> (Table 1). The population density was highest along the eastern boundary of KMTR and lowest in Kogar (Table 1). KMTR had the highest population density and the highest level of protection, and the lowest collection intensity, whereas Kogar had the lowest level of protection, the lowest population density and the highest collection intensity (Table 1, Spearman's rank correlation =  $-0.92$ ,  $p < 0.0001$ ). This suggests that levels of protection significantly influenced collection intensity independent of human density.

Fuel-wood was the major resource harvested from the forest in all three regions (Tables 1). About 90% of the households used fuel-wood as a primary or secondary source of energy in Sigur and 35% in KMTR (Table 2). About 54% of households in the Sigur region and 22% in KMTR used only fuel-wood from the forest. A mixture of fuel-wood, kerosene and liquified petroleum gas (LPG) was more prevalent in villages alongside KMTR (Table 2). Daily wage households were more likely to collect fuel-wood in Sigur (Table 3), whereas both agricultural and daily wage households collected fuel-wood in KMTR ( $\chi^2 = 2.75$ ,  $df = 1$ , ns, Table 3). Agricultural households were predominantly involved in the collection of fodder and green leaves in KMTR (Table 3).

**Table 3.** Occupation of households collecting forest products in the Sigur region and in KMTR

Region	Product	N	Household occupation (%)				$\chi^2$
			Agriculture	Daily wage	Self-employed	Other	
Sigur <sup>1</sup> plateau	Fuel-wood	70	3 (4)	44 (63)	12 (17)	11 (16)	13.9**
	Cattle manure	58	3 (5)	41 (71)	6 (10)	8 (14)	18.8***
KMTR eastern boundary	Fuel-wood	212	92 (43)	63 (30)	42 (20)	9 (4)	43.53***
	Fodder	66	41 (62)	12 (18)	5 (8)	8 (12)	20.55***
	Green <sup>2</sup> leaves	121	95 (79)	2 (2)	6 (5)	18 (15)	55.88***

<sup>1</sup>Excluded agriculture, <sup>2</sup> excluded daily wage; \*\* $p < 0.001$ ; \*\*\* $p < 0.0001$ .

Fuel-wood was collected for domestic consumption and for the local market in Sigur, KMTR and to a limited extent in Kogar (Table 1, Puyravaud, pers. obs.). Fodder and green leaves were collected only for domestic consumption in Kogar<sup>5</sup> and KMTR (Table 1). Cattle manure was commercially collected in Sigur for the regional organic coffee plantations that served the globalized organic coffee industry (Table 1). Preliminary data suggest that the collection intensity of fuel-wood in Sigur and KMTR was similar to that of the pioneering agrarian system at Kogar.

### Kogar region

All the three agrarian systems were heavily dependent on forest resources, particularly fuel-wood, construction wood, fodder and green leaves used as manure<sup>9</sup>. However the high-income cash cropping system had the highest collection intensity of fuel-wood and construction wood, which was higher than the wood productivity of the forests, and therefore not sustainable<sup>9</sup>.

### Sigur Plateau

The major product collected among the four study villages was fuel-wood, followed by cattle manure (Table 1). Daily wage labour, mainly women from low-income households, was significantly involved in the collection of these products (Table 3). Fuel-wood was collected mostly for household consumption, but was also sold to local businesses such as tourist resorts and teashops in Masinagudi and Bokkapuram<sup>40</sup>. Only 3% of the households in Sigur depended solely upon an agricultural income<sup>40</sup>. Tourism was the major economic activity in the region, however opportunities for local communities were limited to wage labour due to lack of skills<sup>40</sup>. About  $3825 \pm 80$  kg of wood were removed per day from Mudumalai Wildlife Sanctuary using four major entry points over an area of 20 km<sup>2</sup>; collection of cattle manure covered over twice this area (Table 1).

A 1991 region-wide evaluation estimated between 12,000 and 15,000 local and migrant livestock (cattle and buffalo) grazed largely in the Reserve Forests and Mudumalai Wildlife Sanctuary for the purpose of dung produc-

tion<sup>31</sup>. About 10–15 truckloads of manure were sent from the study site every week. The purchase price of cattle manure was about Rs 1–2 per kg<sup>40</sup>, and each truckload can carry about a tonne of semi-dried manure.

### KMTR

Arjunan<sup>38</sup> in a study of 786 households in 31 villages showed that agriculture was an important occupation in this fertile region. About 46% of the households used forest resources<sup>38</sup>. Fuel-wood, fodder and green leaves for organic manure were the three major products collected<sup>38</sup> (Table 1). Fuel-wood was collected for sale and for household consumption, whereas the other products were collected only for household consumption<sup>38</sup> (Table 1). An average of  $3501 \pm 1220$  kg of fuel-wood was collected per day, projected to about 1277 tonnes per year. Collection intensity was about 0.13 tonnes ha<sup>-1</sup> of fuel-wood and 0.002 tonnes ha<sup>-1</sup> of fodder annually (Table 1).

## Discussion

### General patterns of resource use

In this article we demonstrate extensive dependence on forest products such as fuel-wood, fodder and green leaves by local communities. Collection intensity was negatively associated with the levels of protection, indicating that protected areas are important in lowering human pressure on forests, regardless of human density.

Collection intensity was higher at Kogar and lower in Sigur and KMTR. However, the dry forests of Sigur and KMTR cannot support the same levels of anthropic pressure as the wet forests of Kogar due to their lower productivity (about 3–4 tonnes ha<sup>-1</sup> per year compared with about 8 tonnes ha<sup>-1</sup> per year for Kogar; Puyravaud unpublished).

Fuel-wood was the major forest product collected in all three regions, and was the primary or secondary source of domestic energy for a high proportion of households<sup>5,38,40</sup>. Fodder and green leaves were also collected but not as intensively. Fuel-wood had a limited local market, whereas fodder and green leaves were collected just for household

consumption<sup>9,38,40</sup>. Commercial collection of cattle manure was a major activity in the Sigur region and in the adjacent Bandipur National Park due to proximity to a regional market<sup>40,42</sup>. Large herds of scrub cattle that have no maintenance costs are driven into the protected areas for grazing, where they have an adverse effect on wild herbivore densities by lowering the carrying capacity of the forest<sup>31,43</sup>. Cattle manure exported to plantations contributes to nutrient loss and thereby increases degradation<sup>31,40</sup>. Markets can accelerate deforestation as shown by Godoy *et al.*<sup>44</sup> in Neotropical rain forests. Many households preferred forest products due to their lower cost although commercial substitutes were locally available<sup>5,9,38,40</sup>.

Both consumptive practices and livelihood support accounted for the harvesting and use of forest resources. However, the consumptive value of fuel-wood, fodder and green manure was higher than their income generating capacity. Godoy *et al.*<sup>15</sup> also showed that the consumptive use of forest products in Neotropical rain forests was higher than their market value; therefore conversion to other land uses was more lucrative than harvesting products for the market.

*Socio-economic status of users:* The users of forest products ranged from the poor and marginalized to wealthier agricultural households and tourist resorts<sup>9,38,40</sup>. In KMTR, households that bought fuel-wood from the fuel-wood sellers, has the highest mean income in the region, households that collected for domestic use had intermediate income levels whereas households that collected wood for sale, the lowest<sup>38</sup>. In Kogar, the wealthier farmers contributed disproportionately to loss of biomass from forests, due to cash cropping and their ability to extract more products from longer distances<sup>9</sup>. Elite tourist resorts in the Sigur region utilized wage labour to harvest forest fuel-wood for bonfires and barbecues<sup>40</sup>.

The availability of wage and farm labour is probably one factor that drives extraction of forest resources by households. Availability of non-farm employment reduces tropical deforestation<sup>27,43</sup>. Therefore any developmental activity or infrastructural projects such as roads and dams that encourage influx of wage labour should increase deforestation.

Many poor rural households depend on forest products to augment household income, however these households face a rapidly diminishing resource base. Therefore in their economic interest, non-forest based livelihood options should be encouraged.

### *Rural needs for energy and fodder*

This article suggests that reliance on forests by rural households as a source of low cost energy and fodder<sup>45</sup> drives forest degradation and loss of biodiversity<sup>24</sup>. Therefore it is crucial that rural energy and fodder requirements are addressed at the policy level. Subsidized community

managed forests and private plantations should be encouraged as a source of fuel-wood and fodder.

### *Conservation of biodiversity in human-dominated landscapes*

Conservation of biodiversity in the Western Ghats is a challenge and studies have shown extensive loss of forest cover and biodiversity<sup>1-3</sup>. A time series analysis of land cover change in the Sigur region using Landsat satellite imagery showed that the rate of loss of forest cover has nearly doubled between 1989 and 1999 (21 ha/year) as compared to between 1973 and 1989 (12 ha/year)<sup>32</sup>.

The protected areas in the Western Ghats have long, porous boundaries, often bordering human settlements. Policing is difficult compounded by problems of governance. However, protected areas are important in reducing human pressure on forests. Upgrading the existing Reserved Forests into more stringently protected areas would necessary be for the long-term conservation of this region. Many indigenous communities such as the Todas of the Nilgiris have conserved biodiversity through traditional practices<sup>46</sup>, and should be integrated into protected area management. It is becoming increasingly clear that forest managers need the support and confidence of local stakeholders for enforcing conservation measures<sup>47</sup>.

Forests have low local use value but high indirect use values for the national and global community<sup>15</sup>. Therefore understanding the local causes of deforestation is a first step towards framing realistic policies and innovative conservation solutions.

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