SURVEY AND ESTIMATION OF BAMBOO RESOURCES OF KERALA

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BIODIVERSITY MAPPING OF SHOLA FORESTS THROUGH REMOTE SENSING AND GIS TECHNIQUES

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Final Report

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Research Project No. KFRI 272/97

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Project Proposal

1	Code	KFRI 272/97
2	Title	Survey and Estimation of Bamboo resources of Kerala
3	Project leader	Director KFRI
	Principal Investigator	A.R.R. Menon *
	Associates	P. Vijayakumaran Nair
		C.N. Krishnankutty
4	Objectives	To assess the extent and nature of bamboo resources of Kerala forests and to undertake survey/sampling to arrive at a global estimate of bamboo stocks in the State using remote sensing.
5	Outline of research programme	The main source of data is satellite images taken by the Indian Remote Sensing Satellite (IRS) 1C. In the present study, images in green, red, near infra red and middle infra-red regions (0.52-0.59 µm, 062-0.68 µm, 0.77-0.86 µm, 1.55-1.7 µm) of the LIS III sensor of IRS IC were used. Satellite images taken in February 1997 were obtained from the National Remote Sensing Agency (NRSA) in CD ROM format. Six multispectral satellite images cover the entire Kerala. The images are assembled and kept in ready to be called format. First the required frame is called and then the required area extracted. Idrisi, a raster based Geographic Information System (GIS), available since several years in PC based systems is used for image processing. This package contains most of the basic GIS and image processing functions, but does lack some features. The gap was filled by GIS Link, a share ware program developed at the Kerala Forest Research Institute for data conversion and supplementing GIS and image processing packages. GIS Link has user friendly modules for digitization, rasterisation, interactive image extraction, geo-coding, and overlaying operations.
		The estimation is done forest range wise. Methods used for estimating bamboo resources could be classified into three steps. The first step consists of extraction of LIS III images from CDs and preparation of RGB composite. Second step is field visits and third step is supervised classification of the images and estimation of area. Maps of the area are digitized using a module of GIS Link. These maps are required for producing masks to eliminate regions outside range boundary, for preparing maps for registration and legends and boundaries during final printing.
		The next step is supervised classification. The FCC image was used for defining the training sites. At this stage, objects could not be delineated individually, but they look sufficiently different to define the training sites. In this method, areas containing known vegetation types are marked for the computer as learning sites. The computer examines the marked regions and analyses the spectral response of each object defined. The result of this analysis, is the computer delivering a signature for each type of landuse defined. The spectral signature is nothing but a statistical description of how each object reflected different regions of the electromagnetic spectrum. During subsequent analysis, spectral values in different bands in each pixel in the image would be compared with the stored signatures and the pixel assigned to the object whose signature matches closest. Appropriate module in the Idrisi program was used for this purpose. Training sites of bamboos, forests, plantations and agriculture classes were defined. It was made sure that almost all the pixels were assigned to one of these classes after classification. The onscreen digitizing feature was used for generating maps of learning sites. The Makesig module of Idrisi extracts the training sites and constructs the signature for each object. The Maxlike module of Idrisi was used for supervised classification by the maximum likelihood algorithm.
6	Date of commencement	January, 1997
7	Date of completion	October, 1999
8	Funding agency	Kerala Forest Department

* From 24/12/98 Dr. P.Vijayakumaran Nair has been designated as the Principal Investigator.

Contents

Abstract

Quantity of bamboo (*Bambusa bambos*) available in the forests of Kerala is estimated through remote sensing techniques and field visits. Multi-spectral images from IRS 1C provide sufficient spatial resolution to identify plant communities. Bamboo is classified into three density categories high, medium and low. The area of bamboo in each of these density categories is determined through analysis of satellite images. The area is converted into quantity through factors established by field sampling. The quantity indicates the standing stock.

The Olavakode region has the maximum quantity of bamboo (34.0 %) among the five regions in the state. Most of the bamboo in this region is in Nilambur North and Nilambur South Forest Divisions and Parambikulam Wildlife Sanctuary. This is followed by the Northern region (30.7 %). The Northern region in this consideration includes the Northern Circle and Wayanad Wildlife Sanctuary. The Southern region comes third (21.7%) in terms of bamboo availability. The Trivandrum Wildlife Division, Trivandrum and Achenkovil Forest Divisions contribute the maximum. The Central region and the High Range region contain 8.9 per cent and 4.66 per cent respectively. In these cases also the Wildlife Sanctuaries/National Parks of the region are included.

Division wise, maximum quantity of bamboo is in the Wayanad Wildlife Sanctuary (16.2% of total) and Nilambur North Division (15.0%). This is followed by Achenkovil (7.9%), Parambikulam (6.0%), Nilambur South (5.7%), Wayanad North (5.3%), Trivandrum (2.8%) and Trivandrum Wildlife (2.68%) Divisions. Other divisions have relatively less bamboo.

The total bamboo stock in the state is to the tune of 2.63 million tonnes. This is much higher than that was reported to be available in 1973 (1.4 million tonnes). Based on present age distribution, it is evident that Parambikulam area will have fully grown bamboo clumps by about 2010. The availability of bamboo can fluctuate because of reasons like gregarious flowering, and utilization plans should take this into account.

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Status of Bamboo

N

0 20 40 60 km

Bamboo high

Bamboo medium

Bamboo low

Bamboo sparse

Kannur

Aralam

Wayanad North

Wayanad WL

Wayanad South

Calicut

Silent Valley NP

Nilambur North

Mannarkad

Nilambur South

Palakkad

Nemmara

Thrissur

Parambikulam WLS

Peechi WL

Chalakudy

Mankulam

Idukki WL

Vazhachal

Munnar

Malayattur

Kothamangalam

Idukki WL

Kottayam

Thekkady

Konni

Ranni

Achankovil

Punalur

Thenmal

Trivandrum

Trivandrum WL

Agasthyavanam BP

Forest Divisions, Kerala

Fig. 1. Status of bamboo in Kerala

Introduction

Estimation of bamboo, an important raw material for paper and pulp industry, is traditionally carried out by field surveys. This is a laborious and time-consuming task. The only information on bamboo resources in the forests of Kerala was the quantitative assessment by Chandrasekharan (1973). This report gives quantity of bamboo available along with that of timber and reeds. In the case of bamboo, the figures provided are hardly applicable at present because of following reasons : 1) The Northern and Olavakkode circles have been thoroughly reorganised and vested forests added. The vested forests which contain large quantity of bamboo were not covered in the resource survey and 2) Bamboo has flowered in many regions and therefore quantity of bamboo reported are no more applicable. Many of the working plans of the divisions, the traditional first source of information, are under revision. The first time vested forests and reserve forests have been considered together and no major division level reorganisation is expected. Therefore the estimates made in this study may be of use for several years.

Bamboo grows for 40-45 years, flowers gregariously and dies. It would take several years for it to establish again. As per forestry regulations, a prescribed number of culms are extracted once in few years from each clump. Bamboo has many features that make it distinct in satellite images. Some of these are : (a) in a deciduous environment, bamboo bears green leaves when surrounding trees are in the process of shedding leaves; (b) bamboo with narrow leaves standing amidst broad-leaved trees produces distinct reflectance pattern in satellite images and (c) the radiating appearance of bamboo makes it distinguishable in aerial photographs and satellite images. Since 1997, images of sufficiently high spatial resolution for estimating resources at species level started becoming available.

This project was undertaken with the objectives to assess the extent and nature of bamboo resources of Kerala forests and to undertake survey/sampling to arrive at a global estimate of bamboo stocks in the State using remote sensing. In this report only bamboo (*Bambusa bambos*) is considered, important from an industrial point of view.

Materials and Methods

The estimation of bamboo was done forest range wise. In cases where the vegetation of few adjoining ranges was similar, image of these ranges was extracted together. For other areas individual ranges were separately extracted. Bamboo resource estimation was done in three steps. The first step consisted of extraction of LIS III images from CDs and preparation of Red Green Blue (RGB) composite. Second step was carrying out field checks and the third step included supervised classification of the images and estimation of area. Maps of the area are digitized using a module of GIS Link. These maps were required for producing masks to eliminate regions outside range boundary, for preparing maps for registration and legends and boundaries during final printing. An RGB composite of a sample bamboo area is shown below.
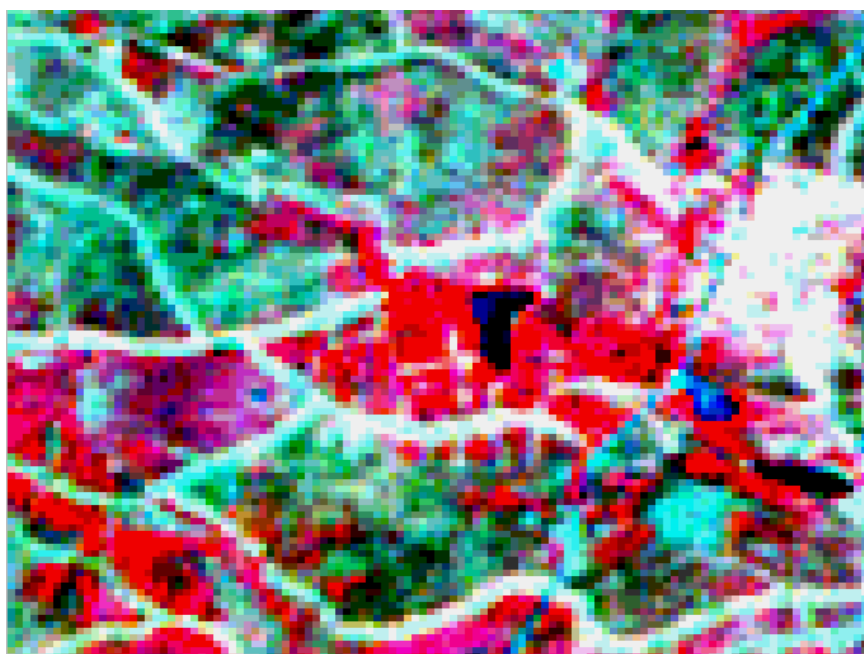
FCC of an area containing bamboo region

Bamboo 1. Red patches near the pond. This is the maximum density bamboo area in the region. It is a pure patch. No enumeration carried out.
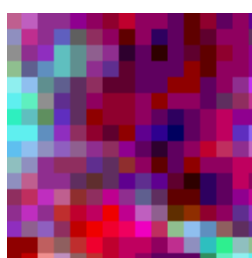
Bamboo 2. This patch, dark violet in colour, is expected to contain 50 to 75 per cent bamboo; rest trees. In other words, more bamboo than trees.
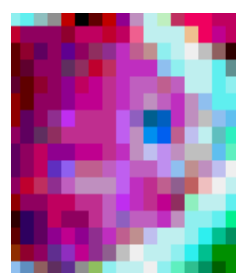
Bamboo 3. This is light violet in colour; 25 to 50 per cent bamboo. More trees than bamboo. The light area on the right side is mud road.
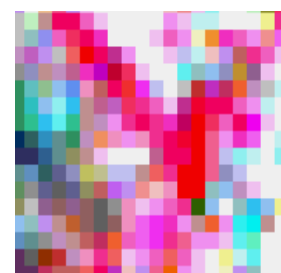
Bamboo 4. This is sparse bamboo area, a combination of violet and blue dots. This is forest with less than 25 per cent bamboo.

LIS III images in CD format consist of 6483x6002 cells. Processing the whole image as one unit was difficult in the PC platform. Interactive extraction of the required area was done using a module of GIS Link program. Sufficient margin was provided all around to accommodate for geo-referencing later. False colour composites (FCC) from green, red and near infra red bands were made using the Idrisi program using the histogram equalization option. The theory behind this is quite well known, a combination of different bands would reveal characteristics of objects not visible in each band separately. This image was taken to the field for identification of bamboo. Dense bamboo areas appeared in red colour in the FCC. Deciduous forests in the month of February appeared in light blue colour. Forest mixed with bamboo appeared in different shades of violet colour in the FCC. Once the bamboo areas were identified, the same was fed in the supervised classification. To be useful in the field the range boundary, rivers, roads and plantation boundaries were added to the FCC. The FCC was geo-referenced with respect to Survey of India topo sheets. A module of GIS Link generated the correspondence file. The resample module of Idrisi was used for geo-referencing. Ten to fifteen points were required to achieve acceptable image registration. Points with high error were omitted. The coordinate limits of the range under consideration were fed to the resampling program. The output was generated as 600 x 600 cell images or as 900x600 cell images in case of rectangular areas. A mask of the range was prepared using the digitizing module of GIS Link. For this, area under the range was marked as polygon, the extent specified properly and the rasterise option chosen. The image size, same as the resampled image, was specified. The resampled image was filtered through the mask of the range. Forests boundaries, roads and place names were added to the filtered image and printed in A4 size using colour ink jet printer. These images were used during the field visits for correlating status of bamboo with different colour patterns in the FCC.

Field checks

Visits to the Muthanga range, Sultan Battery range and Kurichiyat range were carried out to examine the status of bamboo with the aid of the FCC prepared as above. The purpose of the visits was to collect sufficient ground truth information for visual interpretation of aerial photographs and digital processing of satellite images. This information was very crucial for selecting training sites during supervised classification of digital images.

Supervised classification

The FCC image was used for defining the training sites. At this stage, objects could not be delineated individually, but they looked sufficiently different to define the training sites. The training sites were needed in supervised image classification. In this method, areas containing known vegetation types were marked for the computer as learning sites. The computer examined the marked regions, analysed the spectral response of each object defined and delivered a signature for each type of landuse defined. During subsequent analysis,

spectral values in different bands in each pixel in the image were compared with the stored signatures and the pixel assigned to the object whose signature matched the closest. Appropriate module in the Idrisi program was used for this purpose. In the present work, 16 training sites of bamboo, forest, plantation and agriculture classes were defined. It was made sure that almost all the pixels were assigned to one of these classes after classification. The onscreen digitising feature was used for generating maps of learning sites. The Makesig module of Idrisi extracted the training sites and constructed the signature for each object. The Maxlike module of Idrisi was used for supervised classification by the maximum likelihood algorithm.

The classified image, as in the case of FCC was resampled to the extent of the range. The Reclass module of GIS Link was used for merging the non-bamboo forests and for providing appropriate colours to the image. The resampled image was filtered though the mask using the Overlay module of GIS Link. The legend layer was added to this image. Printing in A4 size was carried out by the appropriate module in GIS Link. The bamboo was classified into four density classes. The quantity of bamboo in these classes was estimated from sample plots in the forest. The quantity of bamboo in a class I plot of 100 x 100 m was estimated by complete enumeration. The quantity was estimated to be about 100 tonnes of green bamboo per hectare. Other studies confirm this as a reasonable estimate. The files generated in each step was stored in a subdirectory having the name of the range.

Unsupervised classification

After experience in interpreting major bamboo areas, bamboo could be separated out using clustering. This technique was used for some of the areas with sparse bamboo. The method employed is shown in the appropriate section.

Area calculation

The classified, resampled, reclassed, masked image gives bamboo under different categories in terms of number of cells. Area of one cell is calculated from the coordinates of the image.

$$a = \frac{(x_2 \times 60 - x_1 \times 60) \times 1.810}{ic}$$

$$b = \frac{(y_2 \times 60 - y_1 \times 60) \times 1.810}{ir}$$

$$area = a \times b$$

where x_1, x_2, y_1, y_2 are the coordinates of the area in degrees, *ic* and *ir* are the columns and rows of the image, 1.81 km is the area of one minute. Degree values are converted to minutes and multiplied by 1.81.

There were 15 well-defined steps in processing of the images. These had to be marked in a check sheet and ticked for each range. Nearly 100 computer files consisting of images, signatures and pallets and occupying more than 10 MB disk space were produced for each range. Files were systematically named and stored in separate sub directories for each range. For example, FCC, FCCR, FCCRM corresponded to original, resampled and masked FCC; SUP, SUPR, SUPRC and SUPRCM stand for supervised, resampled, reclassed and masked files. The ground truth was an important factor in defining the training sites. Initial attempts with limited field knowledge led to misclassification of sprouting eucalypt as bamboo. However, when the eucalypt was included in the training sites, the computer was able to classify it accurately. Paddy was also expected to have signature similar to that of bamboo. In the present study this effect was avoided by masking of all cultivation areas.

One important characteristic of this method was that the computer generated a confusion matrix. The confusion matrix listed the number of times each object of the training site got classified into another group. On the basis of this, very similar groups were merged. The accuracy obtainable would be even higher considering the fact that there was slight overlap between different classes of bamboo but very little overlap with other objects. In other words, accuracy would increase if the number of classes for bamboo was reduced.

Area covered

Three ranges, Muthanga, Sulthan Bathery and Kurichiat, were taken up first for standardizing the methodology. Analysis showed that with adequate field visits, bamboo area could be estimated from satellite imageries. The whole forest area in Kerala was covered, starting from the northern end divisions.

Data sources and programmes used

The main source of data was satellite images taken by the Indian Remote Sensing Satellite (IRS) 1C. In the present study, images in green, red, near infra red and middle infra-red regions (0.52-0.59 μm, 062-0.68 μm, 0.77-0.86 μm, 1.55-1.7 μm) of the LIS III sensor of IRS IC were used. Satellite images taken in February 1997 were obtained from the National Remote Sensing Agency (NRSA) in CD ROM format. In addition to this, aerial photographs in 1:15,000 scale taken during 1990-92 period available in the Institute were also used. The satellite images have a spatial resolution of 23 m on the ground. Images are available in four bands green, red, infrared and middle infrared. The spatial resolution is not sufficient for identifying individual trees, but plant formations can be clearly recognized. Images taken in 1997 in the month of February was used for the analysis. For Kannur Division image taken in 1998 February by IRS ID satellite was used for most areas. This image also has same specification as the other images. Details of frames used are shown below.
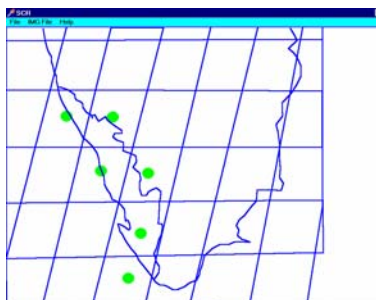
Six multispectral satellite images cover the entire Kerala. The images were assembled and kept in ready to be called format. First the required frame was called and then the required area extracted.

With the increase in capacity of PCs and availability of images in CDs, tasks such as image processing can be done in PC at user sites. For the present study, Idrisi a raster based Geographic Information System (GIS), available since several years in PC based systems was used (Eastman, 1995). This package contains most of the basic GIS and image processing functions, but does lack some features. The gap was filled by GIS Link, a soft ware developed at the Kerala Forest Research Institute for data conversion and supplementing GIS and image processing packages. GIS Link has user friendly modules for digitization, rasterisation, interactive image extraction, geo-coding, and overlaying operations.

Statistical estimation of growing stock

Methodology adopted for the estimation of the mean growing stock per ha of bamboo bearing forests by different density status and total growing stock of bamboo in the forests of Kerala, is described here. Growing stock of bamboo, in this study, refers to the weight (tonnage) of the utilisable portion of standing green culms irrespective of species. Utilisable portion refers to that portion of the bamboo culm which can be used for pulping. It is the portion after removing the branches and tip of the culm.

Bamboo bearing patches were classified on the basis of density of bamboo clumps as (1) high density bamboo patches (areas with pure bamboo), (2) medium density bamboo patches (areas bearing bamboo predominantly) and (3) low density bamboo patches (areas with poor bamboo stock). High density patches are those where bamboo covers most of the canopy cover. Patches where more than half of the area occupied by bamboo, were considered as medium density patches. Any areas with poor stocking of bamboo less than the other two were considered as low density patch. Apart from the above three density classes, bamboo plantations were also considered and formed as the fourth class. Bamboo plantations include plantations mixed with bamboo and those with bamboo as under growth. Forest areas with isolated bamboo clumps here and there were not considered in this study.

Sampling design

For the estimation of growing stock (weight in tonnes) of bamboo per ha in the forests of Kerala, a stratified random sampling design was adopted. The population under study was the totality of the bamboo bearing forests in Kerala. The totality of bamboo bearing patches of a particular density status formed a stratum. Thus, the totality of all high density bamboo patches formed the first stratum, that of all medium density patches formed the second, that of all low density patches formed the third and that of all bamboo plantations formed the fourth stratum[1].

Preparation of sampling frame

A bamboo bearing patch was the unit of sampling in a stratum. It was expected that the list of bamboo bearing patches in different strata and the area under each patch within a stratum would be made available through interpreting the remote sensing data. But, the lists

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[1] Patches, where bamboo flowered within the last 10 years, were excluded. This is because the seedlings which emerge after flowering take 10 to 15 years to mature into full sized culms.

of patches were not made available through the interpretation of remote sensing data. So, another way was adopted upon for the preparation of the sampling frame for the selection of sampling units. Bamboos from Kerala forests are exclusively allotted to Grasim Industries and Hindustan Newsprint Limited as raw material. For each year, specific bamboo bearing forests are allotted to them for extraction. Bamboos are collected from forests and supplied to the companies by their contractors. A list of bamboo bearing patches in the forests of Kerala and bamboo plantations was prepared based on the data available in the files of the Forest Range Offices, registers maintained by the two companies and information obtained through discussions with the Officials of the Raw-material Divisions of the companies for the data on the distribution of bamboo bearing patches). Discussions were also held with the bamboo felling contractors and their agents of the two companies for obtaining information on the density of bamboo clumps in different patches. The list of bamboo bearing patches was further refined and the localities of bamboo bearing patches were stratified on the basis of the three density classes. The lists, thus prepared, were used as the sampling frame for the selection of units in different strata.

Sample size and unit of observation

The sample size was fixed at 16, considering the limited resource available for the survey. Sixteen patches each were selected from each of the four strata by simple random sampling without replacement. During field visits prior to the survey, it was observed that the variation within a patch was relatively low. Moreover, the variation in the growing stock within a stratum is more important than the variation within a patch. With the constraints on cost of the survey, only one plot could be taken for enumeration from each selected patch. The plot was of size 0.4 ha (1 acre). It was taken on a randomly laid out transect in the selected patch. The plot was marked by cutting the boundaries and fixing pegs at four corners. In the sampling plan adopted in this study, the basic observation was the plot-level growing stock of bamboo which was the weight (in tonnes) of utilisable portion of all standing culms in all the bamboo clumps in the plot.

Data collected from the plot

Data collected from a plot included number of clumps, full green culms including new shoots, full dry culms, green and dry butts in each clump. Two elliptical diameters[2],

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[2] The elliptical diameters were taken considering that the base of the clump is usually having a shape of an ellipse.

perpendicular to each other at the base of each clump, were also taken. All the culms by culm-size classes[3] were enumerated in each clump in the plot, where the counting of the exact number of culms was feasible. Often, counting the number of culms by culm-diameter classes was very difficult in certain clumps. This happens, usually, in unworked very old clumps where the green culms were congested due to the nature of thorny branches and dried culms. If counting of culms at the base by culm-diameter class was not feasible, only the two elliptical diameters were taken.

Estimation of average weight of culms in different culm-diameter classes

Based on the list of forest areas allotted to Grasim Industries and Hindustan Newsprint Limited for the extraction of bamboo during the year 1998-99, different bamboo felling coupes in the forests representing different Forest Circles in Kerala were selected. Such felling coupes were visited with the help of the contractors of the companies. Arrangements were made for taking the weight of utilisable portion of full standing green and air-dry culms while felling. Culms in the five culm-diameter classes were selected and weighed immediately after felling, using two spring balances maintaining each culm in horizontal suspension. Individual weight of more than 40 culms each in the five culm-diameter classes were taken separately for green and air-dry culms. Using these data, average weights of green as well as air-dry culms in the five culm-diameter classes were estimated.

The average fresh weight of utilisable portion of a green bamboo culm in different culm-diameter classes are presented in Table 1. The average fresh weight ranged from 16 kg for a very small green culm to 113 kg for a very big green culm. While 63 very small green culms made up one tonne, nine very big culms made up one tonne. The estimated average weight of utilisable portion of an air-dry culm in different culm-diameter classes is also presented in Table 1. The average weight ranged from 9 kg for a very small air-dry culm to 64 kg for a very big air-dry culm. When 106 number of very small air-dry culms made up 1 tonne, 16 very big culms were found equivalent to a weight of 1 tonne. The percentage of air-dry weight to green weight of a culm under natural conditions ranged from 56 to 65.

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[3] The different classes were very small (below 5cm culm-diameter), small (5 to 7.5 cm), medium (7.5 to 10 cm), big (10 to 12.5 cm) and very big (above 12.5 cm). The culm-diameter refers to the diameter at the middle of the second inter-node from the bottom

Table 1. Average weight of utilisable portion of green and air-dry bamboo culms in different culm size classes.

Culm size	Green culms		Air-dry culms	
	Average weight (kg)	Number of green culms equivalent to one tonne	Average weight (kg)	Number of air-dry culms equivalent to one tonne
Very small (<5 cm) *	15.840	63	9.437	106
Small (5 - 7.5)	33.195	30	20.962	48
Medium (7.5 - 10.0)	56.458	18	36.460	27
Big (10 - 12.5)	85.577	12	47.944	21
Very big (> 12.5 cm)	113.027	9	64.325	16

* The figures in brackets are culm-diameter classes. Culm-diameter refers to the diameter at the middle of the second inter node from the bottom.

Calculation of clump weight in the plot

Clump weight refers to the sum of weights of utilisable portion of individual green culms in the clump. If counting of culms by culm-diameter classes was feasible, the clump weight was calculated as the sum of product of the number of standing green culms and average fresh weight of green culms in different culm-diameter classes. The weight of standing green culms in the clump, in air-dry condition, was worked out as the product of the number of green culms and average weight of air-dry culms in different culm-diameter classes. If counting of culms in a clump was not feasible, the weight of such clump was predicted using the estimated functional relationship of clump-weight with the mean basal diameter of the clump. The functional relationship was estimated as follows. Using the data on number of culms and average weight of culms in different culm-diameter classes, the clump-weight(W) was calculated for each clump. Based on the clump-weight (W) and basal mean clump-diameter (D), regression functions were fitted, taking W as regressand and D as regressor. Twenty seven different models were fitted and the best one was selected based on adjusted R^2 value, Furnival index and characteristics of residuals. Among different models fitted, the best model has been selected and given below. The regression coefficients are statistically significant at 1 per cent probability level. The figures given in parentheses below the coefficients are standard errors. The adjusted R^2 value was 0.77.

$$\ln(W) = 1.718 + 0.440\, D^{1/2} - 0.007\, D,$$
$$\quad\;\; (0.08)\;\;\; (0.01)\qquad (0.0005)$$

where W : Fresh weight (in kg) of green culms in the clump and D : mean of the two elliptical diameters (in cm) at the base of the clump.

In situations where the exact number of green culms in a bamboo clump was not available due to difficulties in counting the number in the field, the above equation was used for predicting the weight of that clump based on the measured mean basal diameter of the clump.

Calculation of plot-level growing stock

Weight of bamboo (fresh green or air-dry condition) in each clump in the plot was calculated by the methods mentioned above. The weights of all the clumps in the plot thus calculated were added together to obtain the growing stock (tonnage) in the plot.

Estimation of mean growing stock

The estimated plot level growing stock of bamboo (fresh weight of green culms or weight in air-dry condition) was the basic observation in the sampling scheme. For estimating the mean growing stock of bamboo (weight in tonne) per ha in each stratum, the method initially planned was to calculate the growing stock of the selected patch based on the plot-level growing stock and area under that patch and to use a ratio-type estimator taking the area under the selected patch as the auxiliary variable. But the data on area under each selected bamboo patch in different strata were not available. Therefore, the simple mean based on the plot-level growing stock in each stratum was taken as the mean growing stock per plot in the stratum. Based on this, the mean growing stock per ha in each stratum was estimated.

Table 2. Mean growing stock of bamboo (fresh weight of green culms and weight in air-dry condition) per ha in different density classes of bamboo forests in Kerala.

Bamboo density class	Weight (tonnes) per ha	
	Fresh weight of green culms	Weight equivalent in air-dry condition
Forest areas with pure bamboo stock	147.8 (137.7 - 157.9) [#]	89.5 (84.0 - 95.0)
Forest areas where bamboo growing predominantly	83.8 (70.5 - 97.1)	51.3 (43.3 - 59.3)
Forest areas with poor bamboo stock	29.4 (24.2 - 34.6)	18.0 (14.8 - 21.2)
Bamboo plantations	70.0 (56.3 - 83.7)	43.3 (35.0 - 51.6)

[#] The figures in brackets are the 95% confidence intervals.

The estimates on mean growing stock of bamboo bearing forests by the four density status per ha are shown in Table 2. The growing stock (tonnage) of green culms per ha ranged from 29.4 tonnes in areas with poor bamboo stock to 147.8 tonnes in pure bamboo forests. When the fresh weight of green culms was converted into air-dry weight equivalent, the weight of bamboo in air-dry condition per ha ranged from 18.0 tonnes in area with poor stock to 89.5 tonnes in area with pure bamboo stock.

Estimation of growing stock of bamboo

The mean growing stock of bamboo (in tonnes) per ha was estimated for bamboo bearing forests under each density status. The area (in ha) under each density status was computed through the interpretation of remote sensing data. The total growing stock (in tonne) in bamboo bearing forests under a particular density status was arrived at by multiplying the area (in ha) with the mean growing stock of bamboo (in tonne) per ha under bamboo bearing forests of that density status. In this study, the growing stock is expressed in weight (tonne) of bamboo culms in air-dry condition.

Results and discussions

Area under bamboo and growing stock

The Olavakode region comprising Olavakode Circle and Parambikulam WLS has the maximum quantity (34.0%) of bamboo among the five regions in the state. Most of the bamboo in this region is in Nilambur North, Nilambur South and Parambikulam Wildlife Sanctuary. This was followed by the Northern region (30.7%). The Northern region includes the Northern Circle and Wayanad Wildlife Sanctuary. The Southern region comprising the Southern Circle and protected areas comes to third position (21.7%) in terms of bamboo availability. The Trivandrum Wildlife Division, Trivandrum Division and Achenkovil Division contribute the maximum. The Central region and High Range region contain 8.9 per cent and 4.7 per cent respectively.

Table 3. Status of bamboo indifferent circles of Kerala forests.

Sl.No	Circle	Total forest area $(km^2 *)$	Bamboo stock (Dry, tonnes)	Yearly availability (tonnes)	Per cent (%)
1.	Northern region	1,522.74	807,151.00	67,262.59	30.68
2.	Olavakod region	2,230.98	895,130.80	74,594.25	34.03
3.	Central region	1,723.79	234,205.70	19,517.15	8.91
4.	High range region	2,820.51	122,726.80	10,227.23	4.66
5.	Southern region	2,828.44	571,232.00	47,602.67	21.72
	Total	11,126.46	2,630,446.3	219,203.89	100

Division wise, maximum quantity of bamboo is in the Wayanad Wildlife Sanctuary (16.2% of total) and Nilambur North Division (15.0%). This is followed by Achenkovil (7.9%), Parambikulam (6.0%), Nilambur South (5.7%), Wayanad North (5.6%), Trivandrum (2.8%) and Trivandrum Wildlife (2.6%) Divisions. Other divisions have relatively less bamboo.

The total quantity is a huge figure and is difficult to visualise. Yearly availability of bamboo is also shown in the tables. This is derived by dividing the total quantity by twelve. This is based on the assumption that extraction is carried out every four years and during extraction one third of the clump is removed. The yearly availability can easily be visualised

in terms of truck loads of bamboo. Quantity of bamboo, circle and division wise, is shown in Table 4. Area of bamboo under different density classes is shown in Table 5.

Table 4. Quantity of bamboo available indifferent divisions of Kerala forests.

Sl.No	Division	Total forest area (km^2)	Growing stock (dry, tonnes)		Per cent (%)
			Bamboo stock (Dry, tonnes)	Yearly availability	
Northern Region					
1	Kannur and Aralam WLS	345.32	75473.10	6289.43	2.87
2	Kozhikode	290.83	109081.20	9090.10	4.15
3	Wayanad North	215.89	138989.10	11582.43	5.28
4	Wayanad South	326.14	57119.80	4759.98	2.17
5	Wayanad WLS	344.56	426487.80	35540.65	16.21
Olavakode Region					
6	Nilambur North	393.96	393435.90	32786.33	14.96
7	Nilambur South	365.44	150863.70	12571.98	5.74
8	Silent Valley NP	89.52	---	---	---
9	Mannarkad	530.11	102544.40	8545.37	3.90
10	Palakkad	238.40	41976.00	3498.00	1.60
11	Nemmara	339.41	48675.20	4056.27	1.85
12	Parambikulam WLS	274.14	157635.60	13136.30	5.99
Central Region					
13	Trichur	337.37	16408.80	1367.40	0.62
14	Chalakudy	354.71	41043.20	3420.27	1.56
15	Vazhachal	413.94	112772.10	9397.68	4.29
16	Malayattur	617.77	63981.60	5331.80	2.43
High range Region					
17	Kothamangalam	317.02	44774.40	3731.20	1.70
18	Idukki WLS	317.96	17617.20	1468.10	0.67
19	Munnar	715.84	42675.60	3556.30	1.62
20	Mankulam	---	---	---	---
21	Kottayam	692.15	17659.60	1471.63	0.67
22	Periyar Tiger Reserve	777.54	---	---	---
Southern Region					
23	Ranni	1059.07	67797.60	5649.80	2.58
24	Konni	331.66	27538.80	2294.90	1.05
25	Achenkovil	269.00	207500.80	17291.73	7.89
26	Punalur	280.22	19164.80	1597.07	0.73
27	Thenmala	206.17	108801.20	9066.77	4.14
28	Trivandrum WLS	312.44	67924.80	5660.40	2.58
29	Trivandrum	369.88	72504.00	6042.00	2.76
	Total	11,126.46	2630446.3	219203.89	100.00

--- too sparse; industrial exploitation / area not available

Table 5. Area of bamboo available in different divisions of Kerala forests.

Sl.No	Division	High (km²)	Medium (km²)	Low (km²)
Northern Region				
1	Kannur and Aralam WLS	0.59	8.56	12.59
2	Kozhikode	0.00	10.24	23.39
3	Wayanad North	0.00	21.55	6.03
4	Wayanad South	0.00	3.54	16.77
5	Wayanad WLS	6.53	45.55	45.20
Olavakode Region				
6	Nilambur North	14.03	34.02	17.22
7	Nilambur South	0.00	19.65	17.31
8	Silent Valley NP	0.00	0.00	0.00
9	Mannarkad	0.00	0.00	48.37
10	Palakkad	0.00	0.00	19.80
11	Nemmara	0.00	0.00	22.96
12	Parambikulam WLS	0.00	18.40	23.93
Central Region				
13	Trichur	0.00	0.00	7.74
14	Chalakudy	0.00	0.00	19.36
15	Vazhachal	0.00	19.41	0.00
16	Malayattur	0.00	0.00	30.18
High range Region				
17	Kothamangalam	0.00	0.00	21.12
18	Idukki WLS	0.00	0.00	8.31
19	Munnar	0.00	0.00	20.13
20	Mankulam	0.00	0.00	0.00
21	Kottayam	0.00	0.00	8.33
22	Periyar Tiger Reserve	0.00	0.00	0.00
Southern Region				
23	Ranni	0.00	0.00	31.98
24	Konni	0.00	0.00	12.99
25	Achenkovil	0.00	27.80	21.69
26	Punalur	0.00	0.00	9.04
27	Thenmala	0.00	11.52	19.75
28	Trivandrum WLS	0.00	0.00	32.04
29	Trivandrum	0.00	0.00	34.20
	Total	21.15	220.24	530.43

Division wise estimates of bamboo stock (dry)
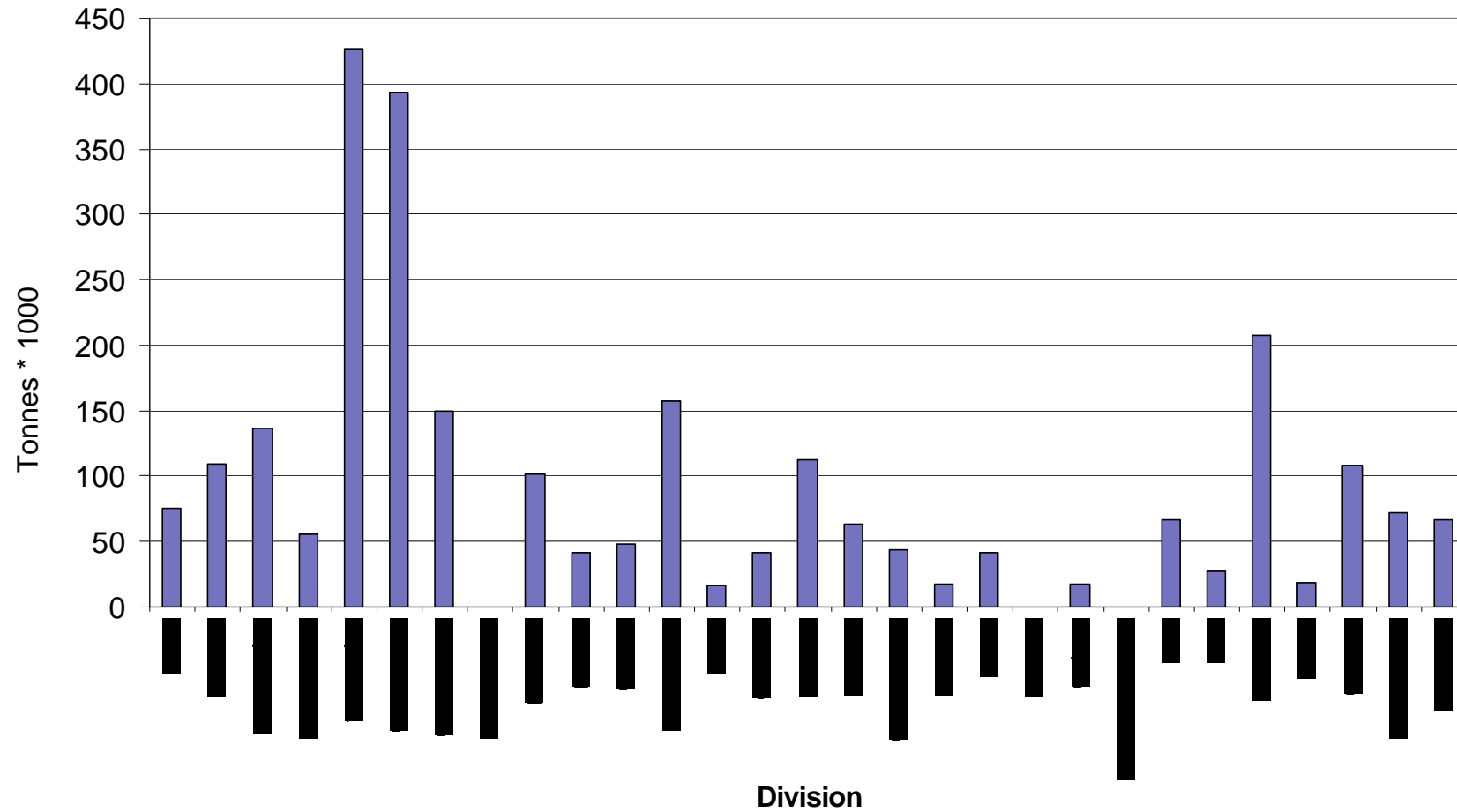
Northern Region

The Northern region consisting of Kannur, Kozhikode, Wayanad North and Wayanad South Divisions along with the Wayanad Wildlife Sanctuary is one of the most important bamboo bearing areas in Kerala. Some of the areas were vested forests and because of this no previous information about bamboo resources was available. The area is near to GRASIM, one of the prime consumers of bamboo as a raw material. Summary of bamboo available in the region is given below (Table 6).

Table 6. Status of bamboo in Northern Region

Sl.No	Division	Total forest area (km^2*)	Bamboo stock (Dry, tonnes)	Yearly availability (tonnes)	Per cent (%)
1	Kannur and Aralam WLS	345.32	75473.10	6289.43	9.35
2	Kozhikode	290.83	109081.20	9090.10	13.51
3	Wayanad North	215.89	138989.10	11582.43	17.22
4	Wayanad South	326.15	57119.80	4759.98	7.08
5	Wayanad WLS	344.56	426487.80	35540.65	52.84
	Total	1,522.74	807151.00	67262.59	100.00

(*) Forest Statistics (1997). Kerala Forest Department

In Northern region, maximum quantity of bamboo is recorded from Wayanad Wildlife Sanctuary (52.8%) and Wayanad North (17.2%) Division. Wayanad South and Kannur Division have the least bamboo (7.1 and 9.4%). Based on survey of an effective area of 352 km^2 of the then Calicut Division, Chandrasekharan (1973) estimated a growing stock of 1,68,000 metric tonnes (air dry) of bamboo. This area includes the present Wayanad Wildlife Sanctuary and excludes the vested forests. Because of the change in area covered no comparison is possible. Division wise details for the region is described below.

Kannur Division

The Kannur Division, the northern most forest division in Kerala consists of reserve forests and previous vested forests. There are five ranges in the division of which Kannavam Range is the largest and Thaliparamba the smallest. Vegetation consists of moist deciduous and lateritic semi evergreen types. Bamboo is found in some parts. Evergreen forest is found in part of Kottiyur, Kannavam and Kanhangad Ranges. From Table 7 it can be seen that Kannavam Range has the maximum quantity of bamboo. Bamboo is located in few small dense patches in this range. There are about 100 ha of bamboo plantations in different parts of the division. Prescription for extraction for Kannavam Range often is of the order of 1000 tonnes per year whereas for area such as Kottiyur and Kanhangad 250 tonnes is the target.

Table 7. Status of bamboo in Kannur Division

Sl.No	Range	Total forest area (km^2 #)	Bamboo stock (Dry, tonnes)	Yearly availability (tonnes)	Method
1	Kannavam	93.85	41526.30	3460.53	+
2	Kottiyur	60.68	15651.20	1304.27	+
3	Thaliparamba	24.85	---	---	+
4	Kanhangad	50.48	6996.00	583.00	+
5	Kasargod	60.46	8458.80	704.90	+
6	Aralam	55.00	2840.80	236.73	-
	Total	345.32	75473.10	6289.43	

(#) Forest Statistics (1997). Kerala Forest Department, (---) Too sparse for industrial exploitation.
(-) Unsupervised classification, no field checking, (+) Unsupervised classification, limited field checking,
(*) Supervised classification extensive field checking.

In Kasargod and Thaliparamba Ranges bamboo is not present in industrially extractable quantities. In Kanhangad Range bamboo is available in Kinnanur RF and Maloth region. In Kottiyur Range industrially exploitable bamboo is limited to Kannavam extension RF. In Kannavam range the Kannavam RF contains bamboo. Interior areas may have transportation problems. Part of Parappa RF is reported to have flowered about 20 years ago. Bamboo is present only in small patches in Aralam Wildlife Sanctuary. Being a Wildlife sanctuary, as per current practice, extraction of bamboo, if any, will be carried out only after flowering.

Kozhikode Division

The Kozhikode Division at present consists of Kuttiady, Peruvannamuzhy and Thamarassery Ranges. The name Calicut Division of the past consisted of different areas. There was also Kozhikode special Division prior to formation of the present Kozhikode division. The Division consists mostly of erstwhile vested forests. Few reserve forests also come within the division. Working plan for the division is still under preparation. Total area of the division is 290.83 km^2 (KFD, 1997). Peruvannamuzhy is the largest range. Kannoth and Periya RF are situated to the north of the division. The Kuttiady hydro electric project area comes within this division. Both sides of the ridge are steep, from 1500 m to 700 m on the Wayanad side and to 100 m on the Calicut side. Kurichiyar mala (1606 m) is the highest peak in the area. There are some high elevation evergreen forest and grassy areas near the Kakkayam dam. Eucalypt plantations were raised in some areas. Large part of Kuttiady Range has rocky areas. Peruvannauzhy Range contains deciduous forest, semi evergreen forest and evergreen forest. Vegetation wise, this range is very rich but rubber plantations, acacia plantations and released areas are also there. The Peruvannamuzhy and Kakkayam reservoirs have also submerged forests as well as teak plantations. Details of bamboo in the division is shown in Table 8.

Table 8. Status of bamboo in Kozhikode Division

Sl.No	Range	Total forest area (km^2#)	Bamboo stock (Dry, tonnes)	Yearly availability (tonnes)	Method
1	Kuttiady	63.39	---	---	+
2	Peruvannamuzhy	127.72	47119.00	3926.58	+
3	Thamarasserry	99.72	61962.20	5163.52	+
	Total	290.83	109081.20	9090.10	

(#) Forest Statistics (1997). Kerala Forest Department, (---) Too sparse for industrial exploitation.
(-) Unsupervised classification, no field checking, (+) Unsupervised classification, limited field checking,
(*) Supervised classification extensive field checking.

Bamboo has in the past been extracted from parts of Peruvannamuzhy and Thamarasserry Ranges. The working plan period for the Kozhikode special division ended in 1990. Since there is no approved working plan after this, extraction of bamboo is carried out on ad hoc basis or after flowering of bamboos. It is possible to extract bamboos located in areas near the reservoir. Bamboo from foothills of Kakkayam can be extracted with some

difficulty. The area adjoining Thamarasserry Range contains bamboo, but it is not easily accessible. The situation is same in the Thamarasserry Range as a large quantity of bamboo is present on the slopes of the previous vested forests adjoining Peruvannamuzhy Range.
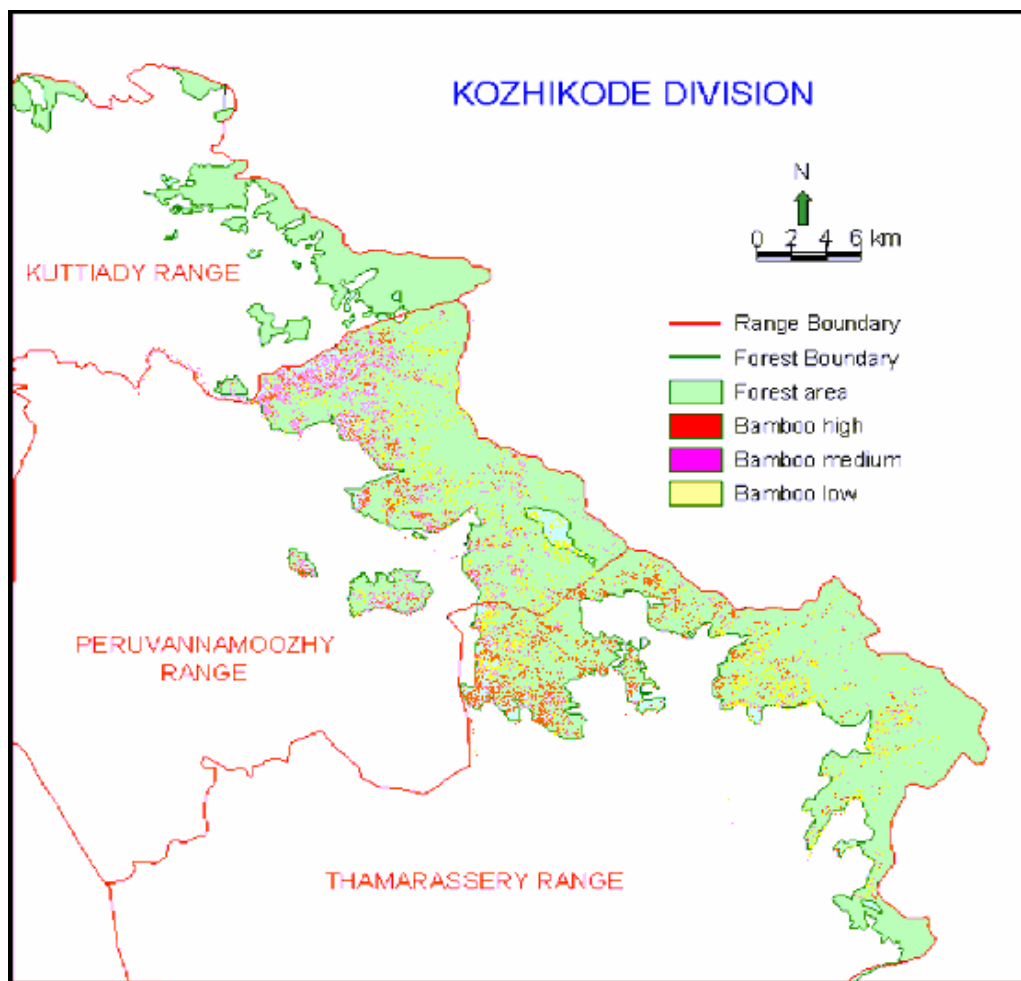
Fig. 3. Status of bamboo in Kozhikode Division

Peruvannamuzhy and Thamarasserry Ranges contain huge quantity of bamboo, which if properly managed can meet a major portion of industrial bamboo requirement in the region. The area of interest is the vested forest at the junction of these two ranges. The forest in this locality between valleys will have to be sub-divided and managed. Area seems to be good for intensive bamboo planting. Road along hill contours will have to be established. There is an area in the 3rd hill called Nilambur Kadu-Patukad eucalypt plantation. That area is mainly occupied by bamboo now. Forest department has decided not to tend eucalypt but to take care of bamboo. Bamboo in parts of Peruvannamuzhy Range and Thamarasserry Range has flowered in 1998. Remaining parts of Thamarasserry Range may flower soon.

Wayanad Wildlife Division

The Wayanad plateau is well known for its deciduous and semi evergreen forest, bamboo and wildlife. Large number of plantations and settlements have broken the forest continuity to some extent. Wayanad Wildlife Sanctuary was declared in 1973. As much as 33 per cent% of the sanctuary is under different types of plantations. The Wayanad Wildlife Sanctuary consists of about 344.56 km^2 of good bamboo area. The three ranges Muthanga, S.Bathery and Kurichiat are contiguous. Tholpetty is a separate chunk of forest, which has continuity with the Nagarhole National Park. The area break up is shown below. Bamboo flowered in 1992 in many parts of the sanctuary. The flowered bamboo was extracted for industrial use. Mature bamboo in many parts of Muthanga and Sulthan Bathery Ranges may flower at any time. Being a wildlife sanctuary bamboo is extracted only after flowering. Details of bamboo in the division are shown in Table 9.
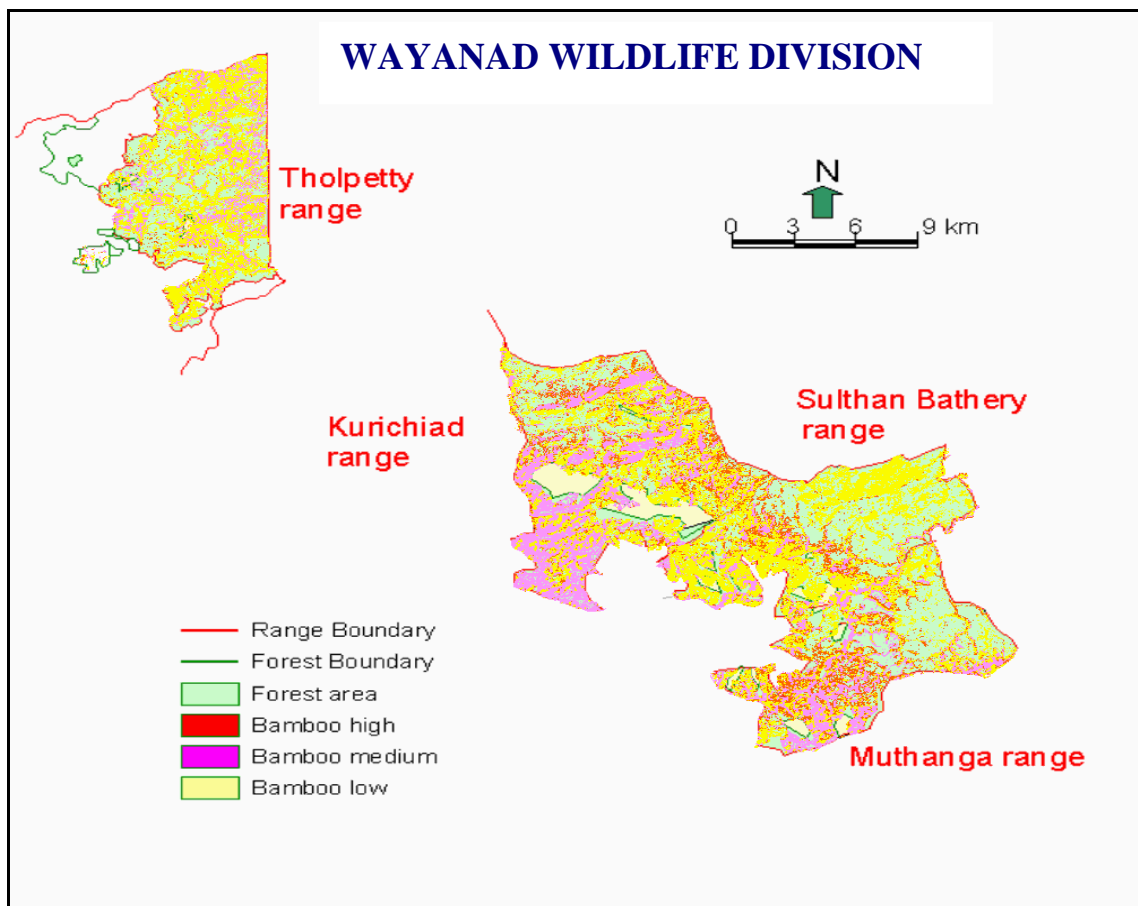
Fig. 4. Status of bamboo in Wayanad Wildlife Division

Table 9. Status of bamboo in Wayanad Wildlife Division

Sl.No	Range	Total forest area (km^2 #)	Bamboo stock (Dry, tonnes)	Yearly availability (tonnes)	Method
1	Tholpetty	77.67	117723.40	9810.28	*
2	Kurichiat	106.56	147398.60	12283.22	*
3	Muthanga	74.30	100656.70	8388.06	*
4	Sulthan Bathery	86.03	60709.10	5059.09	*
	Total	344.56	426487.80	35540.65	

(#) Forest Statistics (1997). Kerala Forest Department,
(-) Unsupervised classification, no field checking, (+) Unsupervised classification, limited field checking,
(*) Supervised classification extensive field checking.

Wayanad North Division

The Wayanad North Division was recently formed. Forest continuity had been the main basis for the reorganization. Reserved forests and vested forests have been brought under unified system of management. The forest coming under the Wayanad Forest Division had been under several administrative units earlier. The Wayanad North Division consists of Begur range, Periya range and Mananthavadi range. The largest is Begur Range followed by Periya Range. Area break up is given below. Many parts of Begur Range contain bamboo. Vast areas of well grown bamboo in the Thirunelly area are the most notable. Several plantations in vested forest areas are also overgrown with bamboo. Periya and Mananthavady Ranges contain only little bamboo. The bamboo in the Thirunelly area may flower in due course. Bamboo in other areas, especially vested forests, appears to be about 20-25 years old, judging from the size of the clumps. Periya and Mananthavady Ranges contain only scattered clumps of young bamboo. There does not seem to be any scope for industrial exploitation. Detailed estimation was not attempted. Details of bamboo in the division area shown in Table 10.

Based on survey of an effective area of 443 km^2 of the then Wayanad Division, Chandrasekharan (1973) estimated a growing stock of 64,000 tonnes (air dry) of bamboo. It is not possible to compare present results of this study with the figure above because the divisions have been totally reorganized.

Table 10. Status of bamboo in Wayanad North Division

Sl.No	Range	Total forest area (km^2#)	Bamboo stock (Dry, tonnes)	Yearly availability (tonnes)	Method
1	Begur	104.78	137989.10	11499.09	+
2	Periya	85.06	500.00	41.67	---
3	Mananthavady	26.05	500.00	41.67	---
	Total	215.89	138989.10	11582.43	

(#) Forest Statistics (1997). Kerala Forest Department, (---) Bamboo too sparse for industrial exploitation.
(-) Unsupervised classification, no field checking, (+) Unsupervised classification, limited field checking,
(*) Supervised classification extensive field checking.
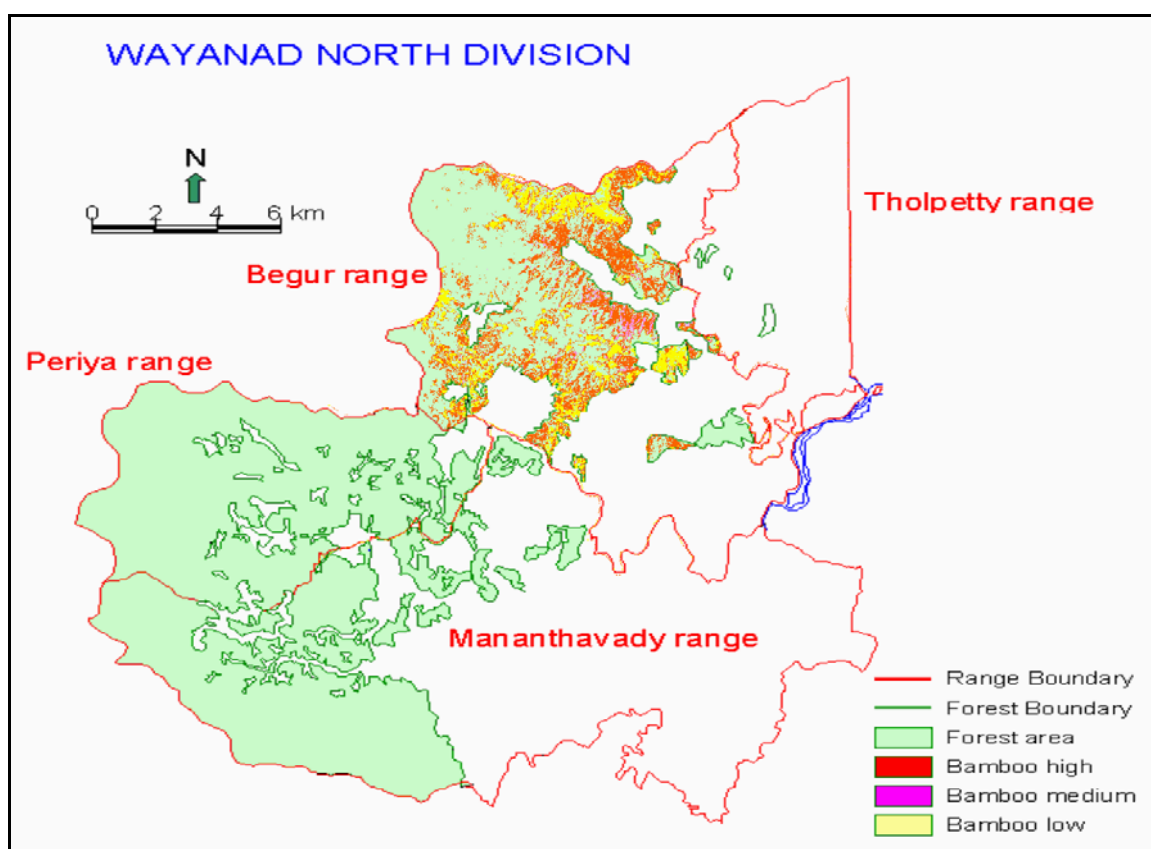
Fig. 5. Status of bamboo in Wayanad North Division

Wayanad South Division

The Wayanad South Division was recently formed. Forest continuity had been the main basis for the reorganisation. Reserved forests and vested forests have been brought under unified system of management. The forest coming under the Wayanad Forest Division had been under several administrative units earlier. Geographically, the Chedleth Range itself

is in two parts. The eastern portion is contiguous with the Kurichiat range of Wayanad Wildlife Sanctuary. The Padri reserve is a well-known bamboo area since several decades. Kalpetta and Meppady Ranges are part of a hill chain running parallel to the main Western Ghats. Estates and cultivation separate these two sets of areas. Kalpetta Range is situated on the eastern side of Thamarassery hills. Meppady Range is situated on the eastern side of Nilambur forest. The hills here are of high elevation with forests sloping to Nilambur valley, Thamarassery valley and Wayanad proper.
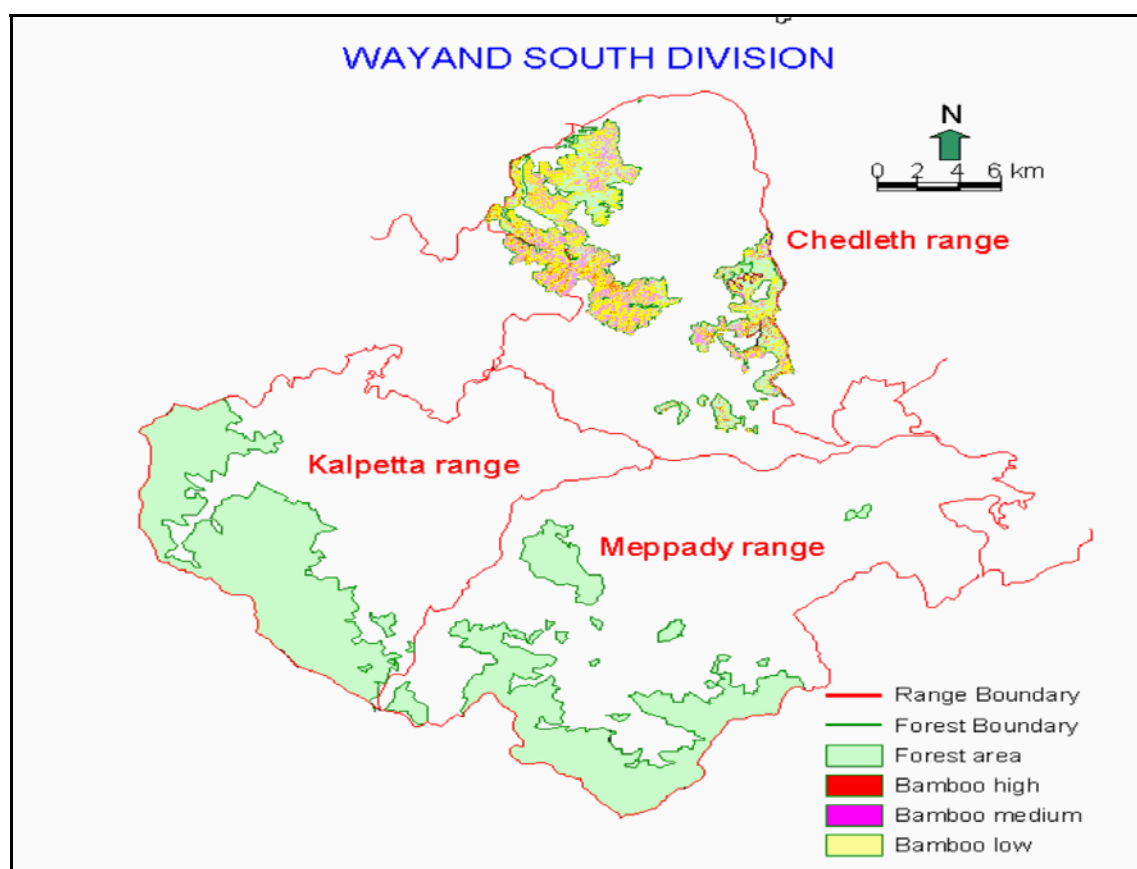
Fig. 6. Status of bamboo in Wayanad South Division

As mentioned earlier, the three ranges are situated in two geographically distinct areas. Chedleth Range is the smallest, but from the point of view of economic value and bamboo, it is richest. Area break up is given below. Bamboo is regularly being extracted from the Padri reserve. The earlier vested forests of Kalpetta and Meppady contain only little quantity of bamboo. Small patches in Kalpetta are reported but there does not seem to be any scope for industrial scale extraction. Small pockets of Meppady Range do contain bamboo. These are situated near roads and hence logically it is feasible to extract them. Bamboo in the areas adjoining Kurichiat Range flowered around 1993. Bamboo is getting established in

these areas. Some pockets still contain mature bamboo clumps. Most parts of Padri reserve, especially the southern parts contain full grown bamboo clumps. Small patches have already flowered and flowering seems to be imminent in the remaining areas. Details of bamboo in the division is shown in Table 11.

Table 11. Status of bamboo in Wayanad South Division

Sl.No	Range	Total forest area (km^2#)	Bamboo stock (Dry, tonnes)	Yearly availability (tonnes)	Method
1	Kalpetta	123.29	500.00	41.67	+
2	Meppady	116.86	500.00	41.67	---
3	Chedelath	86.00	56119.80	4676.65	+
	Total	326.15	57119.80	4759.98	

(#) Forest Statistics (1997). Kerala Forest Department, (---) Bamboo too sparse for industrial exploitation,
(-) Unsupervised classification, no field checking, (+) Unsupervised classification, limited field checking,
(*) Supervised classification extensive field checking.

Olavakode Region

The Olavakode region is situated south of the northern region and comprises Nilambur North, Nilambur South, Mannarkad, Palakkad and Nemmara Forest Divisions. Because of geographic continuity, the Silent Valley National Park and Parambikulam Wildlife Sanctuary are also included under this. Nilambur North Division has maximum (44.0% of bamboo in the region), Parambikulam (17.6%) and Nilambur South (16.9%) have the next highest bamboo in the region (Table 12). This is one of the best bamboo bearing areas in the state. Availability of bamboo in the region is summarised below.

Table 12. Status of bamboo in Olavakode Region

Sl.No	Division	Total forest area (km^2 *)	Bamboo stock (Dry, tonnes)	Yearly availability (tonnes)	Per cent (%)
1	Nilambur North	393.96	393435.90	32786.33	43.95
2	Nilambur South	365.44	150863.70	12571.98	16.85
3	Silent Valley NP	89.52	---	---	---
4	Mannarkad	530.11	102544.40	8545.37	11.46
5	Palakkad	238.40	41976.00	3498.00	4.69
6	Nemmara	339.41	48675.20	4056.27	5.44
7	Parambikulam WLS	274.14	157635.60	13136.30	17.61
	Total	2,230.98	895130.80	74594.25	100.00

(*) Forest Statistics (1997). Kerala Forest Department, (---) Too sparse for industrial exploitation.

Nilambur North Division

Nilambur North Division consists of Nilambur, Edavanna and Vazhikadavu Ranges. These forests were mostly vested forests earlier. Vegetation consists of deciduous and evergreen forests. The main bamboo areas in the Nilambur North Division are Marutha, Vellakatta, Nellikutha, Pothukallu, Mundapotty, Thannikkadavu, Munderi, Cherambadi,, Pokkode, Edakkode, Elenchery, Ramaloor, Urngathiri malavaram, Nedumcheri malavaram and previous Manjery kovilakam regions. Details of bamboo in the division are shown in Table 13.
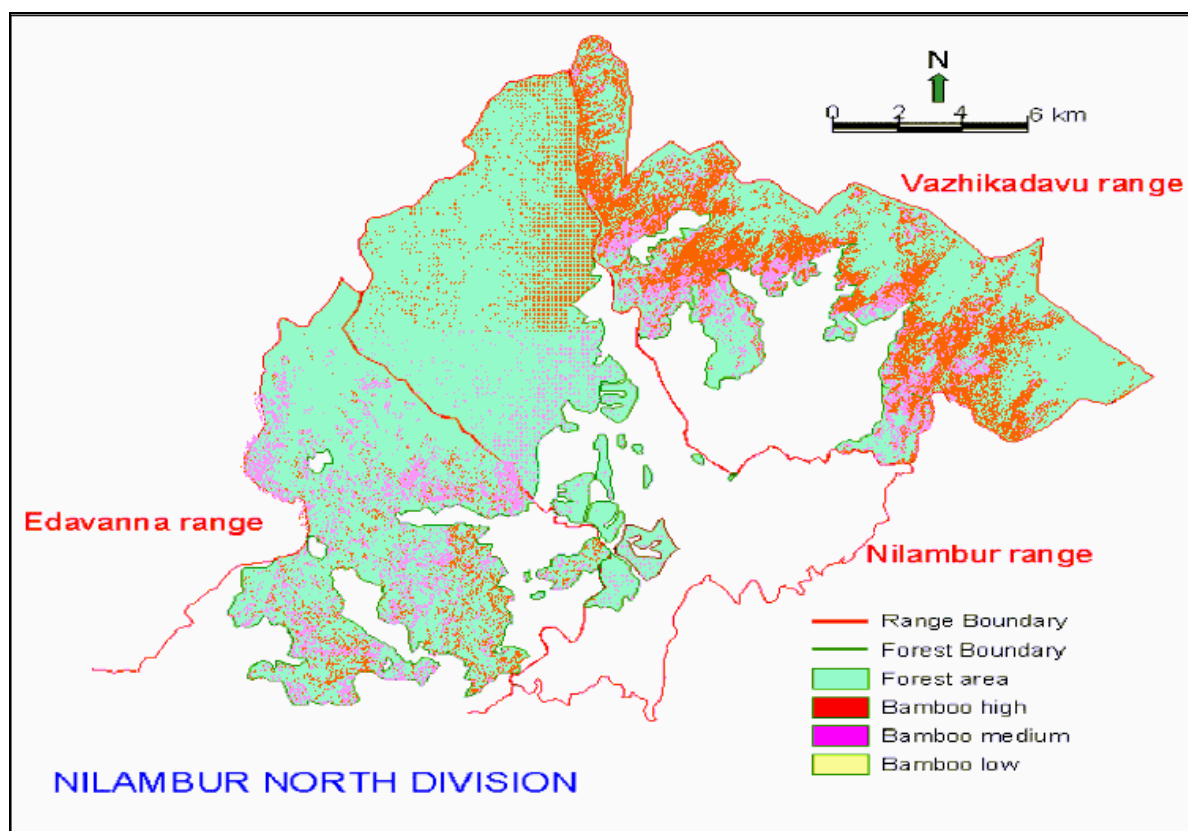
Fig. 7. Status of bamboo in Nilambur North Division

A large quantity of bamboo to the order of 1,000 to 10,000 tonnes is extracted from this region every year. Bamboo is in flowering condition in many parts of the division. This will affect the availability of bamboo in the coming years. The Pothukal station under Vazhikadavu Range had gregarious flowering recently. Marutha, Nellikkutha, Vallakkatta area, based on extraction history, under the same range shows sporadic flowering. In the Edavanna Range gregarious flowering was reported in 1999 from Edakkode RF and Muvaryiram malavaram. From this area approximately 750 tonnes of bamboo may be available. Flowering was also reported from Erampadam, Kanakutha and Kavalappara area of Nilambur Range. Proximity to GRASIM, the prime industrial consumer of bamboos from this division is also notable. There are few bamboo plantations also in the division.

Table 13. Status of bamboo in Nilambur North Division

Sl.No	Range	Total forest area (Km^2#)	Bamboo stock (Dry, tonnes)	Yearly availability (tonnes)	Method
1	Nilambur	140.87	103301.80	8608.48	+
2	Edavanna	97.90	24698.00	2058.17	+
3	Vazhikadavu	155.19	265436.10	22119.68	+
	Total	393.96	393435.90	32786.33	

(#) Forest Statistics (1997). Kerala Forest Department,
(-) Unsupervised classification, no field checking, (+) Unsupervised classification, limited field checking,
(*) Supervised classification extensive field checking.

Nilambur South Division

Nilambur South Division consists of Kalikavu and Karulai Ranges. These are well-known reserve forest areas managed under working plans for several decades. Vegetation consists of deciduous and evergreen types. It contains large quantity of bamboo in areas such as Manjery, Pulimada, Thalichola, Kuppamala and some parts of New Amarambalam RF. Kalikavu Range has bamboo in areas such as Pullankode malavaram, Vadakkekotta malavaram, Cherumba malavaram and Kannoth malavaram. About 10,000 tonnes of flowered and non flowered bamboo are being extracted from the division every year. Details of bamboo in the division are shown in Table 14.

Table 14. Status of bamboo in Nilambur South Division

Sl.No	Range	Total forest area (km^2#)	Bamboo stock (Dry, tonnes)	Yearly availability (tonnes)	Method
1	Kalikavu	99.83	36697.20	3058.10	+
2	Karulai	265.61	114166.50	9513.88	+
	Total	365.44	150863.70	12571.98	

(#) Forest Statistics (1997). Kerala Forest Department,
(-) Unsupervised classification, no field checking, (+) Unsupervised classification, limited field checking,
(*) Supervised classification extensive field checking.

Few bamboo plantations are also present in the division. Bamboo is reported to have flowered in 1993-94 in some parts of Karulai Range.
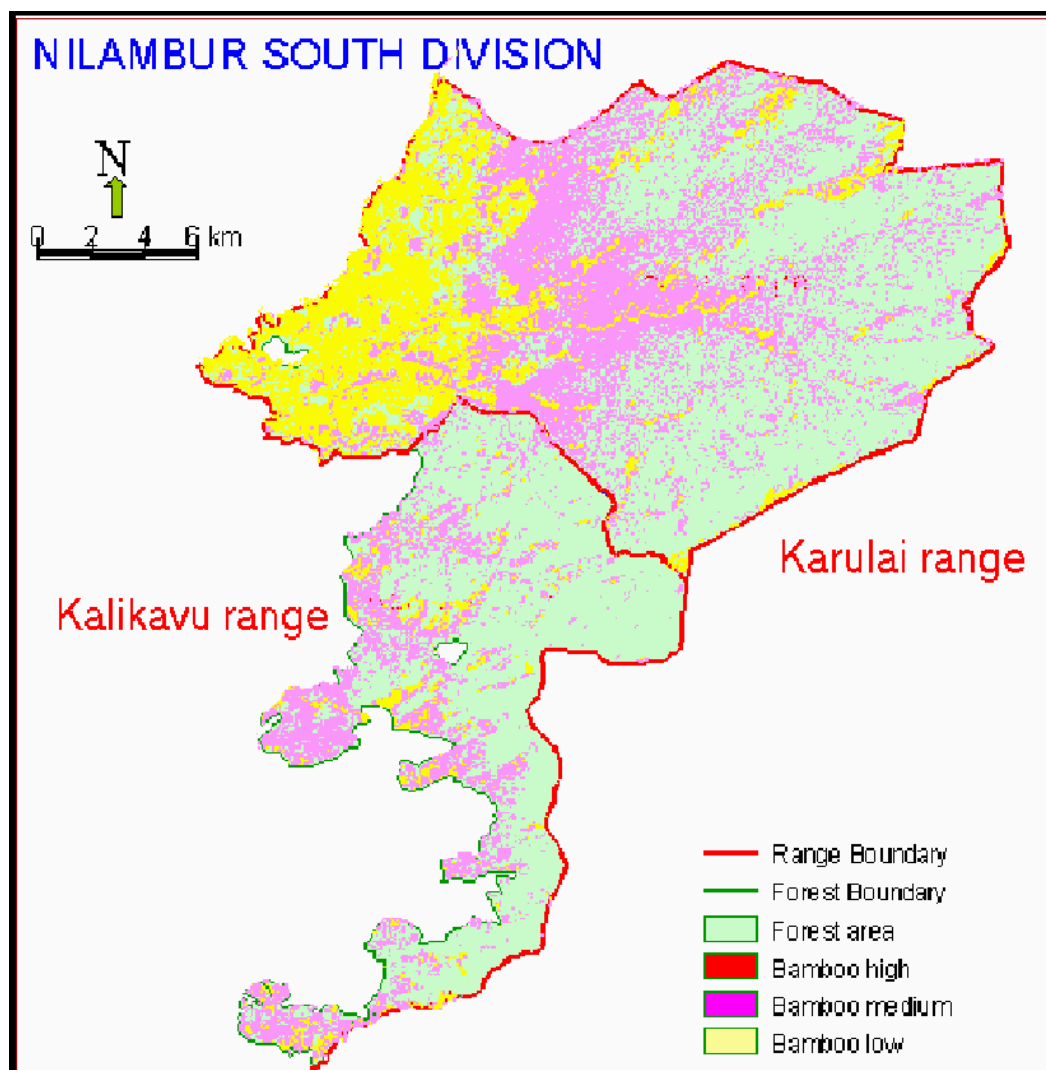
Fig. 8. Status of bamboo in Nilambur South Division

Silent Valley National Park

Silent Valley contains mostly evergreen forests, grasslands and reed brakes. No bamboo in commercially extractable quantity is found in Silent Valley.

Table 15. Status of bamboo in Silent Valley National Park

Sl.No	Range	Total forest area (km^2 #)	Bamboo stock (Dry, tonnes)	Yearly availability (tonnes)	Method
1	Silent Valley NP	89.52	---	---	+
	Total	89.52	---	---	

(#) Forest Statistics (1997). Kerala Forest Department, (---) Too sparse for industrial exploitation.
(-) Unsupervised classification, no field checking, (+) Unsupervised classification, limited field checking,
(*) Supervised classification extensive field checking.

Mannarkad Division

Attappady, Agaly and Mannarkad Ranges come under the Mannarkad Forest Division. Total forest area comes to about 530.11 km^2. Vegetation consists of deciduous and evergreen forests. Of the three ranges, Attappady Range has the largest amount of bamboo. The main bamboo areas in Attappady Range are Gottiarakandy, Thadikkundu, Kadukumanna, Aanavayi, Panthamathode, etc. Bamboo areas under Agaly Range are Thachanmala, Nellippathy, Kuruvambady, Kattekkad, Puliyara, Moochikkundu, Thumbappara, etc. Bamboo areas under Mannarkad Range are Erumbakachola, Injikunnu, Edathanthukara, Cherakkampady vettilachola, Achinatty, Pandan malavaram, etc. Details of bamboo in the division are shown in Table 16.
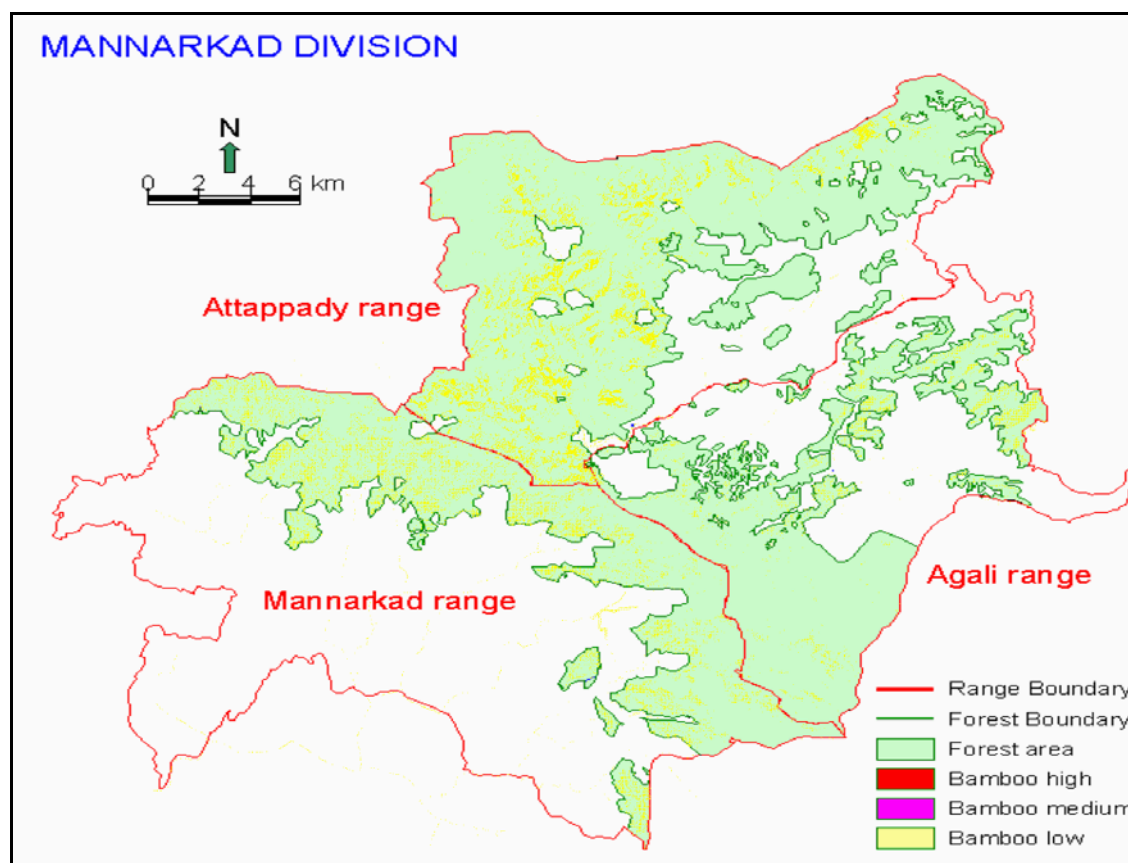
Fig. 9. Status of bamboo in Mannarkad Division.

Annually, 1000 to 4000 tonnes of bamboo are extracted, mainly from Attappady Range. There are few bamboo plantations also in the division. Flowering was reported from many areas under Mannarkad Division. They are Nellippathy estate, Chittoor, Puliyara and Koruvampady. In Puliyara, Koruvampady area bamboo flowered three years ago. From

Attappady Range there is no report of flowering except at one or two isolated places. There is no report of flowering from Mannarkad Range also.

Table 16. Status of bamboo in Mannarkad Division

Sl.No	Range	Total forest area (km^2 #)	Bamboo stock (Dry, tonnes)	Yearly availability (tonnes)	Method
1	Attappadi	249.43	49523.20	4126.93	+
2	Agaly	129.10	21899.60	1824.97	+
3	Mannarkad	151.58	31121.60	2593.47	+
	Total	530.11	102544.40	8545.37	

(#) Forest Statistics (1997). Kerala Forest Department,
(-) Unsupervised classification, no field checking, (+) Unsupervised classification, limited field checking,
(*) Supervised classification extensive field checking.

Palakkad Division

Palakkad Division consists of Olavakode, Ottappalam and Walayar Ranges. Total area is 238.40 km^2 (KFD, 1997). Vegetation consists of deciduous and evergreen forest. Of the three ranges, Walayar Range has comparatively more bamboo and Ottapalam Range is devoid of bamboo. Quantity of bamboo extracted ranges from 73 to 246 tonnes. Details of bamboo in the division are shown in Table 17.

Based on survey of an effective area of 364 km^2 of the then Palakkad Division, Chandrasekharan (1973) estimated a growing stock of 83,000 tonnes (air dry) of bamboo. The division has few bamboo plantations also. Gregarious flowering of bamboo has been reported in some parts. Present study has shown a decrease in quantity of bamboo available.

Table 17. Status of bamboo in Palakkad Division

Sl.No	Range	Total forest area (km^2 #)	Bamboo stock (Dry, tonnes)	Yearly availability (tonnes)	Method
1	Olavakode	81.27	24486.00	2040.50	+
2	Walayar	122.35	17490.00	1457.50	+
3	Ottappalam	34.78	---	---	+
	Total	238.40	41976.00	3498.00	

(#) Forest Statistics (1997). Kerala Forest Department, (---) Too sparse for industrial exploitation,
(-) Unsupervised classification, no field checking, (+) Unsupervised classification, limited field checking,
(*) Supervised classification extensive field checking.
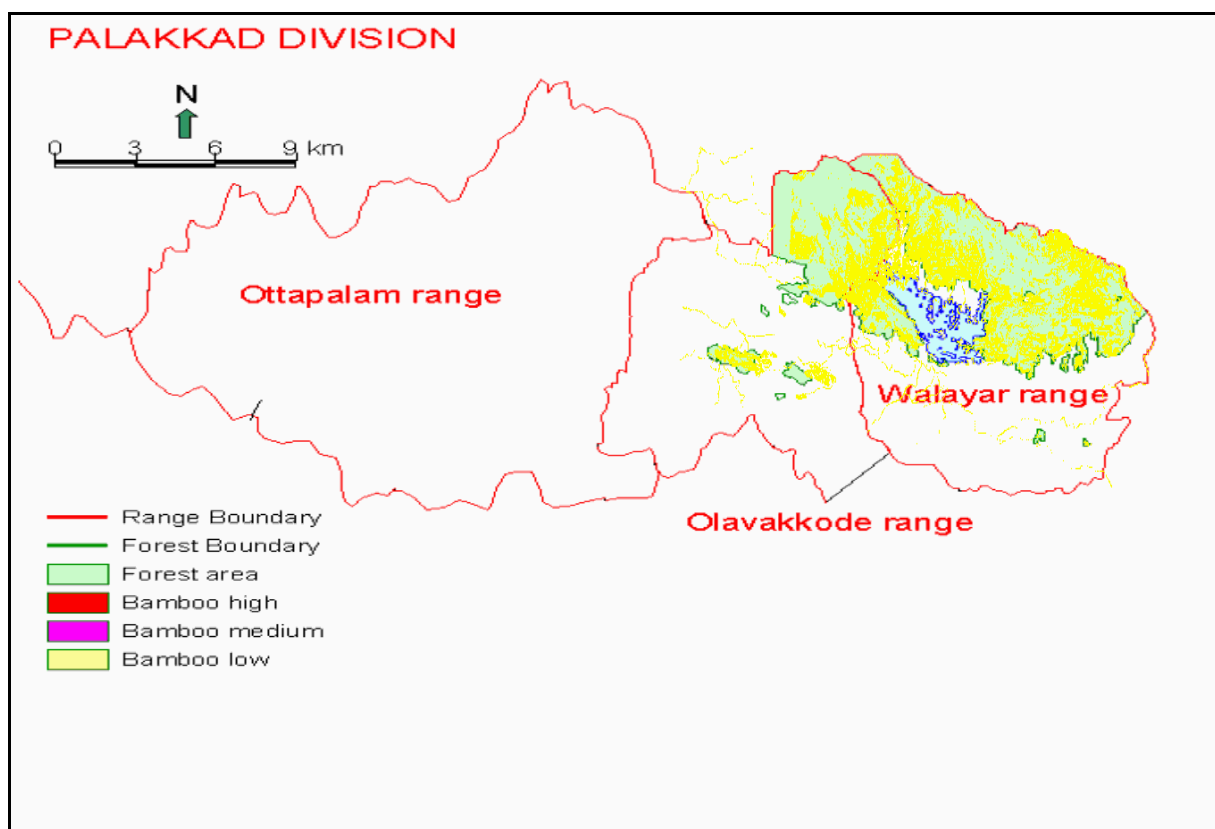
Fig. 10. Status of bamboo in Palakkad Division

Nemmara Division

Nemmara Division consists of Alathur, Kollengode and Nelliampathy Ranges. Total area is 339.41 km^2 (KFD, 1997). Vegetation consists of mostly degraded forests. Some of them were vested forests. Out of the three ranges, sparse bamboo is reported from Alathur Range. Details of bamboo in the division are shown in Table 18.

Table 18. Status of bamboo in Nemmara Division

Sl.No	Range	Total forest area (km^2 #)	Bamboo stock (Dry, tonnes)	Yearly availability (tonnes)	Method
1	Nelliyampathy	205.94	34640.80	2886.73	+
2	Kollengode	51.79	13144.00	1095.33	+
3	Alathur	81.68	890.40	74.20	+
	Total	339.41	48675.20	4056.27	

(#) Forest Statistics (1997). Kerala Forest Department,
(-) Unsupervised classification, no field checking, (+) Unsupervised classification, limited field checking,
(*) Supervised classification extensive field checking.

Based on survey of an effective area of 428 km^2 of the then Nemmara Division, Chandrasekharan (1973) estimated a growing stock of 46,000 tonnes (air dry) of bamboo.
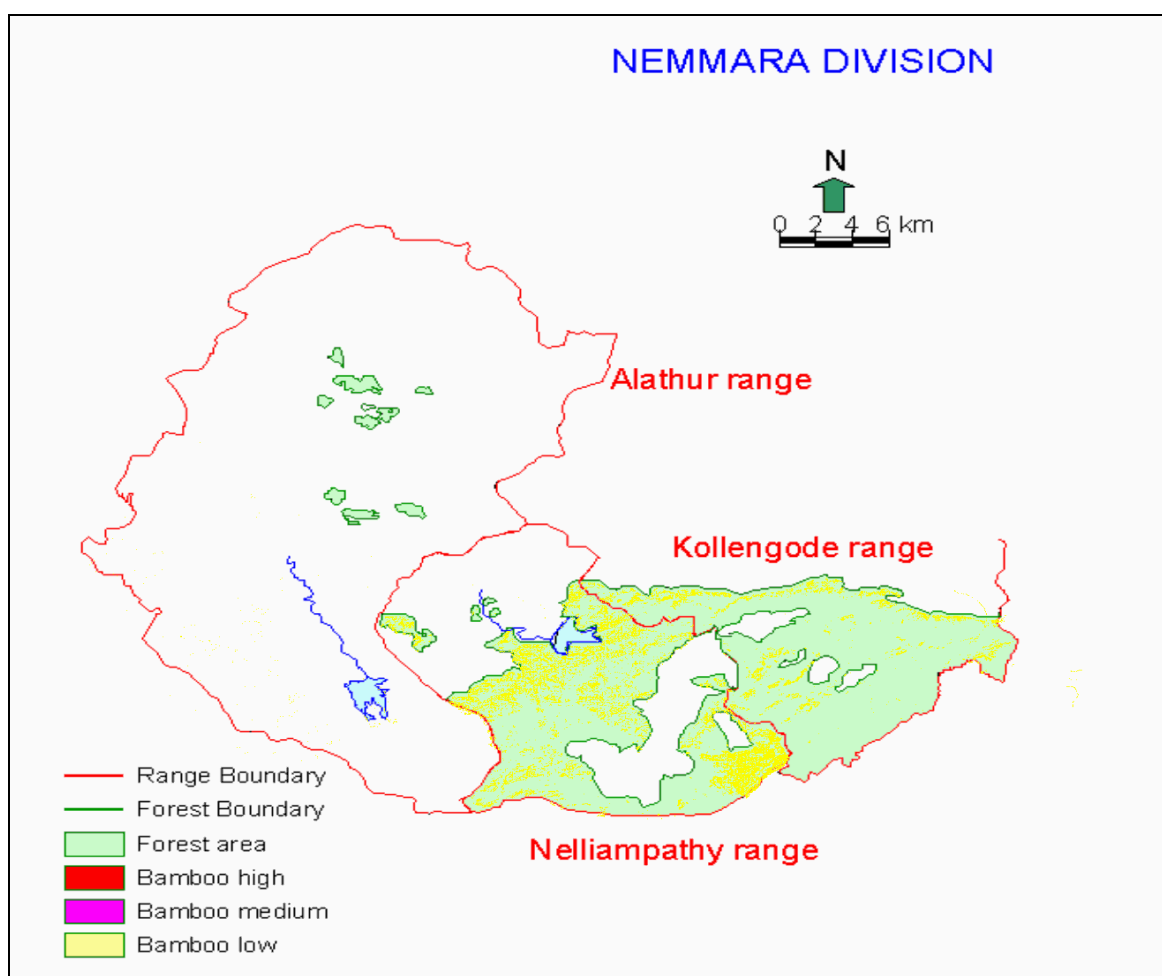
Fig. 11. Status of bamboo in Nemmara Division

Parambikulam Wildlife Sanctuary

Parambikulam Wildlife Sanctuary consisting of Parambikulam, Orukomban, Karimala and Sungam Ranges was one of the best known bamboo areas. After flowering in 1991, bamboo is still in the establishing stages in most areas. It has already established in some areas. The moist deciduous vegetation in this area is suitable for bamboo. Being a wildlife sanctuary bamboo is extracted only after flowering. Details of bamboo in the division are shown in Table 19.

Table 19. Status of bamboo in Parambikulam Wildlife Sanctuary

Sl.No	Range	Total forest area (km^2#)	Bamboo stock (Dry, tonnes)	Yearly availability (tonnes)	Method
1	Parambikulam	52.18	22195.70	1849.64	+
2	Orukomban	71.84	27024.20	2252.02	+
3	Karimala	68.37	57256.10	4771.34	+
4	Sungam	81.75	51159.60	4263.30	+
	Total	274.14	157635.60	13136.30	

(#) Forest Statistics (1997). Kerala Forest Department,
(-) Unsupervised classification, no field checking, (+) Unsupervised classification, limited field checking,
(*) Supervised classification extensive field checking.
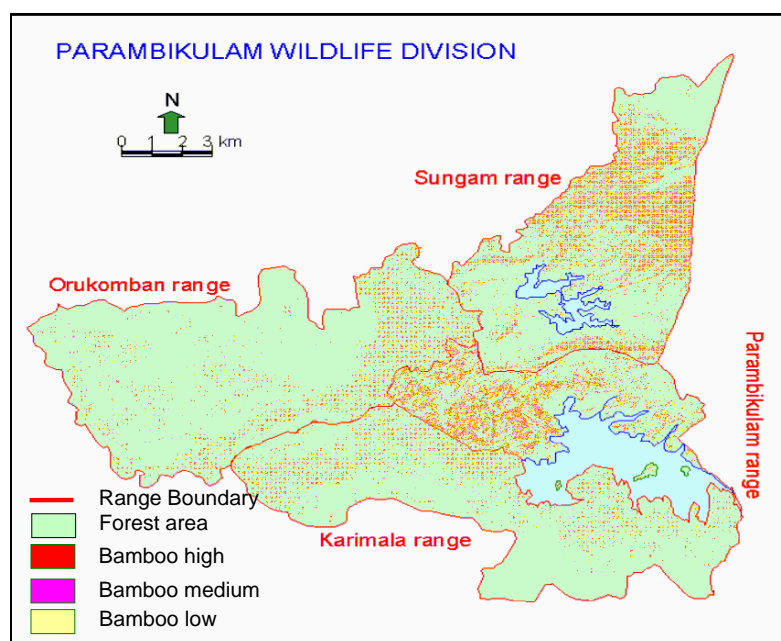
Fig. 12. Status of bamboo in Parambikulam Wildlife Division (Bamboo is getting established after flowering)

Central Region

The central region consists of Trichur, Chalakudy, Vazhachal and Malayattur Divisions. Because of geographical proximity, Peechi-Vazhani and Chimmony Wildlife Sanctuaries are also described here. Maximum bamboo is recorded from Vazhachal Division (48.2% of bamboo in the region) followed by Malayattur (27.3%) and Chalakudy (17.5%) Divisions (Table 20).

Table 20. Status of bamboo in Central Region

Sl.No	Division	Total forest area (km^2 *)	Bamboo stock (Dry, tonnes)	Yearly availability (tonnes)	Per cent (%)
1	Trichur	337.37	16408.80	1367.40	7.01
2	Chalakudy	354.71	41043.20	3420.27	17.52
3	Vazhachal	413.94	112772.10	9397.68	48.15
4	Malayattur	617.77	63981.60	5331.80	27.32
	Total	1723.79	234205.70	19517.15	100.00

(*) Forest Statistics (1997). Kerala Forest Department.

Trichur Division

Trichur Division consists of Vadakkancherry, Pattikkad and Machad Ranges. Because of geographic continuity Peechi Wildlife Sanctuary is also included in this section. Vegetation is mostly deciduous. Bamboo is generally sparse in the drier regions. Bamboo is distributed in small patches all over the division. Chandrasekharan (1973) gives details of bamboo resources of the division. He deals with about 404 km^2 of the then Trichur Division. A portion of this has been covered in the pre-investment survey according to which 20,000 tonnes (air dry) of bamboo is reported. Present study shows slightly less bamboo compared to the figure above. Details of bamboo in the division are shown in Table 21.

Table 21. Status of bamboo in Trichur Division

Sl.No	Range	Total forest area (Km^2 #)	Bamboo stock (Dry, tonnes)	Yearly availability (tonnes)	Method
1	Vadakkancherry	58.86	5194.00	432.83	+
2	Pattikkad	59.44	2098.80	174.90	+
3	Machad	92.34	5300.00	441.67	+
4	Peechi WLS	126.73	3816.00	318.00	+
	Total	337.37	16408.80	1367.40	

(#) Forest Statistics (1997). Kerala Forest Department,
(-) Unsupervised classification, no field checking, (+) Unsupervised classification, limited field checking,
(*) Supervised classification extensive field checking.
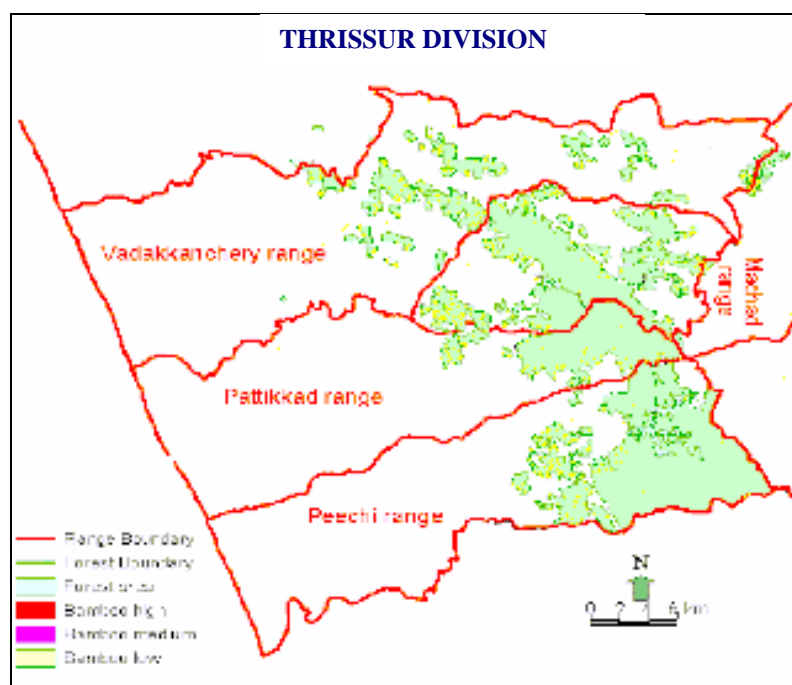
Fig. 13. Status of bamboo in Trichur Division

Chalakudy Division

Chalakudy Division consists of Pariyaram, Palappilly and Vellikulangara Ranges. Because of geographic continuity, Chimmony Wildlife Sanctuary is also included in this section. Bamboo is distributed in small patches all over the division. Chandrasekharan (1973) gives estimates for bamboo based on of the area of the Chalakudy Division which was 776 km^2. Growing stock of bamboo was estimated as 72,000 tonnes (air dry). Bamboo flowered in 1979-80. Between 1972 and 1980, an average of 1,000 tonnes have been extracted every year (Akkara, 1984) from ranges of Pariyaram and Palappilly. The figures for Chalakudy

Division in the present study is comparable to the figure above considering the change in area. Details of bamboo in the division are shown in Table 22.
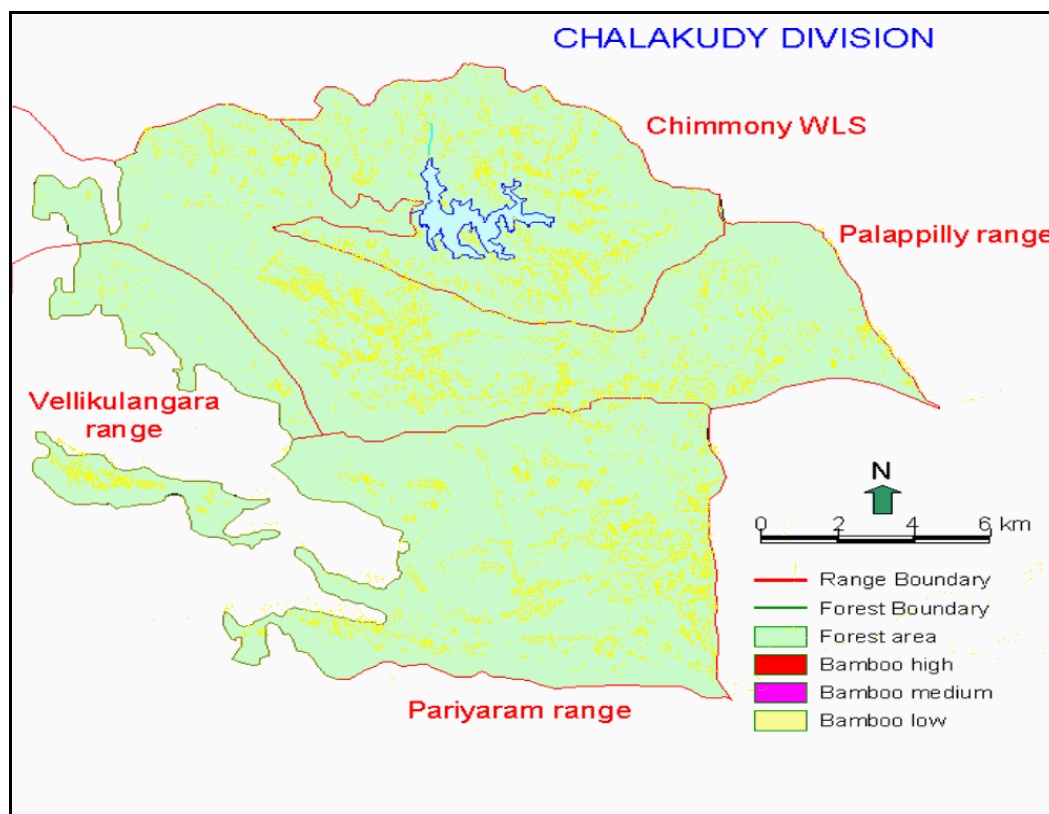
Fig. 14. Status of bamboo in Chalakudy Division

Table 22. Status of bamboo in Chalakudy Division

Sl.No	Range	Total forest area (km^2#)	Bamboo stock (Dry, tonnes)	Yearly availability (tonnes)	Method
1	Pariyaram	115.31	16726.80	1393.90	-
2	Palappilly	56.00	15518.40	1293.20	-
3	Vellikulangara	108.40	1759.60	146.63	-
4	Chimmony WLS	75.00	7038.40	586.53	-
	Total	354.71	41043.20	3420.27	

(#) Forest Statistics (1997). Kerala Forest Department, (---) Too sparse for industrial exploitation,
(-) Unsupervised classification, no field checking, (+) Unsupervised classification, limited field checking,
(*) Supervised classification extensive field checking.

Vazhachal Division

Vazhachal Division consists of Charpa, Vazhachal, Sholayar and Athirappilly Ranges. Bamboo is distributed in small patches more on the western side, along water courses. Details of bamboo in the division are shown in Table 23.

Table 23. Status of bamboo in Vazhachal Division

Sl.No	Range	Total forest area (km^2 #)	Bamboo stock (Dry, tonnes)	Yearly availability (tonnes)	Method
1	Charpa	59.98	26609.80	2217.48	-
2	Vazhachal	90.64	34220.90	2851.74	-
3	Sholayar	138.88	19405.40	1617.12	-
4	Kollathirumedu	29.35	18243.40	1520.28	-
5	Athirappilly	95.10	14292.60	1191.05	-
	Total	413.95	112772.10	9397.68	

(#) Forest Statistics (1997). Kerala Forest Department, (---) Too sparse for industrial exploitation,
(-) Unsupervised classification, no field checking, (+) Unsupervised classification, limited field checking,
(*) Supervised classification extensive field checking.

Malayattur Division

Malayattur Division consists of Kalady, Kodanad, Kuttampuzha and Thundathil Ranges. Bamboo is distributed in small patches all over the division. Chandrasekharan (1973) gives a description of the then Malayattoor Division (area 570 km^2). Growing stock of bamboo was estimated at 37,000 tonnes (air dry). Viswanathan (1951) gives an annual outturn of 12,000 bamboos. In the northern parts of the division, medium density bamboo is seen on the western part of the division and around the reservoir. In the southern portions the western part has medium and sparse bamboo. Present study shows more or less same quantity of bamboo in Malayattur Division. Details of bamboo in the division are shown in Table 24.

Table 24. Status of bamboo in Malayattur Division

Sl.No	Range	Total forest area (km^2 #)	Bamboo stock (Dry, tonnes)	Yearly availability (tonnes)	Method
1	Kalady	72.51	8882.80	740.23	-
2	Kodanad	56.74	3667.60	305.63	-
3	Thundathil	131.40	13462.00	1121.83	-
4	Kuttampuzha	357.11	37969.20	3164.10	-
	Total	617.76	63981.60	5331.80	

(#) Forest Statistics (1997). Kerala Forest Department, (---) Too sparse for industrial exploitation,
(-) Unsupervised classification, no field checking, (+) Unsupervised classification, limited field checking,
(*) Supervised classification extensive field checking.

High Range Region

High Range region is well-known for reeds (genus *Ochlandra*) and some parts do contain bamboo. Region consists of Kothamangalam (36.5% of total bamboo in the circle), Munnar (34.8%), and Kottayam (14.4%) Divisions. Because of geographic continuity, Idukki Wildlife Sanctuary (14.4%) is also included (Table 25).

Table 25. Status of bamboo in High Range Region

Sl.No	Division	Total forest area (km^2*)	Bamboo stock (Dry, tonnes)	Yearly availability (tonnes)	Per cent (%)
1	Kothamangalam	317.02	44774.40	3731.20	36.48
2	Idukki WLS	317.96	17617.20	1468.10	14.35
3	Munnar	715.84	42675.60	3556.30	34.77
4	Mankulam	---	---	---	---
5	Kottayam	692.15	17659.60	1471.63	14.39
6	Periyar Tiger Reserve	777.54	---	---	---
	Total	2,820.51	122726.80	10227.23	100.00

(*) Forest Statistics (1997). Kerala Forest Department.

Kothamangalam Division

Kothamangalam Division consists of Thodupuzha, Kothamangalam, Mullaringad and Kaliyar Ranges. Bamboo is found only in the central part. Details of bamboo in the division are shown in Table 26.

Table 26. Status of bamboo in Kothamangalam Division

Sl.No	Range	Total forest area (km^2#)	Bamboo stock (Dry, tonnes)	Yearly availability (tonnes)	Method
1	Thodupuzha	218.38	17468.80	1455.73	-
2	Kothamangalam	12.17	---	---	-
3	Kaliyar	49.08	18210.80	1517.57	-
4	Mullaringad	37.38	9094.80	757.90	-
	Total	317.01	44774.40	3731.20	

(#) Forest Statistics (1997). Kerala Forest Department, (---) Too sparse for industrial exploitation.
 (-) Unsupervised classification, no field checking, (+) Unsupervised classification, limited field checking,
(*) Supervised classification extensive field checking.

Idukki Wildlife Division

Idukki Wildlife Division consists of Idukki Wildlife Sanctuary, Thattekkad Bird Sanctuary, Eravikulam National Park and Chinnar Wildlife Sanctuary. Eravikulam National Park has mostly evergreen forests and grasslands. Bamboo is not available in commercially extractable quantity. Details of bamboo in the division are shown in Table 27.

Table 27. Status of bamboo in Idukki Wildlife Division

Sl.No	Range	Total forest area (km^2 #)	Bamboo stock (Dry, tonnes)	Yearly availability (tonnes)	Method
1	Idukki WLS	105.36	6953.60	579.47	-
2	Thattekkad BS	25.16	---	---	-
3	Eravikulam NP	97.00	---	---	-
4	Chinnar WLS	90.44	10663.60	888.63	-
	Total	317.96	17617.20	1468.10	

(#) Forest Statistics (1997). Kerala Forest Department, (---) Too sparse for industrial exploitation.
(-) Unsupervised classification, no field checking, (+) Unsupervised classification, limited field checking,
(*) Supervised classification extensive field checking.

Munnar Division

Munnar Division consists of Munnar, Marayur, Devikulam, Adimali and Neriyamangalam Ranges. Bamboo is found only in some areas. Based on survey of an effective area of 418 km^2 of the then Munnar Division, Chandrasekharan (1973) estimated a growing stock of 36,000 tonnes (air dry) of bamboo. Because of reorganisation of territory it is not possible to make meaningful comparisons with present study. Details of bamboo in the division are shown in Table 28.

Table 28. Status of bamboo in Munnar Division

Sl.No	Range	Total forest area (km^2 #)	Bamboo stock (Dry, tonnes)	Yearly availability (tonnes)	Method
1	Munnar	106.00	---	---	-
2	Marayur	71.32	---	---	-
3	Devikulam	324.91	---	---	-
4	Adimali	110.87	23192.80	1932.73	-
5	Neriyamangalam	102.74	19482.80	1623.57	-
	Total	715.84	42675.60	3556.30	

(#) Forest Statistics (1997). Kerala Forest Department, (---) Too sparse for industrial exploitation,
(-) Unsupervised classification, no field checking, (+) Unsupervised classification, limited field checking,
(*) Supervised classification extensive field checking.

Mankulam Division

Mankulam Division consists of Anakulam and Mankulam ranges. Bamboos is found in some patches only.

Table 29. Status of bamboo in Mankulam Division

Sl.No	Range	Total forest area (km^2 #)	Bamboo stock (Dry, tonnes)	Yearly availability (tonnes)	Method
1	Anakulam	---	---	---	-
2	Mankulam	---	---	---	-
	Total	---	---	---	

(#) Forest Statistics (1997). Kerala Forest Department,
(-) Unsupervised classification, no field checking, (+) Unsupervised classification, limited field checking,
(*) Supervised classification extensive field checking.

Kottayam Division

Kottayam Division consists of Erumeli, Ayappankovil, Nagarampara and Kumily Ranges. Bamboo is found along the western portion of the division, mainly in Ayappankovil and Nagarampara Ranges. Based on survey of 423 km^2 of the then Kottayam Division, Chandrasekharan (1973) estimated a growing stock of 38,000 tonnes (air dry) of bamboo. Details of bamboo in the division are shown in Table 30.

Table 30. Status of bamboo in Kottayam Division

Sl.No	Range	Total forest area (km^2 #)	Bamboo stock (Dry, tonnes)	Yearly availability (tonnes)	Method
1	Erumeli	143.56	---	---	-
2	Ayyappankovil	107.00	---	---	-
3	Nagarampara	176.00	17659.60	1471.63	-
4	Kumily	265.59	---	---	-
	Total	692.15	17659.60	1471.63	

(#) Forest Statistics (1997). Kerala Forest Department,
(-) Unsupervised classification, no field checking, (+) Unsupervised classification, limited field checking,
(*) Supervised classification extensive field checking.

Periyar Tiger Reserve

Periyar Tiger Reserve consists of Thekkady and Vallakkadavu Ranges. Bamboo is found sparse in this area. Based on survey of 777 km^2 of the then Thekkady Division, Chandrasekharan (1973) estimated a growing stock of 46,000 tonnes (air dry) of bamboo. Details of bamboo in the division are shown in Table 31.

Table 31. Status of bamboo in Periyar Tiger Reserve

Sl.No	Range	Total forest area (km^2 #)	Bamboo stock (Dry, tonnes)	Yearly availability (tonnes)	Method
1	Thekkady	442.54	---	---	+
2	Vallakkadavu	355.00	---	---	-
	Total	777.54	---	---	

(#) Forest Statistics (1997). Kerala Forest Department, (---) To sparse for industrial extraction
(-) Unsupervised classification, no field checking, (+) Unsupervised classification, limited field checking,
(*) Supervised classification extensive field checking.

Southern Region

Southern region consists of Ranni (11.9% of total bamboo in the circle), Konni (4.8%), Achenkovil (36.3%), Punalur (3.4%), Thenmala (19.1%), Trivandrum Wildlife (11.9%) and Trivandrum (12.7%) Divisions (Table 32).

Table 32. Status of bamboo in Southern Region

Sl.No	Division	Total forest area (Km^2 *)	Bamboo stock (Dry, tonnes)	Yearly availability (tonnes)	Per cent (%)
1	Ranni	1,059.07	67797.60	5649.80	11.87
2	Konni	331.66	27538.80	2294.90	4.82
3	Achenkovil	269.00	207500.80	17291.73	36.33
4	Punalur	280.22	19164.80	1597.07	3.35
5	Thenmala	206.17	108801.20	9066.77	19.05
6	Trivandrum WLS	312.44	67924.80	5660.40	11.89
7	Trivandrum	369.88	72504.00	6042.00	12.69
	Total	2,828.44	571232.00	47602.67	100.00

(*) Forest Statistics (1997). Kerala Forest Department.

Ranni Division

Ranni Division consists of Ranni, Goodrickal and Vadasserrikkara Ranges. Bamboo is found only in the south-west corner in Ranni range. Based on survey of 781 km^2 of the then Ranni division, Chandrasekharan (1973) estimated a growing stock of 90,000 tonnes (air dry) of bamboo. Details of bamboo in the division are shown in Table 33.

Table 33. Status of bamboo in Ranni Division

Sl.No	Range	Total forest area (km^2 #)	Bamboo stock (Dry, tonnes)	Yearly availability (tonnes)	Method
1	Ranni	136.24	19228.40	1602.37	-
2	Goodrickal	653.97	21242.40	1770.20	-
3	Vadasserrikkara	268.86	27326.80	2277.23	-
	Total	1,059.07	67797.60	5649.80	

(#) Forest Statistics (1997). Kerala Forest Department,
(-) Unsupervised classification, no field checking, (+) Unsupervised classification, limited field checking,
(*) Supervised classification extensive field checking.
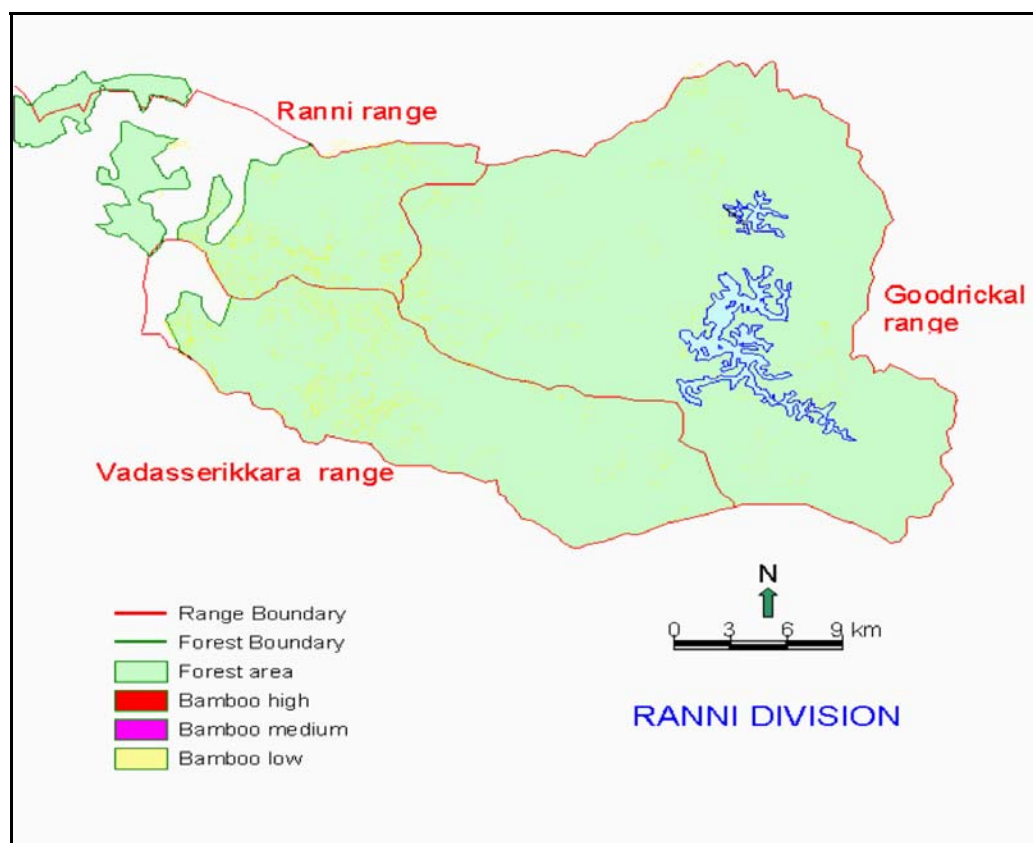
Fig. 15. Status of bamboo in Ranni Division

Konni Division

Konni Division consists of Konni, Naduvathumuzhy and Mannarappara Ranges. Central part of the Division in north-south direction harbours bamboo. Based on survey of 303 km^2 of the then Konni division, Chandrasekharan (1973) estimated a growing stock of 1,80,000 tonnes (air dry) of bamboo. Present study shows much less bamboo in the division compared to the figure above. Details of bamboo in the division is shown in Table 34.

Table 34. Status of bamboo in Konni Division

Sl.No	Range	Total forest area (km^2 #)	Bamboo stock (Dry, tonnes)	Yearly availability (tonnes)	Method
1	Konni	62.73	5321.20	443.43	-
2	Naduvathumuzhy	138.94	9010.00	750.83	-
3	Mannarappara	130.00	13207.60	1100.63	-
	Total	331.67	27538.80	2294.90	

(#) Forest Statistics (1997). Kerala Forest Department,
(-) Unsupervised classification, no field checking, (+) Unsupervised classification, limited field checking,
(*) Supervised classification extensive field checking.
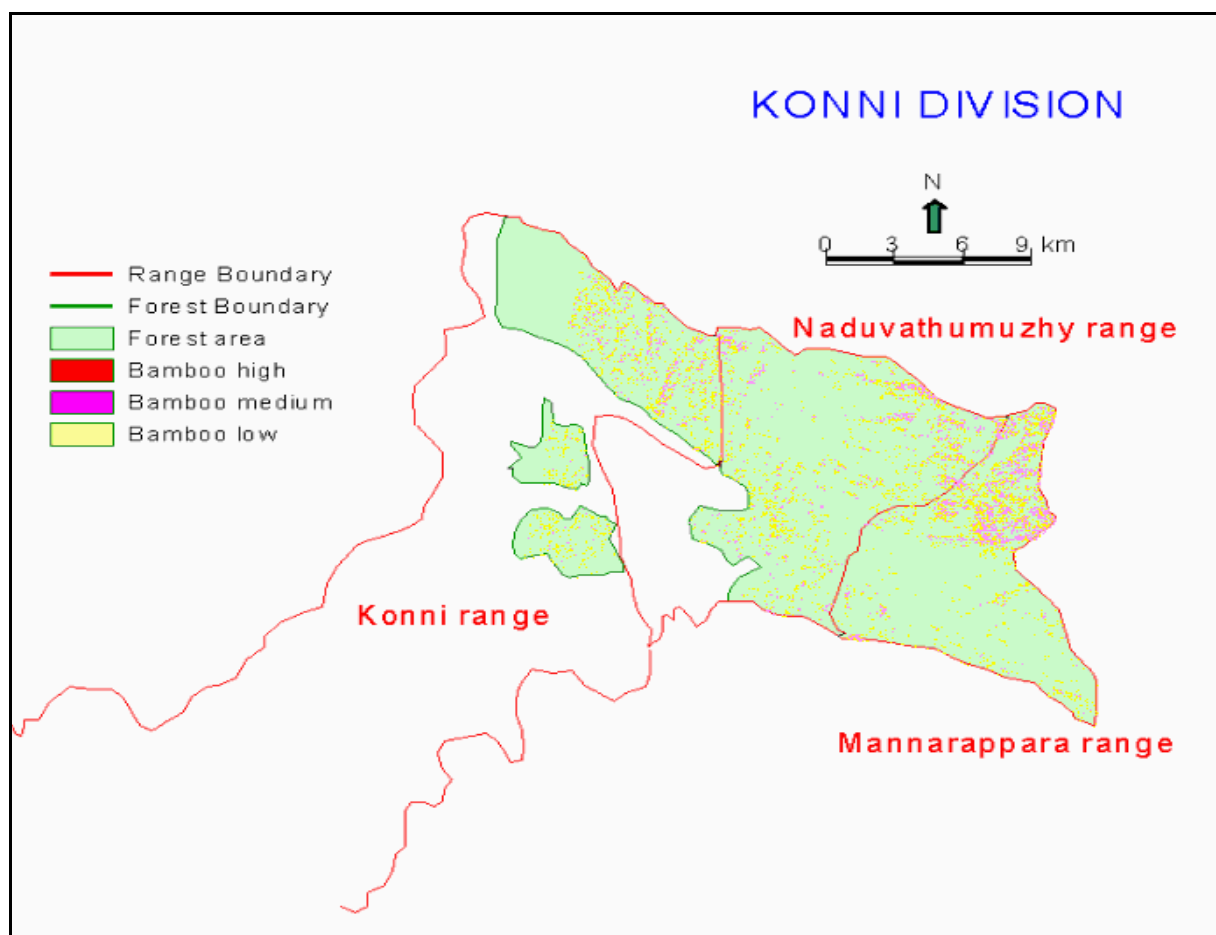
Fig. 16. Status of bamboo in Konni Division

Achenkovil Division

Achenkovil Division consists of Achenkovil, Kallar and Kanayar Ranges. Bamboo is found in the western region of the division. An examination of satellite imagery shows bamboo in many parts of the division. Details of bamboo in the division are shown in Table 35.

Table 35. Status of bamboo in Achenkovil Division

Sl.No	Range	Total forest area (Km^2#)	Bamboo stock (Dry, tonnes)	Yearly availability (tonnes)	Method
1	Achenkovil	84.00	85601.00	7133.42	-
2	Kallar	78.00	64804.80	5400.40	-
3	Kanayar	107.00	57095.00	4757.92	-
	Total	269.00	207500.80	17291.73	

(#) Forest Statistics (1997). Kerala Forest Department,
(-) Unsupervised classification, no field checking, (+) Unsupervised classification, limited field checking,
(*) Supervised classification extensive field checking.

Punalur Division

Punalur Division consists of Anchal and Pathanapuram Ranges. In these two ranges, bamboo are found in some patches. Based on survey of 224 km^2 of the then Punalur Division, Chandrasekharan (1973) estimated a growing stock of 1,17,000 tonnes (air dry) bamboo. Details of bamboo in the division are shown in Table 36.

Table 36. Status of bamboo in Punalur Division

Sl.No	Range	Total forest area (km^2 #)	Bamboo stock (Dry, tonnes)	Yearly availability (tonnes)	Method
1	Anchal	148.41	11575.20	964.60	-
2	Pathanapuram	131.81	7589.60	632.47	-
	Total	280.22	19164.80	1597.07	

(#) Forest Statistics (1997). Kerala Forest Department,
(-) Unsupervised classification, no field checking, (+) Unsupervised classification, limited field checking,
(*) Supervised classification extensive field checking.

Thenmala Division

Thenmala Division consists of Arienkavu and Thenmala Ranges. Bamboo is sparse in the division; there are some bamboo plantations. In the case of Arienkavu Range bamboo is rare. Based on survey of 476 km^2 of the then Thenmala division Chandrasekharan (1973) estimated a growing stock of 1,84,000 tonnes of (air dry) bamboo. Ashary (1960) reported a total yield of about 4,50,000 bamboos for the Thenmala Division. Details of bamboo in the division are shown in Table 37.

Table 37. Status of bamboo in Thenmala Division

Sl.No	Range	Total forest area (km^2 #)	Bamboo stock (Dry, tonnes)	Yearly availability (tonnes)	Method
1	Arienkavu	74.34	84871.90	7072.66	+
2	Thenmala	131.83	23929.30	1994.11	+
	Total	206.17	108801.20	9066.77	

(#) Forest Statistics (1997). Kerala Forest Department,
(-) Unsupervised classification, no field checking, (+) Unsupervised classification, limited field checking,
(*) Supervised classification extensive field checking.

Trivandrum Wildlife Division

Trivandrum Wildlife Division consists of Neyyar, Peppara and Shenduruny Wildlife Sanctuaries. Because of geographical continuity Agasthyavanam Biological Park is also included in this section. In Neyyar Wildlife Sanctuary bamboo is common in patches near the

reservoir and along water courses. Bamboo occurs mainly in valleys between hills. Being wildlife sanctuary, no extraction is carried out. In Peppara bamboo is common in few patches only. Dense patches are mostly near Agasthyavanam. Being wildlife sanctuary, no extraction is carried out at present.
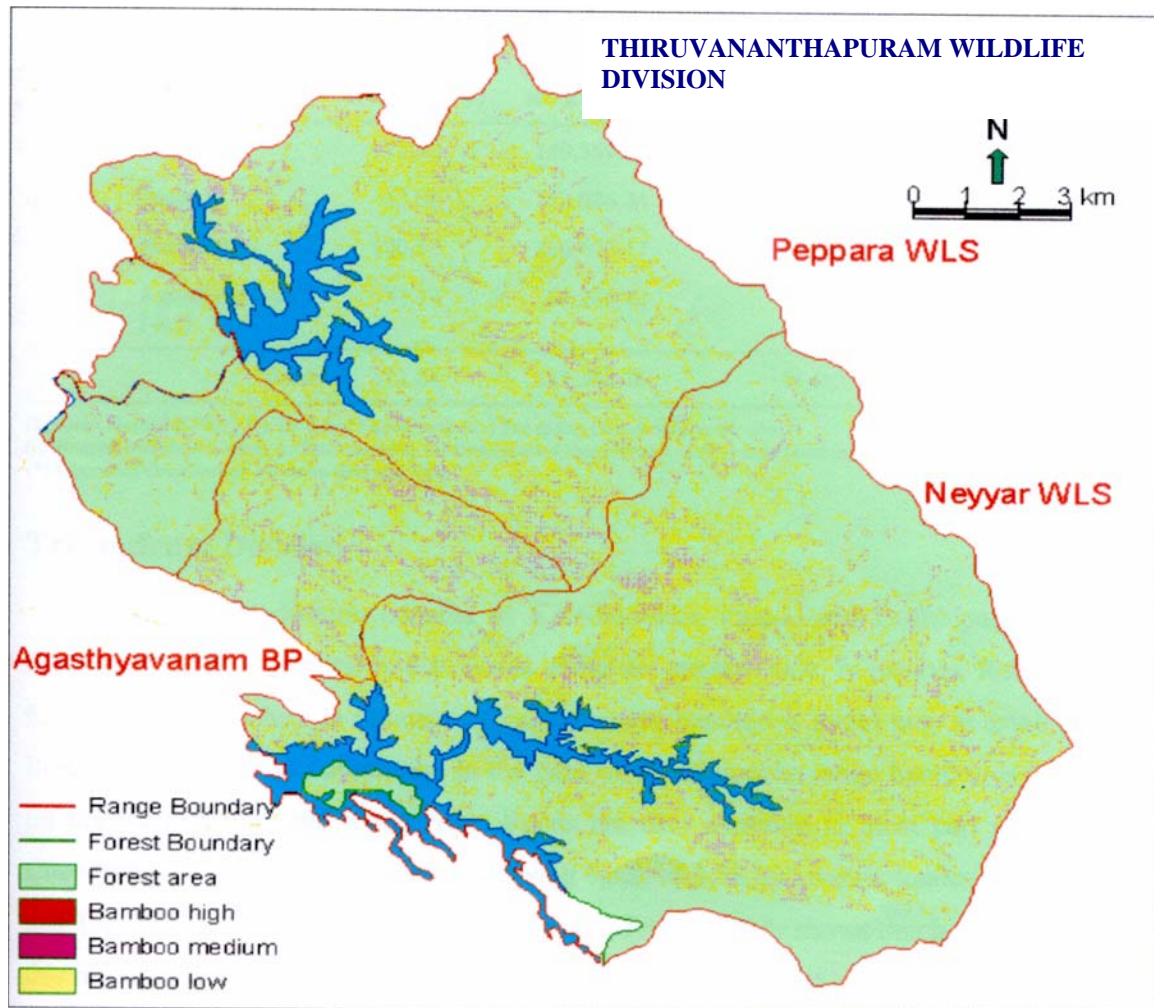

Fig. 17. Status of bamboo in Trivandrum Wildlife Division

Bamboo is found bordering Peppara Wildlife Sanctuary in the case of Agasthyavanam southern part. In the case of northern Agasthyavanam area, bamboo is found in few patches. Bamboo and reed come out very clearly in FCC; reed which is not considered in this report has red or rose colour and has a ginger like appearance spread along river courses.

In Shenduruny Wildlife Sanctuary bamboo is sparsely distributed on the western side and along the river. In Neyyar Wildlife Sanctuary bamboo is common in patches near reservoir and along water courses. The hilly regions have mostly reed. Details of bamboo in the division are shown in Table 38.

Table 38. Status of bamboo in Trivandrum Wildlife Division

Sl.No	Range	Total forest area (km²#)	Bamboo stock (Dry, tonnes)	Yearly availability (tonnes)	Method
1	Neyyar	128.00	10027.60	835.63	*
2	Peppara	53.00	9455.20	787.93	*
3	Shenduruny	100.32	41912.40	3492.70	*
4	Agasthyavanam I & II	31.12	6529.60	544.13	*
	Total	312.44	67924.80	5660.40	

(#) Forest Statistics (1997). Kerala Forest Department, (---) Too sparse for industrial extraction
(-) Unsupervised classification, no field checking, (+) Unsupervised classification, limited field checking,
(*) Supervised classification extensive field checking.

Trivandrum Division

Trivandrum Division consists of Kulathupuzha, Palode and Paruthipally Ranges. In Paruthipally Range, bamboo is distributed along the western side in patches. In the case of Palode Range, bamboo is found only in small patches. In the case of Kulathupuzha Range bamboo is distributed on the western side and along the river. Chandrasekharan (1973) estimated a growing stock of 1,63,000 tonnes (air dry) of bamboo. Present study shows less bamboo in this tract. Details of bamboo in the division are shown in Table 39.

Table 39. Status of bamboo in Trivandrum Division

Sl.No	Range	Total forest area (km²#)	Bamboo stock (tonnes)	Yearly availability (tonnes)	Method
1	Kulathupuzha	219.69	53508.80	4459.07	*
2	Palode	107.50	10345.60	862.13	*
3	Paruthipally	42.69	8649.60	720.80	*
	Total	369.88	72504.00	6042.00	

(#) Forest Statistics (1997). Kerala Forest Department,
(-) Unsupervised classification, no field checking, (+) Unsupervised classification, limited field checking,
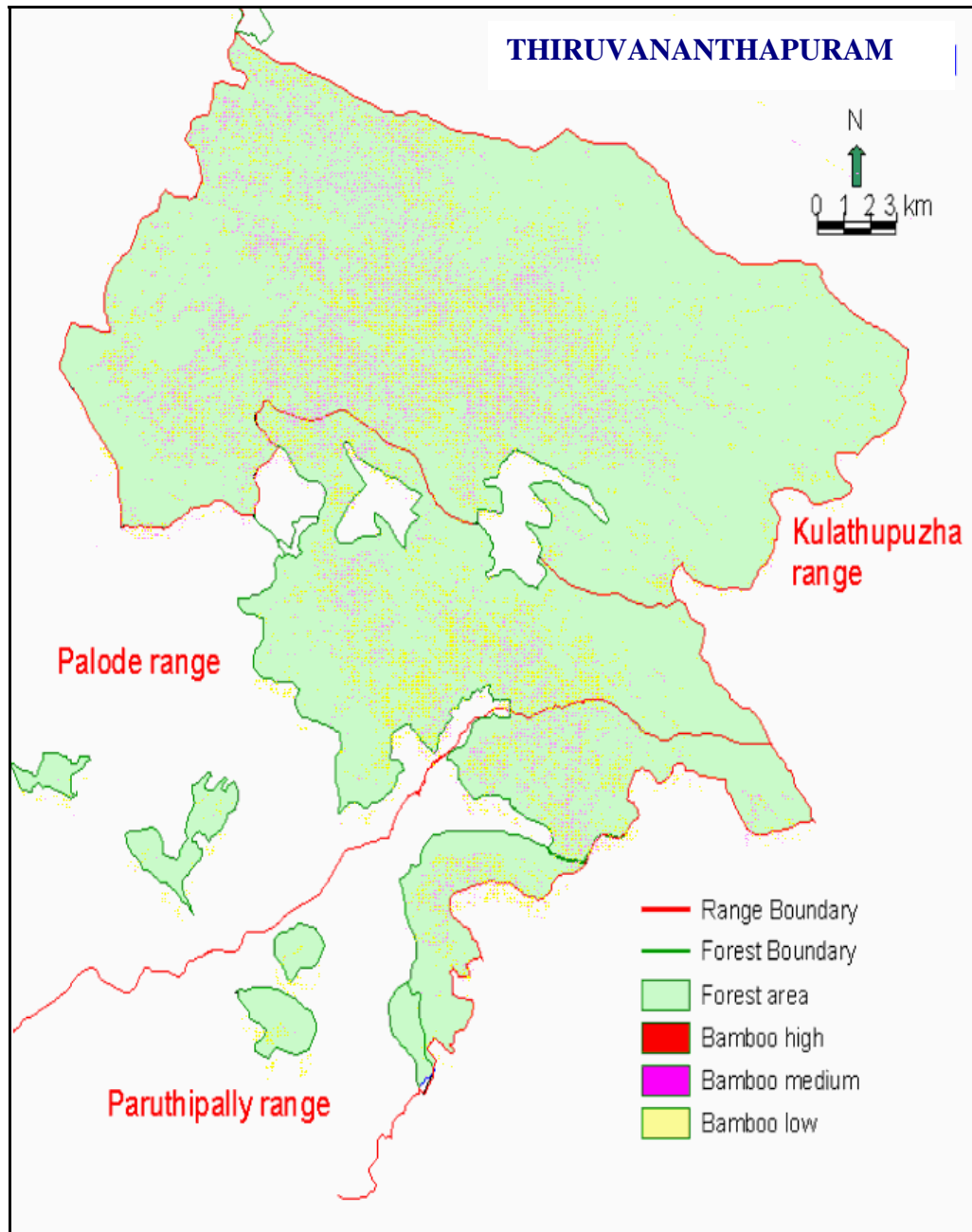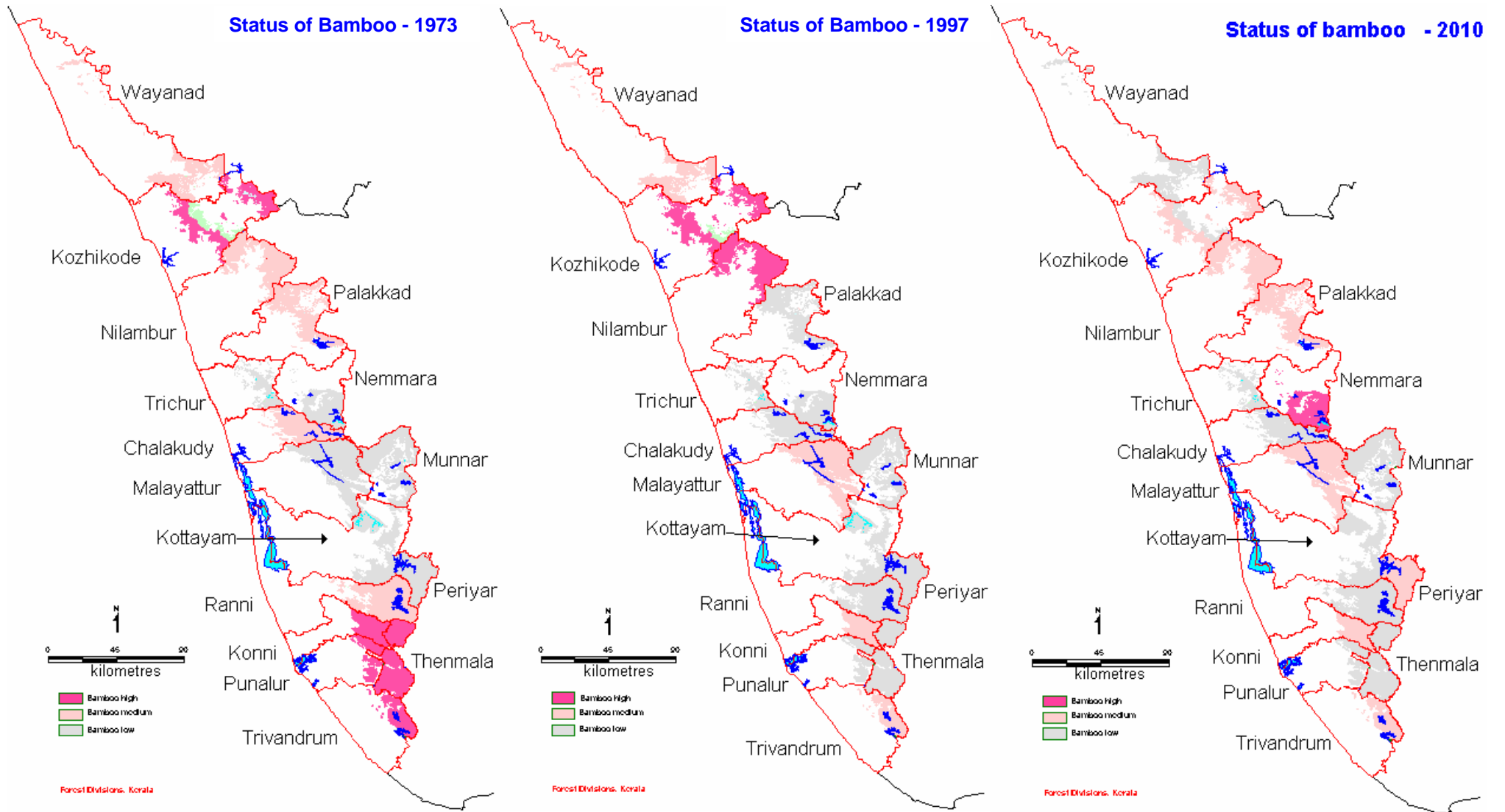(*) Supervised classification extensive field checking.

Fig. 18. Status of bamboo in Trivandrum Division

Conclusion

This is one of the first attempts in India to estimate forest resource using satellite images. The results show that IRS IC, multispectral images of 23 m resolution are sufficient for demarcating bamboo in the forest. Unsupervised classification provides only a crude status, supervised classification with detailed ground check can delineate all bamboo areas. Items such as paddy, rubber, acacias, eucalypts, evergreen forest and to some extent reeds can be separated from bamboo only by examining training sites containing these items during supervised classification. The appearance of bamboo in dry and wet areas is slightly different.

Previous estimates of bamboo in the forest area are more than 15 years old. Addition of vested forests to reserve forests, flowering of bamboo and reorganisation of forest divisions make comparison of present estimate with previous estimate a difficult task. Chandrasekharan (1973) estimated a total quantity of 1.4 million tonnes of bamboo for whole of Kerala (9,400 km^2, excluding the vested forests). The present estimate for whole Kerala including vested forests (11,126 km^2) is 2.63 million tonnes. Flowering is a factor that can cause sudden changes in estimates of quantity of bamboo. Currently the major bamboo bearing belts in Nilambur, Wayanad and Kozhikode are in the process of flowering. Another major bamboo area, Parambikulam flowered about 10 years ago and the bamboo there at present is in establishing stage. GRASIM and HNL are the major consumers of bamboo in the state. HNL started using bamboo only recently. Bamboo from the Southern region goes to HNL and bamboo from the Northern region goes to GRASIM. A total of 1488 metric tonnes of air dry bamboo was supplied from the state forests to HNL during 1996-97 (KFD, 1997). This quantity subsequently is on the increase.

Krishnankutty (1998) found that almost all of industrial requirement of bamboo is met from forests, while most of the domestic requirements are met from private homesteads. Industrial and domestic consumptions are almost equal in terms of quantity. The domestic stock is far less (less than one million tonnes). This indicates over-exploitation in the domestic sector and under-exploitation of bamboo from forest.

Status of Bamboo - 1973

Wayanad

Kozhikode

Palakkad

Nilambur

Nemmara

Trichur

Chalakudy

Munnar

Malayattur

Kottayam

Ranni

Periyar

Konni

Punalur

Thenmala

Trivandrum

kilometres

Bamboo high
Bamboo medium
Bamboo low

Forest Divisions, Kerala

Status of Bamboo - 1997

Wayanad

Kozhikode

Palakkad

Nilambur

Nemmara

Trichur

Chalakudy

Munnar

Malayattur

Kottayam

Ranni

Periyar

Konni

Punalur

Thenmala

Trivandrum

kilometres

Bamboo high
Bamboo medium
Bamboo low

Forest Divisions, Kerala

Status of bamboo - 2010

Wayanad

Kozhikode

Palakkad

Nilambur

Nemmara

Trichur

Chalakudy

Munnar

Malayattur

Kottayam

Ranni

Periyar

Konni

Punalur

Thenmala

Trivandrum

kilometres

Bamboo high
Bamboo medium
Bamboo low

Forest Divisions, Kerala

Quantity of bamboo available in 1997 was much higher than that in 1973. It would be interesting to speculate bamboo availability after in 2010. Based on present age distribution, it is evident that the Parambikulam region will have fully grown bamboo at that time. The total quantity available would be to the tune of 3.3 million tons. From this, it is evident that bamboo is a species availability of which can fluctuate wildly because of reasons like gregarious flowering and utilization plans should take this into account.

Acknowledgements

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