SCRIPTING A SCIENTIFIC WORKING PLAN FOR SIKKIM FOREST

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ABSTRACT

Working plan is a scientific document prepared for the intention of management of forest with specific set of silvicultural principles. This plan is usually prepared for a period of ten years after which it is continually revised before the expiry of the plan term. Working plan is prepared as per the set of guidelines embodied in the National Working Plan Code. Unlike other parts of the country, Sikkim's forestry history did not have a rich legacy of working plans prepared and revised since the time of the British Empire. Realizing this, the State Government provided the impetus for the preparation of this working plan in order to strengthen the scientific management of forests. The working plan of East Division has been prepared incorporating the latest state of art Remote Sensing and Geographical Information System tools. This has been supplemented with point sampling, ground truthing and total enumeration exercises in the ground. The concept of compartments has been introduced in this plan to ensure effective administration and accountability. The process of formulation of the plan has been democratized by incorporating the findings of socio-economic studies conducted all over the State to reflect the needs and aspirations of the locals dependent on forests. Following the State Government's ground breaking practices towards conservation of forests and the environment, there has been a steady increase in the percentage of forest cover as per the reports of the Forest Survey of India, Dehradun (FSI). Comparison of data of the year 2009 with that of 1988 consolidates the findings of the FSI, wherein a clear increase in the volume of the growing stock and a gradual proportionate increase in the number of stems per hectare can be ascertained. Oak ecosystem is a fragile and extremely vital ecosystem in the Himalayas. Specific measures have been prescribed to propagate oak in tracts run over by bamboo thickets. Sustainable practices of eco-tourism to boost the local economy and reduce pressure on forests constitute an integral part of this plan. National set of criteria and indicators have been incorporated into the plan to scientifically quantify the direction of the forest towards sustainability.

KEYWORDS: *stocking density, volume, stems per ha, Himalaya, oak*

Micro-zonation by forming compartments for effective management of forests of East Territorial Division

Dense thickets of dwarf bamboo species occur in degraded oak forests as secondary growth. Dwarf bamboos are aggressive colonizers, leaving very little chance for oak regeneration to thrive in the thickets. These forests are home to the State Animal-Red Panda, which lives extensively on bamboo leaves and shoots

INTRODUCTION

Working plan is a tactical silvicultural plan. It encompasses an integrated and time scheduled package of silvicultural prescriptions to achieve objects of management. It is implemented at landscape or forest management unit (FMU) level. The time horizon of such a plan is generally ten years. It means that the plan will be revised in every ten years. Evolving an appropriate package of silvicultural prescriptions is an uphill task.

Although the history of Sikkim's forestry is over a century old, it did not have a proper and scientific working plan to manage its rich resources. The first working plan for the entire State was written by a forester from Bengal Shri K. C. Roy Chaudhary, for the period of 1951-52 to 1970-71. This plan was extended by the Ministry on behest of the State Government till the year 2000. An approved working plan for South District was operational in the State for quite a few years. Other then these references, there was nothing in place to initiate the first scientific working plan for East Forest Division of Sikkim. The degree of difficulty involved in carrying out this task was immense to say the least. The Government of Sikkim was keen to adopt scientific principles in the management of its natural resources. Hence the task of preparation of the working plan of East Division was initiated in right earnest.

Sal forests occur at the foot hills of the State and are a climatic climax species of the region. Champion and Seth have classified these forests as very moist sal (*Shorea robusta* Gaertn.)-bearing forest (3C/C1). Occurs in the elevation band of 300-900m. These forests are dotted with *taungya* plantations of teak and sal

Description of Forest Types of East Division

As per forest type classification by Champion and Seth (1968), out of the 12 forest types found in the Sikkim Himalayas, 9 forest types are found in the East Division. Each forest type is dramatically different from the other in types of floristic composition and its silvicultural requirements. Hence it was imperative to prescribe specific silvicultural principals for each forest type. The nine forest types found in the division are broadly classified into the following six forest types as given below:

2.1 Lower Hill-Tropical Semi Evergreen Forest 3C/C1(300m-900m):

The vegetation of this zone is confined to an altitude between 300-900 m consists of mainly tropical dry deciduous to semi-evergreen species with sal as a dominant species. Sal is mainly confined to Teesta valley. Some of the common tree species are *Terminalia myriocarpa, Albizzia lucida, Callicarpa arborea, Dalbergia sissoo, Anogeissus latifolia, Adina cordifolia* and certain bamboo species as undergrowth.In the East Division, this forest type is restricted to the low elevation areas of Singtaam Range, Rongli Range and Pakyong Range. This forest type is found in Amba RF, Bhasme RF, Dhanuke RF, Pacheykhani RF, Burdang RF, Linku RF, Ralep RF, Khamdong RF, Song RF, Tinek RF, Burung RF, Salingay RF, Tumlabong RF, Khani RF, Sitey RF, Dikling RF and Tarpin RF.

2.2 Middle Hill-Sub-tropical Mixed Broad Leaved Hill Forest 8B/C1(900m-1800m):

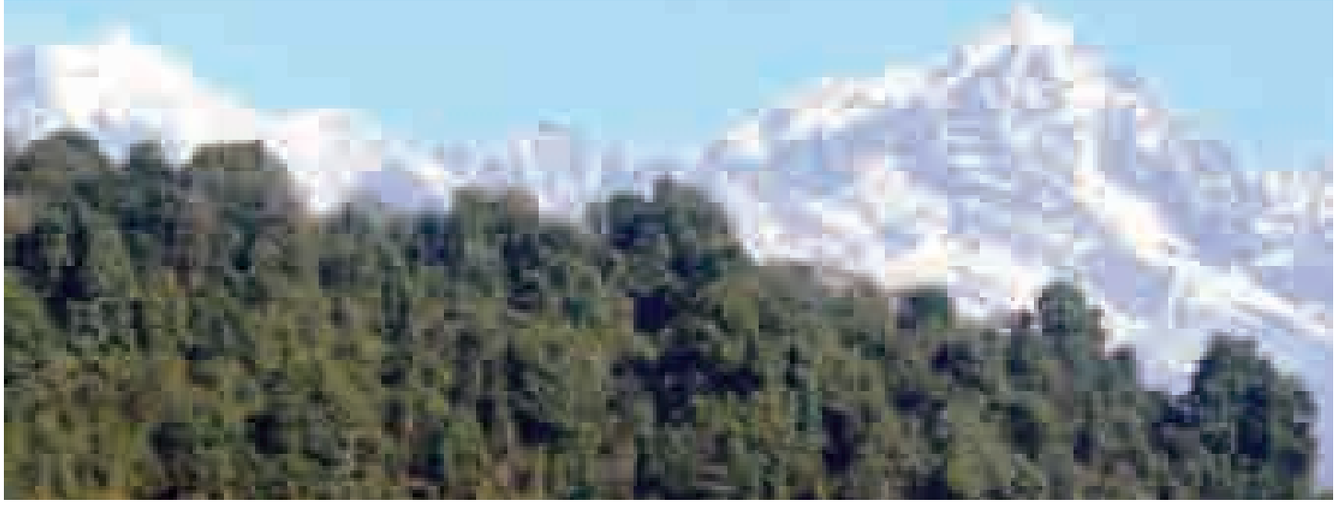
The tall evergreen species of *Alnus nepalensis, Prunus cerasoides, Schima wallichi, Englehardtia spicata* and associated with other species of *Castanopsis, Macaranga, Eugenia, Sapium etc.* are seen in the altitude zone between 900 and 1800 meters. This forest type is mostly found in areas outside forest. In the forest areas it is restricted to Sumin Rf and Karthok Rf of Singtaam and Pakyong Range respectively.

Champion and Seth have classified this forest type as East Himalayan Subtropical wet hill forests 8B/C1. Occurs in the elevation band of 900-1800m. Most of the major towns and settlements of the region are located in this zone. Reserve forests often take the shape of islands in the hills, surrounded by private holdings/settlements

Alder forests are regarded as magic trees of the region due to their sheer versatility. The first pioneers to colonize land slide areas, these trees have frankia-root association, which plays a pivotal role in the nitrogen cycle. These forests are seen all along the river belts. Fast growing and also a favourite for birds/wildlife, these forests extend from the hot valleys uptill the foothills of Lachung in North Sikkim

2.3 Upper Hill-Himalayan Wet Temperate Forest 11B/C1 -(1800m-2400m):

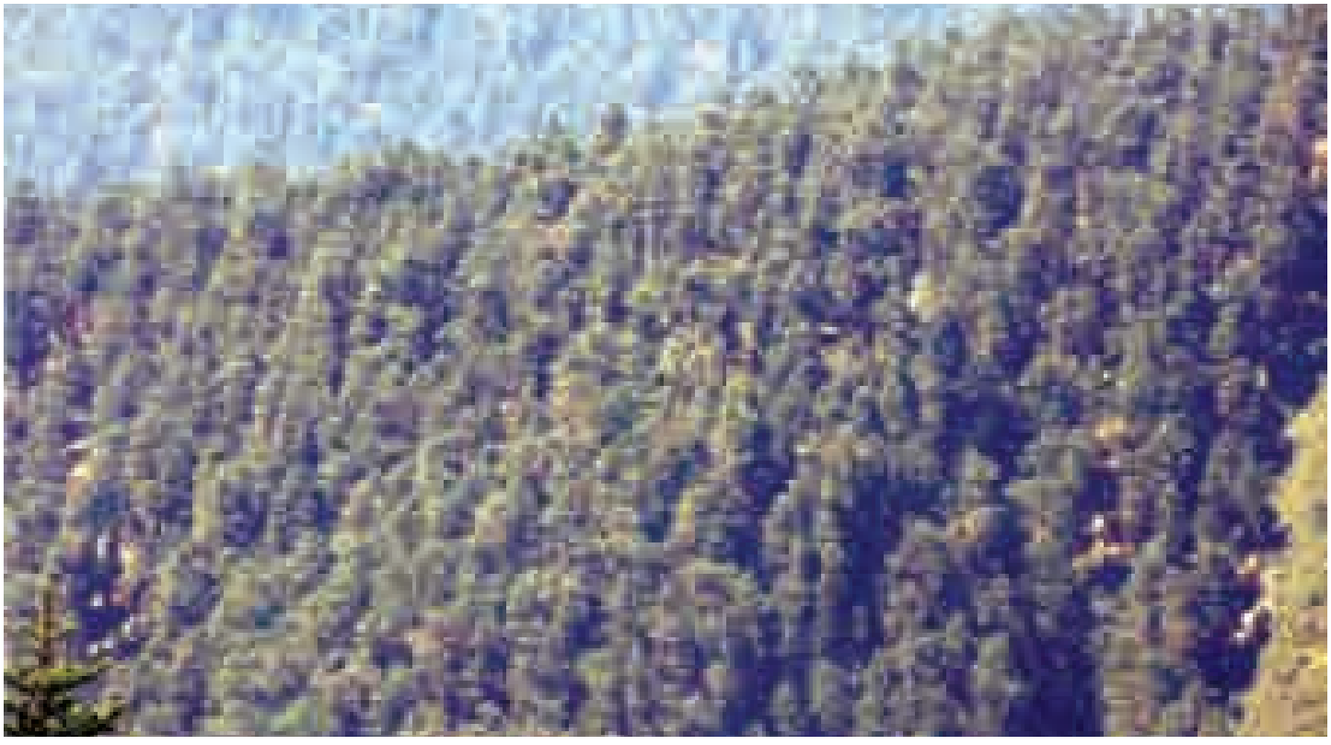
This zone is a transitional zone between subtropical mixed broad leaved to sub-temperate zone with species ranging from *Alnus, Machilus, Quercus* and *Symplocos sp.* The evergreen tree dominates the region and the undergrowth is mainly of dwarf species of bamboos. This forest type is the most widely distributed forest type in the State/division. This forest type is distributed in about 221.19 sq kms of forest land, which is nearly half of the total forest area of 512 sq kms. This forest type is found in 43 compartments in Gangtok Block, Pangthang Block, Pathing Block, Rangpo Block, Pakyong Block, Asam Block, Kyongnosla Block & Rongli Block.



Oak forests are arguably the most important forests in this part of the Himalayas. They are an endemic and endangered ecosystem of the region. These forests occur in the elevation zone of 1700-2400mts. Champion and Seth classified these forests as Upper Hill-East Himalayan Wet Temperate Forest 11B/C1. There are eleven species of oak in the State. These forests are perhaps the most integral ecosystem in maintaining the hydrological dynamics of the rivers in the region

2.4 Sub Alpine Forest-(2400m-3000m)

The typical temperate forests consists of species of *Pinus* and *Abies* mixed with *Picea* and *Tsuga* and *Juniperus* covering extensive areas intermixed with species of *Oak-Rhododendron, Betula* and *Machilus sp*. This forest type is distributed in Kyongnosla Block and Phadamchen Range.



Champion and Seth have classified these forests as East Himalayan Wet Temperate Forests 11B/C1. These forests occur between 2700-4000mts, up to the tree line. At its optimum, silver fir (Abies densa) forms natural mono-specific stands, thereby making it the most difficult forest eco-system to manage

Dwarf bamboo Arundinaria maling occupies the lower strata of Hemlock-Spruce forests in compartment 1 of Lachen Block. This association typifies canopy clearing and logging of trees in the past without adequate replanting in the felled area

2.5 Moist Alpine Forest-(2700m-3700m)

The zone mainly consists of Rhododendron species intermixing with temperate to evergreen species. The vegetation becomes sparse as altitude increases and often restricted to grooves of the hills. This forest type is found in Kyongnosla Block and Phadamchen Range.

2.6 Dry Alpine Forests-(3700m-4500m)

The vegetation is practically of scattered scrubs, often barren. Most of the species are of stunted thorny scrubs nature because of adverse conditions of less soil cover and severe frost. Some of the common species are *Berberis, Juniperous* and *Salix.* There are two zones of this forest type. One is Alpine barren (without vegetative cover) and Alpine scrub (with bush). This forest type is found in Kyongnosla Block and Phadamchen Range.

These alpine thickets have been classified as Champion and Seth as Birch/Rhododendron scrub forests 15/C1. These forests occur in the elevation band of 3500-4500, often occupying areas of degraded silver fir stands. The major species are *Rhododendron* sp., *Juniperus* sp., *Betula* sp. and *Acer* sp.

As per satellite imagery data, alpine scrub forests along with alpine meadows constitute the large chunk of forest area of the State of Sikkim. These scrub forests constituting mostly of Junipers and Rhododendron occur between 4000-5500 meters, way above the tree line. These have been the traditional grazing grounds of the herders in the higher altitudes. These areas are critical habitats of the Blue sheep (*Pseudois nayaur*) and Himalayan musk deer (*Moschus chrysogaster*)

3.0 Extent of forests

The territorial jurisdiction of East Forest Division is co-terminus with East District. The total area of the tract is 954 sq kms. There are three Protected Areas (PAs) in the district falling under the jurisdiction of the wildlife sector of the Forest Department. The total extent of reserve forest in the district is 512.09 sq kms, out of which 301.33 sq kms come under the territorial jurisdiction. The extent of the *Khasmal* and *Goucharan* forest in the tract is 63.28 sq kms. The extent of RF diverted for non forestry purpose under the provisions of the Forest Conversation Act 1980 stands out at 394.27 ha.

The area statement of *Khasmal* land has been taken from the certified area statement from the Land Revenue Department. It is recommended that by the time of the mid term evaluation of this plan, the Survey and Demarcation Division should submit a concrete *khasmal* and *goucharan* land statement after proper verification and pillaring. Encroachment in *khasmal* and *goucharan* land should not prevent the Department from erecting the boundary pillars as per the survey records. The range wise distribution of reserved forests and *khasmal* lands are as in the table below:

Sl no	Range	Reserve forest area in (ha)	*Khasmal* and *Goucharan* land area (in ha)
1.	Gangtok	2520.63	734.69
2.	Ranipool	2508.33	734.79
3.	Pakyong	652.09	878.34
4.	Pathing	1089.87	0
5.	Singtaam	1608.58	1091.56
6.	Phadamchen	3781.47	530.59
7.	Rongli	2087.29	1803.11
8.	Tumin	0.00	555.21
9.	Kyongnosla	15884.48	0.00
	Total East	**30132.74 ha**	**6328.29 ha**

4.0 Past systems of management:

The Forest Department of Sikkim is one of the oldest departments and came to existence in 1890's. Prior to demarcation, forests were cut down, as per the wishes of the local people. So much of the accessible forests in the lower belt were impacted. Reserved Forests were demarcated vide C.M. 03.03.1902. *Khasmal* Forests were demarcated vide Notification No 2 of 29/03/1905. Sidkeong Tulku the king of Sikkim at that point of time, was instrumental in demarcation of forest areas. Forest Department was constituted in 1909 to look after the forests. In the year 1911, *Goucharan* Forests were notified vide Notification No 14 dated 22/11/1911. As cultivation took up most of the areas between 2000-5000 feet, the forests were mostly available beyond this zone. The upper elevation forests which merged into the snowline were demarcated only along the lower boundary. *Khasmal* and G*oucharan* were constituted and demarcated in the field but not mapped properly. Even after the demarcation of Reserve forests and constitution of the Forest Department, felling went on according to public demand and exploitable trees of useful species were selectively harvested.

The first land settlement survey throughout the entire State was carried out in the year 1889 when the administration was under the control of the then Political Officer, Mr. J. C. White, C.L.E. In the course of the settlement survey, jungles, steep hill sides, rocks, hill-tops all were measured and mapped and then according to the quality of land leased out to *Thikadars* and *Kazis* at a very low rental of 3 to 4 Rupees per acre. Distribution of Forest land for cultivation to *kazis* and *Thikadars* prompted the settlement of more and more habitations in different localities and as a result forests were slowly turned into open fields for the purpose of growing food crops. The State as a whole was divided into 52 (fifty two) *thekadari elakhas* managed by independent *thikadars*. The *thikadars* were empowered to issue permits to villagers for collection of forest produce for bonafide purpose and also for grazing of cattle for a nominal fee. Forest Department was mostly responsible for areas in the higher elevations outside the *elakhas*. They were also responsible for clearing and maintaining of Reserved Forest, *Khasmal* and *Goucharan* fee. Forest Department was mostly responsible for areas in the higher elevations outside the *elakhas*. They were also responsible for clearing and maintaining of Reserved Forest, *Khasmal* and *Goucharan* boundaries of their respective *elakhas*. However, the overall control and supervision of the forest was vested with the Forest Department. Separate monastic forests (*Gompa* forest) found in and around the surroundings of monasteries were also created around the same time. *Thikadari* system was at last abolished sometime towards the end of 1950 and all the rights and power vested to *Thikadars* and monastery authorities were finally withdrawn and with this the days of dual system of management of forest in Sikkim came to an end after lasting for a period of about 40 years. For the first time, in the history of the Forest Department of Sikkim, the first Working Plan of Sikkim Forests was written by Shri K. C. Roy Choudhury on deputation from West Bengal Senior Forest Service during the year 1951-52. The Department Administration was set up in the year 1954-55 by designating the Departmental Head as the Conservator of Forests. The whole state was divided into Divisions, Ranges and Blocks to facilitate the proper management of the forest wealth of the state. This plan was written for the period of 1951-52 to 1970-71 and was later extended till the year 2000. As per this plan, forest was divided into Reserve Forests, *Goucharan* Forests, *Khasmal* Forests. Besides these, State owned forests were also divided into two minor reserves called the Slip Reserve and Road Reserve. Other types of forest areas not under the state Forest Department were the Home forests of Kazis, Gumpa forests and the Private forests of his Highness and those of some members of the Royal family.

However forest areas were not mapped properly, no maps were prepared for *Khasmal* and *Goucharan* lands. Conversion, wherever possible, of the existing irregular forests into a regular forest, consisting of even aged trees of normal age graduations, in order to secure a regular supply of produce of the best quality in the greatest quantity possible was the main objective of the plan. After the expiry of the plan in 2000, the preparation of this plan was initiated in the year 2008.

5.0 Threats to forests

The forests of the tract are vulnerable to a number of elements. The main factors are fire, illicit felling, grazing, road construction and the presence of Armed Forces posted in forest pockets.

Fire is a yearly phenomenon in the lower hill sal forest. Fire incidences begin in the month of December till March/April. Usually ground fire/creeping fire have been reported from these areas. Fire causes extensive damage to the undergrowth, particularly hampering sal regeneration and young plantations. During prolong periods of drought, fire incidences have been reported in the temperate forests like in the year 1974. The more recent incidence of high fire occurrence was during the period of December 2008 to March 2009 when 51 fire incidences were reported in the tract alone.

Illicit felling is reported in forest areas near to human habitations. The main hubs of such activities are the major towns of the district like Gangtok, Singtam, Ranipool and Rangpo. The demand of timber is high in these areas. Timber like Sal, Teak, Champ, Katus, Kimboo, Tooni, Silver fir etc. fetch good price in the local market. Assam Reserve Forest, Tsaney Senti Reserve forest, Thekabong reserve forest, Rateychu Reserve Forests, Thekabong reserve forest, Rateychu Reserve Forests, Bhusuk Reserve Forests, Bhasmey Reserve Forests are the main target areas of illicit felling in the tract. Similarly, the fringe forest area like Rumtek, Tumin, Samdong, Martam and Song of Fambong Lho Wildlife Sanctuary and Nimachen, Pongola on the fringes of Pangolakha Wildlife Sanctuary are main areas of illicit felling. Since trees of the Himalayas are poor coppicers, often felled trees fail to coppice copiously.

Grazing is a serious issue in the State. Animal husbandry is the main stay of occupation in the State along with Agriculture. There has been a substantial increase in population of livestock over the last century. The population stood at 2,99,020 in the year 2003. Notwithstanding the ban on grazing in reserve forests, the problem is still malignant in some pockets of the tract, leading to a poor percentage in natural regeneration of trees, which already have a natural tendency to regenerate in lesser proportions as compared to the species in the plains.

East Division has a heavy presence of security forces owing to its proximity to the International Border. Road construction and maintenance under PMGSY and by the BRO is a year long activity. These activities have caused damage to the vegetation in terms of felling of trees and damage to the forest by the excavated material dumped from the road side.

6.0 Stock Mapping

Modern and scientific working plans are written with the aid of latest State of Art Remote Sensing and Geographical Information System. These tools are meant to assist in the process of plan formulation and the results have to be suitably checked in the ground by ground truthing exercises. During the process of the plan, Remote Sensing and Geographical Information System (GIS) were used at several stages to give a synoptic view of the forests from the sky. These tools are indispensable in the writing and interpretation of forest types and forest densities in a modern working plan. For this purpose, the services of the Forest Survey of India (FSI) Dehradun and NRSC (National Remote Sensing Centre) Hyderabad were taken into full use for obtaining latest satellite imageries in both digital and hard copy formats. These imageries were analyzed, interpreted and worked upon for the creation of different maps of forest types and densities in the GIS laboratory of the Forest Department (Table 1).

Table 1. Broad forest types, their density and extent (in ha) in East Sikkim

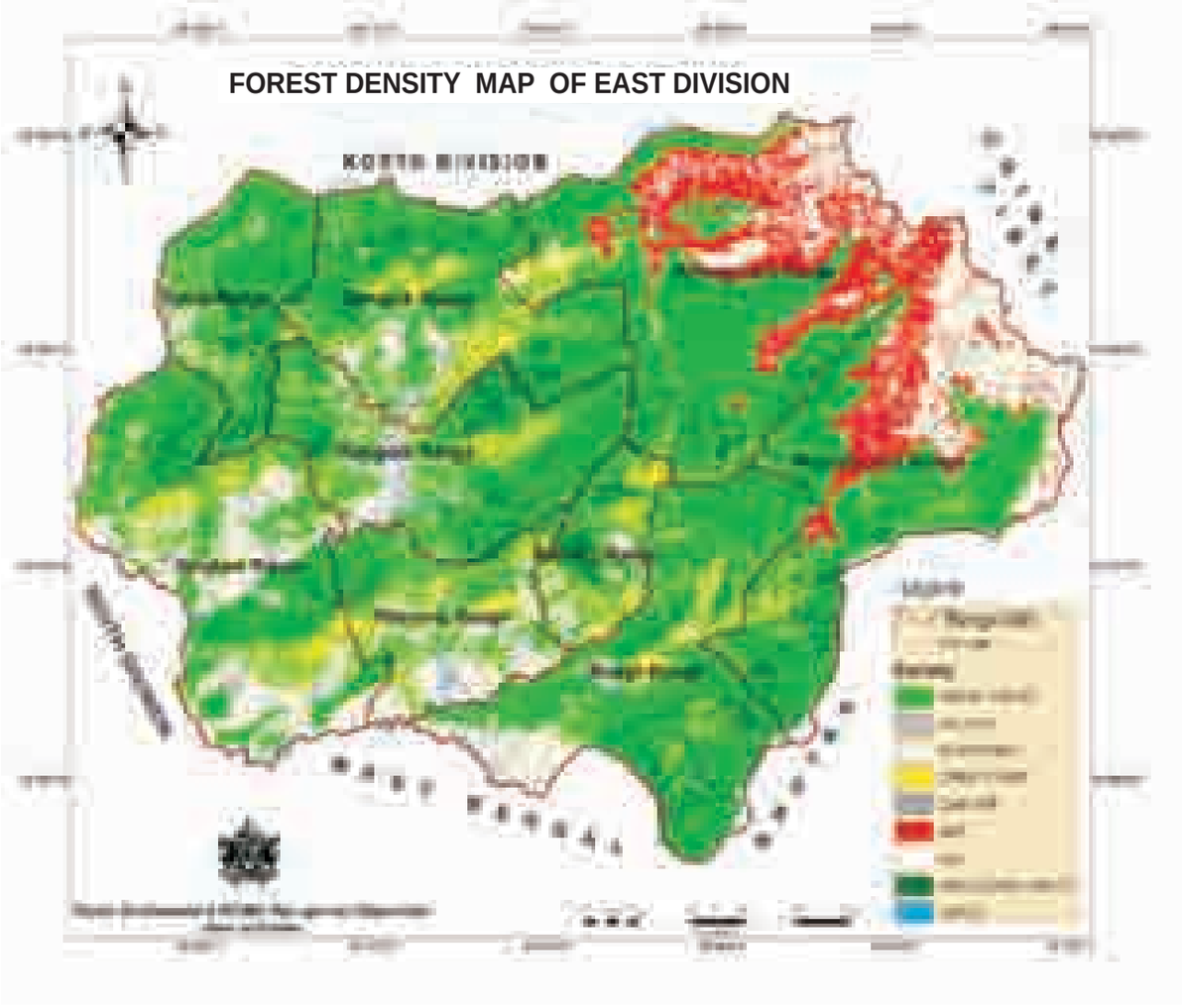
Forest Type	Dense	Open	V. Open	Thicket	Scrub	Blank	Total	Dense %
Conifer forest	4,645	5,981	149	3,362	524	168	14,828	26
Mixed Conifer forest	522	411					933	2
Oak forest	12,197	6,808	3,857				22,863	40
Alder forest	2,990	3,766	2,157		3,562		12,475	22
Warm broad-leaved forest	1,889	928	281		153		3,251	6
Subtropical forest	962	1,279	481		171		2,893	5
Sal forest	27	21	405				452	1
Total	**23,232**	**19,194**	**7,330**	**3,362**	**4,409**	**168**	**57,696**	**100**
% of Total	**40**	**33**	**13**	**6**	**8**	**0**	**100**	

Before this plan, there were no stock maps prepared for the division. Hence fresh stock maps had to be prepared. Stock maps have been prepared for all blocks of the division. Distribution of various forest types and densities have been calculated for each block and displayed on the maps in the form of pie charts and histograms. Stocks maps have been prepared using the satellite imagery classification work done by Shri M.L. Arrawatia IFS & Shri Sandeep Tambe IFS (2009). The study area was surveyed during summer and winter seasons in 14 field visits spanning 125 days over a three year period from 2004 to 2006. A total of 161 ground reference points along with attribute data on location and vegetation characteristics were recorded using a hand-held Garmin Global Positioning System (GPS: 12-channel Etrex summit mode). Winter surveys helped in creating a database of about 200 digital photographs of the landscape which helped during visual interpretation especially of areas under shadow.

The following process was followed namely:
1. Supervised classification
2. Reclassification RF NON RF and within that 500 meter altitude zones in 13 classes
3. Recoding for mixing classes
4. Manual recoding
5. Area calculation
6. Mosaicing

Hence a hybrid classification strategy was adopted. Satellite imagery of IRS-IC LISS III image was used to classify the patches of forest according to density revealed in the Normalized Density Vegetation Index (NDVI) mapping. ERDAS and ARC GIS 8.4 have been used for DIP (Digital image processing) and mapping.

The maps above indicate the forest density and forest types in East Division. After obtaining this imagery from FSI Dehradun, this was subject to digitization of the division and range boundaries.

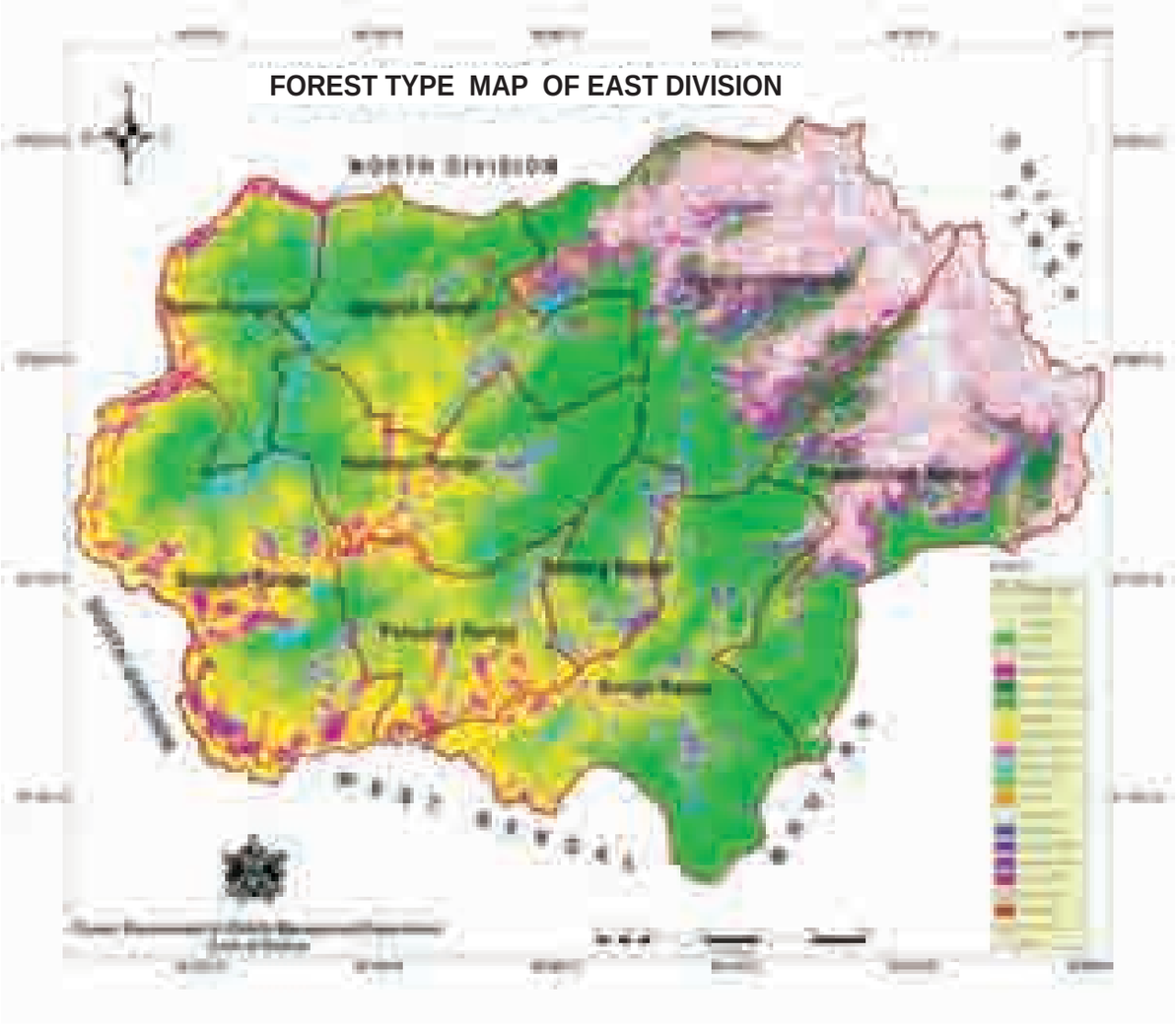


7.0 Forest Management Units

The smallest unit of forest management (FMU) is a compartment. Compartments, hitherto, were not existent in the working of the Department. During this plan, compartments were demarcated for better administration and also for clear demarcation of duties at the field functionary level. Compartments were carved out based on the geographical features of the topography of the landscape. Ninety compartments were delineated in East Division using GIS software Arc GIS 8.4. The map below is the compartment map of East Division.

After the digitization of this map, all that was required was to further delve into the micro levels of the landscape i.e Range level, Block level, Beat level and Compartment level for meeting the purpose of creating this map.

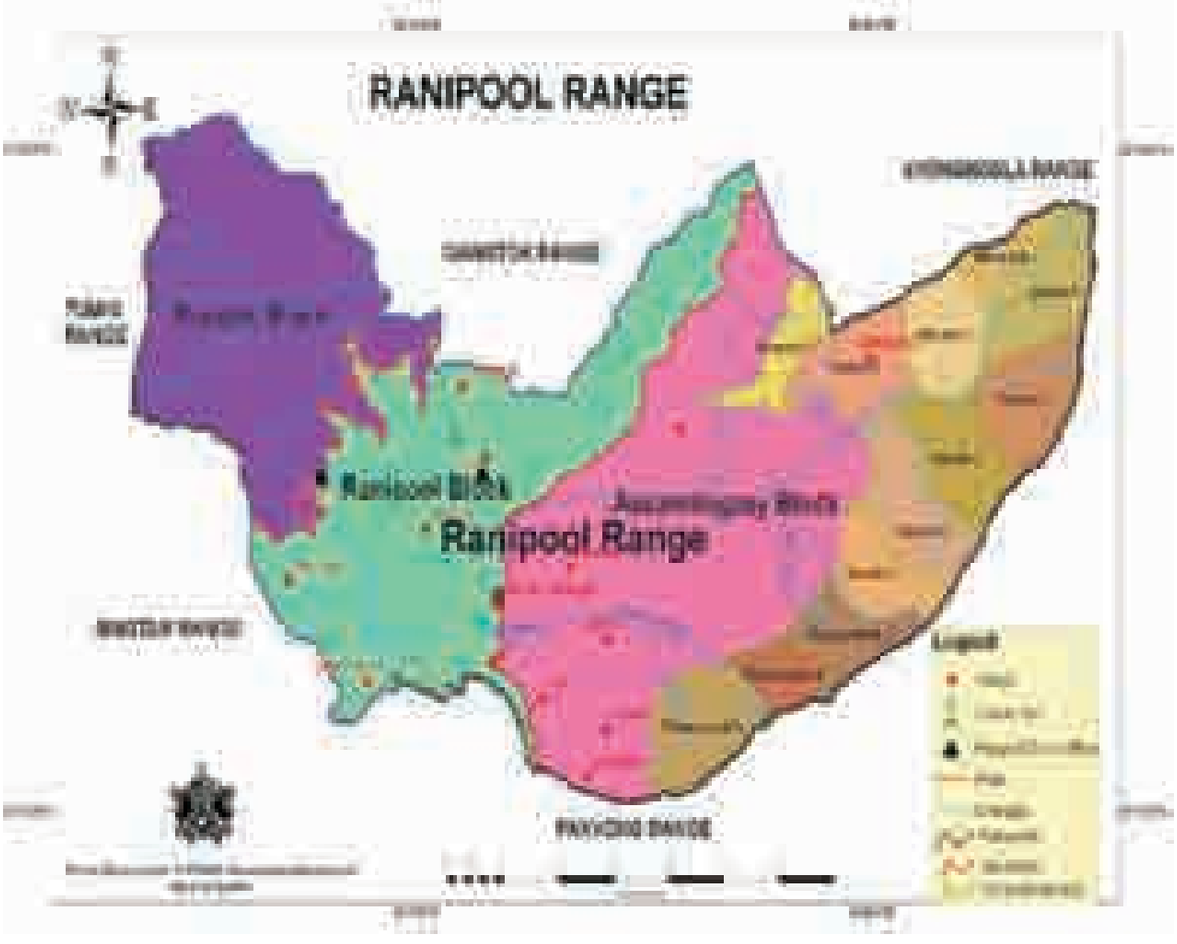
The map indicates Ranipool Range with its set of compartments in Asamlingzey Block. As is apparent from the map, there are no compartments in Rumtek and Ranipool Block since there is no Reserved Forest Area in these two Blocks.



The map shows Assam Lingzey Block draped in Remote Sensing Imagery. This map has been grafted out of the map of Ranipool Range. Compartments are clearly indicated in this map with the bold red markings. The density of the forest in this block has been indicated in various hues. Further, the percentage of distribution of various density classes has been indicated with in the form of a pie chart.

The map again shows Assam Lingzey Block swathed in Remote Sensing Imagery. Like in the earlier map, compartments are clearly discernible in this map. This map is indicative of the distribution of forest types in the demarcated area. The area wise distribution of various forest types has been indicated with in the form of a histogram.

The map indicates the jurisdiction of just one of the compartments of Assam Lingzey Block, which has been designated as Tsaney Senti 1. This map has been cut extracted out of the map indicating Assamlingzey Block. Each compartment has been given a separate identity and detailed compartment description has been written for each of them



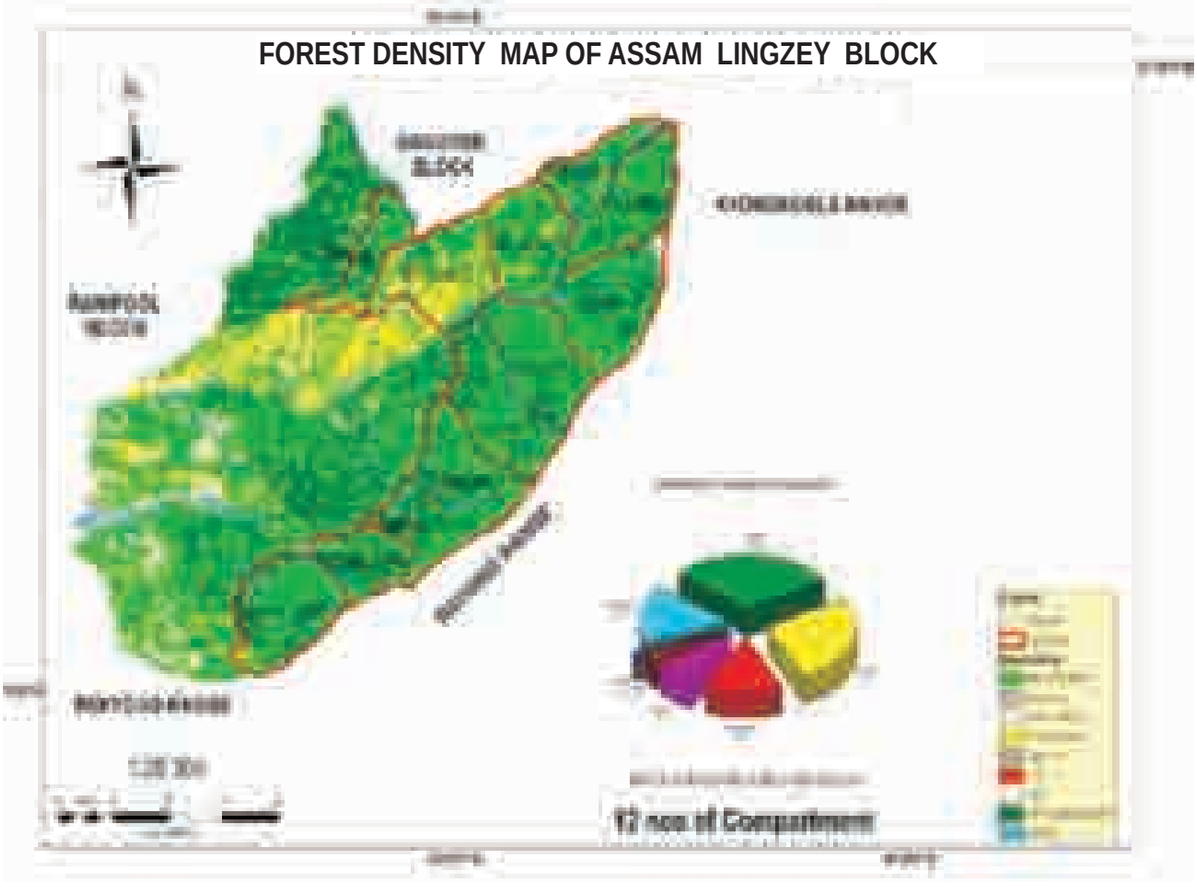
by carrying out point sampling methodology using grid methodology designed by the Forest Survey of India. This was followed by intensive ground truthing exercise to testify the veracity of the point sampling exercise carried earlier on. These ground facts were matched with the latest Remote Sensing imageries procured from the FSI and necessary corrections were made. Several anomalies in the findings of the FSI were also detected and reported accordingly. Compartment level details thus constituted the basic essential building blocks of scientific prescriptions for the working plan. This exercise was carried on individually for all the ninety compartments of the tract.

8.0 Statistics of Growth and Yield

In order to get a clear understanding of the change in forest cover and density of the tract, a time series data comparison was carried out with the data recorded in the year 1988 and the more recent data compiled in the year 2009:

8.1 Growing Stock in 1988

In the year 1988, an in depth study was carried out by the Forest Survey of India on the forest resources survey of East Sikkim. In the study, the whole forest of the district was broadly segregated into four strata based on elevation bands of up to 900 meters, 900-1800 meters, 1800-2400 meters and >2400 meters. The objective of this study was to arrive at an



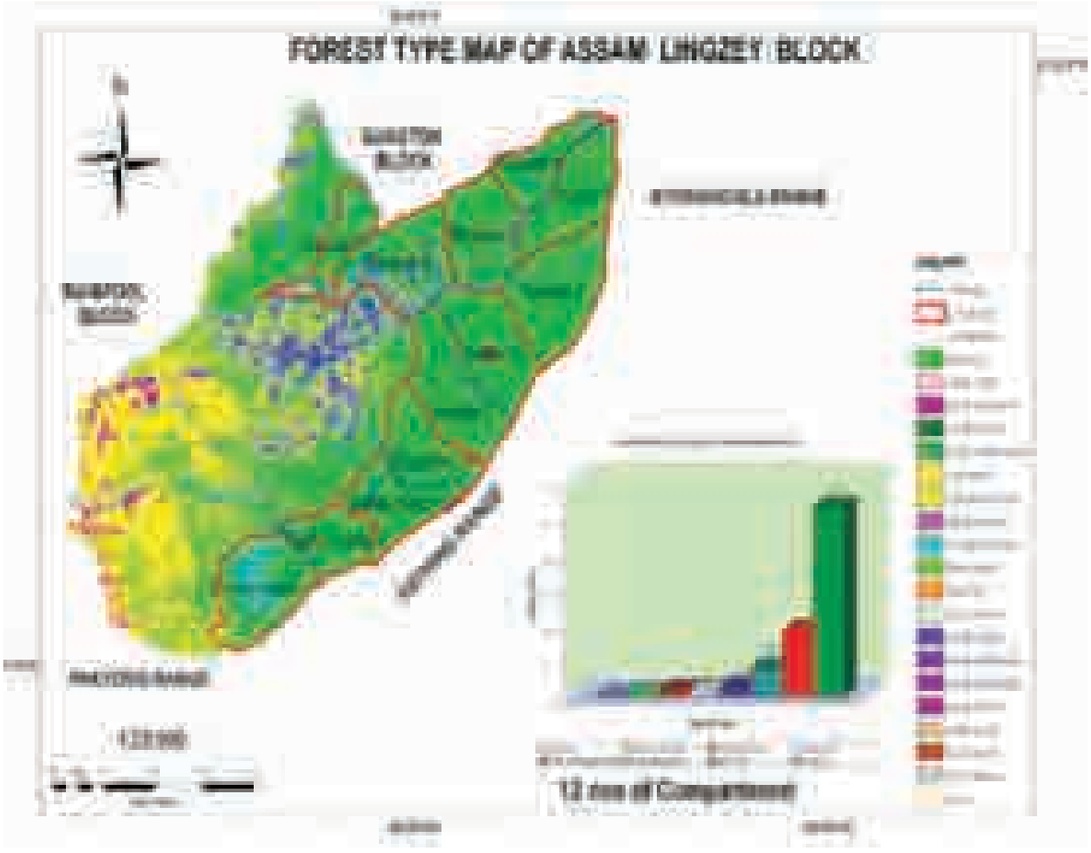
approximate value of stems per ha and volume per ha. Based on these findings, the net demand and supply of forest produce for the entire district was worked out. The findings of the FSI report of 1988 were as below:

Data of East district prepared by FSI 1988			
Strata	**Altitude**	**Stems per ha**	**Volume per ha**
I	900m	200.63	49.44
II	900-1800m	164.38	34.75
III	1800-2400m	245.33	45.51
IV	> 2400m	232.5	77.63

Source: FSI report on Forest Resources Survey of East & South Districts, 1988

8.2 Enumeration in 2009

In the year 2008-09, extensive point sampling of 0.1 ha was carried out in the entire division to ascertain the growing stock. Formats designed by FSI Dehradun were used in this exercise. For enumerating trees, a plot of 31.62m x 31.62m was laid down. For measuring shrub counts, four plots of 3m x 3m were laid from a distance of 50 meters from the centre of the plot. For measuring herb count, four plots of 1m x 1m were laid within the shrub plots. Since compartments were being delineated for the first time in field and laboratory, two to three sample plots were laid in each compartment to get the representative stock and type of vegetation. A total of 180 sample plots were laid through out the division, encompassing all forest types. After completion of point sampling, about 40 to 45% of samples were rechecked and corrected for several parameters. Point sampling data was also verified with the image classified satellite data. In



comparison to the methodology followed in 1988, the distribution of strata in the present data is minuter with five strata, in sync with the five forest types bearing timber. Alpine scrub and alpine meadows have not been taken into account in the stratification since these forest types are above the tree line. In 1988, stems per hectare and volume per hectare have only been accounted for. In the present case, along with the stems per hectare and volume per hectare, a third parameter of basal area per hectare has also been calculated.

Salingey compartments in Singtam Range has teak plantations carried out by *taungyadars*. These plantations need to be thinned for ensuring vigorous growth of the standing trees. Complete enumeration being carried out to identify the weaklings and also to estimate the growing stock of the plantations

8.3 Calculation of Growing Stock

The growing stock of the forest of the division has been calculated on the basis of the standard volume equations prepared by Forest Survey of India. They are as below:

Local Volume Equations Based on Forest Survey of India	
Following local volume equations have been used in volume calculation in the present Inventory	
Form class	**Equations**
I	$V/D^2 = 0.001559 + 0.06674/D^2 - 0.02039/D$
II	$V/D^2 = 0.0012897 + 0.25564/D^2 - 0.030418/D$
III	$V = 0.12652 - 0.018037\ D + 0.000956D^2$
IV	$V/D^2 = 0.001184 + 0.1812/D^2 - 0.02348/D$
Species:	
Abies densa	$V = 0.12167 - 0.0114D + 0.000812D^2$
Alnus nepalensis	$V/D^2 = 0.001559 + 0.06674/D^2 - 0.02039/D$
Michelia exelsa	$V/D^2 = 0.0002138 + 0.002517/D + 0.00001064D - 0.00000004D^2$
Symplocos theaefolia	$V = - 0.03754 + 0.000587D^2$
Tsuga dumosa	$V/D^2 = - 0.00055 + 0.00716/D + 0.000029D - 0.00000012D^2$
Others	$V = 0.3555 - 0.037D + 0.001259D^2$

The findings of the present study are as given below:

District Average	**Stratum**	**Elevation**	**Stem/ha**	**BA/ha**	**Volume/ha**
Conifer Forest	V	3000m +	795.56	96.88	1145.45
Mixed Conifer Forest	IV	2400-3000m	503.33	25.11	262.87
Oak Forest	III	1800-2400m	345.64	64.02	740.82
Wet Hill Forest	II	900-1800m	168.54	28.16	291.53
Sal Forest	I	Upto 900m	224.77	28.87	233.05
	District Average		**407.57**	**48.61**	**534.74**

8.4. Comparison of Growing Stock between 1988 and 2009

On the comparison of growing stock of 1988 and 2009 the following inferences can be drawn:

1. The overall growing stock has increased in the last 20 years. There has been a gradual and proportionate increase in stems per hectare in all the strata.
2. There is a clear indication that the volume of stock has shown a steady increase in girth and height of the trees over the last twenty years.
3. The increase in volume can also be attributed to the fact that in 2009, many samples have been taken in plots having trees >100 cm diameter as compared in 1988 wherein only a few samples had trees >100 cm. The sampling intensity was higher in 2009 as compared to 1988. In 2009, opportunistic sampling was also carried out in dense forests and plantations along with random sampling using grid methodology. The young plantations of *Crptomeria japonica* (Dhuppi) and *Tectona grandis* (Teak) have taken gigantic growth in terms of volume over the last two decades, thereby enhancing the volume data. Lastly, due to stringent conservation measures of the Government, the large openings in the vast stretches of oak forests have been covered with naturally occurring fast growing associate tree species. This fact has also been recorded in the enhanced readings of stem per ha in the oak strata of East Division.
4. Basal area per hectare readings were not taken in 1988, hence no comparison can be drawn.
5. As per the present enumeration, the maximum growing stock is locked up in the conifer forests followed by oak forests.

9.0 Findings of the Socio-Economic Survey

An in-depth socio-economic survey was conducted at the Block Administrative level by involving the Assistant Conservator of Forests posted in all the BACs. This study was conducted in 44 gram panchayat units of the division to assess the needs and aspirations of the people from the forests. Since people have been conferred no rights in the reserved forests, this study covered khasmal and Goucharan lands of the State. Before conducting the socio-economic survey, all the Assistant Conservator of Forests of BACs were given a one day training on participatory rural appraisal techniques. Findings of the socio-economic survey of the gram panchayats are as given in the table below:

Preferred firewood species	Preferred fodder species	Preferred fruit trees
Alnus nepalensis (Uttis), Schima wallichi (Chilaune), Englehardtia spicata (Mahuwa), Macaranga nepalensis (Malata), Acer campbelli (Kapasi), Betula alnoides (Saur) and *Duabanga sonneratoides (Lampatey)*	*Ficus roxburghii (Nebara), Ficus benjamina (Kabra), Hedera helix (Dudhilo), chulatro,Thysamolaena maxima (Amiliso),Ficus cunia (Khaneo), Saurauia fasiculata (Gogun),Litseae citrate (Kutmero)* and *Ficus bengalensis (Bar)*	*Persea americana, Spondias axillaries (Lupsi), Ficus cunia (Khaneu), Baccaurea sapida (Kusum), Ficus roxburghii (Nebahara), Zizyphus sp, Castanopsis (Kattus), Machilus edulis (Pumpsi), Juglans regia (Okhar), Eleocarpus sikkimensis (Bhadrasay), Bassis butryaceae (chewri), Aegle marmelos (Bel)* and *Eriolobus indica (Mel).*

10. Criteria and Indicators

Sustainable forest management (SFM) is the management of forests according to the principles of sustainable development. Sustainable forest management uses very broad social, economic and environmental goals. A range of forestry institutions now practice various forms of sustainable forest management and a broad range of methods and tools are available that have been tested over time. Criteria and indicators are tools which can be used to conceptualize, evaluate and implement sustainable forest management. Criteria define and characterize the essential elements, as well as a set of conditions or processes, by which sustainable forest management may be assessed. Periodically measured indicators reveal the direction of change with respect to each criterion. Criteria and indicators of sustainable forest management are widely used and many countries produce national reports that assess their progress toward sustainable forest management.

As per the National Working Plan Code it becomes mandatory to define a specific set of Criteria and indicators in a working plan. This scientific methodology has been introduced in the plan. In the East Division, a set of eight criteria and forty eight indicators have been identified to assess the trend of the forest towards sustainability. Each indicator has been given a specific code and this has been denoted in all items of assessment. Using this scientific tool, the trend of progression or regression towards sustainability of natural resources can suitably be quantified.

11.0 Objectives and Prescriptions

Keeping in sync with the National Forest Policy 1988, State Policy on Forests and Environment and the directives of the Hon'ble Supreme Court, this plan has been written with the main objective of ecological restoration and to further increase the forest cover of the tract. Plantation of local indigenous tree species has been given preference over exotic species. Exotics like Dhuppi (*Cryptomeria japonica*) have been discouraged in the plan. Thinning schedule of Dhuppi and some old congested plantations occurring in elevations below 1000 msl have been prescribed in the plan to reduce congestion and also to meet the fire wood and small wood requirements of the villages in and around forest areas. Keeping in mind the directives of the Supreme Court, plantations occurring in elevations above 1000 msl have not been prescribed for silvicultural manipulations. Under special circumstances, the Department may approach the Central Empowered Committee, a committee set up by the Supreme Court, for obtaining necessary permission for this purpose.

A paragraph on the oak forests their description, and the problems and prescribed solutions will be useful, since it figures in the abstract with not much description in the main paper.

Keeping the rich biodiversity and multiple forest types of the tract, a total of nineteen working circles have been prescribed to meet the specific silvicultural requirement of each forest types:

Sal selection cum improvement working circle
Middle Hill forests selection -cum-improvement working circle
Oak restoration working circle
Plantation working circle (Overlapping)
NTFP working circle (Overlapping)
Bamboo working circle (Overlapping)
Forest protection working circle (Overlapping)
Joint forest management working circle (Overlapping)
Wildlife management circle (Overlapping)
Soil and Moisture conservation working circle (Overlapping)
Conifer and miscellaneous species development working circle
Monoculture Dhuppi replacement working circle
Wetland working circle
Applied forestry research working circle
Monoculture teak and miscellaneous plantation species thinning working circle
Alpine meadows working circle.
Khasmal forest working circle
Eco-development and Eco-tourism working circle (Overlapping)
Biodiversity conservation working circle (Overlapping
Conifer and miscellaneous species development working circle
Monoculture Dhuppi replacement working circle
Wetland working circle
Applied forestry research working circle
Monoculture teak and miscellaneous plantation species thinning working circle
Alpine meadows working circle.
Khasmal forest working circle
Eco-development and Eco-tourism working circle (Overlapping)
Biodiversity conservation working circle (Overlapping

All mandatory working circles embodied in the National Working Plan Code 2004 have been included in this plan. Amongst all the working circles, Oak Restoration Working Circle and Eco-development and Eco-tourism Working circle needs a special mention. Oak is a climatic climax species of the Eastern Himalayas and today, it stands threatened in the State due to indiscriminate felling in the past and also due to its poor ability to regenerate naturally. To stem this rot, some lessons were taken from the neighbouring State of West Bengal where oak is being successfully planted in bamboo thicket areas. These methodologies have been prescribed for artificial regeneration of oak and its associate species in a time bound phase in all the oak deficit compartments of the tract.

Eco-Tourism working circle has also been given special status keeping in mind, its potential and utility in the State. Forest areas suitable for eco-toursim have been identified and specific time bound prescriptions have been laid down in the chapter. One of the major objectives of this chapter is to enable forest dependent people to earn their livelihoods through eco-tourism practices and thus to lessen the burden on forests for their daily needs.

A separate chapter has been devoted for the management of the Khasmal and Goucharan forests of the tract. For this purpose, an elaborate State wide socio-economic study was conducted utilizing the services of the Assistant Conservator of Forests posted in all the BAC (Block Administrative Centers) of the State. The reports of this study from the grass roots were complied and put in form of prescriptions reflecting the requirements and aspirations of forest dependent people for the next ten years. Thus this plan has been written in a democratic colour keeping the mandate of Joint Forest Management in its true perspective.

12.0 Acknowledgment

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This plan, in all fairness, just serves as a base for scientific forestry management in the State. Now with the history of Sikkim's forestry crossing the millennium mark, it is hoped that future foresters will bring quantum improvements in this plan and place Sikkim's Forestry on the world map with scientific and Sustainable Forest Management techniques.

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Blue sheep herd grazing adjacent to the Teesta Khangtse glacier - the source of the river Teesta in North Sikkim