DESCRIPTION AND ANALYSIS OF GOA'S WESTERN GHATS' VEGETATION WITH REFERENCE TO CASE STUDIES.

Thesis submitted to the Goa University
for the Degree
of
Doctor of Philosophy
in
BOTANY

By

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Dedicated to my beloved parents,
Father Morris, Mother Rachel,
Family members
and to all research
minded persons.

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ACKNOWLEDGEMENT

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CERTIFICATE

As required under R. No. O.19.8 (vi) of the Goa University, I certify that the thesis entitled "Description and analysis of Goa's Western Ghats' vegetation with reference to case studies" submitted by Mr. H. Nyamongo Nyabuto for the award of Doctor of Philosophy is a record of research work done by the candidate during the period of study under my guidance.

(S.G.Torne)

Signature of the Guide

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STATEMENT

As required under R. No. 0.19.8 (ii), I state that the research work entitled **"Description and analysis of Goa's Western Ghats' Vegetation with reference to case studies"** is my original contribution and the same has not been submitted for any degree of this or any other University on any previous occasion.

To the best of my knowledge, the present study is the first of this kind.

The research work comprising this thesis is my original contribution.

1. During the Botanical survey on the entire Goa, Taxon Distribution maps were prepared for Goa region of important medicinal, wild edible, and threatened plant species at 95% confidence limits.
2. Some new plant species were recorded for the first time in Goa, namely; **Atylosia crassa** Prain, **Hypericum mysorense** Wall, **Hugonia mystax** L., **Merremia emarginata** Hallier, **Scutia indica** Brongn and **Aeschynomene aspera** L.
3. An attempt on the life-form spectrum of Goa's Western Ghats' forest has been carried out for the first time, the results indicate the domination of Phanerophytes followed by Therophytes.
4. The present estimate of forest degradation is 2.4% per annum on the upper Western Ghats' of Goa i.e. where a thick vegetation exist in the Satari, Sanguem and Canacona talukas.
5. Vegetation mapping in the case studies of industrial sites and other allied complexes has been done for the first time in this region of the Western Ghats (Goa).

6. Aerial Photographs were procured of case studies "W", "X" and "Z" with the purpose of interpreting the vegetal cover which was done for the first time.

From the Aerial Photographs dated 1935, 1960 1988 and Ground Truth Data on the case studies (W,X and Z) available, revealed the following:

i) Excessive denudation of vegetation is observed within the industrial sites and the allied complexes especially in the non-protected/non-fenced areas compared to adjoining areas owned by individuals.

ii) The studies reveal that what today appears to be a barren rocky plateau in most cases was a dense forest cover fifty years ago.

7. Soil Analysis was done for the first time at "W", "X" and "Y" to correlate it with the vegetation distribution pattern. It was found in all case studies that the deficiency of Phosphorus (1-10 kg/acre) was conspicuous and to a lesser extent zinc (below 1 ppm) for normal plant growth.

8. During the vegetation mapping in the Industrial sites and other allied complexes an environmental awareness was created to the community by labeling plates with Botanical names which were fixed to some important trees.

9. Present vegetation degradation, is approximately 2.0% annually but it is much higher (2.4%) in the last ten years especially on the lower Western Ghats' of Goa viz Panaji, Vasco, Margao, Mapusa, Honda, Ponda, Corlim, Verna and at the mining areas.

10. Long term monitoring of planted species at one of the Iron ore mining sites (case study "Z") between 1987 and 1992 was done for the first time in this region of the Western Ghats.

(Henry Nyamongo Nyabuto)

Signature of the Student.

(S. G. Torne)

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C O N T E N T S

INTRODUCTION

a) Description of area

The Western Ghats of Goa landscape is of great scenic beauty comprising of an area of 3,702 sq. km. The tiny enclave of Goa is located on the West Coast of India at a distance of about 620 kms south of Bombay. It is geographically situated at north latitudes: 14° 53' 57" N - 15° 47' 49" N and east longitudes: 73° 40' 54" E - 74° 20' 11" E. It has a north-south stretch distance of 105 km and west-east stretch distance of 60 km.

To the north it is bounded with Sawantwadi taluka of Sindhudurg and Kolhapur district of Maharashtra, to the south is Karnataka state, to the west is the Arabian Sea which traverses for 105 km and to the east by Sahyadri range of hills.

b) Forest Cover

The forests are mainly confined to the hill slopes on the western foot hills, gorges and several spurs rising from the Sahyadri hill ranges (personal observations).

The forests are covered in the talukas of Pernem, Bicholim, Ponda, Sattari, Sanguem, Quepem and Canacona. The major portion of the thick forest area of Goa is situated in Sattari, Sanguem and Canacona talukas.

The Western Ghats of Goa is endowed with nine perennial rivers. (Table: 1.1) namely the Terekhol, Chapora, Baga, Mandovi, Zuari, Sal, Saleri, Talpona and Galgibag.

The rivers descend from the upper Western Ghats' slopes, carving their way through the mountains, have multiple meandering tributaries on the plains forming picturesque estuaries and backwaters before joining the Arabian Sea through dense coconut groves.

Among the main rivers are the Mandovi and Zuari, both of these run for 555 km allowing navigability over 340 km.

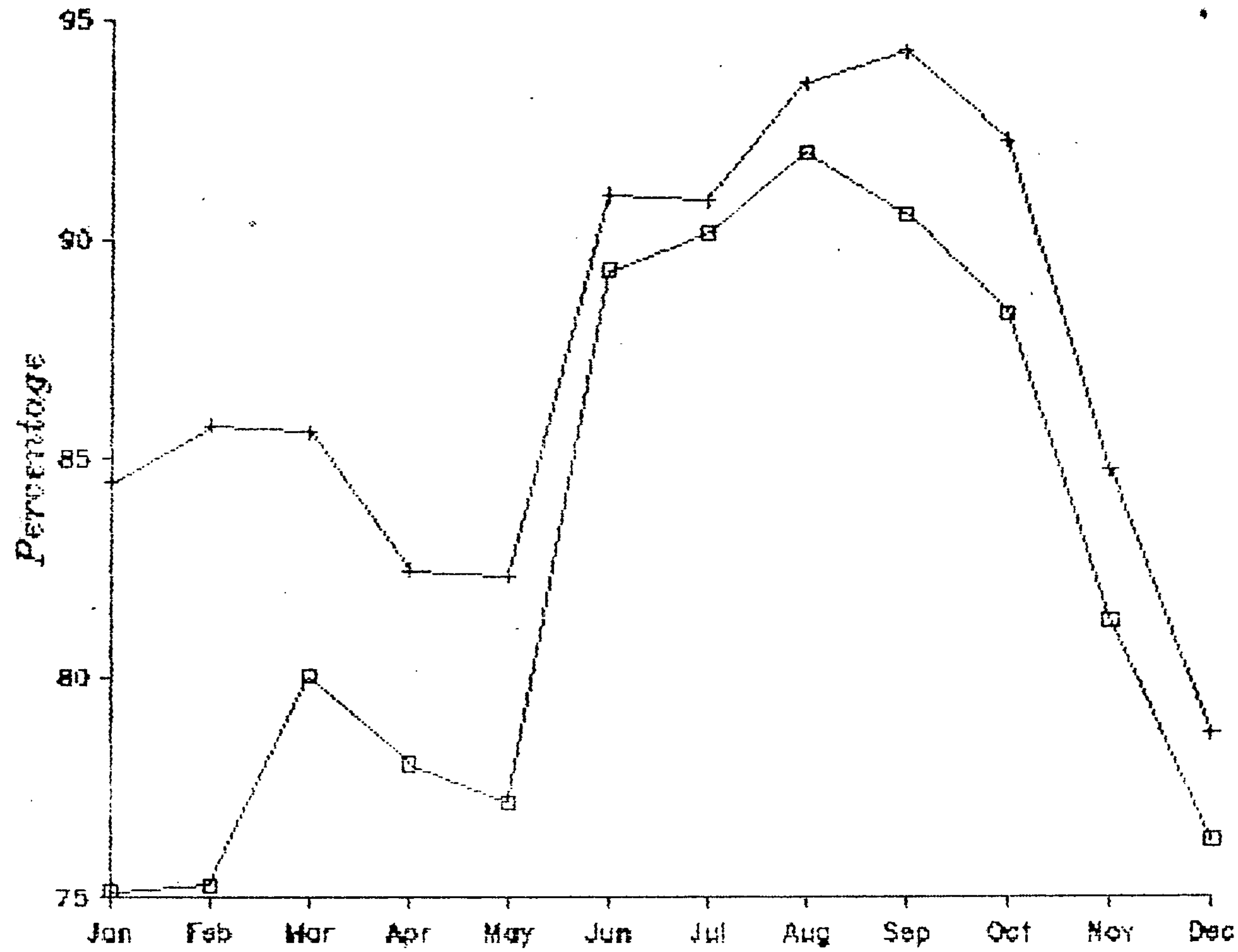

Fig. 1. Average Annual Relative Humidity at 5.30 and 23.30 monthwise for Goa in the past seven years (1986-1992).

Mandovi river which is the longest river has got water catchment area of 1550 sq. km. with water run-off of about 3580.04 million cubic metres. The Zuari river is the second most largest with a catchment area of 973 sq. km., the smallest river is the Baga river with a catchment area of 50 sq. km.

Most spurs are seen rising from the main hill ranges in the central region of Goa gradually merging in the Arabian Sea.

Table: 1 Catchment-wise run-off for rivers in Goa

Sr. No.	RIVER	CATCHMENT AREA IN SQ.KM.	RUN-OFF IN MILLION cu.m.
1.	Terekhol	71	164.25
2.	Chapora	255	588.35
3.	Baga	50	166.42
4.	Mandovi	1550	3580.04
5.	Zuari	973	2247.40
6.	Sal	301	694.39
7.	Salori	149	343.04
8.	Talpona	223	515.59
9.	Galgibag	81	187.11

Source: Anonymous (1985)

c) Climate

The general climate of the Western Ghats through Goa is a tropical type with high percentage of atmospheric humidity prevailing throughout the year.

The incidence of frost is totally absent. Relative humidity of the Western Ghats ranges between 80% and 95% The mean Relative Humidity (Table: 2) is lower at coastal region as compared to the interior (Fig. 1).

The balanced humid climate in Goa is mainly due to the presence

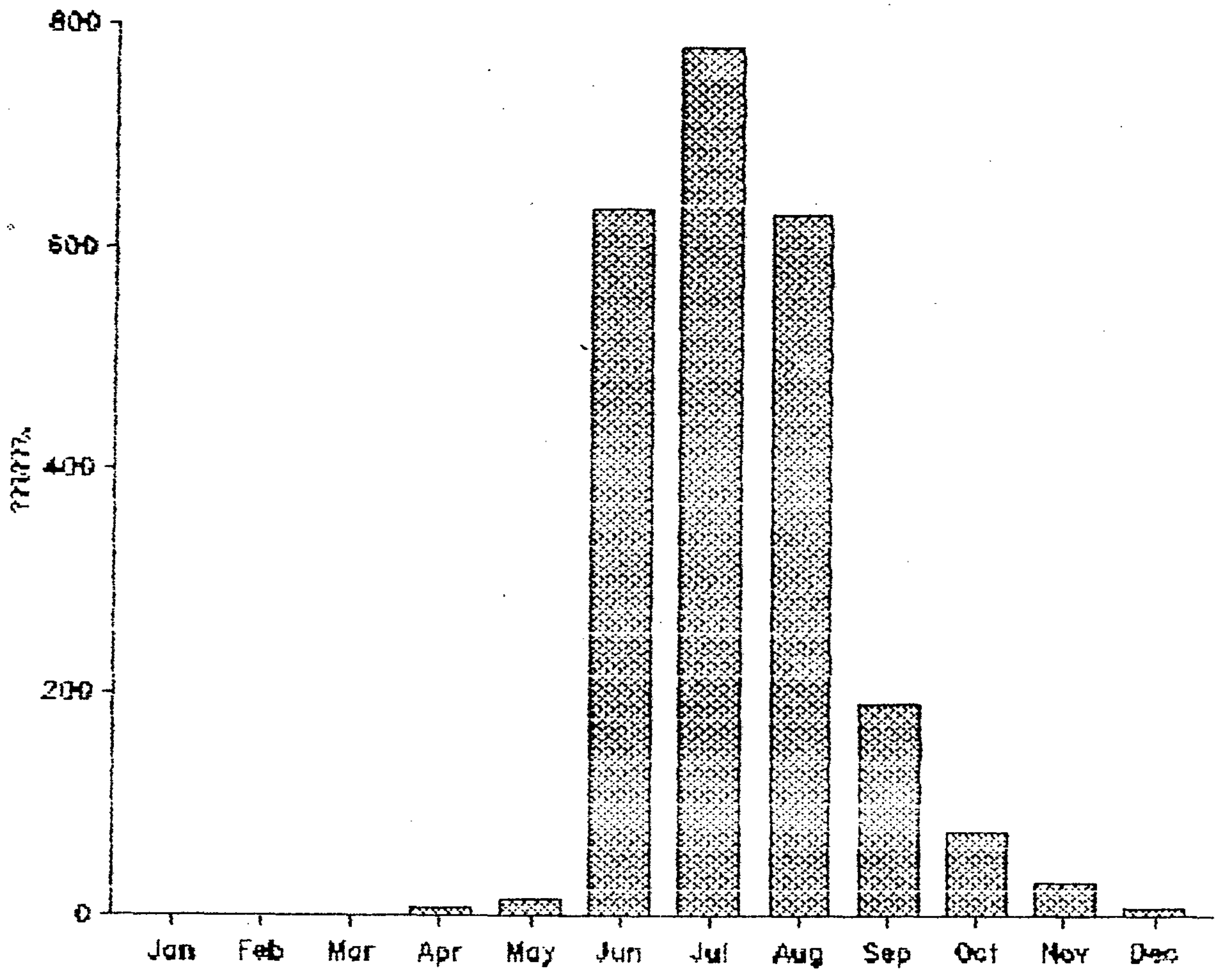

Fig. 2. Average Annual Rainfall monthwise, for Goa in the past seven years (1986-1992).

of Arabian Sea and high mountainous barriers of Sahyadri with tree clad slopes, valleys and spurs.

Three distinct seasons are observed on the Western Ghats of Goa: wet monsoon rain, dry winter and dry summer.

The south-west monsoon rain commences from early June and ceases by end of October, the bulk of rainfall occur in the mid June-July and August months (Fig. 2).

The mean annual rainfall is from 2,000 mm ($\pm$)250 to 4,000 mm ($\pm$)510 which increases from the coastal region to the interior of the upper Ghats. The rainfall is for example earmarked at Collem, Dudhsagar, and Caranzol with 6000 mm during a favourable rainy year. In the post monsoon period dew falls is generally observed which invariably influences the tree growth.

Winter is mild and pleasant spread over a short spell between December to the end of February.

Summer season is relatively warm with temperatures being above 30°C. The season starts from March to the middle of June, which is then followed by heavy monsoon rains. The mean maximum ($\pm$) temperature is 34° C. ($\pm$)2 and mean minimum is 24° C. ($\pm$)2.5 on average (Fig. 3).

Table: 2 Relative Humidity of Important Stations of Goa

S. No.	Station	Mean Relative Humidity (%)
1.	Panaji	81
2.	Mormugao	78
3.	Sanguem	88
4.	Quepem	81
5.	Canacona	83
6.	Valpoi	84

Source: Meteorological department, Altinho-Panjim, Goa. (1993)

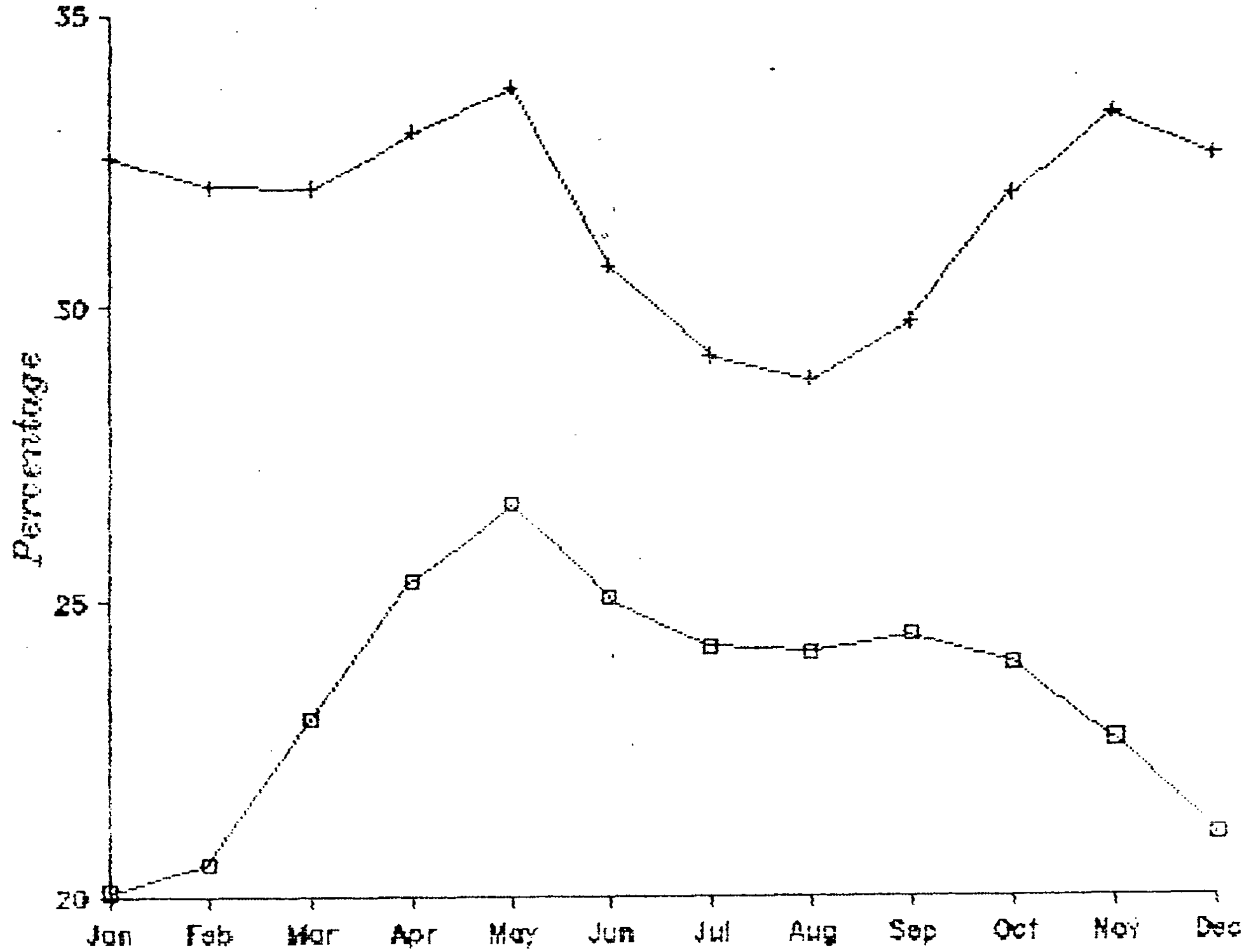

Fig. 3. Average Annual Maximum and Minimum Temperature monthwise for Goa in the past seven years (1986–1992).

Winds in the morning are easterly to north-easterly during October to April backing to north or north east in May, while in the afternoon they tend towards west or north-west, due to the sea breeze effect. During the monsoon months the winds are generally westerly throughout the day.

Winds are fairly strong during the monsoon period otherwise, they are generally moderate in strength. The annual wind speed is within the range of 11.3 Km/hr and 13.6 Km/hr.

d) Geology and Soil

Just as the skin that covers our bodies is a living changing organ, so is the soil, without it the earth would die (Anonymous, 1983). Vegetation is dependent on geological formations and on soil.

Rocks of pre-cambrian age underlie the iron ore deposits (Samant, 1989).

Important differences in soil humus, structure and fertility result from the base status of the parent rock materials.

Though the USDA soil conservation Service (1975) (Brady, 1984) on their generalized world soil map showed the probable occurrence of a single order Inceptisols on the entire of the Western Ghats, Govindarajan et al., (1974) have classified these soils into 4 orders namely; the Inceptisols, Ultisols, Alfisols and Entisols of these, there are 11 series, and 6 suborders, 8 Great soil groups and 9 subgroups (Table: 3).

Table: 3 Classification of soil series mapped in Goa

Sr. no.	Soil series	Order	Sub order	Great soil group	Subgroup
1.	Netorlim	Ultisols	Humult	Tropohumult	Plinthic Tropohumult
2.	Darbandora	Inceptisols	Tropept	Dystropept	Typic Dystropept
3.	Zaimolo	Alfisols	Udalf	Tropudalf	Oxic Tropudalf
4.	Rivona	Alfisols	Udalf	Tropudalf	Aquoxic Tropudalf
5.	Uguem	Alfisols	Udalf	Tropudalf	Aquic Tropudalf
6.	Colva	Inceptisols	Aquept	Tropaquept	Aeric Tropaquept
7.	Calangute	Entisols	Udent	Hapludent	Orthic Hapludent
8.	Chapora	Entisols	Udent	Hapludent	Orthic Hapludent
9.	Batim	Entisols	Fluvent	Tropofluvent	Andic Tropofluvent
10.	Saligao	Entisols	Udent	Hapludent	Thapto Alfic Hapludent
11.	Zuari	Inceptisols	Aquept	Halaquept	Andic Halaquept

Source: Govindarajan et al., (1974).

Nearly two thirds of the area of Goa is covered by a mantle of laterite ranging in thickness from a couple of meters to over 25 meters. Generally the maximum thickness of laterite is observed along the sea coast in the west and minimum along the ghat section in the east. (Gokul et al., 1981).

When forest cover is removed, however, laterization which is always in progress to a limited extent, is greatly accelerated. The major portion of the Western ghats comprises of lateritic soil which is formed due to heavy rainfall and high temperature; typical of a tropical region derived from pink phyllites. The lateritic soils are highly acidic in nature, with pH 5.0 to 6.8, well drained, rich in organic matter but low in bases due to excessive leaching.

1. Netorlim series: are dark red or brown laterite soils with a thick "A" horizon layer (8-15 cm). It mostly occurs in Sanguem, Sattari, Canacona, and Bicholim talukas.

2. Rivona series: consists of yellow brown silt clay-loam which is well drained. They mostly occupy the plains and valleys of Sanguem, Sattari, Bicholim and Canacona talukas.

3. Zaimolo series: are dark brown or yellow-brown, very deep, well drained silt clay-loam to silt clay. They occur over small areas, in some talukas of Goa mainly, Sanguem, Sattari and Bicholim.

4. Zuari series: are yellow to grey-brown in colour and silt clay-loam to silty clay. They are distributed by large in Ponda and Bardez taluka.

5. Uguem series: are light or dark grey in colour, course-textured, strongly acidic, deep to very deep in the surface layer. They are largely distributed in Quepem, Canacona and Salcette and to a small extent in Sanguem taluka Goa.

6. Saligao series: are red or yellow brown sandy-loam in the colluvio alluvial plains and occur in patches along the west coast of Bardez taluka, Goa. The soils are acidic and very poor in organic matter.

7. Colva series: are grey, sandy alluvium occurring along the west coast of Goa, covering the Salcette, Bardez and Pernem talukas. They are acidic, acidity increases with soil depth, and have high organic matter content.

8. Calangute series: are red-brown coastal alluvium of sandy loam texture (is lighter on surface and heavier in the subsoil) occurring along the coast comprising the west portion of Bardez taluka, Goa.

9. Chapora series: are yellow-brown to dark, yellow-brown light textured, occurring in the flood plains of the river Chapora and Tiracol in the northern part of Pernem taluka, Goa. The soils are deep, well drained, the water holding capacity is 36.2% to 51.8% which is fair though the organic matter content is very poor. (0.55%).

10. Betim series: are yellow-brown to dark-brown or strong brown sandy-loam coastal alluvium (are light textured sandy loam on the surface grading, to fine sand in the subsoil layer) which contribute to the constructional land system of Goa, occurring in Canacona and Pernem talukas. The soils are deep to very deep and well drained, with fairly good water holding capacity (27% to 28%) and low organic matter which decreases with depth.

11. Darbandora series: are yellow-brown to strong brown soils developed on the high hill ranges at attitudes of 400 to 600 mts above M.S.L, derived from metabasalts and quartizites under humid climate and dense vegetation. Occurrence: Sahyadri range covered by dense forest vegetation in Sattari, Sanguem and Canacona talukas, Goa. The soils are deep to very deep, moderately drained with silty clay-loam texture associated with stone-lime or gravel horizon. The importance of Darbandora soils is that they form the limits of laterization; it is interesting to note that laterization is confined to certain altitudes beyond which, no traces of it can be observed, except the rocks that have undergone the normal process of weathering. The soils are acidic in nature with high organic matter and water holding capacity. (Govindarajan et al., 1974)

Generally the soils are predominantly lateritic and laterite (73.40%) followed by alluvial and marshy soils (11.70%) sandy coastal soils (10.11%) and Saline soils (4.79%).

Majority of the soil series are coarse, medium textured soils. The soils are well drained but with poor water holding capacity.

The soils are medium in the available Nitrogen but deficient in the available Phosphorus and Potassium.

e) Physiography

The Physiography of Goa state is generally identified into four broad types of terrains. Sahyadri hill ranges, which rise to levels greater than 1000 mts and is second to Himalayas, traverses all along the north east and eastern side bordering Karnataka very conspicuously. The forests occur on the slopes of the hill ranges and valley bottoms in the talukas of Sattari, Sanguem and Canacona.

The slopes of the Western Ghats ranges generally between 15° to 35°.

The elevation on the Western Ghats (Goa) varies from sea level to a height of 1027 mts. with the highest peak in Sonsogod in Sattari Taluka.

The maximum altitude of hill ranges toward the south vary from 883 mts. to 145 mts. in Sanguem and Canacona, respectively.

Some areas with high altitude on the lower slopes are Surla 816.95 mts., Vageri 726.08 mts., Morlem 573.75 mts., and Siddhnath hill 408 mts.

Sahyadri serves as a barrier of the enclave all along the north eastern and eastern side.

The central track of Goa covering talukas of Pernem, Bicholim, Ponda and eastern part of Quepem and Sanguem are occupied with several spurs with moderate slopes, (with Angle of slope being 5° to 15°) having poorly stocked stunted tree vegetation mainly due to the repeated hacking of trees for green manure and fuel.

The flood plains' region is formed on either side of the rivers Mandovi and Zuari in the talukas of Ponda and Tiswadi.

Mangrove vegetation is seen on the flood plains. The coastal plains are distinctively apparent along the Arabian Sea supporting luxuriant coconut and paddy crops.

Few valleys lie along the eastern side which offer a panoramic view of the landscape, particularly while ascending from Mollem to Surla.

f) Land-use surveys

A land-survey forms an integral part of a survey project to provide the information base for development planning. (Kuchler and Zonneveld, 1988).

Some of important uses of land-use surveys are given below:

1. The determination of the areas under particular crop.
2. The determination of crop condition and monitoring crop development.
3. The monitoring of development in land-use as they resulted from certain management/conservation policies or the lack thereof, such as urbanization, deforestation (e.g. by shifting cultivation), erosion, salination, desertification, but also land reform reforestation and impact of introducing new crop types/ varieties and management practices.
4. The determination of the need for detection of effectiveness of irrigation water supply, losses by leakage or illegal tapping.
5. The monitoring of early detection by watching the development of crop diseases, pest-attacks, damage by other agents; the inventory of the ultimate damage caused, also by floods, fires, etc. a special and very important application is the monitory for the localization of locust breeding, places in desert areas.
6. The location of illegal dumping sites of industrial wastes material, threatening the environment (Kuchler and Zonneveld, loc. cit.).

g) Approaches

1. A pure field survey is required, if possible with the aid of a recent topographic map.

2. A field survey with the aid of aerial photography as a base for orientation and recording.

   The advantage of the aerial photographs over the topographic map is that in the former, objects and features such as field boundaries are seen in their natural aspect which facilitates orientation of accurate delineation of land-use units. Enlarged prints of diazo copies may be used giving greater advantage in this work.

3. A survey based on aerial photographs or other remote sensing image interpretation; supported by a minimum of (costly in time and manpower) field work (Kuchler and Zonneveld, loc. cit). It is particularly the possibility of studying (in stereo-vision) the land-use in relation to its physical environment, which considerably adds to the information an understanding of land-use which can be derived from the aerial photographs. Further any approach to land survey, one needs a classification system.

h) Importance of vegetation mapping:

The first of observational ecology approach like the one involved in vegetation mapping involves the definite aims of study.

The selection of an appropriate sampling scheme is also important. As Greig-Smith (1983) states "the value of quantitative data ..... depends on the sampling procedure used by them." Of course, any scheme adopted must be related to the aims of the study and should be designed to maximize the information obtained in return for the effort and time invested (Ludwig and Reynolds, 1988).

vegetation mapping, but in fact the circles are expanding steadily since vegetation consists of plants, it seems logical, therefore, that botanists should be the prime producers and users of vegetation maps.

Among various solutions to deal with this problem - an often used technique is, mapping the climax or the potential natural vegetation. A map of the existing vegetation represents the plant cover at the moment of investigation. This can be the very purpose of the map, but it can also be a disadvantage in view of the overall observed phytodynamics.

Vegetation is so closely tied to its environment that an appreciation of its characters can reveal for qualities of the sites on which it occurs. A qualified analyst looks through a vegetation map just as a physician looks through an X-ray screen. Still at present, a large part of the green cover is subject to destruction, it needs repair. In order to support three times as many people as at present, one needs to "improve" it and most of all, it needs to be managed to keep it in the best condition and prevent any future degeneration or destruction. The only means to monitor effectively the vegetation is repeated vegetation mapping of at least vegetation features that are crucial to base the warning or, in terms of what should happen. Secondly, we need to repair destroyed parts of the previous cover, and if possible we need to improve it. Mending a tissue, or improving it, requires good knowledge about that cover and again watching how repairing process or improvement proceeds. (Kuchler and Zonneveld, loc. cit). Sequential vegetation mapping before, during and after that process is a logical aspect of this.

All these activities about repair and improvement are already common work for vegetation surveyors. A third task is mapping as a base for management, to keep the optimum situation constant.

Such ecologically based planning permits an optimal land-use vegetation mapping, but in fact the circles are expanding steadily since vegetation consists of plants, it seems logical, therefore, that botanists should be the prime producers and users of vegetation maps.

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Such ecologically based planning permits an optimal land-use managing for highest yields on a sustained basis without damaging the environment.

The United Nations Conference on Human Environment held at Stockholm in June 1972 heralded an era of increasing consciousness regarding protection of environment. This aspect has since been receiving worldwide attention and many countries have taken various measures including framing of legislation for protection of environment.

Unless the actual resources in that environment (within our reach) are known the framing of legislation measures will not be adequately relevant and effective. Therefore vegetation mapping is one such an important means of knowing where the resources are located and how much.

i) Monitoring of plantation work at the iron ore mines.

The iron ore mining areas like any disturbed ecosystem requires monitoring of the plantation works from time to time which is essential.

The Botanical names and specific uses of the species within the mines' area (both indigenous and exotics) of jurisdiction have got to be identified and let to be known to the mines' concerns so that they can develop the interest in nurturing them. If the "true work" of restoration has to be done then it is only by bringing back the former local plant communities that existed prior to mining operation viz Associations, consociations etc.

This could be only possible after carrying out vegetation surveys on the remaining patches of scrub forests around the mines.

The long term monitoring of plant species' survival and tolerance will enable the screening of species for large scale propagation and reforestation at the mining sites.

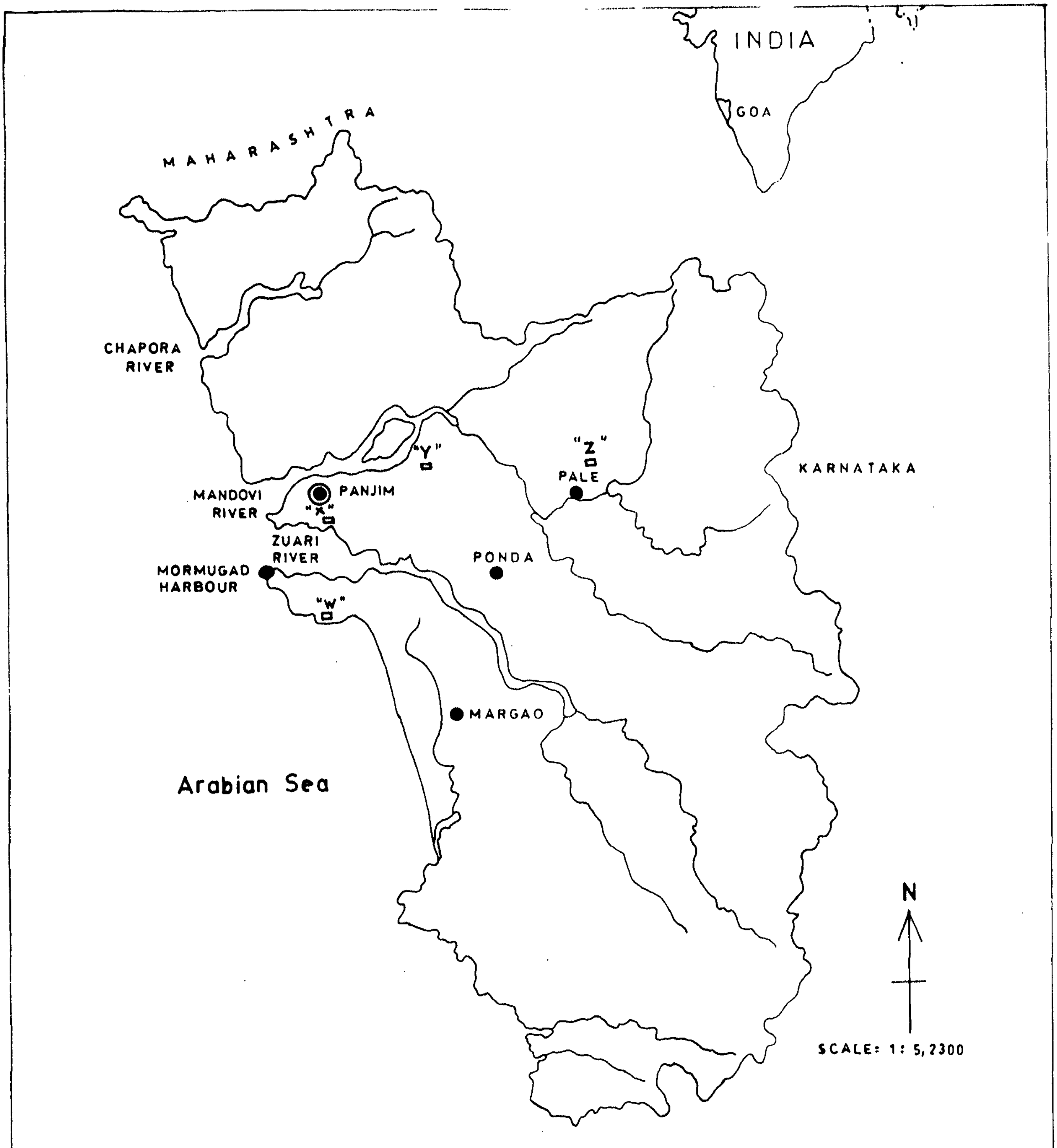

Fig. 4. Map of Goa showing the location of case studies' areas where vegetation mapping of industries and other allied complexes were carried out and the monitoring of plantation work at "Z".

The screening of plant species may require very wide parameters e.g. morphology which will give an indication of the extent of the species adaptability to the new edaphic conditions.

Dust is a major health hazard concern in the mining region, ways have got to be found out to diminish or to find a permanent solution to it.

The hindering factors to the vegetation development at the plantation sites have to be brought to light so that probable solutions could be found.

Though the industries and allied complexes wanted to know the species' composition available in this locality, (i) We were also interested to know how much plantation work is carried out in the case studies (Fig. 4), (2) What extent the vegetation has been disturbed due to urbanization or industrialization compared to the surrounding undisturbed vegetation.

Forest cover of Goa has been worked out by several workers, e.g. Govindarajan et. al., (1974) who gave it as 29.6%, Goa Gazetter (Anonymous, 1979) as 28% and recent Forest Survey of India report (1991) as 33.8%.

Govindarajan et al., (Loc. cit.) while working on the soil series of Goa also high lighted the potential crops that could be grown in this soils after analysis.

The earliest literature on the vegetation of Goa indicates that small publications were made on the Natural History of Goa (d'Silva 1862) with a list of hardly 163 species. This was the only half-hearted attempt made by the Portuguese Government to study the Natural history of Goa which was commissioned to Manuel Galvao da Silva in 1780 to prepare the work Observacoes sobre a historia natural de Goa which was finally published in 1862 at Nova - Panaji, Goa. The work consists of indigenous and exotic species covering more than half the book and the remaining pages with a brief outline of the Linnean system of classification (1753). Except a few random collections made possibly with the permission of the Portuguese administration by Lush and a few others which are cited in J. D. Hooker's "The Flora of British India" (1872 - 1897), there was practically no record of any plant material of India in the Indian publications on Botany of that period.

In 1894 Dalgado published Classificacao botanica das Plantas e drogas descriptas nos "Colloquios da India" in Bombay, classifying the plants described by Garcia da Orta in his Colloquios, with their Botanical names and five drawings of plants. But later, probably with the publication of Hooker's Flora of British India, the Portuguese authorities might have encouraged Dalgado to prepare Flora de Goa e Savantwadi (Dalgado, 1898) to celebrate the 4th century anniversary of the colonial rule in Goa (Rao, 1985). The work consists of a list of

731 wild plant species and 279 cultivated species with vernacular names and very brief notes without specific data on the localities and the specimens collected etc. This book according to Rao (1985) is out of print and the work itself is out of date and unsuitable for revision. However, Dalgado (a medical officer in Savantwadi) expressed in very clear terms the importance of such floristic work and the practical utility of the study of plants used in medicine, food, and industry. He, however, indicated his limitations as not being a professional botanist. Thus, his book as compared with others then published in British India turned out to be only an improved list of plants with brief notes.

Cooke (1903 - 1908) published the "Flora of Bombay Presidency" which covered a wide area including the Konkan region.

In 1966, V. D. Vartak published "Enumeration of plants from Gomantak". He prepared a list of 1512 species mostly gathered from previously published literature. There were hardly 200 species collected from Goa and the surrounding areas.

Rao (1985 - 1986), has worked on the "Flora of Goa, Diu, Daman, Dadra and Nagarhaveli". His work comprises of taxonomy and he has made an attempt in the analysis of the Goa's vegetation at the introductory part.Nyabuto (1989) has worked out on the vegetation close to the iron ore mines at Pale and Sirigao villages, Bicholim taluka-Goa.

Some aspect of work done on the vegetation of the Western Ghats in the neighbouring states.

Perhaps the earliest work done in vegetation touching the Western Ghats is that of Eners (1907). Kadambi, (1941) worked on the Evergreen Ghat rain forest of Agumbe-Kilandur.

Razi, (1946;1955) did some aspects of the vegetation of Poona and neighbouring districts, he also made some observations on plants of the south Indian hilltops and their distribution.

Puri and Mahajan (1960) did studies of the evergreen vegetation of Mahabaleshwar area.

Arora (1963; 1964) analysed the vegetation of North Kanara which lies on the Western Ghats.

Janardhanan (1966) did studies on the flora and vegetation of Bhimashankar and surroundings, Khed taluka Poona district. Reddi (1966) worked on the flora and vegetation of Sakarpathar Ambavane region on the Western Ghats of India, Poona district.

Saldanha (1984) worked on the flora and vegetation of Karnataka State (of which a large portion belongs to the Western Ghats).

Rao (1985-1986), has made an attempt in the analysis of the vegetation of Goa. He has given in brief at the introduction about what species that are found at different habitats.

Meher-Homji (1984) has given a new classification of the phytogeographic zones. Of these, 11 zones concern the Peninsular India, the remaining 3 zones pertain to the Himalayas and the Andaman-Nicobar Islands. The eleven phytogeographic zones of the peninsular India compromise 29 vegetation types. In each case location, elevation, forest physiognomy, important plant, animal, crop species and nature- reserves were enumerated.

The classification which is quite useful, however, is very broad to give a clear picture of the regional phytogeographic levels in detail at state level. There is no information available on the Life-form spectrum on the natural vegetation. Several workers have done studies on vegetation as Land cover i.e. Govindarajan et al., (1974), Forest Survey of India (1991) and of late was IIT report published in 1992, which covered the three talukas - Sattari, Sanguem and Canacona.

Vartak (1981) made some preliminary survey of the wild plant species used as food by the tribal population residing along the hilly region of the Western Ghats' in Maharashtra State and Goa (by then a Union Territory). He enlisted the Botanical names, local names and the parts used.

Perhaps the earliest publications in Goa which concentrated on the medicinal aspects are Coloquios dos simples e Drogas da India (Garcia da orta, 1891) and Tratado de las Drogas (Acosta, 1578). Gaitonde (1988) has worked on "Pharmacognostic study of some medicinal plants from Goa".

Some attempts were made by the author earlier, (Nyabuto, 1989) to survey the threatened plant species found at Pale & Sirigao villages Bicholim Taluka - Goa. These villages lie close to the Iron ore mining areas.

There is no literature available on this locality about the correlation between specific gravity of wood timber and ploidy levels. No literature is available on the vegetation mapping of Western Ghats' (Goa) especially at industrial sites and other allied complexes.

However, earlier work has been done at Pale, which includes Velge, Ambegal, and Chinchinim villages and Sirigao, Asnoda, Sirsai and Poira village areas -Bicholim taluka, on taxonomic and description aspect of vegetation close to the iron ore mines of Goa (Torne and Nyabuto, 1994); in this study, taxon distribution maps were prepared to show the exact distribution of each plant species.

Studies on the response of plant species to the iron ore mine rejects has been carried out at Pale and Sirigao sites - Goa. Veeresh (1989); Torne and Gaonkar (1989) and Coelho, (1990). However, long term monitoring of the species planted on the reject soils has so far, not been done.

Aerial Photography

Law (1981) was able to identify plants of *Poa annua* from photographs of his study plots. This technique though labour saving, can usually only be applied unambiguously for small areas where the vegetation is sparse essentially single layered. However, large-scale Aerial Photography has also successfully been used in woodland surveys, where individual trees can be identified at different dates (Pigott and Wilson, 1978).

P A R T I

AN OUTLINE OF THE GOA'S WESTERN GHATS' VEGETATION

1.1 AREAS BOTANICALLY SURVEYED.

1.1.1 INTRODUCTION

Vegetation ecology has recently gained scientific importance. It has, also become more important in problem solving. This impetus is related to the general realization that the solving of environment questions is so essential to life on this planet. Today, vegetation still forms the immediate environment of man and his domesticated stock over large areas of the earth's surface. Vegetation is usually the most readily recognised component of ecosystems.

An exact knowledge of the structure and composition of plant communities, is therefore, important for an understanding of trophic relationships.

Disturbances of the biological balance through foreign plant or direct interference by man are often readily recognized by changes in the physiognomy, structure and species composition of the vegetation (Mueller-Dombois, 1974).

The Western Ghats is a narrow strip, stretching, approximately from Bombay city in the North to Trivandrum in the South. (Range 8° N to 20° N. approximately)

The entire Western Ghats harbours different vegetation types like the moist deciduous forests, montane grasslands, sholas, and more importantly the precious tropical evergreen and semi-evergreen forests.

Out of the 15,000 flowering plant species found in the country, 4,500 species are located on the Western Ghats (Shetty, 1994). Numerous endemic, rare, endangered, economically important and wild relatives of cultivated plant species are found here.

The Goa's Western Ghats relatively lies on the central Western Ghats region (Range 12° N to 14° 40' N. approximately). Equally the Western Ghats through Goa is blessed with such a rich flora constituting some of the most useful plant species in the world today. Yet knowing this, little efforts have been made to study one of the few remaining tropical forest ecosystems in the world.

There are in total 11 talukas in Goa having about 239 villages out of them 48 villages were botanically surveyed for forest as landcover and ground truth data collected especially on the distribution of wild edible, medicinal and threatened plant species.

The villages surveyed were Caranzol, Caudal, Zaranim, Pendral, Carambolim, Nandrem, Honda, Algote, Mollem, Melauli, Cotorem, Vaguriem, Pale, Valpoi, Naneli, Nanuz, Birondem in Sattari taluka, Dudhsagar, Oxel, Uguem, Potrem, Darbandora, Surla Sanguem, Curpem, Curdi, Collem, Calem, Sigao, Dongor and Netorli in Sanguem taluka, Siddhanath, Borim and Bondla in Ponda taluka, Guirdolim, Curtorim, Rachol and Cuncolim in Salcette taluka, Nerul and Candolim in Bardez taluka. Canacona, Agonda, Palolem, Cola, Cotigao, Poinguinim and Loliem villages in Canacona taluka and Balle in Quepem taluka.

The distribution extent of the wild edible, medicinal and threatened plant species was carried out in all the 11 talukas in the entire area. This was done with an intention of preparing distribution maps.

1.1.2 MATERIALS AND METHODS

A general botanical survey was done on the entire Goa's Western Ghats by making frequent trips to the study areas. Official topographic maps of Goa were used to identify the areas. The average distance covered was determined by using a pedometer.

After making a thorough survey on the Vegetation, unit sketch maps were made in the field with a scale 1 cm on map = 150,000 cm on ground. Various boundaries of vegetation types, depressions, elevations, drainage patterns and emphasis put on permanent objects like crops and large trees, large buildings, bridges, towers, forts were noted down i.e. physiographic and topographic features.

The degree of slope/elavation was determined by Abney level and a clinometer. Relative humidity was determined using a whirling psychrometer, atmospheric temperature was measured with a maximum and minimum thermometer. Wind velocity was determined by anemometer.

The ground truth data on distribution of plant species on the villages surveyed was recorded. The survey was carried out from the north west to the south east along the Western Ghats. The information collected at various villages was prepared in sketch maps prepared in the field. Continuous seasonal monitoring was carried out for several years. Colleotion of plant samples for herbarium specimens. The economically important plants especially wild edible and medicinal were photographed and samples collected.

Where possible, important fruits, seeds, rhizomes and roots of some plants of botanical interest were collected. Plant specimens were processed and placed in herbarium as per Lawrence (1951) methods, and stored in the Botany Department, S.P. Chowgule College, Margao, for future references.

The methods used in the description of vegetation are as those of Ellenburg and Mueller-Dombois (1969) in the tentative physiognomic-ecological classification of plant communities.

1.1.3 OBSERVATIONS

The mature rainforest of the central Western Ghats with dense canopy are of two types (Steeper elevation and Lower elevation) being mainly distinguished from their degree of elevation or slope though other factors may be operating. The forest phases are diverse with a complex structure.

The steeper elevations which are more on the Sahyadri hill ranges comprise a canopy of several layers with frequent large emergent tree crowns like Lagerstroemia lanceolata, Terminalia bellirica, Syzygium cumini Bombax ceiba, Garcinia talbotii, Pterospermum diversifolium and Ficus talbotii.

The trees are characterised by their often plank buttresses (Fig. 5a) and the crown portion are coated with several epiphytes which are often interlaced with lianas (Fig. 5b). Here, the rotting of fallen logs, trees, branches and leaf litter coupled with moist atmosphere, greatly enhances the availability of organic matter.

However, the situation is different on the lower elevation to the lowland where less luxuriant growth is replaced by lowland forest constituting of many ferns, during the monsoon, of wide genetic set-up. The forests are of dense leaf canopy and abundant in tree species which have little undergrowth except a few co-dominating herbaceous flora like Strobilanthes callosus which appears conspicuous at Collem - Sonauli forest.

i) Primary forests of Caranzol, Caudal, Zaranim and Pendral - Sattari Taluka.

A common pattern of vegetation distribution is observed; the slopes exhibit one type of Association whereas the plains show another.

This region which is on the extreme north east of Goa bordering the Karnataka state, is probably one of remaining areas in Goa having a really dense primary vegetation which has had little disturbance for several centuries.

These forests are identified as being primary from their nature of Stratification; the gigantic plant species located here are found to be moderate in other areas elsewhere.

a) Vegetation of Caranzol - Sattari taluka.

Generally the vegetation is less dense in this region as compared to Caudal, Zaranim, Pendral due to the human population encroachment. The plant Association is comprised of Schleichera oleosa, Artocarpus

E X P L A N A T I O N   O F   P L A T E

Photographs showing the mode characteristic of the semi-evergreen forests of the Goa's Western Ghats.

Fig 5a. Butressed trunk of *Holigarna arnottiana* which is a common feature in other species found here like *Alstonia scholaris* & *Artocarpus* spp

Fig 5b. Presence of epiphytes, lianas and climbers like *Photos scandes* is a common characteristic of these forests.

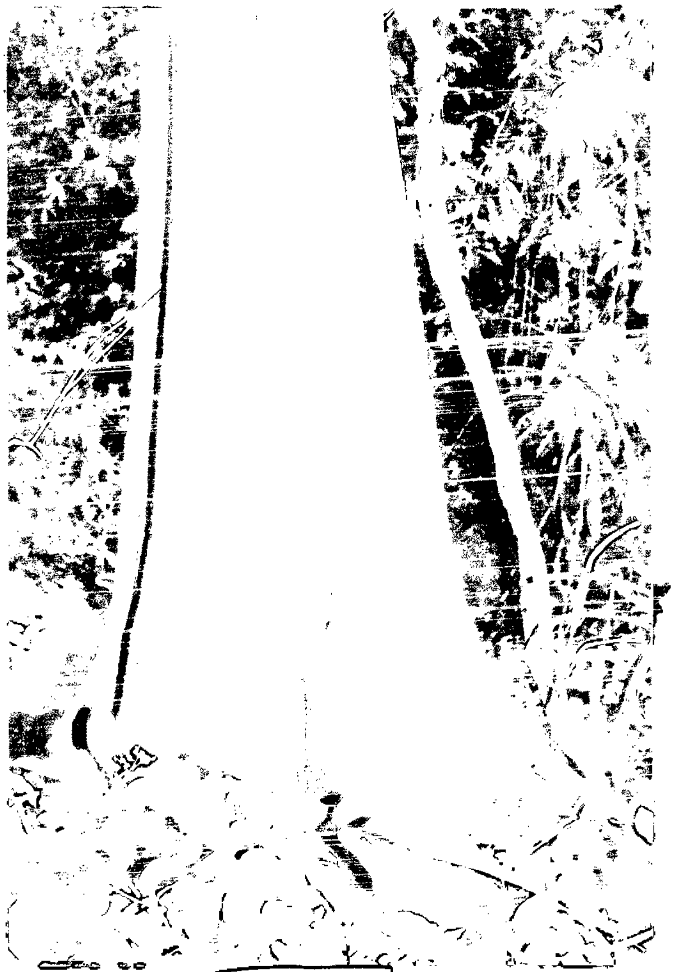

Fig. 5a.

Fig. 5b

heterophyllus, Careya arborea, Hopea wightiana, Heterophragma quadriloculare, Terminalia paniculata, Terminalia tomentosa.

The co-dominant plant species are Psychotria dalzellii, Ixora coccinea, Desmodium triquetrum, Mussaenda laxa, Mimosa pudica and Leea indica on the more open areas.

b) Vegetation of Pendral, Zaranim and Caudal - Sattari Taluka.

The vegetation on flat areas is different from that found on hill slopes. The slopy areas comprise more of mixed evergreen plant species whereas the plains consist of light forest with deciduous elements dominated by different species of Terminalia; Terminalia crenulata, T. paniculata, T. tomentosa, Garcinia talbotii, Lagerstroemia lanceolata, Albizzia lebbeck, Schleichera oelosa, Careya arborea, and Xylia xylocarpa are the dominating Associates of plains along with co-dominants such as Glochidion hohenackeri, Connarus wightii, Dillenia pentagyna, Sarcostigma kleinii, Xeromphis spinosa, Randia dumetorum and occasionally Calycopteris floribunda.

The plant species dominating on the hill slopes are Heterophragma quadriloculare, Xylia xylocarpa, Pterospermum diversifolium (a gigantic tree in Caudal and Zaranim forests), Artocarpus gomezianus, Machilus macrantha, Ancistrocladus heyneanus, Garcinia cambogia, Diospyros ebenum and D. pruriens. The lower tier is comprised of Litsea wightiana, Actinodaphne semecarpifolia, Olea dioca, Lophopetalum wightianum, and Myristica malabaricum. The lowest shrubby layer is noticed by the overclamping of Psychotria dalzellii, and Murraya paniculata, Glycosmis pentaphylla and Ardisia solanacea are the other co-dominants conspicuous plant species on the forest margins.

It is interesting to note, Memecylon malabaricum, a very rare plant species in Goa, to be located here. Gnetum ula (the only Gymnosperm on the Western Ghats of Goa) was found climbing to great

E X P L A N A T I O N   O F   P L A T E

Photographs showing the threatened plant species Calamus pseudo-tenuis in the dense forest of Sonauli-Sanguem.

Fig 6a. Fruiting portion, (some leaves & branch of Gnetum ula are observed in the background)

Fig 6b. Whole plant.

Fig. 6a

Fig. 6b

heights on gigantic trees along with the cane chair palm, Calamus pseudo-tennuis (Fig. 6a & b) which make some parts of the forests impenetrable. Calamus pseudo-tennuis climbs up to the tops of gigantic trees using its hooked spines to expose itself to light. Epiphytic orchids were found to be rare even in the semi-evergreen forests.

Heavy epiphytic growth in shade forests may be made possible by the homogeneous higher and whitish light intensity associated with continuous overcast. If leaves are thin, then proportionately more of the ambient light will come from light transmitted through than reflected from leaves (Endler, 1993).

However, a place like Caudal, the dominance of evergreen tall trees often cut down any light transmission thus the density of epiphytes is greatly reduced.

The litter bio-degradation was high as the forest soil cover was always wet moist almost throughout the year.

The slopes have well drained soils and rich in humus.

Approximately an acre of land in the dense semi-evergreen forests of Goa harbour 85 to 120 medium to large individual tree species. Since the forest trees have remained for many years without undergoing any disturbances their relative stratification is high whereas medium trees may range between 15-25 mts, large trees range between 25 to 60 mts in height. The canopy of the large trees develop little or no branching below the canopy spread, and they are peculiarly, broadly butressed. The understorey is often observed in spots having gaps, here a number of small trees (in comparison with the gigantic large trees) with stratification of 8 to 12 mts are more peculiar which personal observation) tend to regenerate through root suckers especially in species like *Murraya paniculata*, *Derbergia sissoo*, *Dalbergia latifolia* and *Cinnamomum macrocarpa*.

ii) Vegetation along the stream banks of Khandopar river at Zaranim and Caudal - Sattari Taluka.

The stream is interrupted by many smooth granite rock outcrops, offering scenic beauty and clean water.

The most conspicuous tree species met with are Crataeva religiosa var nurvala, Mangifera indica (wild edible drupe with a tough thick fibrous mesocarp), Garcinia indioa, Vateria indica and Caosaria esculenta which is extremely gigantic.

The dominant tree species found submerged especially after the monsoon rains are Vitex leucoxylon and Syzygium heyneanum.

The co-dominant shrub is Homonoia riparia found almost indiscriminately everywhere along the river bank.

Along with these riverine species are occasionals like Syzygium cumini, Hopea wightiana, Stryohnos nux-vomica, Dipterocarpun indica, and Pongamia pinnata. Lianas noticed are Combretum latifolium, Derris scandens, Derris bakeri, Ventilago maderaspatana, Gnetum ula, Leucas aspera and Mollugo pentaphylla as the most frequent annual herbs growing on sandy patches along the banks.

iii) Vegetation of Carambolim, Edorem and Davem Areas.

The area is mainly flat with shallowly undulating hills with less ground flora.

The major formation is comprised of Alstonia scholaris, Garcinia indica, Syzygium cumini, Sterculia urens, Sepium insegne, Terminalia arjuna, paniculata and Bombax ceiba which are found on the upper elevations. Lower elevations close to cultivated fields constitute a different formation of mainly Thespesia populnea, Tamarindus indica, Barringtonia racemosa. A mixture of Artocarpus heterophyllus and Mangifera indica are observed which may have been oultivated.

There are two types of Associations noticed in these areas which seem to be governed by moisture content and soil type amidst other minor operating factors.

Association I

This Association is found on the open undulating shallow hills on less humid and more latosol soil. Major Association is comprised of *Alstonia scholaris*, *Buchanania lanzan*, *Bridelia scandens*, *Sepium insegne*.

Lower tier is composed of *Holarrhena antidysenterica*, *Calycopteris floribunda*, *Grewia microcos*, *Melastoma malabathricum* and *Pogostemon parviflorus*.

Ground flora is comprised of *Canscora decurrens*, *Euphorbia notoptera*, *Justicia micrantha*, *Zornia gibbosa*, *Eriocaulon dianae*, *Amorphophalus campanulatus*, *Ariopsis peltata*, *Elephantopus scaber*, *Cassia mimosoides* and *Lepidagathis prostrata*.

Members of Poaceae are also co-dominant in the post monsoon period comprising of *Ischaemum semisagittatum*, *Arundinella ciliata*, *Panicum paludosum*, *Ischne meliacea*, *Iseilema laxum* and *Heteropogon contortus*.

Association II

The Association is confined to flat lowland moist fields comprised of *Tamarindus indica*, *Artocarpus heterophyllus*, *Thespesia populnea*, *Barringtonia racemosa* and *Mangifera indica*.

Groundflora consists of *Justicia micrantha*, *Geissaspis tenella*, *Indigofera uniflora*, *Elephantopus scaber*, *Cassia tora*, *Emilia sonchifolia*, *Zornia gibbosa*, *Striga lutea*. *Ramphicarpa longifolia*, *Sopubia delphinifolia*, *Neonotis foetida*, *Grewia microcos*, *Pogostemon parviflorus*, *Cassia mimosoides*, *Leea indica*, *Desmodium heterocarpon*, *Alysicarpus vaginalis*, *Senecio grahami*, *Cyperus cyperoides*, *Malvastrum coromandelioum*, *Cyclea peltata* and *Fimbristylis bisumbellata*.

iv) Vegetation of Surla, Algote, and Mollem areas:

There is a thick forest as one approaches Mollem by road which is a government protected forest area.

The area is more or less flat with undisturbed open canopy of species like Terminalia arjuna (the most dominant), Careya arborea, Lagerstroemia lanceolata, Bridelia retusa and Xanthoxylum rhetsa.

Other frequent associations are Terminalia bellirica, Emblica officinalis which are found on more open terrains, Garuga pinnata, Glycosmis mauritiana, Gardenia latifolia, Ziziphus glaberrima, Z. oenoplia, Bombax ceiba, Terminalia paniculata, Syzygium cumini, Ervatamia heyneana, Anogeissus latifolia.

Herbaceous flora consists of several thick root-stocked plants often found at undershades of trees, Curcuma neighelensis, Curculigo orchioides, Hemidesmus indicus, Leea indica, Cyclea peltata.

Occasionally some areas are interrupted by large patches (50 to 80 sq.mts. of grassland.

v) Vegetation of Amboli Ghat:

The area though outside the Goa boundary was found to be of particular importance. It appeared to be the transition point in terms (upper Western Ghats and the lower Western Ghats) of the floral composition. A good number of plant species were found which are not frequently located anywhere on passing through other areas of Goa's Western Ghats.

The major species Association consist of Mallotus tetracoccus, Lasiosiphon eriocephalus, Macaranga peltata, Callicarpa tomentosa, Nothopegia racemosa, Trema orientalis, Chloroxylon swietenia. Ground flora was frequently co-dominated by Lepidagathis spinosa, Chlorophytum malabaricum, Ischne lisboae and Striga lutea.

vi) Vegetation of Dudhsagar area

The landscape offers a splendid scenery due to the Dudhsagar water falls. The vegetation is almost a closed type especially spots which are far reaching below, from the railway track. The formation is that of semi-evergreen biome forest characterized by evergreen plant species like Alstonia scholaris, Syzygium cumini, Hopea wightiana, Cinnamonum macrocarpa, Strychnos nux-vomica, Ixora arborea, Caryota urens along with deciduous species like Sterculia urens, Terminalia paniculata, Careya arborea, Bombax ceiba and Terminalia bellirica.

The dominant species extend up to 20-25 mts. in height, giving a large leaf canopy of nearly the same size as the height.

The formation shows a potentially evergreen type of physiognomy with a more or less uniform floral composition.

In some areas in the lower valleys several streams intersect this land, and the soils are found to be deep alluvial especially at Caranzol, Dudhsagar, Boma, Oxel and Sonauli, Sanguem Taluka. Under this kind of climatical influence the floral composition tend to vary from the one on the hilly slopes. The upper stratum composition consist of Hopea wightiana, Cinnamomum macrocarpum, Glycosmis pentaphylla, Flacourtia montana, Actinodaphne semecarpifolia, Machilus macrantha, Mimusops elengi, Holigarna arnottiana, Mangifera indica, Mesua ferrea and Myristica fragrans as the evergreen elements along with Terminalia paniculata, T. arjuna, T. crenulata, Careya arborea, and Barringtonia racemosa as the deciduous elements.

The ground flora consists of Desmodium triquetrium, Plantanthera susanae, Habenaria longifloriformis, Osmunda regalis and Selaginella pronifera.

Calamus pseudo-tennuis is found in the upper pockets of the ghats and currently its extent is limited between Sonauli, Sigao, Caranzol and Boma areas - Sanguem and Sattari talukas.

vii) Vogetation aspect of Oxel, Uguem, Curdi and Curpem areas

The major species association consist of *Bombax ceiba*, *Ficus benghalensis*, *Syzygium cumini*, *Heterophragma quadriloculare*, *Terminalia paniculata*, *T. bellirica*, *Careya arborea* and *Lannea coromandelica*.

Though most of the areas are under cultivation, the uncultivated lands constitute of secondary degraded scrub. A number of species are found here which are co-dominating namely, *Phyllanthus reticulatus*, *Calycopteris floribunda*, *Adhatoda vasica*, *Jatropha curcas* planted along the roadsides. Occasionally *Syzygium umbellatum* and *S. zeylanicum* are observed on field hedges.

The ground flora is essentially composed of *Cleome chelidonii*, *Curcuma neilgherrensis* and *Phyllanthus fraternus*.

The excavation of the root system means the destruction of the entire tree which poses a great threat to the species survival.

viii) Vegetation of Bondla, Melauli, Cotorem, Ambeli and Assodem areas

Vegetation at Melauli and Cotorem areas is mainly of scrub forest while the vegetation at Bondla is of a thick forest canopy type which is semi-deciduous, potentially evergreen.

The major association consist of *Careya arborea*, *Dillenia pentagyna*, *Lagerstroemia lanceolata*, *Terminalia paniculata* and *bellirica* as the thickly crowned species. The co-dominants especially to the open plateau are composed of *Memecylon wightii*, *Holarrhena antidysenterica*. The major portion of Melauli and Cotorem areas are under cultivation ospecially in cashew nut tree, *Anacardium occidentale* and human settlements.

Vegetation at Bondla hill was surveyed and was found to be interesting as there appeared to be changes as one moved from the hill base to top. The lower elevation constitutes of dominants like *Lannea coromandelica*, *Lagerstroemia lanceolata* and *Terminalia bellirica*.

The co-dominants are Pavetta crassicaulis, Holarrhena antidysenterica and Tylophora indica a twining undershrub which is potentially valued as a medicinal plant in this locality.

The massive invasion of the weed Chromolaena odorata is noticed at slopes of angle 10-15°. Mucuna pruriens is found to be very much abundant climbing on Anacardium occidentale species. The floral composition start to vary at higher elevations towards the middle of the hill. Anacardium occidentale dominates at this point along with Buchanania lanzan, Careya arborea, Lagerstroemia lanceolata, Dillenia pentagyna and occasionally Terminalia bellirica. The co-dominants are Xeromphis spinosa, Ervatamia heyneana, Calycopteris floribunda and Hemidesmus indicus.

The top most elevation forms a dense forest with light canopy. The floral components dominating this point are Emblica officinalis (= Phyllanthus emblica), Putranjiva roxburghii, Terminalia tomentosa and Careya arborea.

The extreme top (which is flat) is dominated by Xylia xylocarpa a very conspiouous species which is rarely found in secondary degraded forests. Other less abundant species are Careya arborea, Mallotus albus, Xeromphis spinosa, Ervatamia heyneana.

Degraded scrub forests close to residential areas often consist of fruit trees like Artocarpus heterophyllus, Emblica officinalis, Tamarindus indica and Psidium guajava which are indications of human activity and habituation.

ix) Vegetation of Sanguem, Birondem, Surla, Darbandora, Siddhanath and Borim areas

These areas are characterized by a Semi-Evergreen biome forest with evergreen elements like Alstonia scholaris, Mangifera indica, Artocarpus heterophyllus, Holigarna arnottiana and deciduous elements like Bombax ceiba.

The vegetation of these areas is comprised of four associations which are marked out mainly due to changes in altitude though other factors may be in operation. This is conspicouous especially in areas close to Siddhanath hill.

Association 1: is comprised of Tamarindus indica, Bombax ceiba, Anthocephalus kadamba, Mitragyna parvifolia, Terminalia arjuna, T. paniculata, Careya arborea and Strychnos nux-vomica. There are as many consociations as there are dominants. The lower tier constitutes gregarious shrubs like Holarrhena antidysenterica, Calotrophis gigantea, Calycopteris floribunda, Vitex negundo and Clerodendrum serratum. The latter two species are indicators of a depleted secondary vegetation.

The ground flora consists of Cassia tora, Justicia micrantha, Justicia procumbens, Ludwgia parviflora, L. linifolia, along with perennial herbs with starchy corms like Colocasia esculenta and Amorphophallus campanulatus and Dioscorea bulbifera which thick leafy bushes in the monsoon rains.

Between Ponda and Borim is a large monocultured Eucalyptus hybrid plantation. The growth of this species appears to impart stress to the ground storey flora since very scant herbs and shrubs are observed in and around the plantation.

Association 2: lies close to the moist fields near bank streams. It is comprised of Holigarna arnottiana, Glochidion zeylanicum, Artocarpus heterophyllus and Lannea coromandelica. The lower tier consists of Ficus hispida, Mussaenda laxa on the forest margins. Scandent climbers most co-dominant are Derris scandens, Dioscorea bulbifera, hispida, Mucuna pruriens and Smilax zeylanica. Ipomoea digitata is found occasional closer to the steeper areas of the river banks.

Association 3: is composed of Terminalia chebula, Macaranga peltata, Mallotus philipense, Buchanania lanzan, Bridelia retusa. Lower tier consist of Bambusa arundinacea, Sapium insegne, Bridelia scandens, Phyllanthus reticulatus, Ziziphus glaberrima, oenoplia, Vangueria spinosa, Randia dumetorum, Ixora coccinea and Gloriosa superba. Thorny shrubs are co-dominating in this tier. The same species appear common on the middle portion of Sidhanath hill.

Association 4: is observed on the upper most of Siddhanath which shows more luxuriant vegetation compared to any of the four associations. Dominants are Terminalia bellirica, Hydnocarpus laurifolia, Caryota urens and Bridelia retusa as an occasional. The lower tier is conspicuous with Ziziphus glaberrima and Ziziphus oenoplia.

Groundflora is co-dominated by Boehmeria platyphylla a delicate fruticose herb found on wet shaddy areas, with stinging hairs, it is more confined to the edges of the dense humid forest. Several other shade loving plants common in this Association are Leea edgeworthii and rarely Leea macrophylla.

A large number of pteridophytes are observed here like Pteris vittata, Pteris pellucida, Schizoloma heterophyllum, Cheilanthes tenue, Selaginella tenera. Co-dominant poaceae members found here are Digitaria longiflora and Setaria pumila.

Some rare species are located at this zone, namely: Lasiosiphon eriocephalus (quite abundant here at this spot though rarely noticed on the Western Ghats), Cissus discolour, Salvia coccinea, Impatiens incospicua, Adelocaryum coelostinum, Habenaria marginata, Habenaria multicaudata and Habenaria heyneana.

A permanent water spring is located close to a temple which harbour several hydrophytes like Vallisneria spiralis and Hydrilla verticillata.

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x) Vegetation of Canaoona and the surrounding villages; Cuncolim, Bali, Agonda, Palolem and Cotigao

The areas around Cuncolim, Bali and Agonda which lie just before the higher elevation of the Western Ghats are sparse in vegetation. The probable reason being, high human population encroachment and further intensification to cultivation. The major plant association consists of Bombax ceiba, Alstonia scholaris and Careya arborea.

The lower lifts of Canacona is encountered at about an altitude of 250 mts above M.S.L. The vegetation showed a change in the species dominancy oonsisting of Terminalia paniculata, and Bombax ceiba. The lower tier consist of Holarrhena antidysenterica, Phyllanthus reticulatus, Pongamia pinnata and Ageratum conyzoides as the herbaceous co-dominant on flat terrains.

Close to Bali area is a large plantation of Tectona grandis and Eucalyptus hybrid (about 30 years old) which marks the end of the Eastern hill slopes.

Vegetation around Canacona hillsides is mainly dominated by Bambusa arundinacea which appears to be in the protected forest zone category - occasionally with Anacardium occidentale, Terminalia crenulata and Bombax ceiba.

The forest edges are earmarked by dense populations of Rauvolfia tetraphylla as the co-dominating species along with Ixora coccinea and Desmodium triquetrum. The lower elevation towards the extreme south of Palolem. The vegetation type is constituted of Pongamia pinnata, Garcinia indica, Bombax ceiba as dominants. Co-dominants observed were Carissa congesta, Holarrhena antidysenterica, Leea indica, Cassia dalbergioides.

The sea shore on sandy areas is dominated by Thespesia populnea as natural medium sized tree besides the cultivated coconut palm groves, Cocos nucifera, Calotropis gigantea and Vitex negundo are the

Table: 4 Some vascular plant species collected during the survey of the Western Ghats' (Goa) vegetation.(Identification of the plant species has been confirmed.)

N.B. : The following is a Key to the numbers used in the tables on the column of habit.

1.0 Tree	2.0 Shrub	3.0 Under shrub.	4.0 Herb
1.1 Large	2.1 Twiner	3.1 Erect	4.1 Perennial
1.2 Medium	2.2 Climber	3.2 Climber	4.2 Annual
1.3 Small	2.3 Stoloniferous	3.3 Parasite	4.3 Prostrate
	2.4 Scandent	3.4 Twiner	4.4 Erect
	2.5 Erect	3.5 Scandent	4.5 Insectivore
	2.6 Succulent	3.6 Prostrate	4.6 Succulent
			4.7 Aquatic
			4.8 Climber
			4.9 Twiner
			4.9.1 Diffused
			4.9.2 Parasite
			5.0 Epiphyte

Asterik * means cultivated species, though found in the wild state also.

Sr. No.	Taxon	Family	Habit	1st Rank of Economic Importance
	PTERIDOPHYTAE			
1.	*Ophioglossum costum* R. Br.	Ophioglossaceae	4.0	---
2.	*Angiopteris evecta* (Forst.) Hoffm.	Marratiaceae	2.3	Sometimes ornamental
3.	*Osmunda regalis* L.	Osmundaceae	4.0	---
4.	*Lygodium flexuosum* Bedd.	Schizaeaceae	4.9	---
5.	*Acrostichum aureum* L.	Pteridaceae	2.5	Young fronds: Vegetable

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(Cont....)

6.	Adiantum philippense L.	Pteridaceae	4.0	---
7.	Cheilanthus tenuifolia (Burm.) Swatz.	Pteridaceae	4.0	----
8.	Pityrogamia calomelanos (L.) Link.	Pteridaceae	4.0	----
9.	Pteris pellucida Presl.	Pteridaceae	4.0	----
10.	Pteris vittata L.	Pteridaceae	4.0	-----
11.	P. quardiaurita Retz.	Pteridaceae	4.0	----
12.	Polystichum aculeatum L.	Pteridaceae	4.0	-----
13.	Pteris schizolenia L.	Pteridaceae	4.0	-----
14.	Gleichenia Linearis Bedd.	Gleicheniaceae	2.3	-----
15.	Nephrolepis falcata cav.	Davalliaceae	4.3	-----
16.	Cyclosorus parasiticus (L.) Tard.	Aspidiaceae	4.0	-----
17.	Blechnum orientale L.	Blechnaceae	4.0	-----
18.	Drynaria quercifolia (L.) Sm.	Polypodiaceae	4.0	-----
19.	Pyrrosia admascens (Sw.) Ching	Polypodiaceae	4.0	-----
20.	Selaginella proniflora (Lam) Baker	Selaginellaceae	4.0	-----
21.	S. tenera (Hk. & Grev.) Spring.	Selaginellaceae	4.0	----
	GYMNOSPERMAE			
22.	Gnetum ula Brongn.	Gnetaceae	2.1	-----
	ANGIOSPERMAE			
23.	Clematis hedysarifolia DC	Ranunculaceae	3	-----
24.	Naravelia zeylanica (L.) DC	Ranunculaceae	3	----
25.	Clematis gouriana L.	Ranunculaceae	3	Leaves and stem: vesicant

(Cont....)

26.	Dillenia pentagyna Roxb	Dilleniaceae	1.2	Timber - Leaves used for Packing
27.	Dillenia indica L.	Dilleniaceae	1.2	Timber
28.	Annona reticulata L.	Annonaceae	1.2	Edible fruit
29.	Annona squamosa L.	Annonaceae	1.3	Edible fruit
30.	Miliusa tomentosa Roxb	Annonaceae	1.2	---
31.	Cyclea peltata Lam.	Menispermaceae	4	---
32.	Diploclisia glaucescens (Bl. Diels	Menispermaceae	2	---
33.	Tinospora cordifolia (Willd) Miers	Menispermaceae	2	----
34.	Nelumbium speciosum Willd.	Nymphaceae	4.7	Edible tubers
35.	Nymphaea nouchali Burm.	Nymphaceae	4.7	Edible tubers
36.	Argemone mexicana L.	Papaveraceae	4.4	Juice: Malaria, jaundice
37.	Brassica juncea(L). Czern.*	Brassicaceae	4.4	Edible leaves
38.	Raphanus sativus L.*	Brassicaceae	4.4	Edible leaves & roots
39.	Brassica campestris L.*	Brassicaceae	4.4	seeds : antiscorbutic
40.	Cleome viscosa L.	Capparaceae	4.4	---
41.	Capparis zeylanica L.	Capparaceae	2	Fruits: pickled
42.	Capparis rotundifolia L.	Capparaceae	1.3	---
43.	Capparis sepiara L.	Capparaceae	2	Fruits: pickled
44.	Capparis baducca Rheedi.	Capparaceae	2	---
45.	Crateva nurvala Buch-Ham.	Capparaceae	1.2	Juice: rheumatism
46.	Flacourtia indica (Burm.) Merr.	Flacourtiaceae	1.3	Fruit : edible
47.	Hydnocarpus laurifolia (Dennst.) Sleumer.	Flacourtiaceae	1.2	Seeds oil: leprosy
48.	Flacourtia montana Grah.	Flacourtiaceae	1.3	Ripe fruits : edible

(Cont....)

49.	Casearia esculenta Roxb.	Flacourtiaceae	1.2	Medicinal
50.	Polygala arvensis Willd.	Polygalaceae	4.4	---
51.	Polygala erioptera DC.	Polygalaceae	4.4	---
52.	Polycarpon prostratum (Forsk.) A. & S.	Caryophyllaceae	4.4	---
53.	Hopea wightiana Wall ex Wt. & Arn.	Dipterocarpaceae	1.2	---
54.	Garcinia xanthochymus Hk. ex. Anders.	Clusiaceae	1.1	---
55.	Garcinia mangostana L.	Clusiaceae	1.2	Rind: edible
56.	Calophyllum inophyllum L.	Clusiaceae	1.3	Construction
57.	Garcinia indica Choisy.	Clusiaceae	1.2	Rind : edible
58.	Portulaca oleracea L.	Portulacaceae	4.8	leaves : vegetable
59.	Portulaca grandiflora L.*	Portulacaceae	4.8	leaves : vegetable
60.	Malvastrum coromandelianum (L.) Garcke.	Malvaceae	4.4	Roots: rheumatism
61.	Hibiscus cannabinus L.	Malvaceae	4.4	Flower juice: Piles & constipation
62.	Hibiscus furcatus Willd.	Malvaceae	4.4	---
63.	Abutilon indicum (L.) Sweet.	Malvaceae	4.4	---
64.	Sida acuta Burm.	Malvaceae	4.4	Roots : rheumatism
65.	Sida cordata (Burm.) Borss.	Malvaceae	4.4	---
66.	Sida rhombifolia L.	Malvaceae	4.4	Stem : febrifuge
67.	Sida cordifolia L.	Malvaceae	4.4	Roots: urinary infection
68.	Thespesia Lampas Cav.	Malvaceae	2.5	---
69.	Thespesia populnea (L.) Sol.	Malvaceae	1.2	Ornamental, Timber
70.	Hibiscus vitifolius L.	Malvaceae	2.5	Ornamental

(Cont...)

71.	Gossypium hirsutum L.*	Malvaceae	2.5	Fibre
72.	Abutilon persicum Burm	Malvaceae	1.3	Ornamental
73.	Hibiscus sabdariffa L.	Malvaceae	2	Leaves : sedative.
74.	Gossypium arboreum L.*	Malvaceae	1.3	Fibre
75.	Bombax ceiba auct.	Bombacaceae	1.2	Fibres; stuffing pillows
76.	Firmiana colorata (Roxb) R.Br.	Bombacaceae	1.2	Potential ornamental
77.	Helicteres isora L.	Sterculiaceae	2.4	Fruits :diarrhoea,
78.	Melochia corchorifolia L.	Sterculiaceae	4.4	---
79.	Sterculia guttata Roxb.	Sterculiaceae	1.2	Bark : strong fibre
80.	S. foetida L.*	Sterculiaceae	1.1	Fruit : edible
81.	S. urens Roxb.	Sterculiaceae	1.2	Stem exudate: Gum
82.	Grewia tiliaefolia Vahl	Tiliaceae	1.2	Timber
83.	Grewia pilosa Lam	Tiliaceae	2.5	Fuel
84.	Grewia umbellifera Bedd	Tiliaceae	2.4	Timber
85.	Microcos paniculata L.	Tiliaceae	2.5	Fruits : edible, fuel
86.	Corchorus aestuans L.	Tiliaceae	4.4	---
87.	Corchorus capsularis L.	Tiliaceae	4.4	Fibres : cordage
88.	Grewia villosa Willd	Tiliaceae	2.0	Root : diarrhoea,
89.	Muntingia Calabura L.*	Tiliaceae	2.0	Ornamental
90.	Erinocarpus nimmonii Grah.	Tiliaceae	2.0	---
91.	Oxalis corniculata L.	Oxalidaceae	4.0	Juice of leaves : piles,
92.	Biophytum condolleanum Wt.	Oxalidaceae	4.0	---
93.	Biophytum sensitivum (L.) DC.	Oxalidaceae	4.0	---

(Cont...)

94.	Impatiens balsamina L.	Balsaminaceae	4.0	---
95.	I. Kleinii Wt. & Arn. & A	Balsaminaceae	4.0	---
96.	I. oppositifolia L.	Balsaminaceae	4.0	---
97.	Zanthoxylum rhetsa (Roxb) DC.	Rutaceae	1.2	Fruit: stomachic
98.	Glycosmis mauritiana (Lam). Tanaka.	Rutaceae	1.3	Wood : snakebite
99.	Murraya paniculata (L.) Jack.	Rutaceae	1.3	Leaves : Spices
100.	Murraya exotica L.*	Rutaceae	1.3	Leaves : spices
101.	Citrus medica DC.*	Rutaceae	1.3	---
102.	Ochna obtusata DC.	Ochnaceae	3.0	-----
103.	Garuga pinnata Roxb.	Burseraceae	1.3	Fruit pickled
104.	Naregamia alata Wt & Arn.	Meliaceae	3.0	Root: bronchitis, asthma
105.	Chukrassia tabularis Juss.	Meliaceae	1.2	Wood: construction
106.	Azadhiracta indica A. Juss.*	Meliaceae	1.2	----
107.	Celastrus paniculatus Willd	Celastraceae	2.2	Oil: rheumatism, paralysis
108.	Hippocratea indica L.	Celastraceae	2.2	Alkaloid
109.	Ziziphus xylopyrus Willd.	Rhamnaceae	2.4	Leaves : fumigatory
110.	Ziziphus glaberrima Sant.	Rhamnaceae	1.3	Fruits: edible
111.	Ziziphus mauritiana Lam*	Rhamnaceae	1.3	Fruits: edible
112.	Ziziphus oenoplia Miller	Rhamnaceae	2.0	Fuel wood
113.	Ziziphus rugosa Lam	Rhamnaceae	2.0	Fuel wood
114.	Ventilago denticulata Willd.	Rhamnaceae	2.0	---
115.	Ventilago madraspatana Gaertn.	Rhamnaceae	2.2	Fuel wood

(Cont....)

116.	Ampelocissus latifolia Roxb.	Vitaceae	4.0	---
117.	A. tomentosa (Roth) Planchon.	Vitaceae	4.0	---
118.	Leea edgeworthii Sant.	Vitaceae	4.0	---
119.	Leea indica (Burm) Merr.	Vitaceae	2.0	Roots : rheumatism
120.	Leea macrophylla Roxb.	Vitaceae	3.0	---
121.	Cayratia elongata (Roxb). Suesseng.	Vitaceae	2.2	---
122.	Cissus repanda Vahl).	Vitaceae	2.2	----
123.	Cissus discolor (Blume) Bijdr.	Vitaceae	4.0	Ornamental
124.	Leea crispa L.	Vitaceae	2.4	Tubers: guinea worms
125.	Leea herbacea Buch - Ham.	Vitaceae	4.0	-----
126.	Cardiospermum halicacabum L.	Sapindaceae	2.2	Whole Plant: rheumatism
127.	Lepisanthes tetraphylla (Vahl) Radlk.	Sapindaceae	2.0	Fuel wood
128.	Allophylus cobbe (L.) Raeusch.	Sapindaceae	2.4	-------
129.	Schleichera oleosa (Lour) Mao.	Sapindaceae	1.1	Timber
130.	Anacardium occidentale L.*	Anacardiaceae	1.2	Nuts edible
131.	Buchanania Lanzan Spreng.	Anacardiaceae	1.3	Wood timber
132.	Holigarna arnottiana Hk. f.	Anacardiaceae	1.1	Wood timber
133.	Lannea coromandelica Rich.	Anacardiaceae	1.3	Wood construction
134.	Mangifera indica L.*	Anacardiaceae	1.2	Drupe edible
135.	Spondias acuminata Roxb.*	Anacardiaceae	1.3	Leaves: earache, Bark: dyes
136.	Connarus wightii (Hk. f.) Cooke.	Connaraceae	2.4	---
137.	Abrus precatorius. L.	Fabaceae	2.4	Leaf juice : rheumatism.
138.	Aeschynomene indica L.	Fabaceae	4.0	Floats

(Cont....)

139.	Alysicarpus bupleurifolius (L.) DC.	Fabaceae	4.3	---
140.	A. rugosus DC.	Fabaceae	4.3	---
141.	A. vaginalis L.	Fabaceae	4.9	---
142.	Atylosia scarabaeoides (L.) Benth.	Fabaceae	4.3	Roots: rheumatism, piles
143.	Butea monosperma (Lamk.) Taub.	Fabaceae	1.3	Whole plant : dysentery.
144.	Clitoria ternatea L.	Fabaceae	3.0	Seeds : tumours, dropsy
145.	Crotalaria albida Roth.	Fabaceae	4.4	---
146.	Crotalaria epunctata Dalz.	Fabaceae	4.3	---
147.	Crotalaria linifolia L.	Fabaceae	4.0	---
148.	Crotalaria pallida Ait.	Fabaceae	3.4	---
149.	Crotalaria retusa L.	Fabaceae	3.4	---
150.	Crotalaria triquetra Dalz.	Fabaceae	4.4	---
151.	Crotalaria verrucosa L.	Fabaceae	4.4	---
152.	Cyanopsis psoralioides DC.	Fabaceae	4.0	---
153.	Dalbergia latifolia Roxb.	Fabaceae	1.2	Timber
154.	Canavalia macrocarpa (DC.) Piper.*	Fabaceae	2.2	Seed : edible
155.	C. gladiata (Jacq.) DC.*	Fabaceae	2.1	Seeds : edible
156.	Desmodium dichotomum. (Willd.) DC.	Fabaceae	4.0	-----
157.	D. heterocarpon (L.) DC.	Fabaceae	2.1	---
158.	Desmodium triangulare (Retz) Merr.	Fabaceae	2.1	---
159.	D.trifolium (L.) DC.	Fabaceae	3.0	---
160.	Derris scandens (Roxb) Cooke.	Fabaceae	2.1	---

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(Cont....)

161.	Derris trifoliata Lour.	Fabaceae	2.0	---
162.	Dolichos biflorus L.*	Fabaceae	2.0	Pods & seeds : edible
163.	Flemingia strobilifera R.Br.	Fabaceae	2.0	---
164.	Geissaspis cristata Wt. & Arn.	Fabaceae	4.3	---
165.	G. tenella Benth.	Fabaceae	4.3	---
166.	Erythrina stricta Roxb.	Fabaceae	1.2	Ornamental
167.	Erythrina variegata L.*	Fabaceae	1.2	Ornamental
168.	Indigofera cassioides Rott.	Fabaceae	2.0	---
169.	Indigofera dalzellii Cooke.	Fabaceae	3.0	-----
170.	Indigofera linifolia (L.f.) Retz.	Fabaceae	3.2	----
171.	I. prostrata Willd.	Fabaceae	4.3	---
172.	I. tinctoria L.	Fabaceae	4.0	Leaf juice : asthma.
173.	I. trifoliata L.	Fabaceae	4.0	---
174.	I. uniflora Buch - Ham.	Fabaceae	4.0	----
175.	Mucuna pruriens (L.) DC.	Fabaceae	4.9	Seeds : leucorrhoea
176.	Ougeinia oojeinensis (Roxb) Hochr.	Fabaceae	1.2	Timber
177.	Phaseolus mungo L.	Fabaceae	4.3	Seeds: Food
178.	Pongamia pinnata (L.) Pierre	Fabaceae	1.2	Seed : medicinal oil
179.	Pterocarpus marsupium Roxb.	Fabaceae	1.2	Timber
180.	Sesbania bispinosa Jacq.	Fabaceae	4.4	Fodder
181.	Smithia conferta Sm.	Fabaceae	4.3	----
182.	S. sensitiva Ait.	Fabaceae	4.3	------
183.	Tephrosia purpurea (L.) Pers.	Fabaceae	4.4	Leaves : dropsy.

(Cont...)

184.	Teramnus labialis (L.f.) Spreng.	Fabaceae	4.3	---
185.	Zornia gibbosa spanoghe.	Fabaceae	4.3	---
186.	Tephrosia coccinea Wall.	Fabaceae	4.4	---
187.	Desmodium triquetrum (L.) Dc.	Fabaceae	4.9	---
188.	Mucuna monosperma L.	Fabaceae	1.3	Seeds : edible
189.	Crotalaria filipes Benth.	Fabaceae	4.3	---
190.	Crotalaria quinquefolia L.	Fabaceae	4.0	---
191.	Teramnus mollis Benth.	Fabaeae	4.3	Seeds : edible
192.	Atylosia crassa Prain	Fabaceae	4.9	------
193.	Aeschynomene aspera L.	Fabaceae	4.4	Wood : making floats
194.	Sesbania grandiflora L.*	Fabaceae	1.3	Ornamental
195.	Atylosia lineata Wt. & Arn.	Fabaceae	4.9	------
196.	Desmodium motorium (Houtt) Merr.	Fabaceae	2.1	-----
197.	Desmodium polycarpum DC.	Fabaceae	4.0	---
198.	Flemingia tuberosa Dalz.	Fabaceae	4.0	Tubers : edible
199.	Desmodium gyrans DC.	Fabaceae	4.9	-----
200.	Cassia absus L.	Caesalpiniaceae	4.4	-----
201.	C. alata L.	Caesalpiniaceae	2.5	Leaves decoction : snake-bite
202.	C. fistula L.	Caesalpiniaceae	1.3	Ornamental
203.	C. mimosoides L.	Caesalpiniaceae	4.3	---
204.	C. glauca Lam.	Caesalpiniaceae	1.3	Ornamental
205.	Bauhinia racemosa Lamk.	Caesalpiniaceae	1.3	Ornamental

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(Cont...)

206.	Bauhinia tomentosa L.	Caesalpiniaceae	1.3	Ornamental and Timber
207.	Cassia sophera L.	Caesalpiniaceae	4.4	Roots:Snakebite. Plant:Purgative
208.	Cassia nodosa L.*	Caesalpiniaceae	1.3	Ornamental
209.	Bauhinia purpurea L.	Caesalpiniaceae	1.2	----
210.	Piliostigma malabaricum Roxb.	Caesalpiniaceae	2.4	Fruit: laxative,
211.	Cassia occidentalis L.	Caesalpiniaceae	2.5	Bark (externally): skin diseases
212.	C. tora L.	Caesalpiniaceae	4.4	Tender leaves : vegetable
213.	C. obtusifolia L.	Caesalpiniaceae	4.4	Tender leaves : vegetable
214.	Tamarindus indica L.	Caesalpiniaceae	1.1	Pods : spices
215.	Wagatea spicata Dalz.	Caesalpiniaceae	2.4	Roots : Pneumonia, bark: skin diseases.
216.	Adenanthera pavonina L.*	Mimosaceae	1.2	Ornamental
217.	Albizia lebbeck (L.) Benth.	Mimosaceae	1.2	Timber
218.	Samanea saman L.*	Mimosaceae	1.1	Ornamental
219.	Xylia xylocarpa Taub.	Mimosaceae	1.1	Timber
220.	Acacia chundra (Roxb). Willd	Mimosaceae	1.2	Substitute for A. Catechu.
221.	A. nilotica (L.) Rao.	Mimosaceae	1.3	Stem exudate : Gum
222.	A. pennata (L.) Willd	Mimosaceae	1.3	-----
223.	A. torta (Roxb.) Craib.	Mimosaceae	1.3	---
224.	Albizzia lebbeck (L.) Willd.	Mimosaceae	1.2	Timber
225.	Mimosa pudica L.	Mimosaceae	4.3	Juice : piles & sores
226.	Pithecellobium dulce (Roxb.) Benth.	Mimosaceae	1.3	Fencing
227.	Entada pusaertha DC.	Mimosaceae	3.2	---
228.	Acacia catechu (Roxb) Willd	Mimosaceae	1.3	Bark : astrigent, diarrhoea

(Cont....)

229.	Kalanchoe pinnata (Lam.) Pers.	Crassulaceae	4.1	Ornamental
230.	Drosera burmanii Vahl.	Droseraceae	4.5	----
231.	D. indica L.	Droseraceae	4.5	Timber
232.	Rhizophora mucronata Lam.	Rhizophoraceae	1.3	Fuel wood
233.	Kandelia candel (L.) Dru.	Rhizophoraceae	1.3	Fuel wood
234.	Rhizophora conjugata L.	Rhizophoraceae	1.3	---
235.	Anogeissus latifolia (DC) Wall.	Combretaceae	1.3	----
236.	Combretum ovalifolium Roxb.	Combretaceae	2.1	Timber
237.	C. latifolium Bl.	Combretaceae	2.1	Timber
238.	Calycopteris floribunda (Roxb) Lam.	Combretaceae	2.4	Fruit : jaundice
239.	Terminalia arjuna (Roxb) Wt. & Arn.	Combretaceae	1.2	Timber
240.	Terminalia bellirica (Gaertn.) Roxb.	Combretaceae	1.2	Timber
241.	Terminalia chebula (Gaertn.) Retz	Combretaceae	1.2	Timber
242.	Terminalia paniculata Roth.	Combretaceae	1.2	Timber
243.	Terminalia tomentosa W & A.	Combretaceae	1.2	Timber
244.	Quisqualis indica L.	Combretaceae	2.4	Ornamental
245.	Syzygium caryophyllatum (L.) Alton	Myrtaceae	1.2	Timber
246.	Syzygium cumini (L.) Skeels	Myrtaceae	1.2	Edible drupes
247.	Syzygium heyneanum Wall.	Myrtaceae	1.3	Fuel
248.	Syzygium zeylanicum (L.) DC.	Myrtaceae	1.3	Fuel
249.	Barringtonia acutangula (L.) Gaertn.	Barringtoniaceae	1.2	Timber
250.	Barringtonia racemosa (L.) Spreng.	Barringtoniaceae	1.2	Timber

(Cont....)

251.	Careya arborea Roxb.	Barringtoniaceae	1.2	Construction
252.	Melastoma malabathricum L.	Melastomataceae	2.5	---
253.	Memecylon umbellatum Burm.	Melastomataceae	1.3	---
254.	Memecylon wightii Thw.	Melastomataceae	2.4	Fuel
255.	Osbeckia truncata Don.	Lythraceae	4.4	---
256.	Ammania baccifera Roxb.	Lythraceae	4.7	----
257.	A. multiflora L.	Lythraceae	4.7	---
258.	Lagerstroemia lanceolata Clarke.	Lythraceae	1.2	Timber
259.	Rotala densiflora (Roth) Koehne.	Lythraceae	4.7	---
260.	Woodfordia fruticosa (L.) Kurz.	Lythraceae	2.5	Ornamental
261.	Ludwigia linifolia (Vahl.) Rao	Onagraceae	4.0	------
262.	L. perennis L.	Onagraceae	4.0	-----
263.	Passiflora foetida L.*	Passifloraceae	4.9	Ornamental
264.	Citrullus colocynthis (L.) Schr. *	Cucurbitaceae	4.8	Tender fruit edible
265.	Luffa cylindrica L.	Cucurbitaceae	4.8	Edible fruit Tender fruit :edible
266.	Luffa acutangula (L.) Roxb.	Cucurbitaceae	4.8	Edible fruit Tender fruit :edible
267.	Trichosanthes tricuspidata L.	Cucurbitaceae	4.8	Edible fruit
268.	T. bracteata (Lam.) Voigt.	Cucurbitaceae	4.8	Edible fruit
269.	Cucumis melo L. *	Cucurbitaceae	4.8	Edible fruit
270.	Momordica dioca Roxb.	Cucurbitaceae	4.8	Ornamental
271.	Melothria heterophylla (Lour.) Cogn.	Cucurbitaceae	4.8	----
272.	Mukia maderaspatana Roem.	Cucurbitaceae	4.8	---
273.	Trichosanthes cucumerina L.	Cucurbitaceae	4.8	-----

(Cont...)

274.	Begonia crenata Dryand.	Begoniaceae	4.6	Ornamental
275.	Opuntia elator Mill. *	Cactaceae	2.5	---
276.	Mollugo pentaphylla L.	Molluginaceae	4.3	---
277.	Mollugo oppositifolia L.	Molluginaceae	4.3	---
278.	Centella asiatica (L.) Urb.	Apiaceae	4.3	Leaves' decoction : head-tonic
279.	Pimpinella heyneana (D.G) Kurz.	Apiaceae	4.3	----
280.	Pimpinella wallichiana (Miq) Gandhi.	Apiaceae	4.3	----
281.	Spermacoce articularis L.	Rubiaceae	4.4	---
282.	S. hispida L.	Rubiaceae	4.4	----
283.	S. pusilla Wall.	Rubiaceae	4.4	----
284.	S.stricta Auct.	Rubiaceae	4.4	-----
285.	Canthium dicoccum Teysm.	Rubiaceae	4.4	----
286.	Dentella repens (L.) J & G. Forst.	Rubiaceae	4.4	-----
287.	Hedyotis auricularia L.	Rubiaceae	4.4	Whole Plant : dysentery & Cholera
288.	H. diffusa Willd.	Rubiaceae	4.4	Plant Decoction : piles
289.	H. Corymbosa L.	Rubiaceae	4.4	Jaindice & Fever
290.	H. herbacea L.	Rubiaceae	4.4	Whole plant : Malaria
291.	Ixora coccinea L.	Rubiaceae	2.5	Ornamental
292.	I. arborea Roxb.	Rubiaceae	1.3	Timber
293.	Hymenodictyon obovatum Wall.	Rubiaceae	1.3	Fuel wood
294.	Meyna laxiflora Robyns.	Rubiaceae	1.2	Timber
295.	Mitragyna parviflora (Roxb.) Korth.	Rubiaceae	1.2	Timber
296.	Morinda citrifolia L.	Rubiaceae	1.3	Fruit : asthma & dysentery.

(Cont....)

297.	Mussaenda laxa (H.k.) Gamble.	Rubiaceae	2.4	Ornamental
298.	Mussaenda frondosa L.*	Rubiaceae	2.4	Ornamental
299.	Neonotis foetida (Dalz.) Lewis.	Rubiaceae	4.4	----
300.	Neonauclea purpurea Merr.	Rubiaceae	1.2	Timber
301.	Gardenia latifolia Ait.	Rubiaceae	2.4	Fuel wood
302.	Pavetta crassicaulis Bremek.	Rubiaceae	2.4	Fuel wood
303.	Psychotria dalzellii (Hk) Cooke.	Rubiaceae	1.2	Fuel wood
304.	Anthocephalus chinensis (Lamk) Rich.*	Rubiaceae	1.2	Ornamental & Timber
305.	Wendlandia thyrsoidea (Roem & Schul) Steud	Rubiaceae	2.4	-----
306.	Xeromphis spinosa (Thumb.) Keay.	Rubiaceae	2.5	Fuel wood
307.	Morinda tomentosa Heyne.	Rubiaceae	2.4	----
308.	Ixora brachiata Roxb	Rubiaceae	1.3	----
309.	Coffea arabica L.*	Rubiaceae	1.3	Coffee seeds
310.	Spermacoce ocymoides (Burm) DC.	Rubiaceae	4.3	----
311.	Tarenia zeylanica Gaertn.	Rubiaceae	3.1	-----
312.	Adina cordifolia Roxb	Rubiaceae	1.2	Timber
313.	Ageratum conyzoides L.	Asteraceae	4.4	Root & juice : antilithic
314.	Blumea eriantha Dc.	Asteraceae	4.3	Leaf juice : carminative
315.	Zinnia elegans Jacq.*	Asteraceae	4.4	Ornamental
316.	Tagetes patula*	Asteraceae	4.4	Ornamental
317.	Chromolaena odoratum (L.) King & Robs.	Asteraceae	4.4	----
318.	Senecio dalzelli C.B. Clarke	Asteraceae	4.4	---
319.	Echinops echinatus Roxb.*	Asteraceae	4.4	---
320.	Vedelia urticaefolia DC.	Asteraceae	4.9	----

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(Cont...)

321.	Launaea nudicaulis Hk. f.	Asteraceae	4.9	----
322.	Spilanthes paniculata Wall.	Asteraceae	4.3	-----
323.	Wedelia biflora DC.	Asteraceae	4.9	-----
324.	Blumea malcolmii (Cl.) Hk. f.	Asteraceae	4.4	---
325.	Blumea membranacea DC.	Asteraceae	4.4	----
326.	Blumea mollis (Don) Merr.	Asteraceae	4.4	-----
327.	B. virens DC.	Asteraceae	4.4	----
328.	Centhratherum tenue (Wight) C.B. Clarke.	Asteraceae	4.4	-----
329.	Elephantopus scaber L.	Asteraceae	4.4	Whole plant : cardiac, tonic
330.	Emilia sonchifolia (L.) DC.	Asteraceae	4.9	---
331.	Gynura cusimbua (D. Don) DC.	Asteraceae	4.4	----
332.	Lactuca runcinata DC.	Asteraceae	4.9	----
333.	Senecio grahami Hk.f.	Asteraceae	4.4	-----
334.	S. belgaumensis C.B. Clarke.	Asteraceae	4.4	----
335.	Sphaeranthus indicus L.	Asteraceae	4.3	----
336.	Synedrella nodiflora (L.) Gaertn.	Asteraceae	4.3	----
337.	Acanthospermum hispidium DC.	Asteraceae	4.4	-----
338.	Artemisia nilagirica (Cl.) Pamp.	Asteraceae	4.4	Leaves : ashtma
339.	Tricholepis glaberrima DC.	Asteraceae	4.4	Whole plant : leucoderma
340.	Tridax procumbens L.	Asteraceae	4.3	----
341.	Tithonia diversifolia (Hems) Gray.	Asteraceae	2.4	Ornamental
342.	Vernonia anthelmintica Willd.	Asteraceae	2.0	Seeds : anthelmintic, diuretic.

(Cont....)

343.	V. cinerea (L.) Less.	Asteraceae	3.1	Roots : dropsy
344.	Eclipta alba L.	Asteraceae	4.3	Decoction : jaundice
345.	Blumea lacera (Burm. f.) DC.	Asteraceae	4.4	-----
346.	Lactuca remotiflora DC.	Asteraceae	4.3	-----
347.	Maba nigrescens Dalz.	E benaceae	2.4	Fuel wood
348.	Diospyros pruriens Dalz.	E benaceae	1.3	Timber
349.	Olea dioica Roxb	Oleaceae	2.4	----
350.	Jasminum malabaricum Wt.	Oleaceae	2.4	Ornamental
351.	Parsonsia helicandra HK.	Apocynaceae	2.1	-----
352.	Nerium indicum L.*	Apocynaceae	2.4	Ornamental
353.	Allamanda cathartica L.*	Apocynaceae	2.4	Ornamental
354.	Ervatamia heyneana (Wall) Cooke.	Apocynaceae	1.3	---
355.	Alstonia scholaris (L.) R. Br.	Apocynaceae	1.1	------
356.	Catharanthus roseus Don.	Apocynaceae	3.1	Ornamental
357.	Carissa inermis Vahl.	Apocynaceae	2.4	Fruits : edible
358.	Carissa congesta Wt.	Apocynaceae	2.4	Fruits : edible
359.	Ellertonia rheedi Wt. Ic.	Apocynaceae	2.4	----
360.	Holarrhena antidysenterica (Roth) DC.	Apocynaceae	2.4	Root: dysentery & piles
361.	Ichnocarpus frutescens (L.) R.Br.	Apocynaceae	2.2	-----
362.	Plumeria rubra L.*	Apocynaceae	1.3	Ornamental
363.	Rauvolfia serpentina (L.) Benth.	Apocynaceae	2.5	Root : reduces blood pressure
364.	R. tetraphylla L. Rao	Apocynaceae	2.5	Root : sedative
365.	Wrightia tinctoria R. Br.	Apocynaceae	2.5	Fuel wood

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(Cont....)

366.	Asclepias curassavica L.	Asclepiadaceae	3.1	Root :
367.	Calotrophis gigantea (L.) R.Br.	Asclepiadaceae	2.5	Latex : antiseptic for wounds
368.	Ceropegia attenuata Hk.	Asclepiadaceae	3.1	---
369.	Gymnema sylvestre (Retz.) Schultes.	Asclepiadaceae	2.2	Leaves : diabetes
370.	Tylophora dalzellii Hk.	Asclepiadaceae	3.1	----
371.	Tylophora indica (Burm.) Merr.	Asclepiadaceae	2.1	Root : expectorant
372.	T. fasciculata Ham.	Asclepiadaceae	3.1	-----
373.	Wattakaka volubilis L.	Asclepiadaceae	2.1	----
374.	Hemidesmus indicus (L.) R. Br.	Periplocaceae	2.1	Roots : diuretic & skin diseases
375.	Strychnos nux-vomica L.	Loganiaceae	1.2	Seeds : nervine tonics.
376.	Strychnos colubrina L.	Loganiaceae	2.4	Fuel wood.
377.	Canscora diffusa (Vahl.) R.Br.	Gentiniaceae	4.9	Whole plant : nervine tonic
378.	C. decurrens Dalz.	Gentiniaceae	4.4	----
379.	C. pauciflora Dalz	Gentiniaceae	4.4	-----
380.	Cordia dichotoma Forst.	Boraginaceae	4.0	Ornamental
381.	Heliotropium indicum L.	Boraginaceae	1.2	Ornamental
382.	H. ovalifolium Forst.	Boraginaceae	4.0	----
383.	Coldenia procumbens L.	Boraginaceae	4.0	---
384.	Cordia sebestena L.*	Boraginaceae	1.3	Ornamental
385.	Tabebuia argentea (B & S.) Britt.*	Boraginaceae	1.3	Orneamental
386.	Cordia wallichii Don.	Braginaceae	1.2	Timber
387.	Adelocaryum coelestinum (Lindl) Brand.	Boraginaceae	3.5	---

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(Cont....)

387.	Convolvulus microphyllus Sieb.	Convolvulaceae	4.9	-----
389.	Argyreia nervosa Burm.	Convolvulaceae	4.9	-----
390.	A. sericea Dalz.	Convolvulaceae	4.9	----
391.	Rivea hypocrateriformis Choisy.	Convolvulaceae	2.1	-----
392.	Merremia emarginata Burm.	Convolvulaceae	2.1	-----
393.	Argyreia involucrata Clarke.	Convolvulaceae	2.1	---
394.	Cuscuta reflexa Roxb.	Convolvulaceae	3.4	---
395.	Evolvulus alsinoides L.	Convolvulaceae	4.3	Whole plant : brain tonic
396.	Ipomoea digitata L.	Convolvulaceae	4.3	Tubers : edible
397.	I. marina (L.f) Don.	Convolvulaceae	4.3	---
398.	I. obscura (L.) R.G.	Convolvulaceae	4.3	---
399.	I. quamoclit L. *	Convolvulaceae	4.3	---
400.	I. pes-caprae (L.) Sweet.	Convolvulaceae	4.3	Sand binder
401.	Merremia tridentata (L.) Hall. f.	Convolvulaceae	4.3	----
402.	M. umbellata (L.) Hall.f.	Convolvulaceae	4.3	-----
403.	M. vitifolia (L.) Hall.f.	Convolvulaceae	4.9	-----
404.	Datura metel L.	Solanaceae	4.4	Seeds : insancity & fever
405.	D. stramonium L.	Solanaceae	4.4	- do -
406.	Physalis minima L.	Solanaceae	4.4	Fruit : edible
407.	Solanum nigrum L.	Solanaceae	4.4	Leaves : vegetable
408.	S. surattense Burm.f.	Solanaceae	4.4	-----
409.	Cestrum nocturnum L. *	Solanaceae	2.4	Ornamental
410.	Capsicum annuum L.*	Solanaceae	4.4	Spices.

(Cont...)

411.	Capsicum frutescens L.*	Solanaceae	4.4	Spices
412.	Solaeum xyathocarpum L.	Solanaceae	3.5	---
413.	S. indicum auct.	Solanaceae	2.5	---
414.	Aeginetia indica L.	Orobanchaceae	4.4	---
415.	Centranthera indica (L.) Gamble.	Scrophulariaceae	4.4	---
416.	Lindernia ciliata (Colsm) Pennell.	Scrophulariaceae	4.3	---
417.	L. hirta (C & S) Pennell.	Scrophulariaceae	4.3	----
418.	L. viscosa Zakfl.	Scrophulariaceae	4.3	----
419.	Rhamphicarpa longiflora Benth.	Scrophulariaceae	4.4	-----
420.	Scoparia dulcis L.	Scrophulariaceae	4.4	-----
421.	Sopubia delphinifolia (L.) Don.	Scrophulariaceae	4.4	-----
422.	Striga lutea Lour.	Scrophulariaceae	4.9.2	----
423.	Russelia juncea Zucc.*	Scrophulariaceae	4.9	Ornamental
424.	Linderuia cordifolia (Colsm) Merr.	Scrophulariaceae	4.3	----
425.	L. antipoda (L.) Alston.	Scrophulariaceae	4.3	---
426.	Stemodia viscosa Roxb.	Scrophulariaceae	4.0	---
427.	Utricularia caerulea L.	Lentibulariaceae	4.5	-----
428.	U. exoleta R. Br.	Lentibulariaceae	4.5	----
429.	U. reticulata Sm.	Lentibulariaceae	4.5	-----
430.	U. aurea Lour.	Lentibulariaceae	4.5	-----
431.	Heterophragma quadriloculare Roxb.	Bignoniaceae	1.3	Timber
432.	Oroxylum indicum Vent.	Bignoniaceae	1.3	Timber
433.	Bignonia unguis - Cati L.*	Bignoniaceae	2.2	Ornamental

(Cont...)

434.	Sesamum indicum L.*	Pedaliaceae	4.4	Seed oil : lighting
435.	Sesamum mulayanum Nair.	Pedaliaceae	4.4	---
436.	Adhatoda vasica Nees.	Acanthaceae	2.4	Roots & leaves : cough
437.	Acanthus illicifolius L.	Acanthaceae	2.4	----
438.	Andrographis paniculata Nees.	Acanthaceae	4.4	Whole plant : vermifuge.
439.	Barleria cristata L.	Acanthaceae	4.4	---
440.	B. strigosa Willd.	Acanthaceae	4.4	---
441.	Haplanthus verticillatus (Roxb.) Nees.	Acanthaceae	4.4	---
442.	Dicliptera zeylanica Nees.	Acanthaceae	4.3	-----
443.	Asystasia dalzelliana Sant.	Acanthaceae	3.5	----
444.	Eranthemum roseum Br.	Acanthaceae	4.4	Ornamental
445.	Hemigraphis latebrosa Nees.	Acanthaceae	3.4	Bark & leaves : bitter tonic
446.	Hygrophila auriculata auct.	Acanthaceae	4.4	Seed : gonorrhea
447.	Hyplanthodes neigherryensis Wt.	Acanthaceae	4.3	---
448.	Justicia micrantha Heyne.	Acanthaceae	4.3	----
449.	J. procumbens L.	Acanthaceae	4.0	---
450.	J. gendarussa Burm.*	Acanthaceae	4.0	Ornamental
451.	Lepidagathis cristata Willd.	Acanthaceae	3.6	---
452.	L. cuspidata Nees.	Acanthaceae	3.6	---
453.	L. prostrata Dalz.	Acanthaceae	3.6	---
454.	Rungia pectinata Nees.	Acanthaceae	4.3	---
455.	R. linifolia Nees.	Acanthaceae	4.3	----

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(Cont...)

456.	Neuracanthus sphaerostachyus Nees.	Acanthaceae	4.4	----
457.	Barleria prionitis L.	Acanthaceae	4.4	----
458.	Blepharis asperrima Nees.	Acanthaceae	4.4	----
459.	Justica trinervia Vahl.	Acanthaceae	4.3	----
460.	Adhatoda zeylanica L.	Acanthaceae	2.4	Ornamental
461.	Strobilanthes callosus Nees.	Acanthaceae	2.4	----
462.	Asystasia gangetica L.	Acanthaceae	2.4	----
463.	Blepharis maderaspatensis L.	Acanthaceae	2.0	----
464.	Crossandra infundibuliformis Nees.	Acanthaceae	2.4	----
465.	Rungia elegans Dalz.	Acanthaceae	4.3	----
466.	Avicennia officinalis L.	Verbenaceae	2.4	Fuel wood.
467.	Callicarpa tomentosa (L.) Murr.	Verbenaceae	1.3	Fibre : cordage
468.	Clerodendrum inerme (L.) Gaertn.	Verbenaceae	2.4	Ornamental
469.	C. serratum (L.) Moon.	Verbenaceae	2.5	----
470.	C. viscosum Vent.	Verbenaceae	2.5	Ornamental
471.	Gmelina arborea Roxb.	Verbenaceae	1.3	Wood : Musical instruments.
472.	Stachytarpheta jamaicensis (L.) Vahl.	Verbenaceae	2.5	Ornamental
473.	Tectona grandis L.	Verbenaceae	1.2	Timber
474.	Vitex negundo L.	Verbenaceae	2.5	Leaves : rheumatism, insect repellant.
475.	Vitex altissima L.	Verbenaceae	1.2	Timber
476.	Clerodendrum squamatum Vahl.	Verbenaceae	2.5	---
477.	C. thomsonae Balf. *	Verbenaceae	2.1	Ornamental
478.	Duranta plumieri Jacq. *	Verbenaceae	2.4	Hedge plant

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(Cont...)

479.	Avicennia marina var.	Verbenaceae	2.4	----
480.	Acrocephalus indicus (Burm.) Kuntze.	Lamiaceae	4.4	----
481.	Anisochilus verticillatus Hook.	Lamiaceae	4.4	---
482.	Hyptis suaveolens (L.) Poit	Lamiaceae	3.5	Plant: parasitical skin diseases
483.	Leucas aspera Spreng.	Lamiaceae	4.4	Plant: psoriasis, scabies.
484.	L. lavandulaefolia Rees.	Lamiaceae	4.4	- do -
485.	L. zeylanica R. Br.	Lamiaceae	4.4	- do -
486.	Pogostemon paniculatus (Willd) Benth.	Lamiaceae	4.4	---
487.	P. parviflorus Benth.	Lamiaceae	4.4	Root : haemorrage
488.	Ocimum basilicum L.*	Lamiaceae	4.4	Seeds: dysentery, gonorrhoea
489.	O. americanum L.	Lamiaceae	4.4	Leaves : parasitical skin disease
490.	O. sanctum L. *	Lamiaceae	4.4	Leaves : expectorant, earache
491.	Leonotis nepetifolia Br.	Lamiaceae	4.4	----
492.	Boerhavia diffusa L.	Nyctaginaceae	4.3	Roots : anthelmintic & febrifuge
493.	Bougainvillea spectabilis Willd.*	Nyctaginaceae	2.4	Ornamental
494.	Achyranthes aspera L.	Amaranthaceae	4.3	Whole Plant purgative, dropsy
495.	Celosia argentea L.	Amaranthaceae	4.0	Ornamental
496.	Amaranthus spinosus L.	Amaranthaceae	4.4	Leaves: vegetable
497.	Aerva lanata L.	Amaranthaceae	4.4	----
498.	Gomphrena celosiodes L.	Amaranthaceae	4.3	----
499.	Amaranthus hybridus L.	Amaranthaceae	4.4	Leaves : vegetable
500.	Alternanthera sessilis L.	Amaranthaceae	4.3	----

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(Cont...)

501.	Aerva persica Burm.	Amaranthaceae	4.0	---
502.	Polygonum glabrum Willd.	Polygonaceae	2.4	Leaves: colic pain
503.	P. plebeium R.Br.	Polygonaceae	4.3	---
504.	Muehlenbeckia platycladon L.	Polygonaceae	2.1	Ornamental
505.	Aristolochia indica L.	Aristolochiaceae	2.1	Root: tonic, emetic, in feve
506.	Piper trichostachyon (Miq) DC.	Piperaceae	2.1	----
507.	Peperomia pellucida(L)H.B.K.	Piperaceae	4.4	Whole plant : edible
508.	Piper nigrum L.	Piperaceae	2.1	Seeds : spices
509.	Myristica fragrans Houtt.*	Myristicaceae	1.3	Spices
510.	Machilus macrantha Nees.	Lauraceae	1.3	Leaves: ulcers. Bark: rheumatism
511.	Cinnamomum zeylanicum Bl.	Lauraceae	1.2	Bark : spices, stimulant
512.	Elaegnus latifolia L.	Elaegnaceae	2.0	----
513.	Helicanthes elastica (Desr.) Dans.	Loranthaceae	3.3	---
514.	Dendropthoe falcata (L.) Etting	Loranthaceae	3.3	----
515.	Macrosolen capitellatus (Wt. & Arn) Danser	Loranthaceae	3.3	-----
516.	Scurrula philippensis (Cham & Schl.) G. Don	Loranthaceae	3.3	----
517.	Santalum album L.*	Santalaceae	1.3	Wood: costmetic industry.
518.	Bridelia retusa (L.) Spreng.	Euphorbiaceae	1.2	Timber
519.	Bridelia scandens (Rorb) Willd.	Euphorbiaceae	1.3	Fuel wood
520.	Croton bonplandianum Baill	Euphorbiaceae	4.4	Ornamental
521.	Eurhorbia hirta L.	Euphorbiaceae	4.3	----
522.	E. heterophylla L.	Euphorbiaceae	4.3	----
523.	E. thymifolia L.	Euphorbiaceae	4.3	------

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(Cont....)

524.	E. notoptera Boiss.	Euphorbiaceae	4.3	---
525.	Glochidion hohenackeri Bedd.	Euphorbiaceae	1.3	Fuel wood
526.	Jatropha carcus L.	Euphorbiaceae	1.3	Ornamental fence.
527.	Ricinus communis L.	Euphorbiaceae	2.5	Seeds: purgative.
528.	Breynia retusa (Dennst) Alston.	Euphorbiaceae	2.4	Fruits edible
529.	Mallotus albus auct.	Euphorbiaceae	1.3	Fuel wood
530.	M. philippensis (Lam.) Muell.	Euphorbiaceae	1.3	-----
531.	Phyllanthus emblica L. *	Euphorbiaceae	1.3	Fruit : source of vitamin C
532.	P. maderaspatensis L.	Euphorbiaceae	1.3	---
533.	P. reticulatus Poir.	Euphorbiaceae	1.3	---
534.	P. fraternus Webs.	Euphorbiaceae	4.3	---
535.	Sapium insigne Benth.	Euphorbiaceae	1.3	-----
536.	Tragia involucrata L.	Euphorbiaceae	3.4	---
537.	Pedilanthus tithymaloides (L.) Poit.*	Euphorbiaceae	2.5	Ornamental, fencing
538.	Macaranga peltata (Roxb.) Muell-Arg.	Euphorbiaceae	1.3	Fuel wood
539.	Breynia patens Rolfe.	Euphorbiaceae	2.4	----
540.	Bischofia javanica Blume.	Euphorbiaceae	1.2	----
541.	Bridelia hamiltonia Wall.	Euphorbiaceae	1.3	---
542.	Putranjiva roxburghii Wall.	Euphorbiaceae	1.2	----
543.	Poinsettia pulcherrima Willd. *	Euphorbiaceae	2.5	Ornamental
544.	Homonoia riparia Lour.	Euphorbiaceae	2.4	----
545.	Euphorbia neriifolia L. *	Euphorbiaceae	2.6	Ornamental, fencing.

(Cont...)

546.	Glochidion zeylanicum A. Juss	Euphorbiaceae	1.3	Fuel wood.
547.	Euphorbia parvifolia L.	Euphorbiaceae	4.0	---
548.	E. pynostegia L.	Euphorbiaceae	2.0	---
549.	Trema orientalis (L.) Blume.	Ulmaceae	1.2	Best for reclamation
550.	Boehmeria scabrella Roxb	Urticaceae	3.1	---
551.	Pouzolzia zeylanica L.	Urticaceae	4.3	Whole Plant: syphilis
552.	Pilea microphylla L	Urticaceae	4.3	----
553.	Elastostemma cuneatum Wt.	Urticaceae	4.3	----
554.	Celtis cinnamomea Lindl.	Urticaceae	1.3	----
555.	Ficus macrophylla L.	Moraceae	1.3	---
556.	Morus alba L.	Moraceae	1.3	----
557.	Artocarpus gomezianus Wall ex Trec.	Moraceae	1.2	Fruit: edible
558.	Artocarpus heterophyllus Lamk. *	Moraceae	1.2	Fruit: edible
559.	Ficus asperrima Roxb.	Moraceae	1.3	------
560.	Ficus benghalensis L.	Moraceae	1.1	Ornamental, secred tree.
561.	Ficus heterophylla L.	Moraceae	1.2	---
562.	Ficus hispida L.	Moraceae	1.3	---
563.	Ficus racemosa L.	Moraceae	1.3	Fruits: edible
564.	Ficus tinctoria Forst.	Moraceae	1.3	-----
565.	Ficus drupacea Thunb.	Moraceae	1.3	Fruit: edible
566.	Ficus glomerata Roxb.	Moraceae	1.2	Ornamental
567.	Ficus religiosa L.*	Moraceae	1.2	Ornamental, secred tree.
568.	Ficus rumphii L.	Moraceae	1.3	Ornamental

(Cont...)

569.	Casuarina equisefolia J. R & G. *	Cauarinaceae	1.2	Reclamation
570.	Salix tetrasperma Roxb.	Salicaceae	2.5	----
571.	Ceratophyllum demersum L.	Cellatophyllao	2.5	----
572.	Vallisneria spiralis L.	Hydricharitaceae	4.9	Ornamental
573.	Burmannia pusilla (Vall ex Miers) Thw.	Burmaniaceae	4.4	---
574.	Luisia tenuifolia Bl.	Orchidaceae	5.0	----
575.	Acampe praemorsa (Roxb). Blatt & McCann.	Orchidaceae	5.0	---
576.	Aerides crispum Lindl	Orchidaceae	5.0	Ornamental
577.	Aerides maculosum Lindl	Orchidaceae	5.0	---
578.	Dendrobium ovatum (Willd) Kranz.	Orchidaceae	5.0	---
579.	Eria microchilos Lindl.	Orchidaceae	5.0	---
580.	Habenaria grandifloriformis Blatt & McCann	Orchidaceae	4.4	Ornamental
581.	Habenaria marginata Coleb.	Orchidaceae	4.4	----
582.	Nervilia aragoana Gaud	Orchidaceae	4.4	---
583.	Rhynchostylis retusa (L.) Bl.	Orchidaceae	5.0	Ornamental
584.	Vanda tesselata (Roxb.) Hook.	Orchidaceae	5.0	Ornamental
585.	Costus speciosus (Koenig) Sm.	Zingiberaceae	4.4	Root: astringent, purgative, snake-bite.
586.	Curcumia aromatica Salisb. *	Zingiberaceae	4.4	Rhizome: carminative, snake-bite
587.	C. neilgherrensis Wt.	Zingiberaceae	4.0	---
588.	Curcuma decipiens Dalz.	Zingiberaceae	4.0	---
589.	Curculigo orchioides Gaertn.	Zingiberaceae	4.3	Rhizome : piles, jaundice.
590.	Crinum latifolium L.	Amaryllidaceae	4.4	Rhizome : reumatism & piles.

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(Cont....)

591.	Dioscorea bulbifera L.	Dioscoreaceae	4.9	Bulbs - rheumatism, piles. L
592.	D. glabra Roxb.	Dioscoreaceae	4.9	Bulbs and bulbils: edible
593.	D. hispida Dennst.	Dioscoreaceae	4.9	---
594.	D. oppositifolia L.	Dioscoreaceae	4.9 .	Bulb edible
595.	D. pentaphylla L.	Dioscoreaceae	4.9	---
596.	D. wallichii Hook. f.	Dioscoreaceae	4.9	Bulb edible
597.	Asparagus racemosus Willd.	Liliaceae	4.9	Tuber edible
598.	Dracaena terniflora Roxb.	Liliaceae	4.9	-----
599.	Gloriosa superba L.	Liliaceae	4.9	Root : anthelmintic, leprosy.
600.	Urginea indica (Roxb.) Kunth	Liliaceae	4.4	Bulb : bronchitis.
601.	Smilax zeylanica L.	Smilaceae	2.2	Root : rheumatism, dysentery.
602.	Monochoria vaginalis Burm. f.	Pontederiaceae	4.4	----
603.	Commelina attenuata Koen.	Commelianaceae	4.9.1	---
604.	C. diffusa Burm.	Commelianaceae	4.9.1	---
605.	C. paludosa Bl.	Commelinaceae	4.9.1	---
606.	Cyanotis cristata (L.) D. Don.	Commelinaceae	3.5	---
607.	Murdannia nudiflora (L.) Brenan	Commelinaceae	4.9.1	---
608.	M. semiteres (Dalz). Sant.	Commelinaceae	4.9.1	---
609.	M. Simplex Vahl	Commelinaceae	4.9.1	---
610.	M. Crocea (Griff.) Faden.	Commelinaceae	4.9.1	---
611.	Flagellaria indica L.	Flagellariaceae	2.5	---
612.	Calamus pseudo-tenuuis Becc. & Hk	Arecaceae	1.3	Wood : Furniture
613.	Caryota urens L.	Arecaceae	1.2	-----

(Cont...)

614.	Pandanus tectorius Sol.	Pandanaceae	1.3	Flower : perfumery.
615.	Amorphophallus bulbifer (Roxb) Bl.	Araceae	4.6	Rhizomes edible.
616.	A. campanulatus (Roxb) Bl.	Araceae	4.6	Rhizomes edible
617.	Pothos scandens L.	Araceae	3.2	-----
618.	Colocasia esculenta (L.) Schott	Araceae	4.6	Rhizomes edible
619.	Theriophonum dalzellii Schott	Araceae	4.3	---
620.	Alocasia indica Schott.	Araceae	4.6	Edible tuber
621.	Ariopsis peltata Nimmo	Araceae	4.6	---
622.	Remusatia vivipara (Roxb.) Schott.	Araceae	4.6	-----
623.	Arisaemia turtuosum (Wall) Schott.	Araceae	4.6	---
624.	Pistia stratiotes L.	Araceae	4.6	---
625.	Eriocaulon dianae Fyson	Eriocaularaceae	4.0	---
626.	E. dianae Fyson var longibracteata Fyson.	Eriocaularaceae	4.0	---
627.	E. stellulatum Koern.	Eriocaularaceae	4.0	---
628.	E. robusta-brownianum Ruhl.	Eriocaulaceae	4.0	---
629.	E. ritchieanum Ruhl.	Eriocaulaceae	4.0	---
630.	Bulbostylis densa (Wall.) Hand.	Cyperaceae	4.9.1	---
631.	Cyperus compressus L.	Cyperaceae	4.9.1	---
632.	Cyperus corymbosa Rottb.	Cyperaceae	4.9.1	---
633.	Cyperus cyperoides (L.) O. Kuntze.	Cyperaceae	4.9.1	---
634.	C. haspan L.	Cyperaceae	4.9.1	---
635.	C. Kyllinga Endl.	Cyperaceae	4.9.1	---

(Cont...)

636.	C. leucocephalus Retz.	Cyperaceae	4.9.1	---
637.	C. squarrosus L.	Cyperaceae	4.9.1	---
638.	Fimbristylis dichotoma (L.) Vahl.	Cyperaceae	4.9.1	---
639.	F. digitata Boeck.	Cyperaceae	4.9.1	---
640.	F. miliacea (L.) Vahl.	Cyperaceae	4.9.1	---
641.	F. tenera Roem. & Schult.	Cyperaceae	4.9.1	---
642.	F. woodrowii Clke.	Cyperaceae	4.9.1	---
643.	Rhynchospora wightiana Steud.	Cyperaceae	4.4	---
644.	Cyperus conglomeratus Rottb.	Cyperaceae	4.0	---
645.	Kyllinga brevifolia Rottb.	Cyperaceae	4.0	-----
646.	K. triceps. Rottb.	Cyperaceae	4.0	-----
647.	Fimbristylis compalanata (Retz) Link.	Cyperaceae	4.0	---
648.	Cyperus odoratus L.*	Cyperaceae	4.9.1	----
649.	Fimbristylis juncoides Lamk.	Cyperaceae	4.0	----
650.	Cyperus malaccensis Lamk.	Cyperaceae	4.0	----
651.	C. rotundus L.*	Cyperaceae	4.0	Tubers: stomachic, duiretic
652.	Digitaria marginata. Link.	Poaceae	4.0	---
653.	Cymbopogon parkeri Stapf.	Poaceae	4.0	-----
654.	Panicum psilopodium Trin	Poaceae	4.0	----
655.	Eragrostis pilosa L.	Poaceae	4.0	----
656.	Ischaemum semisagittatum Roxb.	Poaceae	4.0	----
657.	I. rugosum Salisb.	Poaceae	4.0	----
658.	Cymbopogon citratus L.*	Poaceae	4.0	----

(Cont....)

659.	Digitaria sticta Roth.	Poaceae	4.0	----
660.	Indopoa paupercula Bor.	Poaceae	4.0	----
661.	Elytrophorus spicatus (Willd) Camus	Poaceae	4.0	----
662.	Isachne globosa Kuntze	Poaceae	4.0	----
663.	Pennisetum hohenackeri Hochst	Poaceae	4.0	----
664.	Digitaria ciliaris Prain	Poaceae	4.0	----
665.	Arundinella ciliata L.	Poaceae	4.0	----
666.	Bothriochloa foulkesii Hk.	Poaceae	4.0	----
667.	Arundinella pumila (Hochst.) Steud.	Poaceae	4.0	----
668.	A. pygamaea Hk.	Poaceae	4.0	----
669.	Bambusa arundinacea (Retz.) Willd	Poaceae	1.0	Wood construction
670.	Bothriochloa pertusa (L.) A. Camus.	Poaceae	4.0	---
671.	Cynodon dactylon (L.) Pers.	Poaceae	4.0	Fodder
672.	Dactyloctenium aegyptium (L.) P. Beauv.	Poaceae	4.0	Fodder
673.	D. aristatum Link.	Poaceae	4.0	---
674.	Dendrocalamus strictus (Roxb) Nees.	Poaceae	1.0	Wood construction
675.	Digitaria adescendens (H. Bk.) Henr.	Poaceae	4.2	Fodder
676.	Digitaria longiflora Retz.	Poaceae	4.0	Fodder
677.	Dimeria woodrowii Stapf.	Poaceae	4.0	---
678.	Echnochloa colonum (L.) Link	Poaceae	4.0	---
679.	Eragrostis ciliaris (L.) R.Br.	Poaceae	4.0	---
680.	E. unioloides (Retz.) Nees.	Poaceae	4.0	----

(Cont...)

681.	Heteropogon contortus (L.) P. Beav.	Poaceae	4.0	For thatching
682.	Isachne miliacea Roth	Poaceae	4.0	Fodder
683.	Ischaemum conjugatum Roxb.	Poaceae	4.0	---
684.	Iseilema laxum Hack.	Poaceae	4.0	Fodder
685.	Manisuris acuminata (Hack) Kuntze.	Poaceae	4.2	---
686.	Manisuris goensis Bolla	Poaceae	4.2	---
687.	M. talbotii (Hk.f.) Bor.	Poaceae	4.2	---
688.	Panicum paludosum Roxb.	Poaceae	4.0	Fodder
689.	Phragmites karka (Retz.) Trin.	Poaceae	4.0	----
690.	Setaria pumila L	Poaceae	4.0	----
691.	Sporobolus diander (Retz.) P. Beauv.	Poaceae	4.0	----
692.	Spinifex littoreus (Burm. f.) Merr.	Poaceae	4.1	----

co-dominants. Herbaceous flora is mainly comprised of Datura metel, Cassia tora, occidentalis, Alocasia indica, Mimosa pudica, Leea indica and Ipomoea pes-caprae a creeper on the sand terrain.

A good number of plant species are found in these forests with a pulvinus which is the enlarged cushion like of a leaf. It is a mechanism which enables many plants to change direction and move the position of their leaves according to the amount of external stimulus especially light and water. The mechanism make a number of legume species to fold their pinnate leaves, remarkable examples are those of Tamarindus indica, Albizzia lebbek, Cassia absus, Cassia tora, C. occidentalis and many other species of the genus Cassia.

The most sensitive species are the young and immature which are exposed to the danger of browsing hence, they have the tendency to fold leaves earlier even before sunset. The most rapid folding species through the pulvinus mechanism are Mimosa pudica, Smithia sensitiva and Biophytum sensitivum.

About nine hundred vascular plant species were collected in triplicate and placed in herbarium. Some of the plant species which were not found flowering in the previous seasons had to be collected in flowering condition in the following season. The plant species mentioned in the list overleaf (Table: 4) are those whose economic importance are widely in use and deserve to be in the first ranking position. Out of about nine hundred plant specimens so far collected, it is well about 500 plant species with high economic values that are generally accepted in this locality.

Salient behavioural patterns of plant communities

a) From the studies done on the ground truth data, it was found that some plant species are broad in their distribution on the plains (plateau) and lowland areas of the western Ghats of Goa and the largest bulk of plant species biomass are namely:

Abrus precatorius, *Bombax ceiba*, *Calycopteris floribunda*, *Careya arborea*, *Ervatamia heyneana*, *Holarrhena antidysenterica*, *Lannea coromandelica*, *Microcos paniculata*, *Terminalia paniculata* and *Randia dumetorum*.

b) Slopes influence soils and drainage whioh, in turn, affeot plant life. On steep sloping land the soil is apt to be thin, stony and immature, and the depth texture of such soils will influence the kinds of plants that grow. Slope lands are more particularly prone to the influence of gravity and the downslope movement of regolith and soil will occur. Under such gravitational movements a sequence of plant life and hence the pattern of the vegetation is modified accordingly (Robinson, 1972).

During the study a number of species have been found to grow on extreme solely selected habitats viz. very steep slopes.

Table: 5 Species that were found to thrive best on very steep slopes (between 10° and 45°):

S. No.	Taxon	Family	Angle of slope
1.	*Woodfordia fruticosa*	Lythraceae	20° - 40°
2.	*Breynia patens*	Euphorbiaceae	15° - 35°
3.	*Wendlandia thysoidea*	Rubiaceae	10° - 30°
4.	*Pteris pellucida*	Pteridaceae	20° - 40°
5.	*P. vittata*	Pteridaceae	15° - 35°
6.	*Capparis monii*	Capparidaceae	20° - 45°
7.	*Connarus wightii*	Connaraceae	10° - 35°

The species probably require well drained soils along with other probable factors like higher intensity of light and moisture content of the soils.

c) Four categories of coppicing powers have been identified in the species found on the Western Ghats of Goa namely: the species that Coppice strongly, Coppice fairly, Coppice badly and those that do not Coppice or very rarely, if at all.

Category: 1. Coppice strongly; Acacia catechu, Dalbergia sissoo, Ficus asperrima, F. benghalensis, F. tinctoria, Macaranga peltata, Syzygium cumini and Syzygium zeylanicum.

Category: 2. Coppice fairly; Alstonia scholaris, Terminalia paniculata, Terminalia bellerica, Terminalia arjuna, Anacardium occidentale, Lannea coromandelica, Garcinia indica and Mangifera indica.

Category: 3. Coppice badly; Leucaena leucocephala, Acacia chundra, A. arabica and A. torta.

Category: 4. Do not coppice, very rarely if at all; Acacia auriculiformis, Casuarina equisetifolia and Acacia mangium.

d) During the survey of the Western Ghats vegetation (Goa) some new plant species were recorded for the first time for this region namely:

Table: 6 Some new recorded plant species of the Goa's Western Ghats region.

S. No.	Taxon	Family
1.	Atylosia crassa Prain	Fabaceae
2.	Hypericum mysorense Wall	Hypericeae
3.	Hugonia mystax L. (Fig. 7a)	Linaceae
4.	Merremia emarginata Hallier	Convolvulaceae
5.	Scutia indica Brongn (Fig. 7b)	Rhamnaceae
7.	Ventilago denticulata Willd	Connaraceae

Atylosia crassa Prain and *Merremia emarginata* Hallier are more confined to the lower Ghats at Mormugao and Verna areas.

Hypericum mysorense Wall and *Scutia indica* Brongn are rarely distributed in the upper Western Ghats near Caranzol (Sattari). *Hugonia mystax* L. was found on banks of fresh water tributaries of River Mandovi (Dudhsagar river) at Collem and areas between Cotorem and Birondem - Goa. *Ventilago dentilago* is found in the Cotigao forest. *Aeschynomene aspera* is located at Zuarinagar - Marmagao, Nuvem, Margao - Salcette.

1.1.4. DISCUSSION

Rao (1985 - 1986) has botanically surveyed many of the villages the author surveyed. The observations made by him are more or less similar with the author's findings (though the author's interests in the present work was more in phytosociology and not on pure taxonomy). The species composition at Caranzol, Caudal and Penderal reflect a stable but "delicate" ecosystem which has remained undisturbed probably for several centuries. One major indication is that of finding abundant natural wild populations of the cultivated species like *Cinamomum macrocarpum*, *Mangifera indica*, *Murraya paniculata* and *Artocarpus heterophyllus* growing gregariously in these forests.

The main reason might be due to the extremely low human population density which is 79 persons per sq.km. (Singh and Ahuja, 1990) therefore the exploitation of the forests by the villagers has remained quite low. Some of the villages which were botanically surveyed by the author which confirmed with the findings of Rao (Loc. cit) are Caranzol, Caudal, Pendral, Honda, Vaguriem Valpoi - Sattari taluka, Dudhsagar, oxel, Uguem, Surla, Mollem-Sanguem taluka and Agonda, Palolem, Cola, Canacona, Cotigao, Poinguinim and Loliem in Canacona taluka. Though several villages on the plains, which are interrupted by a few hills, have been modified by agricultural crops, some still harbour a wide range of plant species especially Siddhanath hill, Borim - Ponda taluka and Curtorim - Maina villages - Salcette taluka.

Plant species which were predicted by the previous workers of their probability of oocurrence in Goa have been confirmed by the author to be in this locality namely;

Crateva nurvala Buch - Ham. Loc: Borim - Ponda, Zaranim, Caudal - Sattari.

Ventilago denticulata Gaertn. which was located only in Nagarhavelli by Rao (1985). The same has been found in the Canacona forests extending down to north Kanara by the author.

Butea monosperma (Lamk.) Taub. Loc: Mollem - Collem and Sonauli - Sanguem. It is a rare species in this locality. Dalgado (1989) recorded it in the Goa forests but did not mention the locality.

Ougeinia oojeinensis (Roxb.) Hochreut. Loc: a Pale village - Bicholim. It is not clear whether it might have been introduced or not; since the author has not located it anywhere in the Goa region.

Oroxylum indicum (L.) K. Schum. Loc: Maina, Raia, Fatorda and Margao - Salcette. Rao (1986) has mentioned the species as being common in the evergreen forest of Concan and Kanara ghats. Holoptelea integrifolia Planch. Loc: a Fatorda village 1/2 km from J. Nerhu stadium, Margao - Salcette.

Persea macrantha (Nees) Kosterm. Loc: Pale village - Bicholim, Raia village - Salcette and Borim village - Ponda.

Rao (1986) predicted its locality in Goa since it is frequent in the north Kanara and Concan. (N.B. Please note that the localities given here are as per the findings of the author).

Gaitonde (1994) has mentioned in his research paper on "Medicinal resources from Western Ghats forest (Goa)" of a species Paedaria foetida being in the Goa's forest as indigenous. This species is found in the central and eastern Himalayas upto 5,000 ft, extending to Calcutta and Malay peninsula. Such mistakes would not have arisen had the species been identified by a taxonomist, then reconfirmed with an authentic voucher specimen and reference made with the local floral textbooks. The same author has made a mention of Grewia microcos which Rao (1950) after careful analysis of several African and Malaysian species, is convinced that this single Indian species should be considered under Microcos only. This genus is distinct from Grewia by several characters as indicated by him. Gaitonde (Loc. cit.) mentioned the taxon Microcos paniculata as Grewia microcos which is under a distinct different genus from Grewia.

The most serious issue, is the misidentification of a plant species which is being diagnosed for some chemical properties and may find its way to the public through a pharmaceutical industry. Gaitonde (1988) has misidentified a plant species Embelia ribes as Maesa indica of which he has made detailed pharmacognostic study without confirming the taxon identity.

Local names of plant species vary from one region to another therefore it was wrong to use merely the local name "Vavding" to refer to Embelia ribes as Maesa indica. The use of local names of a species as authentic for pharmacological diagnosis test or any other related studies, can be very misleading.

To cite an example is that of a pharmaceutical firm in the U.S.A which initiated a program of obtaining information by searching books on medical botany concerning the flora of primitive countries. Interesting uses of plants were noted, and orders were placed for the collection of 1 kg quantities of each plant for initial pharmacological screening. Commercial plant suppliers usually operate by notifying their botanist collaborators to collect specific plants (giving them the Latin name and any other pertinent information). In most cases, the botanists recognises the Latin name of the plant as one which is known popularly by the natives under some common (vernacular) name. A native in the area who is knowledgeable in herbal medicine is dispatched to collect 2 kg of "the bark of capinuri" (as a hypothetical sample).

The native collects what to him is "capinuri", but a native in an adjoining village or province might have collected an entirely different plant that he knew as "capinuri". This is not too difficult to understand; even in Europe, if a person was asked to collect 2 kg of "periwinkle", that person could conceivably return with any one of four or five different species of plants, each quite distinctly unrelated. Thus, the shipment of "capinuri" is shipped to the pharmaceutical firm (invariably the collector does not supply for future reference, a voucher herbarium specimen of the plant being collected). The extract from the "capinuri" shows very interesting pharmacological effects, and the commercial supplier is requested to obtain 500 kg of the bark of the specified Latin name plant. Our supplier again notifies his contact (usually several months or years later), and porhaps a different native is dispatched to collect the 500 kg of "capinuri". Again no voucher specimen is made and the 500 kg of bark, after extraction and testing for confirmation of the original activity, is found to be devoid of that activity!

Several years ago, more than 20 plants with extremely interesting pharmacological effects were obtained by the aforementioned pharmaceutical firm, but the pharmacological effects shown by most of the plants could not be duplicated when collected samples were tested subsequently. The obvious answer to the mystery (by those in charge of the operation) was that this simply represented the trials and tribulations of botanical - chemical - pharmacological research and/or biological variation from one batch of plant material to the next.

Could not all this have been avoided if all parties concerned had been more aware of the need for proper precautions in documenting botanical specimens so that identical collections could have been made at a later date? (Torne, 1986). Millions of dollars might have been spent in this project which resulted to no achievement but losses. This is surely a lesson each one of us should learn and try to avoid.

A large number of exotic plant species are found in the Goan home backyards whose clear identity or origin have not been investigated, this is because the Portuguese (who were frequent sailors world-wide) used to collect any attractive plant species they could come across with and introduce them in their colonies. There is need to do more investigations also into the exotic flora of this region.

Some areas on the Sayhadri hills are impenetrable and in certain cases, rocky outcrops makes it challenging to obtain a precise botanical survey for an entire analysis of the vegetation of Goa's Western Ghats.

Goa being blessed by nature with dense semi-evergreen forests at the foot hills of the mountains, a rich fauna, a natural architectural landscape with bountiful of fresh water rivers should be appreciated and respected by all. For the survival of mankind and generations to come, this unique gift of nature ought to be protected and looked after at all costs.

1.2 COMMON PLANT ASSOCIATIONS OF THE WESTERN GHATS OF GOA.

1.2.1 INTRODUCTION

Plants tend to occur together in associations. The associations are determined by a variety of factors including climate, soils and drainage. Plant association is used in ecology in either the abstract sense to refer to a characteristic assemblage of species comparable to a community, that appear as a unit vegetation or in concrete sense as a measure of similarity of occurrence of two species.

Plant association can act as understorey indication of site quality for example the occurrence of Calamus pseudo-tenuis, Murraya paniculata, Ardisia solanacea in the primary semi-evergreen forest is an indication of a good site quality on the other hand the occurrence of Calotropis gigantea, Trema orientalis, Lantana camara is an indication of poor quality sites (Personal observation).

According to Meher-Homji (1984), Goa lies in one of the phytogeographic zones which is along the West coast and Western Ghats. The zone consists of a potentially evergreen forest dominated by Dipterocarpus - Mesua - Palaqium species.

Though the classification is rather fair for such a very large country like India, but it is rather broad to be applied in this area. For instance the above named species especially Palaqium are rare on the Goa's Western Ghats. Rao (1985) has broadly classified Goa's vegetation into 6 types. During the survey there appeared to be species' composition variation, (Personal observation) and therefore, detailed investigation was carried out on the vegetation types.

1.2.2 MATERIALS AND METHODS

Plant association in its abstract sense was used which was later reconfirmed by statistical methods such as chi-square (X^2), poisson series for detection of pattern. A large number of random quadrats were sampled and data recorded in contingency tables for each of the qualitatively detected association.

a) X^2 - test for association between species. The presence or absence of each plant species are recorded at each qualitative association.

Plant species with extremely low frequency are eliminated and a two by two contingency table constructed for all the plant species. The reciprocal (1/n) of the calculated value of X^2 between each species pair is used to construct diagrams.

Thus a pair of plant species highly positively associated and with a large X^2 value are positioned close to each other.

The use of X^2 test to prove the significance of the relationship between expected and observed occurrences is a valuable tool in vegetation type analysis.

b) Poisson series of detection of non-randomness. By relating the observed number of individuals per quadrat to the expected number derived from the formula below;

$$e^{-m}, \quad me^{-m}, \quad \frac{m^2e^{-m}}{2!}, \quad \frac{m^3e^{-m}}{3!} \; . \; . \; . \; . \; . \; . \; . \text{ etc.}$$

Where e = 2.718 and m = mean density of the population.

This can be tested using statistical tables to prove their significance whether they are randomly distributed or they occur by chance. (Kershaw, 1973).

Transect Method: It is a sampling strip extending across a stand or several stands (Oosting, 1958) which is useful where one is concerned with the analysis of vegetation changing in composition through an ecotone (transitional zone between any two communities). The size and number of transects varied with extent of the different stands.

A calibrated string of 1 meter segments or more was run across the vegetation in the north-south direction. The presence and absence of plant species in each one meter segment was noted down. Only those plant species which touched the string, were considered. The method is useful especially for grassland (Misra, 1968) sampling.

Another appropriate use of transects is in the study of pattern (Moore and Chapman, 1986).

1.2.3. OBSERVATIONS

During a botanical survey of the Western Ghats (Goa) about nine different species associations type were identified which are as follows (Fig. 7c).

A) Mangrove association: Rhizophora mucronata, R. conjugata, Kandelia candel, Avicennia marina, Acanthus ilicifolius, Bruguiera gymnorrhiza, Cyperus Laevigatus and Cyperus arenanus.

B) Sandy area association: Pandanus tectorius, Vitex negundo, Thespesia populnea, (Fig. 8a) Pogostemon paniculatus, spinifex littareus (co-dominant), Ipomoea biloba, launea fallax, Urginea indica, Cassytha filiformis, Plumbago zeylanica, (Fig. 8b) Lantana camara, Phyllanthus reticulatus, Calophyllum inophyllum (Fig. 8c) and Polycarpaea corymbosa.

C) River banks - fresh water association:Barringtonia acutangula, Ficus glomerata, Lagerstroemia parviflora, Pandanus tectorius occasionally, Pongamia pinnata and Vitex leucoxylon.

N.B: Hydrophytes lie under this category especially those in marshy areas and slow moving water.

e.g. Flagellaria indica, Acrostichum aureum, Cyperus Spps, Nymphaea spps, Utricularia spps and Drosera spps.

D) Rocky plateau association: Alstonia scholaris, Hydnocarpus laurifolia, Sterculia urens, Careya arborea, Bombax ceiba, Holarrhena antidysenterica, (co-dominant) Lepidagathis cristata, Lepidagathis prostrata.

E) Moist field association: Syzygium cumini, Mangifera indica, Holigarna arnottiana, Artocarpus gomezianus and Buchanania lanzan.

EXPLANATION OF PLATE

KEY TO THE MAP SHOWING COMMON PLANT SPECIES ASSOCIATIONS OF THE WESTERN GHATS' (GOA).

S. No.	PLANT ASSOCIATION	SYMBOL
1.	Mangrove Association	A
2.	Sandy Association	B
3.	River Banks - Fresh Water Association	C
4.	Rocky Plateau Association	D
5.	Moist Field Association	E
6.	Scrub Association	F
7.	Semi - evergreen Forest Association	G
8.	Grassland Association	H
9.	Deciduous Forest Association	I
10.	Cultivated Fields-Man Made Association	- Blank space; no symbol was given

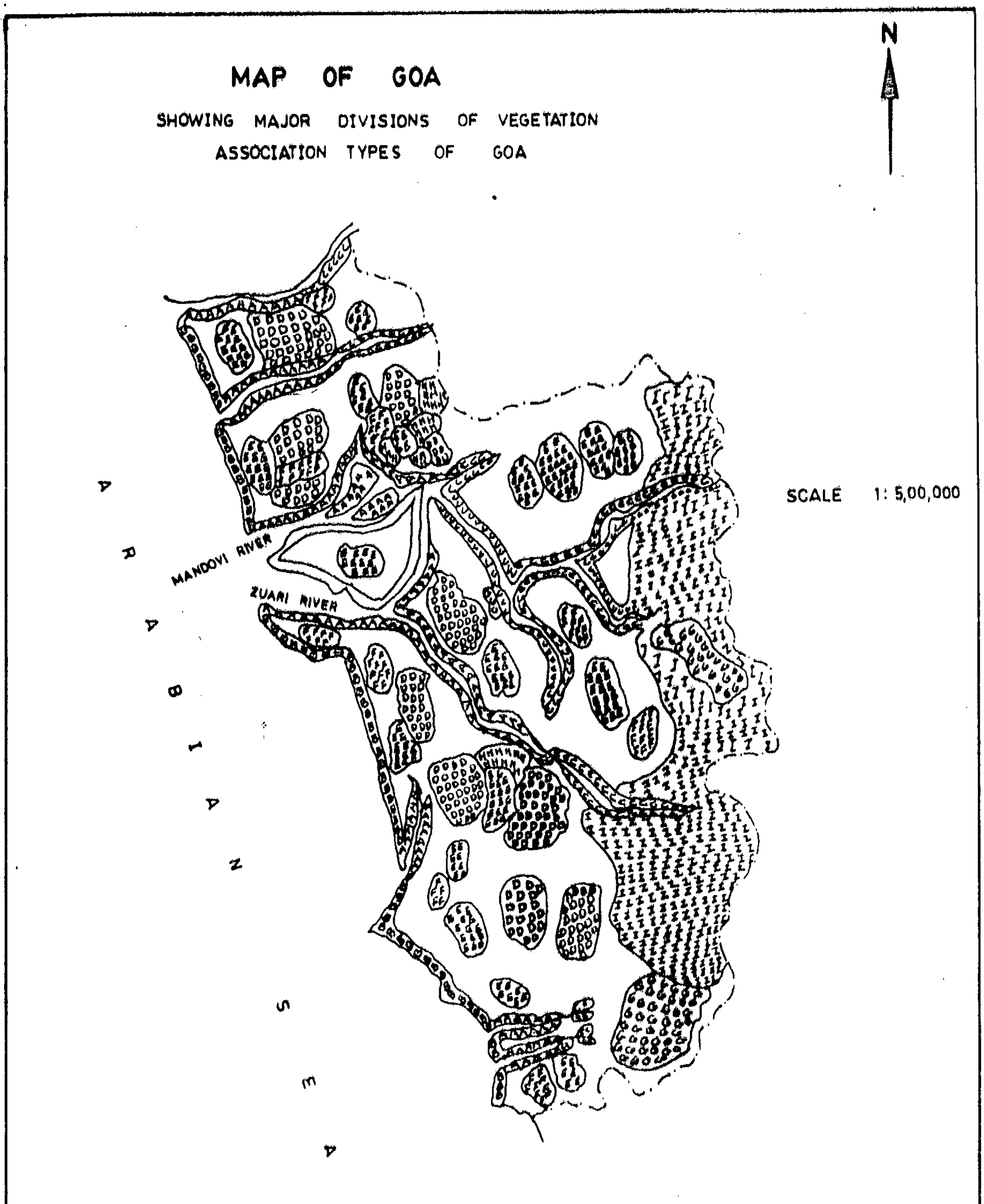


FIG. 7C. MAJOR DIVISIONS OF VEGETATION: ASSOCIATION TYPES OF GOA.

F) Scrub association: _Ziziphus glaberrima, Z. Oenoplia, Abrus precatorus, Terminalia paniculata, Calycopteris floribunda, Memecylon wightii, Celastrus paniculata, Wagatea spicata_ and _Merremia vitifolia_ (Fig. 9a, b and c).

G) Semi - evergreen forest association: _Xylia xylocarpa, Schleichera oleosa, Hopea wightiana, Vitex altissima, Viteria indica, Dalbergia latifolia, Diospyros pruriens, Calamus pseudo-tenuis, Glycosmis pentaphylla, Dillenia indica, Ardisia solanaceae_ (Fig. 11a and b) _Pyschotria dalzellii,_ and _Lagerstroemia lanceolata_.

H) Patches of grassland association: _Iseilema laxum, Ischaemum conjugatum, I. pilosum, Heteropogon contortus, Digitaria longiflora, Isachne globosa_ and _Echinochloa colonum_ (Fig. 10a, b, c and d).

I) Deciduous forest association: _Garcinia indica, Mimusops elengi, Strychnos nux-vomica, Bridelia retusa, Terminalia arjuna, T. bellirica, T. tomentosa, T. crenulata, Caryota urens_ and _Actinodaphne angustifolia_.

J) Cultivated fields (Man-made association): All known crops e.g. _Oryza sativa, Musa paradisiaca, Mangifera indica, Cocos nucifera_ etc. Some transects were prepared to show the different vegetation type (Fig. 8d).

N.B. The same alphabets (A, B, C .....) have been used in the key map except cultivated areas which are left blank.

Estimates are based at 95% confidence limits of probability. Estimate of total diversity = 1150 vascular plant species covering an area of 3702 Sq. km.

a) Diversity and role of Plant Association in the Goa's Western Ghats.

A) Mangrove association: Estimated diversity is 35 which is 3.04% of the total plant species diversity. It is the hatching, breeding and spawning ground for several fishes, crustaceans and reptiles. Stilt roots of _Rhizophora_ and pneumatophores in _Avicennia_ help aid soil

Fig. 9a. *Celastrus paniculata* Willd.

Flowering twig.

Fig. 9b. *Wagatea spicata* Dalz.

Flowering twig & a pod.

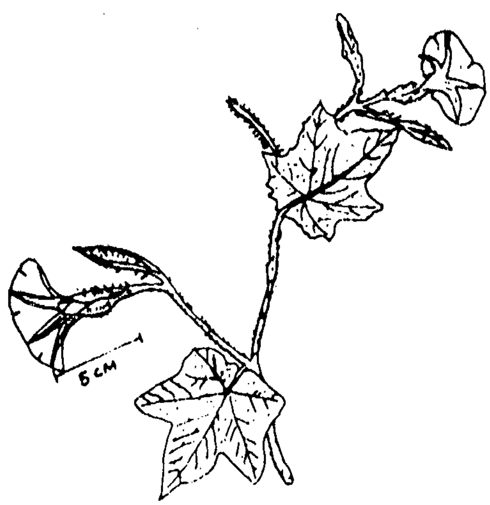


Fig 9c. *Merremia vitifolia* Hall.

flowering branch.

Some plant species of the scrub Association

Fig. 7a Scutia indica Brongn.

flowering & fruiting branch.

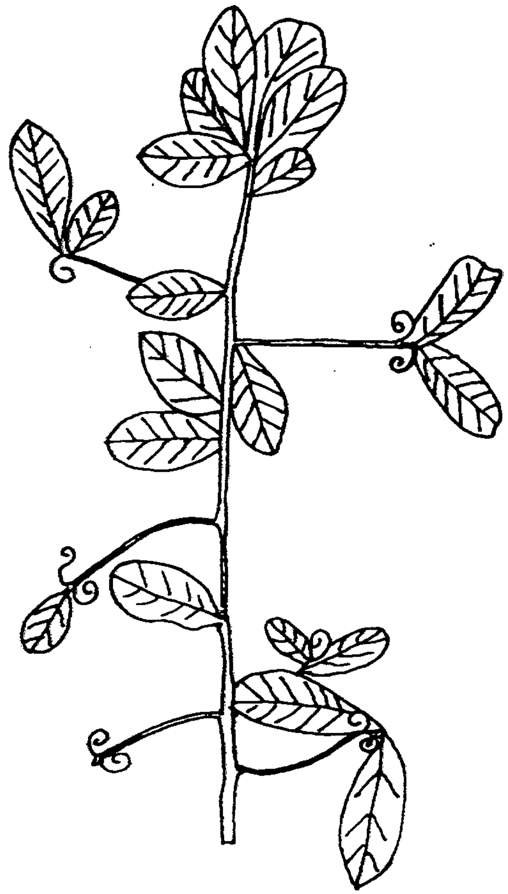


Fig. 7b. Hugonia mystax L.

showing a twig.

Some rare plant species of Goa's Western Ghats

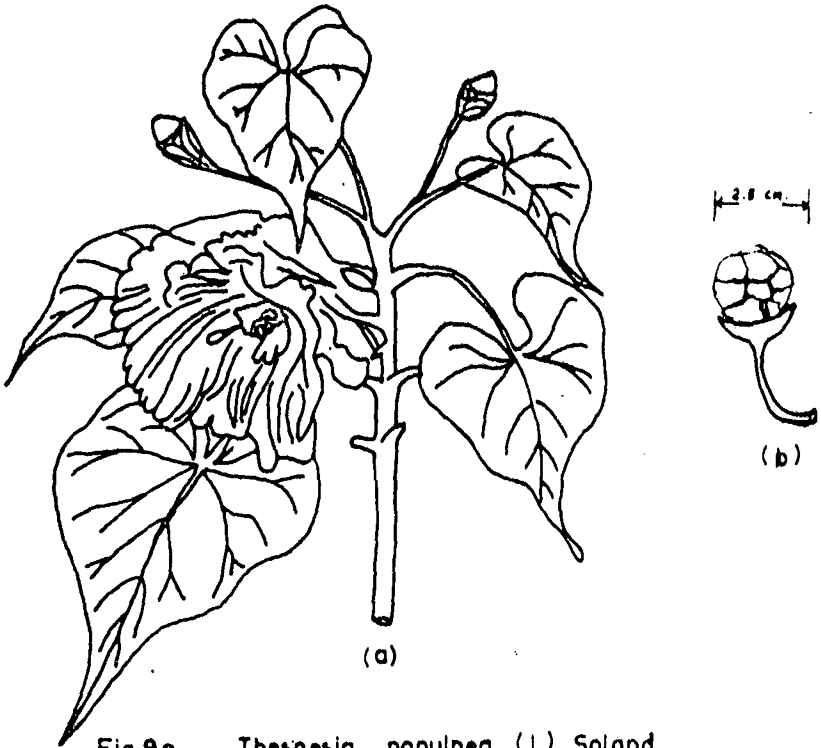


Fig.8a *Thespesia populnea* (L.) Soland
showing (a) a flowering twig.
(b) a dry globose wrinkled capsule.

Fig.8b *Plumbago zeylanica* L.
flowering & fruiting bran

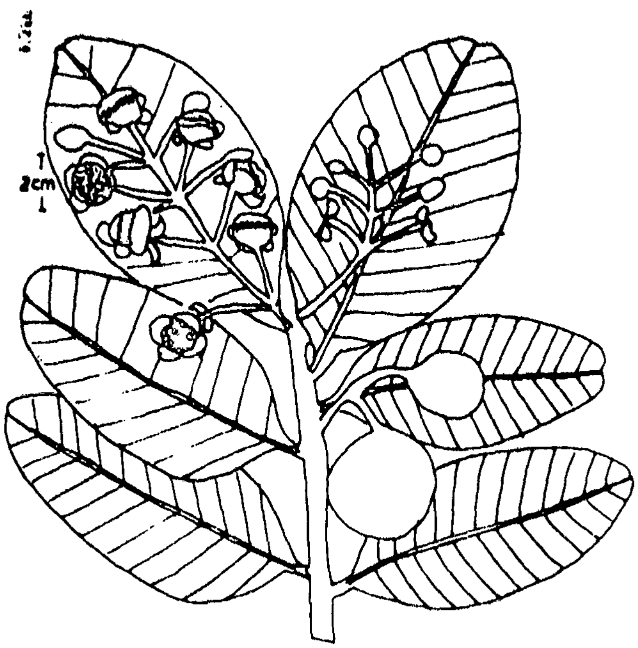


Fig.8c *Calophyllum inophyllum* L.
Flowering & fruiting twig.

Some plant species that comprise the sandy area Association

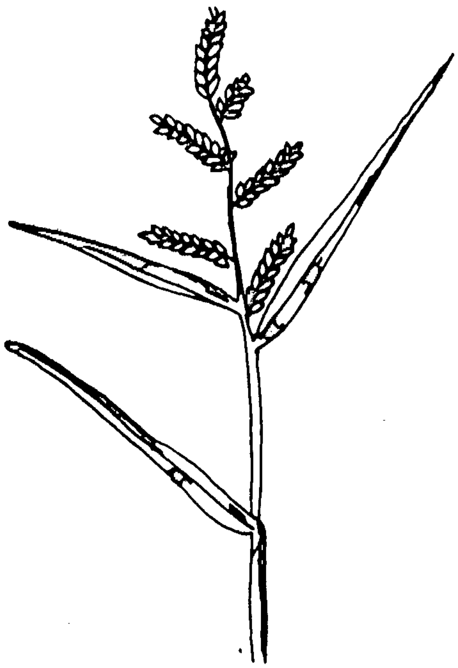


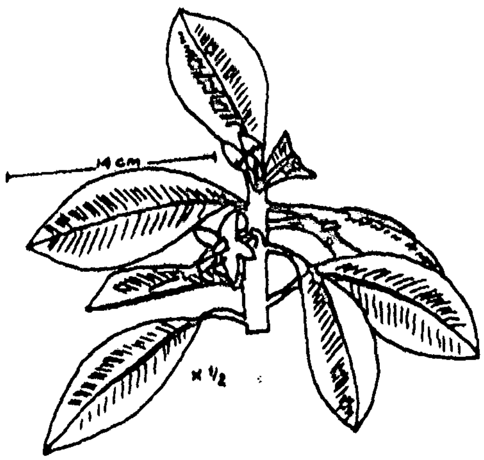
Fig.10a Echinochloa colonum (L) Saldanha & Nicolson.

Fig. 10b. Isachne globosa (Thunb) O.Kuntze.

Fig. 10c. Ischaemium pilosum Hack.

Fig.10d. Iseilema laxum Hack.

Some plant species in the form of patches in grassland Association



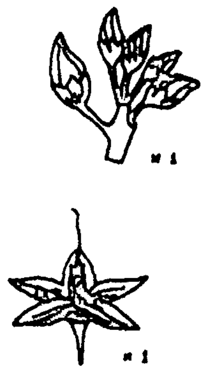


Fig. 11a.
Ardisia solanacea Roxb. showing

a) flowering twig   b) corymbose inflorescence and

c) a single whole flower.

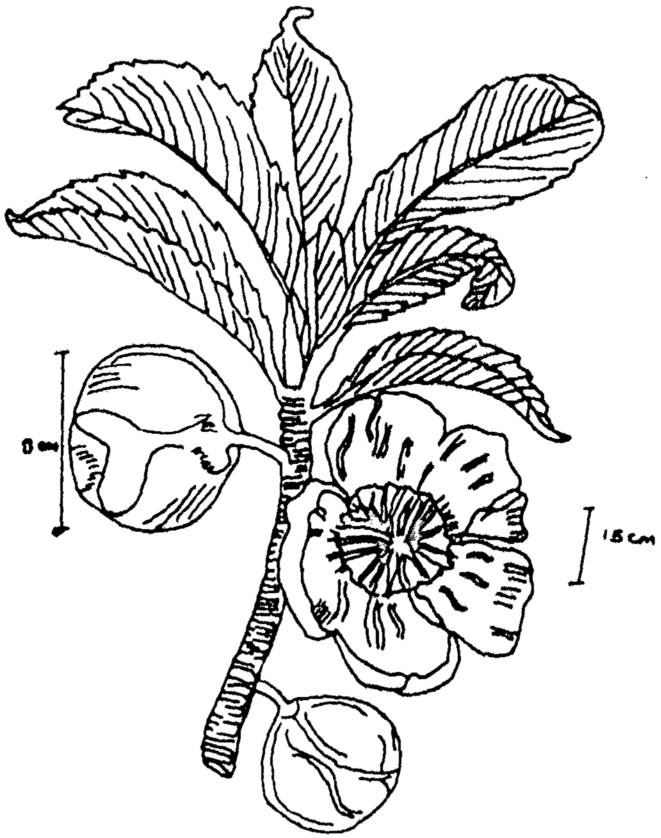


Fig. 11b. Dillenia indica Linn.
showing a flowering & fruiting twig

Some plant species found in the semi-evergreen forests.

E X P L A N A T I O N   O F   P L A T E

Photographs of some rare plant species in the dense semi-evergreen forest of botanical interest

Fig 7a. *Pursaertha scandens* showing pod and seed (scale at the background of the paper in centimeters) collected from Nandor forest-Sattari. Pods measure about 75 cm in length; being probably the largest among the indigenous Leguminosae species of this locality.

Fig 7b. Drooping fruits of *Diploclisia glaucescens* which are directly produced from the trunk portion located at Sonauli-Sanguem.

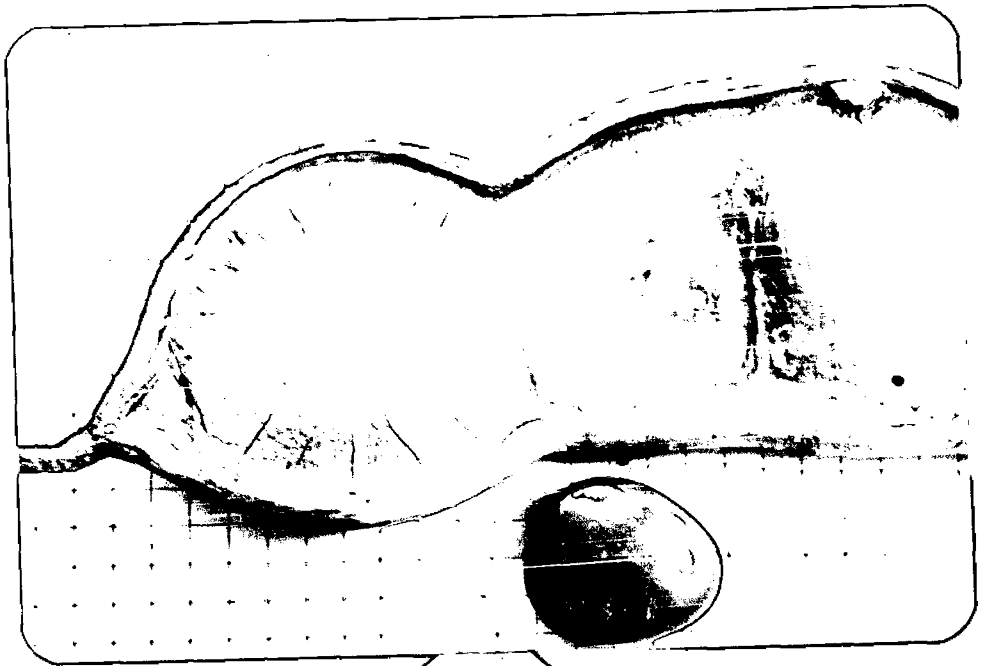


Fig. 7a


Fig. 7b

formation by trapping debris (Dawes, 1981).

There is frequent indiscriminate cutting down of mangroves for firewood which may lead to disturbance of this association.

B) Sandy area association: Can act as an effective sand binder. Estimated diversity is 202 species, which is 17.56% of the total diversity.

With the immense, emerging of hotels and other allied activities, several plant species of this association are getting destroyed which may lead to sand erosion.

C) River banks - fresh water association: Generally reduces the soil erosion along the river bank. Fresh water river banks in Goa, harbour a large diversity of vascular plants including threatened plant species like <u>Angiopteris evecta</u>, <u>Gnetum ula</u> and <u>Osmunda regalis</u>. Estimated diversity is 300 species to the total diversity being 26.08%.

The cutting down of this association along the river bank, has led to soil erosion eg. Khandepar river bank in Usgao - Ponda taluka.

D) Rocky plateau association: Contains the best known lithophytes (rock loving plants) including several threatened plant species like <u>Rauvolfia Serpentina</u>, <u>Hemidesmus indicus</u>, <u>Rauvolfia tetraphylla</u> and <u>Hippocratea indica</u>. Estimate diversity of this association is 520 species i.e. 45.21% of the total diversity.

Denudation of the plant species has resulted to acceleration of superficial lateritic in the event of time.

E) Moist field association: A number of leguminous plant species do exist here like <u>Pongamia pinnata</u> and <u>Desmodium Indigofera</u> which nodulate and hence improve soil fertility. Estimate diversity of this association is 462, which is about 40.17% of the total diversity.

This association has got a number of evergreen economic plants which give shade to the surrounding and also they are beneficial economic plants for food and timber and understorey is relatively dense compared to other associations.

F) Scrub association: Indicates the extent of degradation close to residential areas, clearing of forest land for construction purpose, orchard plantation etc. Several plant species used for firewood are found in this association. Estimate diversity is 456 species, which is about 39.65% of the total diversity.

This association is highly exploited for firewood and timber.

G) Semi - evergreen forest association: Depicts the climax vegetation of Goa's Western ghats which comprises the natural intact actual forest (Fig. 11c). This association comprises dominantly evergreen elements amidst few deciduous plant species. The scarce population of deciduous elements makes it appear almost uniformly green in all the seasons of the year. They are the main producers of economic goods, fruits, fibre, timber and a variety of other forest produce. It contains the highest genetic diversity as it can be reflected in the species diversity 804, which is 69.91% of the total diversity.

This forest, like any other dense tropical forests, moderate quantities of peak discharges from the watershed, decrease sedimentation and reduce possibilities of floods. Forest reduce quantities of water reaching streams surface flow.

1) By canopy interception and evaporation from foliage.
2) Litter interception and finally by increasing infilteration into the ground.
3) Canopy and litter interception also have a significant effect on rainfall impact and the force that initiates erosion from the bare soil.

H) Patches of grassland association: Is important for forage in livestock. Estimate diversity of this association is 130 species i.e. 11.30% of the total diversity.

Overgrazing by livestock might lead to disturbance resulting into disappearance of herbaceous plants species and soil erosion. Deliberate burning of grass is a common practise in Goa which may result to emerging of resistant varieties. Moreover, it is universally accepted fact that fires bring in unpalatable grasses of low-protein content (Anonymous, 1984).

I) **Deciduous forest association:** It comprises of many deciduous elements as compared to the semi-evergreen. The trees are found to shed their leaves in winter and summer and thereby give more open spaces and during monsoon they all together show a different picturesque view. It harbours great diversity of orchid plants which are highly threatened. Estimate diversity is 628 species, which is 54.6% of the total diversity.

It was formerly a dense semi-evergreen forest which has been disturbed mainly for its timber and exploitation of important medicinal plant species.

J) **Cultivated fields:** (Man-made association) constitute mostly paddy fields, orchard plantation, also several man made plantations have been carried out especially constituting *Acacia auriculiformis* and *Tectona grandis*.

General Observations

Setbacks: Mangrove, river bank and sandy area associations should be protected by setbacks to limit land use for a certain distance from mean high water marks for example River bank fresh water association (7 to 10 mts.) on both sides of the river bank) and sandy area association (200 to 250 mts) stretching from the sea should be protected "zones".

Protected areas: representative samples of these ecosystems should be preserved as protected areas by declaring the areas as sanctuaries.

Land use zoning: Land use activities which could have negative impacts on various plant associations should be cited accordingly and measures to curb deliberate burning of grass.

Use of indigenous species: Land use development should use indigenous adapted to specific sites rather than introduced species. The use of native flora and fauna in socio-economic development will aid locally in preservation of this tropical ecosystem unlike in the case of using imported plant species which may carry the risk of accidentally introducing all sorts of other species such as the microbes of which so little is known eg. accidental introduction of avian malaria to Hawaii. (Harrison, 1987 a).

For example sandy association could use *Ipomoea pes-caprae* rather than *Casuarina equisetifolia*.

1.2.4 DISCUSSION

Some aspects on the semi-evergreen forest.

Central Government issued the following directive in 1987 which still stands: On February 17, 1987 the Ministry of Industry, Government of India sent on a circular to the industries departments of all the states, which states: "With a view to ensuring that ecologically fragile regions in the country are protected from adverse effects of industries which emit harmful effluents, the Department of Environment and Forests have identified a list of districts which they consider as totally protected and also those districts where non-polluting industries could be located. They have also identified a list of industries which could be set up in these districts in the various States/Union Territories". The East and South belt of Goa along the Western Ghats have been declared "protected districts" according to the circular.

Some aspects on rock plateau association.

In the present work the author has estimated 45.2% as the plant diversity of the rocky plateau association. Probably prior to 1930 there must have been a dense scrub forest but the human disturbance and starting of industries has resulted to the present day naked rocky plateau.

In mid April 1992 the Government of Goa announced its intention to acquire about 650 ha and 490 ha at Verna and Betul respectively for starting golf courses.

Golf like any other field game is good for physical exercise but need not be given any consideration if it might cause deleterious effects to the environment.

If the proposed project proceeds, the rocky plateau plant association (species diversity 45%) which constitutes many lithophytes would be badly disturbed and might disappear from the site; the lithophytes which are in most cases deep rooted, often avoid competition with shallow rooted plants thus play a significant role to the ecological balance in plant nutrition and water uptake.

Some aspects on cultivated field association.

Agriculture creates artifical association of plant species. These are in many cases, products of natural and human selection and contain genetic treasures for resistance to pests, diseases and adaptability to stress conditions. They are like natural "gene banks".

For many centuries, Goans have had a long standing traditional practise of farming which has involved well organised crop conservation. This has helped to preserve the local land races and a variety of crop plants such as mangoes, cashew, coconuts, jack fruits and rice. Unfortunately the traditional practise of crop conservation is gradually being replaced by exotic hybrids which may pose a threat to the local varieties of crop species.

1.3 LIFE-FORM SPECTRUM OF THE GOA'S WESTERN GHATS' VEGETATION.

1.3.1 INTRODUCTION

A plant life-form is usually understood to be a growth form which displays an obvious relationship to important environmental factors (Mueller-Dombois and Ellenberg, 1974). For example, a deciduous tree is a plant life-form that responds to an unfavourable season by shedding its leaves.

Plants of the similar life-form growing together are likely to compete directly for the same space or niche. Their similarity in structure and form indicates a similarity in adaptation to the utilization of the environmental resources offered in a given space.

At the begining of this century the Danish botanist Raunkiaer (1860 - 1938) devised a system of classifying life forms which is based on the distance between ground level and the position of the highest bud. Raunkiaer's classification allows to sum up the composition of vegetation according to broad groups of life-forms of terrestrial plants. Various life-forms adapt land plants to a variety of environmental situations or conditions and, in a broad way, Raunkiaer's classification indicates how plants exhibit increasing adaptation to adverse conditions of moisture and temperature.

Raunkiaer's grouping is a functional grading unrelated to taxonomic order but is very useful in that it allows the geographer to categorise the composition and compare the composition of vegetation in various broad climatic regions.

Raunkiaer (1934) drew up six primary categories of life-forms, based upon the position of the renewal bud or regenerating organ and related them to the protection they gave in the period of cold or drought. The classes are: Phanerophytes, Chamaephytes, Hemicryptophytes, Cryptophytes, Therophytes and Epiphytes (Robinson, 1972).

Phanerophytes bear their perennating buds freely in the air at varying heights, at least 25 cm above the ground. They are mostly woody plants (trees and shrubs) which are sub-divided into classes according to their heights: Megaphanerophytes 30 + m, Mesophanerophytes 8 - 30 m, Microphanerophytes 2 - 8 m and Nanophanerophytes 25 cm - 2 m.

Chamaephytes are also woody or semi-woody perennials bearing their buds close to the ground but less than 25 cm from the surface: i) Suffrutescent or semi-shrubby forms, ii) Passively decumbent forms, iii) Actively creeping or stoloniferous forms and iv) Cushion plants.

Hemicrytophytes bear their renewal buds at the surface of the ground. They are a large and diverse group and include many graminaccous and herbaceous species.

Crytophytes have their buds beneath the soil surface or in water. These includes groups like geophytes, hydrophytes and helophytes, because the protection given by the water is analogous to that provided by the soil.

Therophytes are annuals where the unfavourable season is passed as an embryo in the seed. In other words they complete their life cycle from seed in a single growing season (Moore and Chapman, 1986). Epiphytes are plant species which grow non-parasitically on stems or branches of other species. (Burrows, 1990).

Raunkiaer established the percentage of each of these categories of life-forms in differing environments, showing that Phanerophytes predominate in moist, tropical regions, Hemicryptophytes in moist temperate regions and Therophytes arid regions.

To the percentage breakdown of the life-forms in any area he gave the name "biological spectrum". Because of its simplicity, the system has been widely applied and is a helpful method of characterising vegetation zones (Robinson, 1972).

Life form spectrum (Biological spectrum) provide a useful basis for comparing the structure of communities that occur in different parts of the world. A list of species, even with some indication of their relative abundance, will convey no information about the nature of a community to a botanist who is not familiar with the flora of that region. Presentation of the same data in the form of a biological spectrum, however, will enable botanists in other countries to form a mental picture of the community (Loveless, 1983).

The main idea of Raunkiaer's life-form system is that similar environmental conditions will bear same life-forms. This he called as "Equiconditional regions". Life-form system has the following advantages: i) in selecting plants for afforestation, ii) in the comparison of the conditions in different communities, iii) in the determining successional trends and iv) in planning silviculture practises.

Some caution should be taken not to interpret the results to economic botany; since the figures relate to the flora and not to the bulk of the species growing in the region their social value is lost and the preponderance of one life-form over the other has a limited meaning.

iii) Biological spectrum actually reflects the most operative factor of the environment and not the climate; or to modify this a little, biological spectrum is the result of the sum of the environment and not only one factor of climate (Pandeya et al., 1968).

According to Mclean and Ivimey-Cook (1973) Raunkiaer's classification points of criticism. First, the limits of the classes are too indefinite and there is some overlapping. The distinction between Hemicryptophytes and Helophytes and between the former and Chamaephytes is often dubious and individual cases difficult to allocate to one class or the other. Second, many plants show marked changes of life-form in different climates or in different areas. Third, that the biological spectrum is not entirely governed by climate but historical causes are also important, so that similar climates in different parts of the world may show different spectra because of their differing flora.

Several ecologists have tried to modify plant life-form in different ways for example the two dimensional r - K "strategy" approach of McArthur and Wilson (1967) and the more elaborate three dimensional method of Grime, 1979.

None of these approaches is very satisfactory for expressing the whole gamut of ecologically meaningful plant life form.

Therefore the author feels there is no ideal classification which has so far been developed to surpass Raunkiaer's life form classification.

1.3.2 MATERIALS AND METHODS.

Almost all, indigenous, plant species located in this region (Goa) were botanically identified and confirmed. Seasonal ecological observations were made on these plant species on their mode of growth, height of perennating buds from the ground level, and presence or absence of modified special organs like tubers, bulbs and thizomes for over a period of six years. Using the Raunkiaer's method of life form (1934) the number of species were summed up by life form classes and expressed in percentage. The extremely rare species were not included in the life-form classification.

1.3.3 OBSERVATIONS

The life-form spectrum of the Goa's Western Ghats vegetation is basically dominated by Phanerophytes 35.2% followed by Therophytes 28.5%, Cryptophytes 13.9%, Hemicryptophytes 12.1%, Chamaephytes 8.7%, Epiphytes 1.3% and Succulents 0.3% in respective order (Fig. 12f).

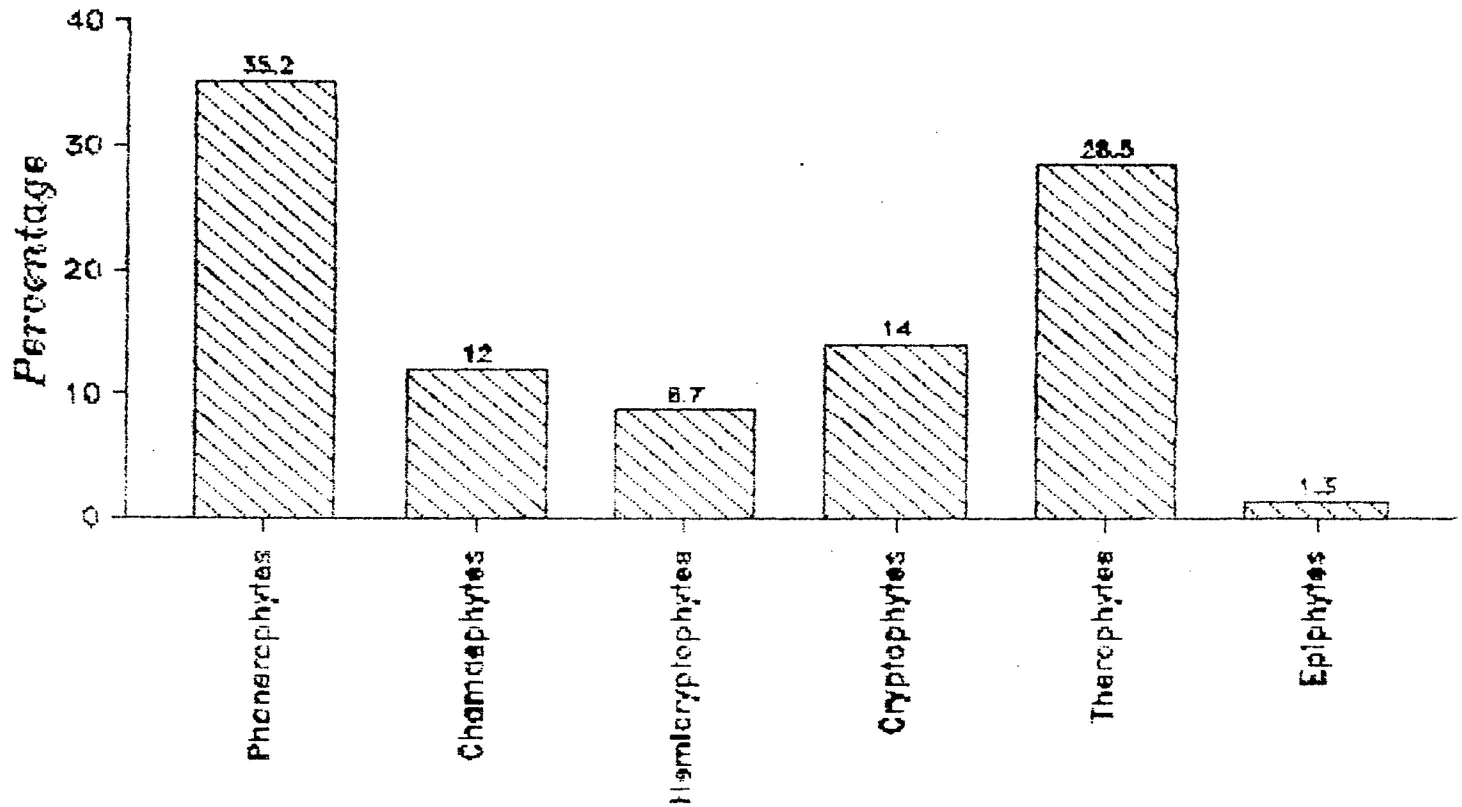


Fig. 12 f. *Life form Spectrum for Goa's Western Ghat's Vegetation*

Table: 7. Life Form Spectrum of Goa's Western Ghats' Forest.

Class	S	E	Phanerophytes				CH	HEMI	CRY	TH
			Mega	Meso	Micro	Nano				
No. of Species	3	14	16	70	141	142	91	127	146	299
			369							
Percentage	0.3%	1.3%	1.5%	6.7%	13.4%	13.5%	8.7%	12.1%	14%	28.5%
			35.2%							
Raunkiaer's life form	1%	3%	6%	17%	20%	-	9%	27%	4%	13%
			43%							
Confidence limits of probability	95%	95%	99%	99%	99%	95%	95%	98%	99.2%	98%

Some aspects on Life-form, family-wise in Goa.

Phanerophyte is the most diverse class having representatives from more than three quarters of the families of vascular plant species found in the Goa region.

Several family representatives of Clussiaceae (Guttiferae) Dipterocarpaceae, Sterculiaceae, and Moracea are observed growing to more than 60 mts in height which belong to this class.

The Hemicryptophytic life form class in this region is found to be mostly confined to perennial tufted "grasses" especially in the poaceae, Cyperaceae. Some members of Asteraceae are also observed to be confined to this class.

The Chamaephytic life form is mostly confined to a large number of Apocynaceae, Asclepiadaceae and Convolvulaceae members which are often non-woody twiners and scandent undershrubs.

The Cryptophytic class which comprises many tuberous species is more in the families of Zingiberaceae, Orchidaceae (terrestrial), Amaryllidaceae, Hypoxidaceae, Liliaceae Dioscoreaceae and Araceae.

Therophytes in this region are quite diverse representing many families. Members of Poaceae, Malvaceae, Fabaceae, Asteraceae, Scrophulariaceae and Acanthaceae represent a large proportion of the Therophytes in this locality. The epiphyte class is confined mainly to the families orchidaceae and Polypodiaceae family (Pteridophyta).

Aerial parasites (0.95%) which actually are not Epiphytes do not find place in the classification. This is one short fall of this classification from the author's view point. For example some plant species under different environmental conditions show two life-forms. This is a common characteristic in several members with tufts in Poaceae and Cyperaceae families, where depending on the prevailing conditions the species can parennate through buds just close to the surface and by seeds also. The species tend to show Hemicrytophytic and therophytic life-form. (personal observation).

Perennial grasses proliferate vegetatively and some species spread widely in this way. The perennial grass plant has basal stem axes from which emerge tillers (branches, each having a cluster of leaves enfolding one another and successively younger towards the centre of the cluster. Many tillers are terminated eventually, by a flower stem. Some grasses have a series of very short axes on which the tillers are clustered together to form a tussock or bunch grass, like Heteropogon contortus. In other species there are somewhat longer to form a tussock or bunch grass.

Table: 8 Comparison of Goa's Western Ghats' Life form spectrum with other regions of the world.

Life form class (%)	S	E	PH	CH	H	CRY	TH
Seychelles (Mclean & Ivimey-Cook, 1973)	1	3	57	6	12	5	16
Sahara desert (Loveless, 1983)	0	0	27	6	39	23	5
Equatorial rain-forest of Guyana, S. America (Loveless, 1983)	0	22	66	12	0	0	0
Temperate deciduous Woodland Germany (Loveless, 1983)	0	0	27	6	39	23	5
Goa's Western Ghat's Monsoon rain-forest	0.3	1.3	35.2	8.7	12.1	14.0	28.5
Raunkiaer's normal spectrum (Mclean and Ivimey-Cook, 1973)	1	3	43	9	27	4	13

S - Succulent E - Epiphytes PH - Phanerophytes CH - Chamaephytes H - Hemicryptophytes CRY - Cryptophytes TH - Therophytes.

1.3.4 DISCUSSION

Generally the spectrum of the Goa's Western Ghats, is well represented in all the individuals of life-forms although it seems to deviate slightly in the percentage from the Raunkiaer's normal spectrum.

Although groups of plant species can be found which are similar in many respects, species differ in general form and stature, seasonal activity, growth rates reproductive patterns, aspects of their physiology and various other attributes. A very wide range of permutations and combinations of characteristics is possible and as far as is known each species is uniquely different from every other species in at least some respects. This means that each species must respond uniquely to the ecological situation in which it occurs, compared with other species exposed to the same set of conditions. In fact, genotypic variation within species and even within individuals will cause some ecological differences between populations of the same species (Mueller - Dombois and Ellenberg, 1974).

The type of flora in a region may cause some effects on the vegetation hence the life forms. The influence of the flora on the vegetation can only be appreciated properly if one travels in a wider geographic area and then attempts a comparison of different parts of the world. One will find that similar habitats may be occupied by quite different plant communities, wherever these habitats occur in different floristic regions. Good examples of this are the evergreen scrub and forest formations of the mediterranean region. When one compares these to four other World-regions with Mediterranean climates - the South African Cape Province, parts of South America (in Southern California and Chile). These areas have similar climates and as a consequence, life forms dominate in the natural vegetation. However the evergreen formations of these five regions are floristically entirely different (Mueller - Dombois and Ellenberg Loc. cit).

Long standing biotic and abiotic factors might result to a swift of the life forms from Raunkiaer's normal spectrum due to disturbance for example, Pandeya (1964), while working in the grasslands of Sagar (India) observed that the life forms of the flora of each of the associations is maintained by the intensity of grazing. However the situation in Goa's Western Ghats is slightly different as grazing does not appear to be a real major anthropogenic factor. However minor cases do exist for example on the coastal sandy association, where coincidentally large populations of pigs are nurtured, Urginea indica bulb is a delicacy among other bulbiferous plants, to them. They bore holes of even up to 60 cm depth in the sand in order to uproot the bulbs. In a way, this can change the life form diversity with the event of time though not significantly. On the other hand the relinquishing of the bulbs by the pigs has helped to keep down the population of this species which may become a serious weed on the agricultural fields.

Though the high amount of Therophytic class may be attributed to the seasonal ohanges in the climate governed by heavy monsoon rains followed by along dry period, the acceleration is due to the clearance of vast areas of forests for mining operation, agricultural use and fuelwood. As a result of these the phanerophytic flora is getting reduced whereas the Therophytic vegetation is increasing.

Studies carried out earlier at the areas close to the mining areas of Goa showed a domination of Phanerophytes (34.1%) followed by Therophytes (31.7%), Epiphytes (14%), Chamaephytes (12.7%), Cryptophytes 10% and Hemicryptophytes 7% respectively (Nyabuto, 1989; Torne and Nyabuto, 1994). From those studies, it is found that it is due to the indiscriminate clearing of vegetation by the local people prior to mining operations that has led to the increase of Therophytes. Secondly it is found, that, in very old dump sites, natural succession is mainly composed of Therophytic and to some extent Cryptophytic and Hemicryptophytic life forms. The natural succession of Phanerophytes would probably occur at the abandoned reject sites, after a long time may be to the tune of 50 to 100 years to come.

The Chamaephytes which are most numerous in regions of cold and dry climate (Robinson, Loc. cit.), are not a large group on this locality. Their percentage available in this region is almost equal to the Raunkiaer's Normal Spectrum, this truly justifies Raunkiaer's classification in this respect.

Hemicryptophytes are far less below the Raunkiaer's Normal spectrum probably because they require less humid conditions regardless of temperature. Though Robinson (Loc. cit.) states that they are characteristic of regions having rather cold, moist climates, the author argues that if the same can dominate the Sahara desert (Table: 8) then cold is not the controlling factor but rather moisture amidst other factors.

Cryptophytes are extremely high as compared to the Raunkiaer's Normal Spectrum in this region. Robinson (Loc. cit.) states that these are plants which owing to drought or cold die down below the soil level. The cryptophytic class may have tripled with the event time; with the gradual reduction of phanerophytic class, it is the species which can get protection in the soil due to the dry period and high temperatures. Moreover, several species like in Dioscoreaceae family have more developed forms of vegetation propagation through bulbs.

The bulb, tuber or rhizomes are in many cases toxic (due to glycosides) which make it unpalatable to many mammals and birds. Thus little disturbance is felt in this class. In some cases, some epiphytic members were found to be extremely rare so they could not be included in the spectrum. This does not mean that the diversity of Epiphytes specially orchids is low but moderate, probably reflecting the constantly humid atmosphere in the forests of this region. As Shukla and Ramakrishnan (1984) states, seasonal rhythms, not necessarily synchronized for different species, are apparent in leaf flush, leaf shed, flowering and fruiting. Some species have more than one flush of leaves and flowers. Some species flower and seed for most of the year, others flower only at intervals of two years or more. Some species may be deciduous, briefly or for longer periods, while others are evergreen. Burrows (Loc. cit.) concludes that dry periods or rainy periods are the cues for these rhythms.

This life form spectrum cannot be said to be finally complete it is subject to revision in case new plant species' life forms are brought about. However the changes will not be very wide as from the data already obtained. The 35.2% Phanerophytes is only depicted for the Goa region but it is predicted to be much higher to the tune of 55% in the evergreen forests (which are outside Goa region) on the Western Ghats.

Raunkiaer himself did not claim that his system was in any way final, and several authors have attempted to improve or enlarge it. No Cryptogams are included in the original system, but applied it to perennial Algae with suitably modified classes. Braun-Blanquet also added three extra classes: Planktophytes (plant plankton), Edaphophytes (soil Cryptogams) and Endophytes, which covers both Endolithophytes soil (plants boring in rocks) and also internal parasites of plants and animals. It is difficult to see that this adds anything to the usefulness of Raunkiaer's classification.

Valuable as the latter undoubtedly is an index of climatic relationships, it cannot by itself provide a means of classifying plant communities. No more than any other physiognomic-ecological classification can it give a complete picture of communities or their relationships, without taking into account the all-important floristic composition of the communities, to which it must be considered as ancillary (Burrows, Loc. cit.).

The life form spectrum for the Western Ghats (Goa) is potentially evergreen and semi-deciduous biome with varying degrees of stratification. The phytoclimate of the Western Ghats of Goa may be designated as Phanero-therophytic. This is in agreement with the climate of the Western Ghats. The co-dominance of Therophytes is as a result of heavy monsoon rainfall followed by a long dry span period.

Comparing Life forms of other regions and Goa.

The Phanerophytes are less from the Raunkiaer's normal spectrum by 10% they are also less compared even to the equatorial forests of Guyana, and the temperate rainforest of Germany (Table: 8). The Chamaephytes are less by 1.2% from Raunkiaer's normal spectrum but in a way they are almost equal to the normal spectrum because the difference is small. Chamaephytes are found to be much higher than the temperate forests of Germany though less in the equatorial forest of Guyana. The Hemicryptophytes are less by 14.9% from the normal spectrum. They are found to dominate the Sahara desert and in the temperate deciduous forest of Germany but not found in the equatorial forest of Guyana. The Cryptophytes are three times much more compared to the normal spectrum. They are found in all types of regions compared with (Table: 8) in the text.

The equatorial forest of Guyana laoks Hemicryptophytes and Cryptophytes but the Therophytes are twice more than (by 15.5%) the normal spectrum. The Epiphytes are less compared to the normal spectrum. They are found to be even less as compared to the equatorial forest of Guyana but which are missing in the temperate deciduous forest of Germany.

The spectrum for tropical Rain forest is notable for the enormous preponderance of Phanerophytes, the abundance of Epiphytes (which probably reflects the constantly humid atmosphere within the forest, and the absence of life forms showing adaptation to seasonal drought or cold (i.e. Hemicryptophytes, Cryptophytes and Therophytes).

By contrast, the spectra for temperate, Deciduous Woodland and the Desert are characterized by a preponderance of Hemicryptophytes and Therophytes, respectively (Loveless, 1983). This is quite different from the Western Ghats' life form spectrum in this respect.

1.4 VEGETATION AS LAND COVER

1.4.1 INTRODUCTION

Tropical forests (like the Western Ghats of Goa's forest) cover only 7% of the earth's land surface, yet they harbour between 45% and 50% of the plant and animal species. The forests as a natural resource play a vital role to mankind especially in wood which is used for many purposes; over 2 billion people in the third world depend solely on wood for their domestic energy needs. The realisation of shrinking forest resources in the country, especially after the publication of the National Remote Sensing Agency report based on the 1985 aggravated the controversy and heated the debate (Lal, 1989).

As early as the 1950s, the use of aerial photographs in forest survey in Canada was found to reduce survey cost up to 80 times, and in the same period, the introduction of aerial photography and statistical sampling into forest land system assesment in Western Tanzania enabled ten times the ground area to be covered without increasing the size of the field teams (Howard, 1959; Howard and Mitchell, 1985).

In general, using aerial photographic mosaics, stereoscopic pairs of aerial photographs and single photographs, landforms can be identified, their boundaries mapped, and the natural vegetation divided into plant formations and plant subformations, and the landscape divided into land units. (Howard & Mitchell, 1985).

There are 11 talukas (districts) in Goa, out of this, only seven talukas have a forest cover (Anonymous, 1985). However the most densely forest talukas are three namely, Sattari, Sanguem and Canacona.

Therefore it was with this intent in view, that the author thought it worthwhile to undertake at regional level the study of the vegetation as land cover in three talukas.

The extent to which these forests cover the land need to be continously and repeatedly surveyed thoroughly so that their rate of degradation could be monitored. Such knowledge could help in ammending their mode of utilization and conservation.

1.4.2. MATERIALS AND METHODS

After obtaining the Ground truth data on the actual vegetation of Goa's Western Ghats, the author proceeded directly for the aerial photographic interpretation.

Tracing of the index maps for the aerial photographs dated Jan. 1988 was carried out at the Agricultural Department, Panjim. Three talukas namely Sattari, Sanguem and Canacona were taken for intensive studies as these areas constitute dense vegetation cover. The index maps form a guiding key to find out the exact specific aerial photographs.

The Howard and Mitchell (Loc. cit) method of aerial photograph interpretation was followed which involved examining numerous stereoscopic pairs of aerial photographs under a mirror stereoscope model no. 2 serial no. 0528. The vegetation details were interpreted by tracing them on maps. The bits of maps were joined together after completing the tracing for each taluka. The approximate Ground truth data obtained previously in these talukas was synchronized with aerial photographs' information to prepare an authentic map for each taluka. Aerial photographs dated Jan 1988, panchromatic stereoscopic pair type with scale of photography 1: 10,000 and scale index 1: 50,000 were acquired for the vegetal cover interpretation.

The index to the survey of India toposheets used were 48 I/2, 3 and 4, 48 E/16, 48 I/6, 7 and 8, 48 J/1, 5 for Sattari, Sanguem and Canacona talukas respectively. The aerial photographs dated 1935 and 1960 were also examined. Due to the expenses involved in the purchasing of satellite imageries only two were acquired - systematic geocoded type No. N 15 38E 74-87 GRS D 207 - 319/045 from "satellite spot" visible wave band dated 17-3-1989, which showed only a portion of the Western Ghats through Goa. (only a portion of Sattari is present). Otherwise the major part of vegetation analysis was based on the physical verification (ground truth data) and aerial photographs interpretation.

1.4.3 OBSERVATIONS

About 70 stereoscopic aerial photographs were studied for Sattari taluka 150 for Sanguem taluka, and 90 for Canacona taluka.

From the aerial photographs interpretation as well as field observations, it appears in the recent twenty years many changes have taken place in land cover of the three taluka especially on the valley basins mainly due to the exploitation of the natural resources; Clearing of forest for agriculture, rehabilitation and mining.

a) Interpretation of vegetation as land cover of SATTARI TALUKA - GOA

A semi-evergreen dense vegetation is observed on the East and North eastern region bordering Karnataka State. The middle ventral portion is a flat area comprising of mining activities which are adjacent to rice fields. Towards the west are rocky plateau and small hilly terrains with scrub forest which contain large number of cashew plantation mixed with jack-fruit and mangoes at lower elevation.

More human settlements are found in Rivona-Poriem and a part of Molem. Open areas which are more or less marshy are found towards the south west in Sonum-Vonvoliem, Ponocem and Vantem (Fig. 13 a).

Mid-ventral portion of Sattari is thickly populated and is composed of a number of cultivated fields especially around Valpoi, Satorem, Ambedem, Davem, Bombedem and Nagargao and towards the south of Sanvordem, Advoi, Nanus, Ansolem and Codiem villages. Pissurlem is the most affected village due to mining and partly sonus.

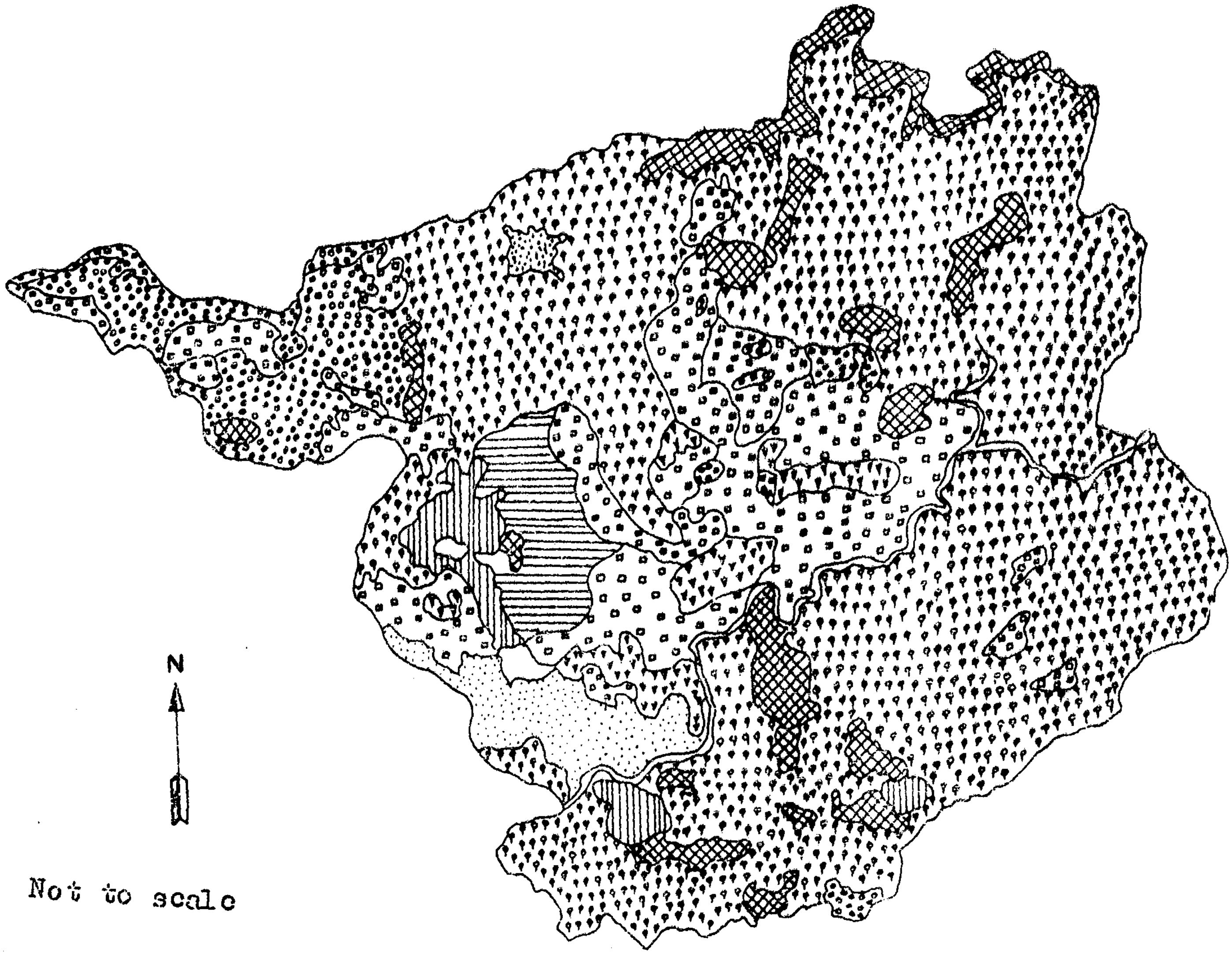


Fig.13a. Map of Sattari Taluka - Goa, Showing Vegetation land Cover as interpreted from GTD (1987 - 1992) and with the help of panchromatic stereoscopic aerial photographs dated Jan. 1988.

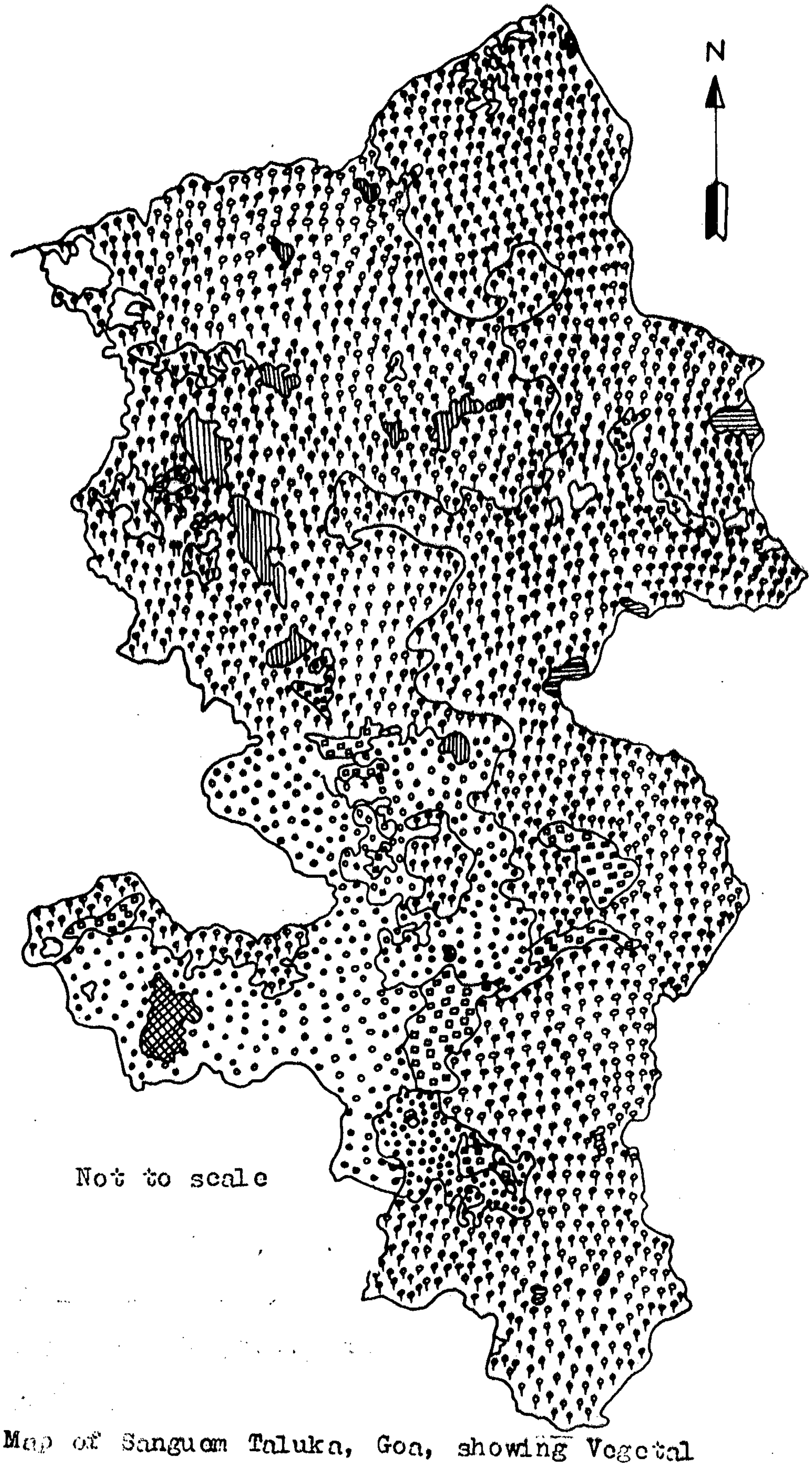


Fig. 13b. Map of Sanguem Taluka, Goa, showing Vegetal Land Cover as interpreted from GTD (1987 - 1992) and with the help of Panchromatic Stereoscopic Aerial Photographs dated 1988.

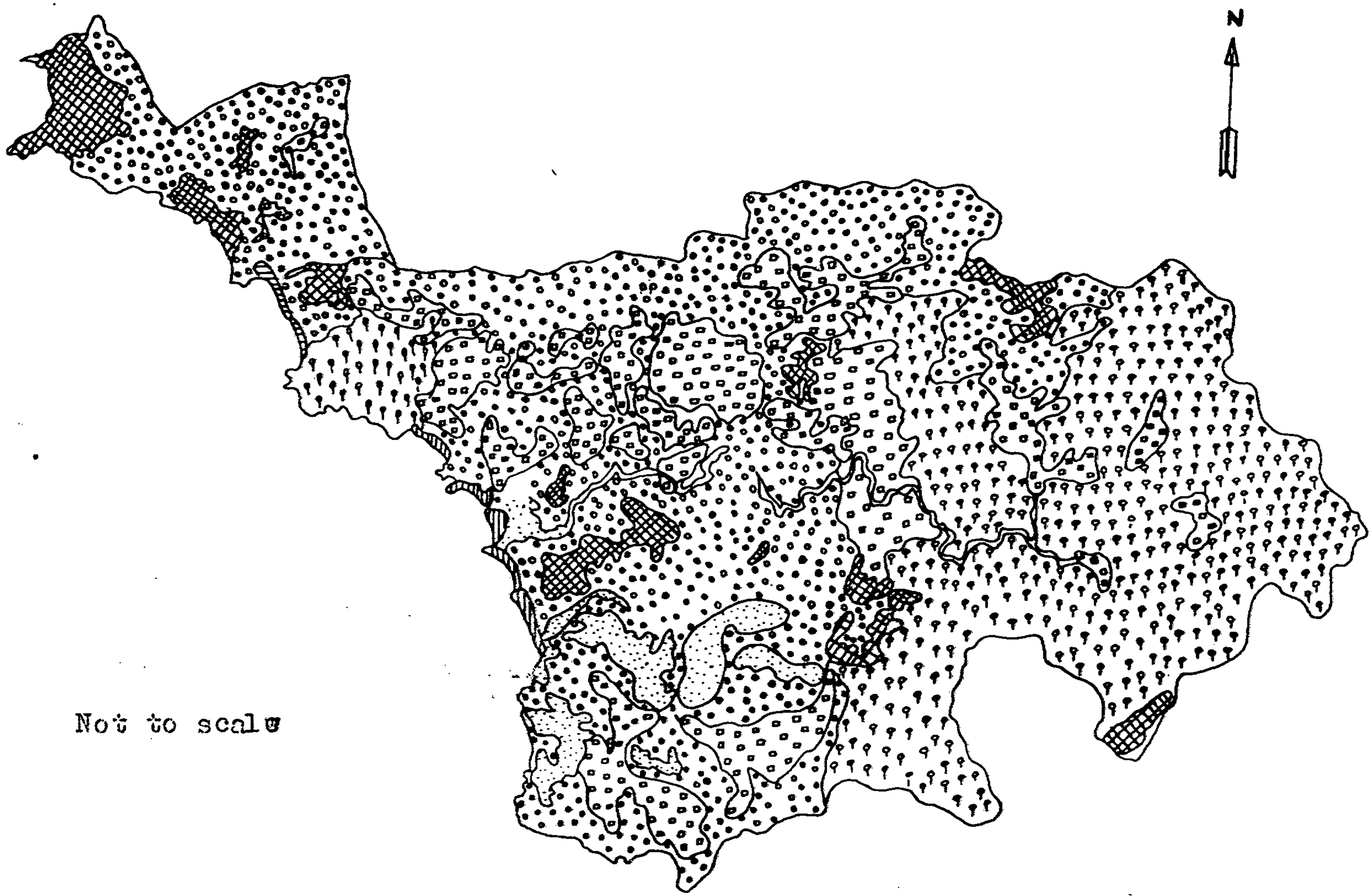


Fig. 13c. Map of Canacona Taluka, Goa, showing Vegetal Land Cover as interpreted from GTD (1987 - 1992) and with the help of Panchromatic stereoscopic Aerial Photographs dated Jan. 1988.

The vegetation on the extreme north east of the boundary between Goa and Karnataka State is of a deciduous dense forest which appears to have been degraded due to biotic factors like grazers and man's forest clearance for agricultural use. All other areas on the extreme eastern side of Goa, the vegetation is of a semi-evergreen dense forest which is not disturbed even up to the boundary between Karnataka and Goa. About 46% of the land is under dense forest cover.

b) Interpretation of vegetation land cover of SANGUEM TALUKA - GOA

Generally the vegetation is thick towards the eastern region of the taluka. A dense semi-evergreen vegetation is observed along parts of Molem, Caranzol, Collem, Surla, Sonauli, Boma, Potrem though interrupted by human settlements such as Cumbari, Sigonem and Verlem.

Along the mid-ventral western portion a number of areas are interrupted by mines like Dongor, Sancordem, Sigao, Codli, Rivona, Costi and Patem. The areas are mostly of deciduous and scrub forest which have frequently been degraded. A number of rocky outcrops are frequent along the slopes of Caranzol, Sonauli and Okel and occasionally at Verlem areas (Fig. 13 b). About 54% of the Sanguem taluka is under forest.

c) Interpretation of vegetation land cover of CANACONA TALUKA - GOA

About 35% of Canacona is under semi-evergreen dense forest which cover the eastern, south east portion viz. Cotigao and a part of western portion of Agonda. The rest of the other areas are deciduous to scrub forests. The coast of Poinguinium, Nagorcem, Palolem offer a wide open sandy areas which are suitable for beaches (Fig. 13c).

No mining activities are observed in this taluka as per the aerial photograph interpretation. Canacona village has the highest human settlements followed by Loliem. Other villages seemed to have very little or no human settlements at all and the vegetation cover was more.

The total area where dense vegetation that existed in 1960 was 486 sq. km; presently only an area of 255.2 sq. km has got vegetal cover. The total land degraded is 230.8 sq. km. during the last 30 years on the areas covered in the study.

During the studies on aerial photographs and Ground truth data, it was estimated that the Western Ghats of Goa forest viz, Sattari, Sanguem and Canacona, degradation since the last 30 years had been loosing its forest cover by approximately 2.0% annually; in other words about 55% of the original forest cover to cultivated lands, mining, illicit felling of trees and human settlements. The results were based on aerial photographs of 1935, 1960 and 1988 and the present ground truth data, but it was felt that the annual degradation may be as high as 2.4% in the recent past ten years.

The major portions that existed as a closed dense primary forests in 1935 (personal observation, 1935 aerial photographs) have been reduced to scrub (1988) even sometimes to no vegetation at all.

1.4.4. DISCUSSION

The denudation of the world's forest cover has proceeded during the last several years at an estimated rate of about 11.5 million hectares per year. As a result of such deforestation, plains and valleys are being subjected to recurrent excessive flooding. In India, for example, more than 20 million hectares of land are currently being affected annually by flooding due to deforestation with disastrous consequences such as silting of dams and salination and alkalination of soils. In the Gangetic plains of India alone, the loss due to flood damage has been estimated to exceed one billion dollars annually. (Gopalan, 1990).

From the present studies carried out on the Western Ghats of Goa large amount of forest cover is disappearing annually at an alarming rate. The causal factors are quite many; the increased population pressure, conversion of forest to agricultural lands, the opening up of roads and pathways and other modes of communication through forests and by far the most contributing factor is that of open caste mining; the large excavation of soils takes along with it thousands of plant species each day at the sites.

Forest cover in Goa has been expressed by many previous workers to be of different percentage cover for example (Govindarajan, et al., 1974) gave the figure when calculated as 29.6%, Goa Gazetteer (Anonymous, 1979) 28%, the same was quoted by Alvares (1993) and Vishwa nirmal magazine (1993) whereas Singh and Ahuja (1990), have given it as 29.27% and recently the Forest survey of India gave it as 33.4% (Anonymous, 1991).

This has led to the doubtfulness of the exact figures. One wonders whether really the forest cover has expanded in the two decades as the figure given by the Forest Survey of India! To any keen observer, need not necessarily be an environmentalist, the forest cover could never be constant in the same way it was more than 2 or 3 decades ago. The new development activities taking place at all places in Goa could never render the forests constant e.g. the timber used for constructions most probably must be coming from these forests whether by legal or illegal means. This should be an accepted fact!

Though, mining areas are small in Goa, they create a great impact on the environment of this region. Most of the mines are confined to Bicholim, Sattari and Sanguem talukas (Districts) distributed in about sixteen villages namely Advapale, Velge Bicholim, Aravalem, Cudnem, Sanguelim, Pale, Surla and Sirigao in Bicholim taluka; Pissurlem and sonus in Sattari and Sigao-Bimbol, Sancordem, Dongor, Codli, Rivona in Sanguem taluka. The villages most adversely affected due to mining because of overburden of rejects are Bicholim, Velge, Pale, Sirigao Pissurlem and Codli villages (Personal observation).

According to Singh and Ahuja, (1990) forest cover is highest in the Sanguem taluka 56.48%, followed by Sattari taluka 47.29% and Canacona taluka 41.25%, Quepem taluka 33.65%, Ponda taluka 11.62%, Pernem taluka 5.45% and Bicholim taluka 3.03%. According to the report, Tiswadi, Salcete, Bardez and Mormugao taluka do not have any forest cover.

According to Mr. S.S. Guha, incharge of Agro-climatic Regional planning unit, Ahmedabad, (Indian express 14.9.92) in recent times ecological and socio-economical issues relating to forests are becoming increasing critical and indiscriminate exploitation of forests have resulted in ecological imbalance and reduction in the carrying capacity of land. The problem of deforestation has been compounded by increasing industrialisation and urbanisation leading to commercial exploitation of forest even the increasing population has contributed to decline in the yield of forest. The progressive conversion of forest to reserve forest has, by and large, ignored the needs of the forest communities, and their exclusion from the planning and management process has aggravated the problem of encroachment and exploitation. He suggested that new forms of farm forestry which advocated new species, patterns of investments, adoption, plantation and income generation need to be researched and encouraged.

According to IIT Report, Bombay (1992) forest cover change over the period 1981-1989 in 5 main mining blocks of Goa (992 sq. km area), viz Bicholim, Sanguem, Pissurlem, Pale and Codli villages, mining activities increased from 19.6 sq.km to 57.6 sq.km, crop land declined from 101.4 sq. km to 90.2 sq. km whereas, fallow land increased from 35.8 sq. km to 40.8 sq. km. Thick forest declined from 54.5 sq. km to 51 sq. km, the scrub increased from 219.3 sq. km to 243.5 sq. km.

According to the finding, the most adversely affected land cover are the moderate forest (declined from 277.3 sq. km to 215.3 sq. km and the sparse forest (declined from 245 sq. km to 215.3 sq. km).

The author's interpretation of the aerial photographs of vegetation as land cover of Sattari, Sanguem and Canacona (1988) was found to almost confirm the results of IIT, Bombay Report (1992).

However, the satellite imageries (1988) used by IIT, Bombay could not overlap with the author's findings, but the intensity of vegetation land cover was approximately similar; the reason being due to the curvature of earth's rotation when satellite imageries are taken.

Global concept of biological diversity convention and some issuos in the Economics of Conservation

Over 155 countries including India have signed the convention on biological diversity adopted at the Earth Summit in Rio de Janeiro in June 1992. The convention establishes commitments on conservation, access to genetic resources, transfer of technology and benefit sharing and finance that are likely to make it an extremely important instrument for the conservation and sustainable use of all components of biological diversity. Article 7 of the convention obliges each party as far as possible and as appropriate, to identify components of biological diversity important for its conservation and sustainable use, to monitor through sampling and other techniques, the components of biological diversity so identified and to identify processes responsible for significant adverse impacts on the biological diversity and monitor their effects. Because we are now party to this international convention, and even otherwise, it is our obligation to protect and safeguard the biodiversity for posterity (Singh et al., 1994).

Goa is being impoverished by the loss and degradation of its most fundamental capital stock - its genes, species, habitats and ecosystems.

This loss of the tiny richness of the state has profound implications for its development. Natural habitats have long provided local people with the means for survival, supplying food (meat, nuts, fruits and vegetables), fodder and firewood, construction materials, medicinal plants, wild genes for domestic plants and animals and so forth. The highly diverse natural ecosystems which support this wealth of species also provide important ecological services, including maintenance of hydrological cycles, regulation of climate, contribution and the processes of soil formation and maturation, storing of cycling of essential nutrients, absorption and break down of pollutants and provision of sites for tourism, recreation and research.

But instead of conserving the rich resource of forests, wetlands and the seas, (e.g. establishment of Free Port) current processes of development are depleting many biological resources at such a rate that they are rendered essentially non-renewable, leading to forms of development that are not sustainable. The root of this problem lies in the maldistribution of costs and benefits of both overexploitation and conservation.

Overexploitation is quite different from conversion. If a forest is converted into agricultural land which can be sustained, productivity for humans can be often be greatly increased, which is one of the objectives of development. So some conversion of natural ecosystems is probably inevitable and even beneficial.

But the available evidence suggests that current rates and patterns of conversion of natural habitats are not sustainable (conversion of land are as to many industrial zones) and that many species are being lost as a result. For example, the most recent estimates suggest that more than 14.22 mha of tropical forests were lost in 1989, at the rate of about 27 ha per minute (Myers, 1990).

Since tropical forests hold well over half the world's biological diversity, and many of the species are confined to relatively small areas, the numbers of species being lost is certain to be high; some experts suggest that at least several hundred species are lost every year. Many forces are blamed for this overexploitation, but it is useful to ask who benefits from it. The lion's share of the benefits have flowed into relatively few pockets, and most of the profits are earned by the wealthier sectors of the population.

Who pays for the loss:

Some conservationists would answer this question by saying 'everybody', to the extent that everybody benefits from biological diversity and, therefore, suffers when it is reduced. This is not a satisfactory answer. While nature certainly has some built-in redundancy and some species could disappear (indeed are disappearing) without any body missing them, little data is available on which species are particularly important in the functioning of ecosystems. In the case of Goa's forests, the people who pay are very often the people who live closest to the forest and who had for a long earned sustainable benefits from harvesting the goods of services from the natural productivity of the system. On many occasions, the people (farmers), common environmentalists, ecosystem preservers, etc. are up in arms over government forest policies which enable outside concessionaires (e.g. chemical industry, recent nylon 6,6 - Du Pont, Kerim,.case) to deplete the forests which had long been the source of their irrigation water, construction materials, medicinal plants and game animals (Anonymous, 1990).

Out of an area of 2 sq. km (200 hectares) allotted for the proposed Nylon 6,6 project at Kerim it is only 1.5% that is alloted to gardening (Anonymous, 1990) in other words this is what the original people might benefit or not at all. This is indeed a very small proportion compared to the amount of deforestation that would take place. Who pays for the opportunity costs ?

The opportunity costs of conserving biological diversity are paid disproportionately by the people who live closest to the greatest biological diversity. Individuals who live amidst the greatest biological wealth tend to be the poorest of the poor. In fact the opportunity costs of modern conservation programmes which restrict access to resources are falling disproportionately upon the very communities that development projects (e.g. are as designated for playing golf) are designed to assist. If conservation programmes are to be socially accepted then the new and more appropriate means of apportioning (=division or distribution) opportunity costs, or providing compensation for them need to be sought.

1.5 WILD EDIBLE, MEDICINAL AND THREATENED PLANT SPECIES

1.5.1 INTRODUCTION

Presently, humanity largely depends on no more than 20 cultivated plant species for food though in totality, including those which are used to a limited extent by a very small number of people, it uses about 3000 plant species to obtain edibles. With growing population, which may, or may not stabilise at 8000 million as envisaged by demographers, and the changing environmental conditions which, unfortunately, are helping in the evolution of more aggressive varieties of pests and virulent strains of fungi, dependence on limited plant species for food may spell doom for humanity. Yet as the prospect of food shortages becomes more acute, people must depend increasingly on plants rather than animals for the protein in their diet (Anonymous, 1975).

Man has to discover not only new species for food, but also evolve new varieties of known species, which are more resistant to pest attack and fungus infection. To evolve new varieties of known plant species, it is necessary that their wild ancestors as well as the still existing cousins of those ancestors are preserved. New species for food of course, can be discovered only if wilderness is not lost. Even the present knowledge indicates that about 75,000 plant species can be used for food (Lal, 1989)

More than thirty percent of the currently used drugs and medicines contain gradients which are extracted from plants. In future, we may need new medicines and new drugs. Forests are the eco-systems richest in plant species, and have to be preserved to enable the future scientists develop medicines and drugs which may be required (Lal, Loc. cit.).

The wild edible, medicinal and threatened plant species found on the Western Ghats of Goa region have not been clearly documented especially in their extent of distribution.

Today, few institutions in the world offer training in tropical botany, tropical horticulture and tropical agronomy. Facilities for training and research should be established rapidly because the time left for the study of undisturbed tropical vegetation is limited. Local governments must be made more aware of the importance of their native flora resources to their country's economic development and of the need to inventory, maintain, and capitalize on their indigenous vegetative materials (Anonymous, 1975).

It is estimated that the world stands to lose between 437,000 and 1,875,000 species within the next twenty years. The loss could average 50,000 species a year. True, species got extinct even before the human history began. Dinosaurs and some other big mammals disappeared before humans were born but they disappeared at a rate of no more than one every 1000 years. To lose 50,000 species a year is indeed some acceleration. And the cause for this acceleration is the rapid depletion of tropical forests (Lal, Loc. cit.).

1.5.2 MATERIALS AND METHODS

A botanical survey was carried out in the forty one villages (list already given in the introduction) in Goa. Information was acquired from people in different localities on their uses specially as being medicinal or wild edible. Notes were made on the species as being medicinal or wild edible. Observations regarding their pattern of distribution, frequency and abundance was noted. To avoid ambiguity of a plant being called medicinal or wild edible, only those species which have been widely accepted for a long time at different localities in Goa for their uses have been mentioned in the list. Information given by people about useful plant species was confirmed with the available literature (Nadkarni, 1954; Dastur, 1962; Jain, 1981).

Generally, plants whose efficacy in medicine have now been tested and recognised and those plants which have been included in the Indian Pharmacopoeia, British Pharmaceutical Codex, and United States Pharmacopeial have been included.

The method used by IUCN (The International Union for Conservation of Natural Resources) (Jain & Sastry, 1980) was followed in identifying the plant species in this locality as being threatened. The IUCN recognizes six categories of rare plant species namely Endangered, Vulnerable, Rare, Threatened, Out of danger and Indeterminate.

The category that was used in the studies is that of threatened. The term is used in the conservation context for species which are in one of the three categories: Endangered, Vulnerable, and Rare.

The causal factors upon which the species were selected, are as follows: i) the present and past distribution, ii) decline in number of populations in course of time, iii) abundance and quality of natural habitats and iv) biology and potential value of the species.

In several cases many villages and markets which are separated far apart have frequently been repeatedly given the same names, for example the Caranzol in Sattari and the Caranzol of Sanguem; the Pale and Surla of Sattari and the Pale and Surla of Bicholim etc. Such confusions did not arise when distribution maps were prepared which could suffice in giving the proximity distribution of the given species at 95% confidence limits.

The plant specimens were processed as per the methods mentioned by Lawrence (1951) and placed in the Department of Botany, S.P. Chowgule College, Margao, Goa for future references.

1.5.3 OBSERVATIONS

Distribution maps of the most important 32 medicinal, 49 wild edible and 24 threatened plant species in the Goa's Western Ghats have been prepared. The points given on the maps implies where the population of individual species; i) Trees are 8 per hectare or more, ii) Shrubs are 80 per hectare or more and iii) Herbs are 250 per hectare or more, on an average, are situated.

The species distribution on the maps has not been confined to the Sattari, Sanguem and Canacona talukas only; the rest of the other areas of Goa have been taken into consideration also. The distribution is at 95% confidence interval of means obtained by the extensive sampling. The factors which may have led to the taxon getting threatened have been investigated (Table: 9).

Please note that the species distribution is given wherever it has been located in Goa even upto the seashore. This is because the Western Ghats implies the different descending steps until the sea level is reached.

The areas depicted in the distribution maps may be termed as "hot spots" sites of Goa region, where the specimen might be located easily.

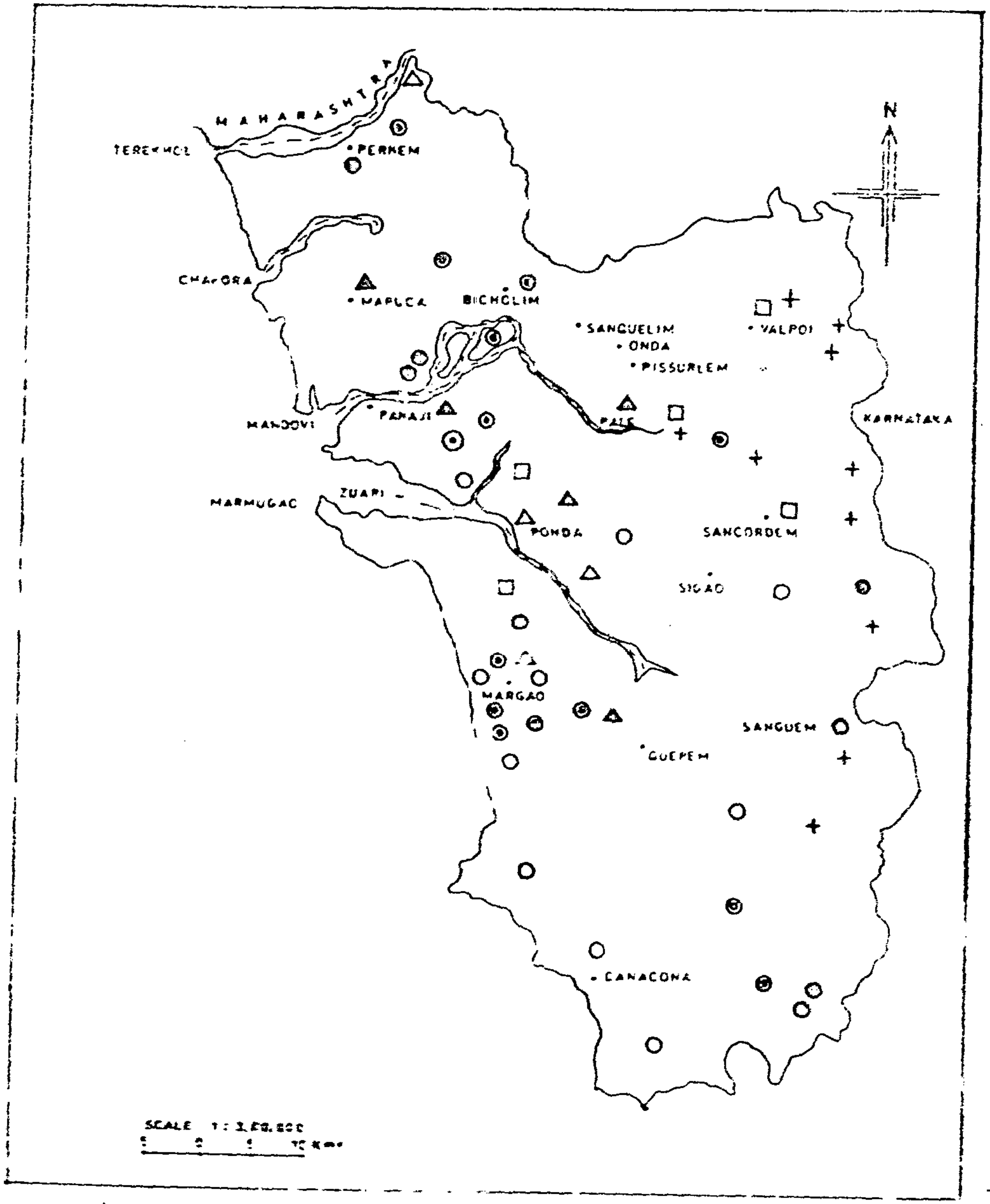


Fig : MAP OF GOA SHOWING THE DISTRIBUTION OF WILD EDIBLE PLANT SPECIES.

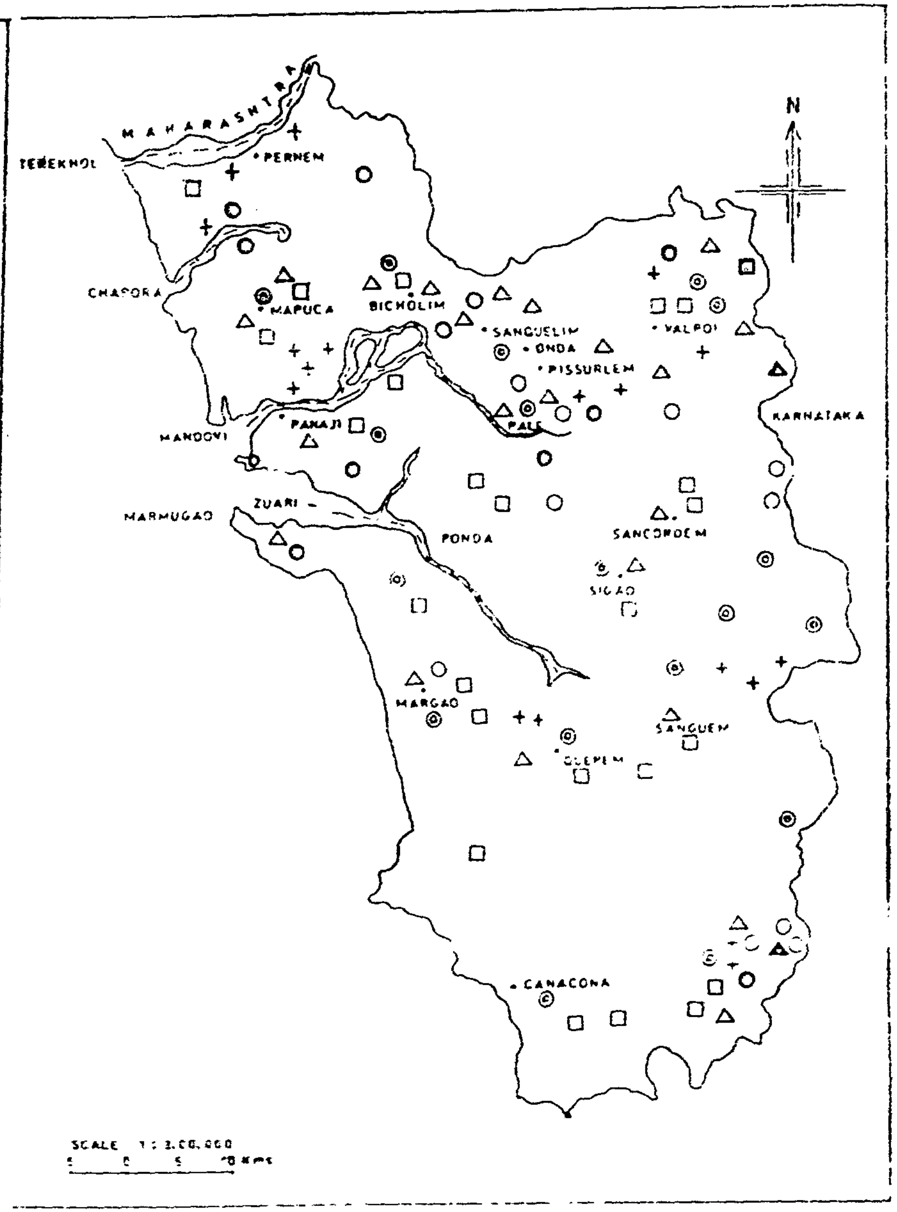


Fig : MAP OF GOA SHOWING THE DISTRIBUTION OF WILD EDIBLE PLANT SPECIES.

TAXON ON THE DISTRIBUTION MAPS

B. Wild Edible Plant Species

MAP NUMBER

1.	*Annona reticulata* L.	□
2.	*Nymphaea pubescens* Willd.	◎
3.	*Portulaca oleracea* L.	○
4.	*Chenopodium album* L.	△
5.	*Amaranthus viridis* L.	■
6.	*Amaranthus spinosus* L.	▲
7.	*Dillenia pentagyna* Roxb.	+
8.	*Flacourtia indica* (Burm. f.) Morill	●
9.	*Garcinia indica* Choisy	□
10.	*Tamarindus indica* L.	◎
11.	*Phaseolus mungo* L.	○
12.	*Artocarpus heterophyllus* Lamk	△
13.	*Artocarpus hirsutus* Lamk	■
14.	*Artocarpus gomezianus* Wall ex Trec.	▲
15.	*Ziziphus rugosa* Lamk.	+
16.	*Ziziphus mauritiana* Lamk	●

TAXON ON THE DISTRIBUTION MAPS

B. Wild Edible Plant Species

MAP NUMBER

17.	*Carissa congesta* Wt.	□
18.	*Solanum nigrum* L.	◎
19.	*Physalis minima* L.	○
20.	*Curcuma neigherrensis* Wt.	△
21.	*Dioscorea bulbifera* L.	■
22.	*Dioscorea hispida* Dennst.	▲
23.	*Cassia tora* L.	+
24.	*Buchanania lanzan* Spreng.	⦶

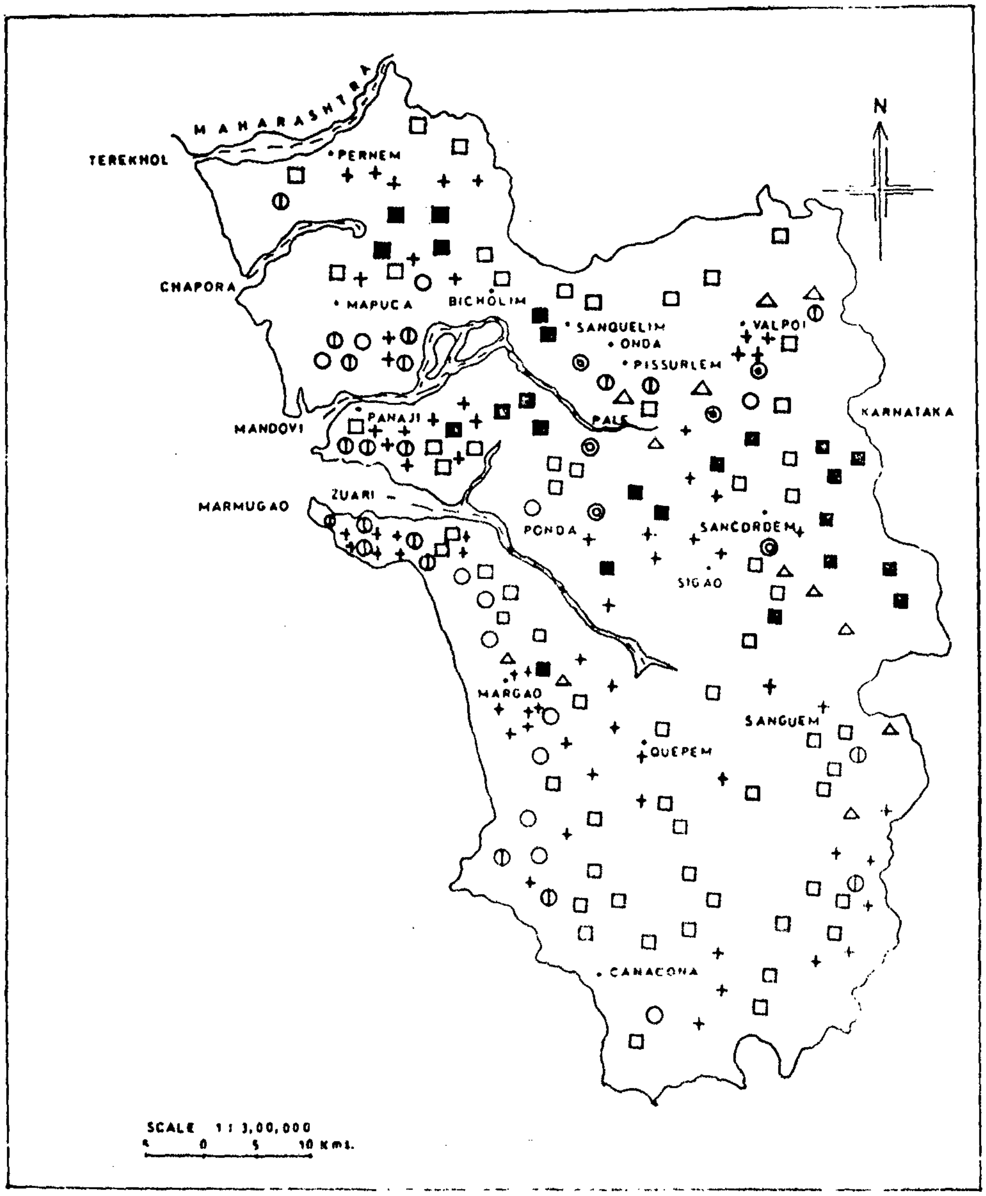


Fig: MAP OF GOA SHOWING THE DISTRIBUTION OF WILD EDIBLE PLANT SPECIES.

TAXON ON THE DISTRIBUTION MAPS

B. Wild Edible Plant Species.

MAP NUMBER 4.

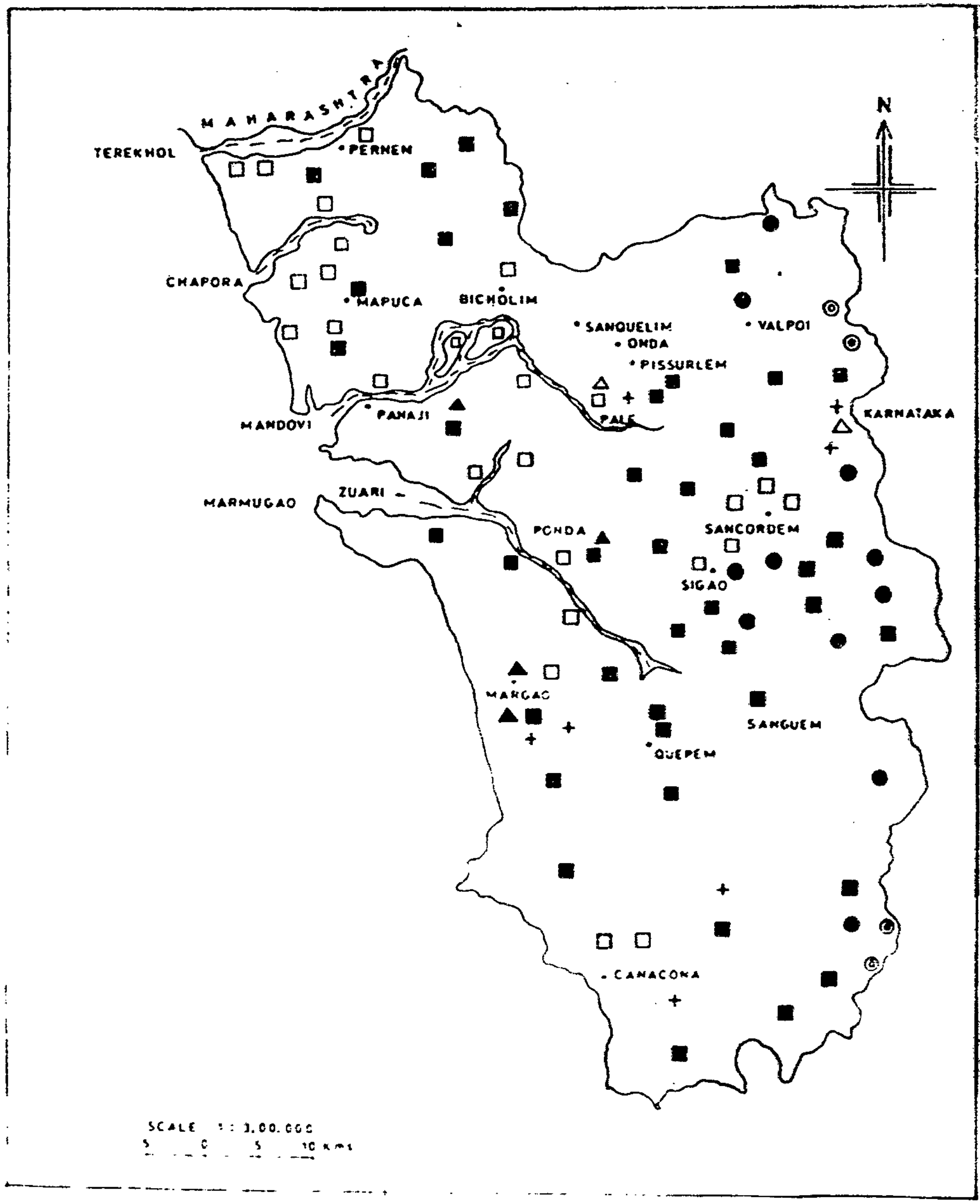
25. *Acrostichium aureum* Linn. □
26. *Garuga pinnata* Roxb. ◎
27. *Spondias pinnata* (L.) Kurz. △
28. *Syzygium cumini* (L.) Skeels. □
29. *Sterculia foetida* Linn. ▲
30. *Zanthxylum rhetsa*(Roxb) DC. +
31. *Cinnamomum zeylanicum* Bl. Bijdr. ●

MAP NUMBER 5.

32. *Carissa inermis* Vahl. □
33. *Carissa congesta* Wt.Ic. ◎
34. *Phaseolus mungo* L. △
35. *Microcos paniculata* L. ■
36. *Ficus drupacea* Thunb. △
37. *Luffa acutangula* (L) Roxb. +
38. *Asparagus racemosa* L. ●
39. *Garcinia mangostana* L. ⧄
40. *Breynia retusa* (Dennst.) Alston. ⦶

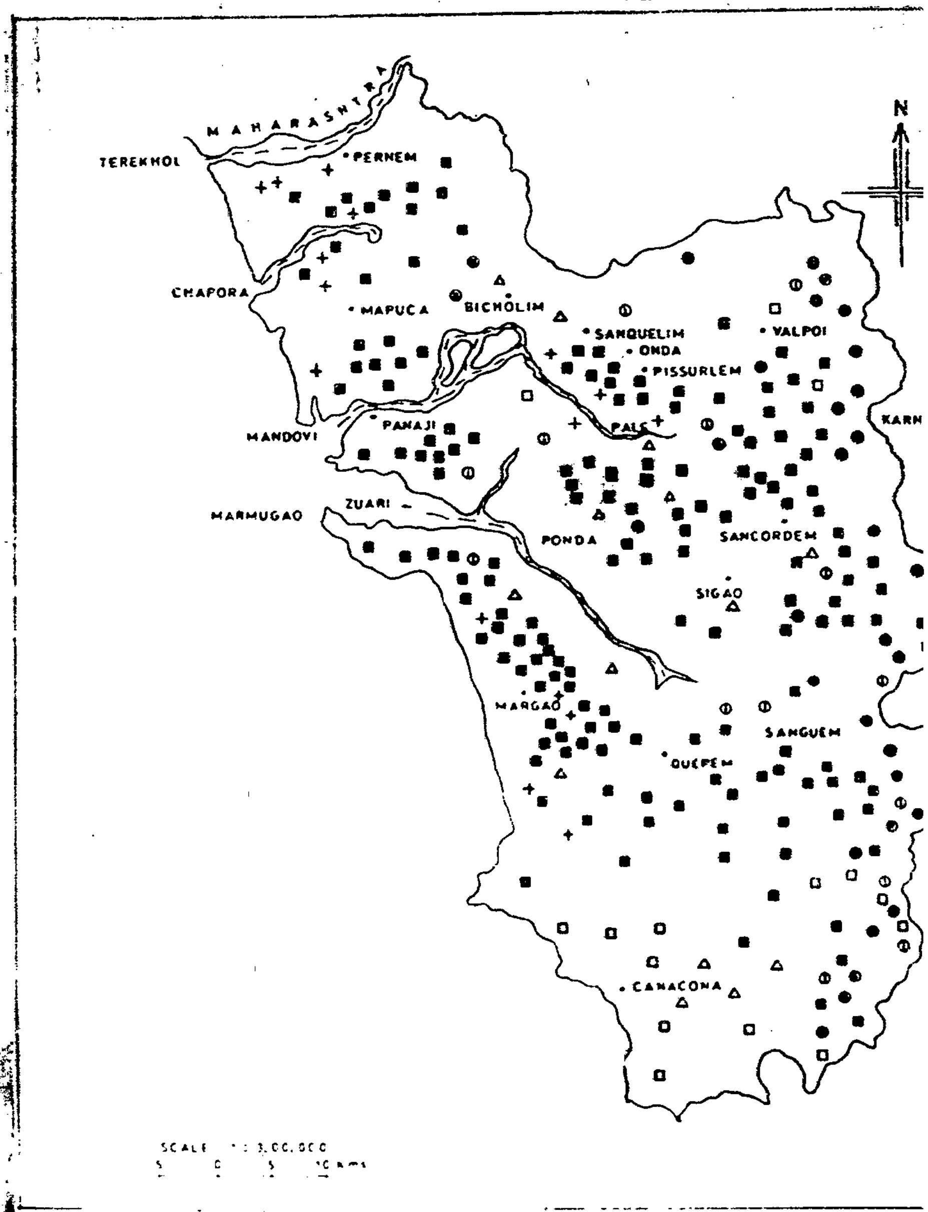
NB. *Phyllanthus emblica* L. and *Holostemma annulare* (Roxb)K.Schum. have been given in the distribution maps of Medicinal plant species.

MAP NO.4



MAP OF GOA SHOWING THE DISTRIBUTION OF WILD EDIBLE PLANT SPECIES.

MAP NO.5



MAP OF GOA SHOWING THE DISTRIBUTION OF WILD EDIBLE PLANT SPECIES.

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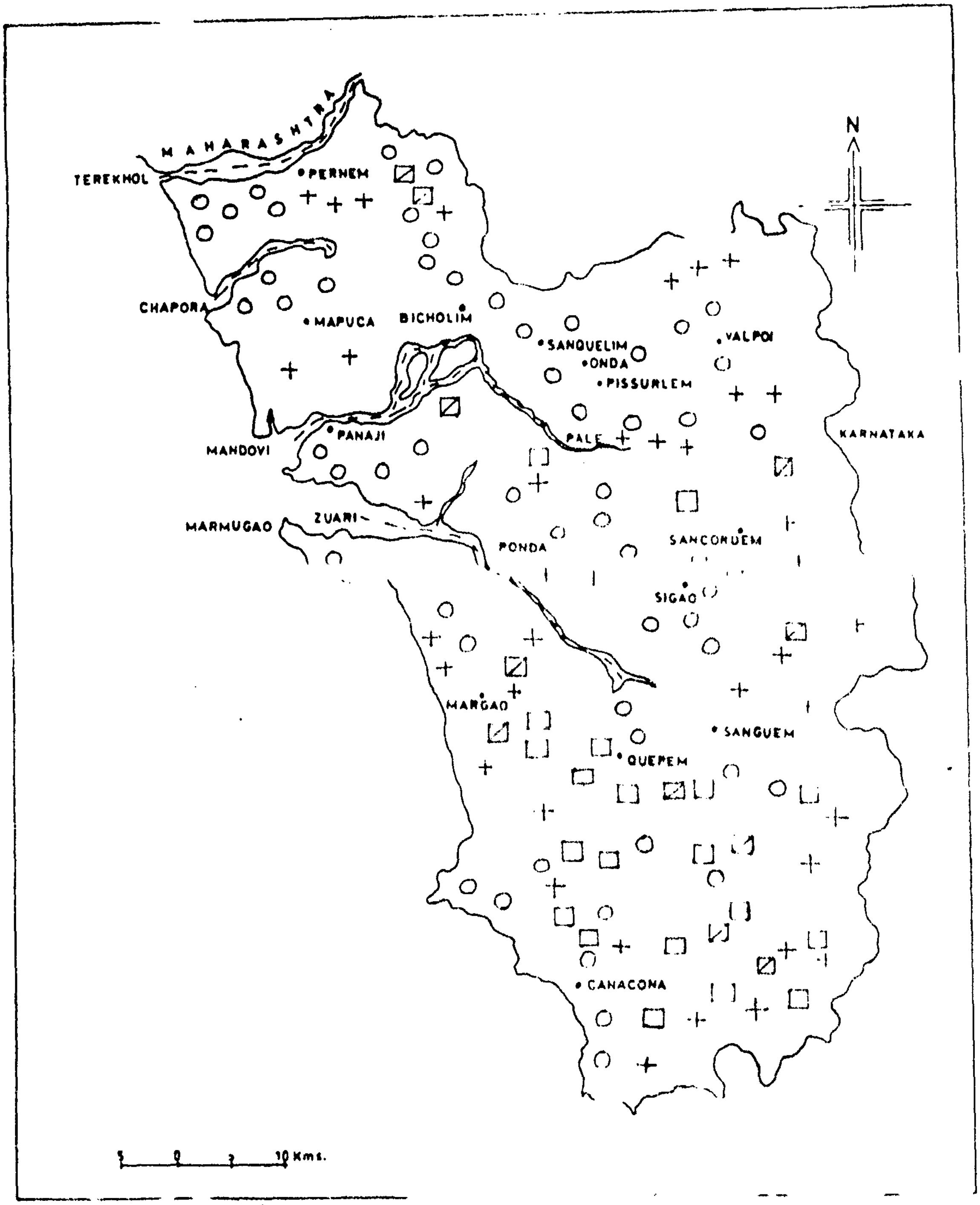


MAP OF GOA SHOWING THE DISTRIBUTION OF IMPORTANT MEDICINAL PLANT SPECIES .

TAXON ON THE DISTRIBUTION MAPS

A. Medicinal Plant Species.

MAP NUMBER 5.

33. _Holostemma annulare_(Roxb)K.Schum. ⧄

34. _Andrographis paniculata_(Burm.)Wall.ex Nees. +

35. _Leucas lavandulaefolia_ Rees,Cyclop. ○

36. _Rauvolfia tetraphylla_ L. □

E X P L A N A T I O N O F P L A T E

Photographs showing some of the threatened plant species of the Goa's Western Ghats.

Fig 14a. *Rauvolfia serpentina* whole plant during flowering.

Fig 14b. *Holostemma annulare* flowering portion.

Fig. 14a.

Fig. 14b.

Table: 9 Threatened plant species in Goa, and their causal factors.

Sr. No.	Threatened plant species	Causal factors (specific for Goa's region)
1.	Angiopteris evecta Forsk.	Destruction of natural habitats & exploitation as ornamental.
2.	Gnetum ula Brongn.	Exploitation of seeds and stem & destruction of their natural habitats.
3.	Hippocratea indica Willd.	Exploitation of seeds and stem & destruction of their natural habitats.
4.	Zanthoxylum rhetsa (Roxb.) DC	Exploitation of the root system.
5.	Drosera burmanni L.	Destruction of natural habitats & exploitation by the student communities for studies.
6.	Drosera indica L.	Destruction of natural habitats & exploitation by the student communities for studies.
7.	Garcinia indica Gaertn.	Exploitation of fruits & seeds therefore, natural regeneration is greatly hampered.
8.	Hemidesmus indicus (L) Schult	Overexploitation of the root system.
9.	Rauvolfia serpentina L. (Fig. 14a)	Overexploitation of the root system.
10.	Rauvolfia tetraphylla L. (Fig. 15 a)	Overexploitation of the root system and as a substitute for R. serpentina.

Sr. No.	Threatened plant species	Causal factors (specific for Goa's region)
11.	Acampe praemorsa (Roxb) Blatt & Mcc.	Destruction of their natural habitats.
12.	Aerides crispum Lindl.	Destruction of their natural habitats.
13.	Aerides maculosum Lindl.	Destruction of their natural habitats.
14.	Dendrobium ovatum Willd.	Destruction of their natural habitats.
15.	Eria microchilos Lindl.	Destruction of their natural habitats.
16.	Habenaria grandifloriformis Blatt. & McC.	Destruction of their natural habitats.
17.	Habenaria marginata Coleb.	Destruction of their natural habitats.
18.	Habenaria plantaginea Lindl.	Destruction of their natural habitats.
19.	Luisia tenuifolia Bl.	Destruction of their natural habitats.
20.	Nervilia aragoana Gaud.	Destruction of their natural habitats.
21.	Plantanthera susannae (L) Lindl. (Fig. 15 b)	Destruction of their natural habitats & exploitation of the conspicuous white attractive flowers.
22.	Rhynchostylis retusa (L) Bl.	Like above, light pale-pink flowers

Sr. No.	Threatened plant species	Causal factors (specific for Goa's region)
23.	Calamus pseudo-tenuis Becc & BK.	Exploitation for cane wood.
24.	Bambusa arundinacea (Retz.) Roxb.	Poor regeneration per seeds & over exploitation for the poles.
25.	Holostemma annulare (Roxb.) Schum. (Fig. 14b)	Over exploitation of flowers & roots.

The medicinal plant species have been mentioned and their uses given in the text however a word of caution for their use as medicine: unless a detail knowledge of dose concentration and vast experience in practising the medicinal plants their parts to cure diseases may pose serious danger. So never try to use the medicinal plant without proper guidelines and knowledge.

An aspect on some of the threatened plant species.

Holostemma annulare though reported as very common by Dalgado (1898) about one century back the species population is extremely rare today. Since the species is being exploited for both its flowers and roots its population is fast diminishing.

Urgent needs to bring it under cultivation is wanting; moreover it is a real beautiful species when in flower which could admirably be introduced as an ornamental in the homesteads and public gardens (Fig. 14 b).

Hemidesmus indicus is an important species which is internationally known as a blood purifier "sarsaparilla". Cooke (1903) states that the species' root has been employed as a substitute for sarsaparilla and in 1864 (about 130 years ago) was made officinal in the British Pharmacopoeia.

The species is threatened because of overexploitation of its

E X P L A N A T I O N   O F   P L A T E

Photographs showing threatened plant species.

Fig 15a. *Rauvolfia tetraphylla*, in fruiting condition at Rala-Salcete.

Fig 15b. *Platanthera susannae*, flower portion at Caranzol-Sattari.

Fig. 15a.

Fig. 15b.

roots for various uses. The species though abundant in some areas where accessibility is less, it got to be accepted that it is under threat in the Goa state and other pocket areas of the Western Ghats.

Garcinia indica is an important culinary in every household in this region; the fruit rind is widely used, whereas seeds are used in making oil. Though many people may argue that the species is abundant in this region, ground survey conducted showed enormous decline of the species population in their natural habitats in the recent years.

Bambusa arundinacea and Dendrocalamus strictus have become rare plant species in their natural habitats. Some efforts are being made to introduce them in the homesteads by the locals but the efforts are not sufficient enough. The high demand of the species for several domestic uses and in paper industry requires both private and public institutions to start large scale cultivation for commercial purpose in this territory.

Cane plant, Calamus pseudo-tenuis is one of the species being exploited for making furniture. Though its populations are high in the semi-evergreen forests, their rate of exploitation is high necessitating precautions to be taken.

So far no efforts have been made to introduce the species in the homesteads. If the species is made available on large scale cultivation then we will be rest assured that the species remaining in the natural forest will be spared.

1.5.4 DISCUSSION

Already several areas in Goa have been declared as protected zones in form of sanctuaries. It is in these areas where focus of attention should be made and introduce the threatened plant species.

The threatened species especially those exploited for food or medicine or any other use have had the long standing tradition which may have gone from generation to generation for centuries for their

Fig. 12b. Dioscorea bulbifera L.
tuber & fruiting branch

Fig. 12c. Dioscorea
oppositifolia L.
& fruiting branch

Fig. 12a. Dioscorea alata L.
bulbils attached to the stem

Fig. 12d. Dioscorea hispida Dennst.
flowering branches

Fig. 12c. Diocorea pentaphylla L.
flowering bud condition.

use, therefore, it is difficult to break the tradition.

The only alternative is to educate the masses/local people of the usefulness and their danger of getting extinct of these plants and encourage them to cultivate these plant species in the home yards.

For example the roots of Hemidesmus indicus are sold (1994) in the markets at Rupees 20/- per bundle, (5 to 8 pieces are equivalent to about 1/4 kg), this serves as a recruitive business to some village people who collect it freely from the surrounding rocky plateau and sell it to the local market.

Measures to save the plant: is not to stop people from their utilisation of the plant species but rather educate them on the species' value.

If the products of this species are exported abroad, they could definitely earn much more in terms of foreign exchange (which is badly required for any nation's development).

One cannot imagine a situation, as Ayensu (1978) says, if Penicillium had been eliminated from the earth before humankind made use of it as an antibiotic, or if Cinchona had become extinct before quinine was discovered as a cure for malaria. It is therefore in our own interest to conserve our plant as also animal and microorganism wealth (Khoshoo, 1986).

Sarma (1991) while working out on the forest resources and utilisation in Assam quotes that orchids and medicinal plants and herbs can be sources of earning foreign exchange since demand for orchids and medicinal herbs is universal. Collection of these from wild growth, their planned cultivation and sale in India and abroad have immense prospects.

The same should be done to the Goa's orchards and medicinal herbs which if planted under extensive cultivation may generate high income.

It can be said that the 1990's is the critical decade for the persistence of many tropical species. If appropriate conservation action is taken, these species will survive into the third millennium; without urgent action many species will be known only from museum specimens, or be unknown, in the third millennium. The question therefore becomes not what research is needed? "but" "what indicators are there for action to be taken now?" (Usher, 1991)

Threatened plant species may be observed in different retrospective in different states and other regions of the world.

Of course a species found in Goa as being threatened may not be as such threatened in the thick forests of Assam. Culture and tradition also play a big role in the utilisation of some forest species. In general many of threatened species are those which are being exploited for parts specially for food, medicine and timber to a little extent but no attempts have been made to regenorate them hence the enormous decline in their populations.

As Khoshoo (1986) states that "no amount of laws and policing can save these species because it affects socio-economically the hereditary vocation of rural communities. Production of these species is called for because otherwise conservation for the sake of conservation cannot be "sold" to the rural people of our country who can be both the destroyers as also protectors of our wildlife.

Owing to the continuously accelerating forest degradation in Goa, it is high time both public and private institutions try to set reserve germplasm seedbanks for the medicinal, wild edible and threatened plant species for example the introduction of these plants in the gardens both at the home backyards and public gardens might assist in their preservation, especially for the threatened plant species.

1.6 SPECIFIC GRAVITY OF WOOD TIMBER SPECIES AND PLOIDY LEVEL

1.6.1 INTRODUCTION

There is no question that wood specific gravity or wood density, is by far the most important within species wood characteristic for nearly all products (Einsphar et al., 1969; Barefoot et al., 1970; Zobel and Talbert, 1984).

Specific gravity is primarily determined by three different wood characteristics namely by amount of Summerwood, cell size and thickness of cell wall. Therefore it is not a simple wood characteristic but it is a combination of characteristics. Specific gravity is of key importance of foresters because it has major effect on both yield and quality of the final product (Barefoot et al., 1970) and because it is strongly inherited (Van Buijtenen, 1962; Harris, 1965; Zobel, 1966; Zobel and Talbert, 1984).

Overall biomass productivity cannot be determined unless wood specific gravity is known.

Specific gravity and pulp of wood

Much has been written about the effect of specific gravity on the quality of pulp and paper; a few publications summarising these findings are those of Barefoot et al. (Loc. cit); Kirk et al., (1972); Bendtsen (1978) and Zobel (1981). It is clear from these and many other summaries that the importance of specific gravity many times overshadows the importance of other wood properties; this is especially true for the key paper characteristics referred to as tree strength. It is so important that in most programmes which have pulp and paper as final product specific gravity is the only wood characteristic manipulated. Because of its effect on quality and yield and its high heritability, it has become of major interest in most tree improvement programmes - no matter if the objective is to produce fibre or solid wood products (Zobel et al., 1978; Zobel and Talbert, 1984).

A wider investigation into different species to find whether there is a correlation between sp. gr. of wood (stem) and the chromosome numbers is required. If a correlation is found it will help in selecting out species for particular uses in the timber industry by directly determining the chromosome number of a given specimen.

Some attempt was done in this direction on five different species namely; Tectona grandis L., Terminalia chebula Retz, Strychnos nux-vomica L., Syzygium cumini (L) Skeels, and Gmelina arborea Roxb.

1.6.2 MATERIALS AND METHODS

Experiments were conducted to find any correlation between the specific gravity of wood and the ploidy level of timber species.

If any correlation is found, it will help in selecting out timber species for particular use in the timber industry by directly determining the chromosome numbers of a given specimen.

Experiments were conducted in the PG Dept. of Botany, S.P. Chowgule College, Margao on five different species, namely Tectona grandis L.; Terminalia chebula Retz.; Strychnos nux-vomica L.; Syzygium cumini (L.) Skeels; and Gmelina arborea Roxb.

Chromosome count.

Seeds of 5 plant species mentioned above and wood portion of tree populations showing distinct variations such as plant height, stem girth and DBH of even aged-stands were collected from different forests and labelled in the field. The seeds were separately germinated in pots with vermiculite. Healthy root tips were excised, washed and pre-treated with saturated aqueous solution of p-dichlorobenzene for two hours at 10°C. Pre-heated root tips were washed thoroughly and fixed in modified Carnoy's fluid. Fixation was followed by hydrolysis at 60°C in 2N HCl and then staining with 2% aceto-orcein which gave satisfactory results. Chromosome number was then counted at metaphase.

Determination of specific gravity.

Different pulp woods of tree species whose chromosome numbers had been determined, were collected from different localities of forests and labelled on the spot in the field. The samples were put in water by keeping a weight over them for about ten minutes; this was done in order to fill the superficial pores of the wood.

The wood samples were then weighed in air and appropriate sinker was weighed separately (immersed in water) the wood sample was then tied with a sinker and immersed in water. The weight of the sample in air and the loss of weight of the sample in water was found by the following formula.

$$\text{Sp.gr.} = \frac{\text{Wt. of sample in air}}{\text{Loss of wt. sample in water}}$$

Wt. of sample in Air = W_1 gms

Wt. of sample + sinker in water = W_2 gms

Sinker alone in water = (W_2-W_3)gms (-ve value)

Loss of wt. of sample in water = $W_1-(W_2-W_3)$

$$\text{Specific gravity of wood sample} = \frac{W}{W_1 - (W_2 - W_3)}$$

1.6.3 OBSERVATIONS

During the study of the Chromosome Number of polyploidy and diploidy, the species showed no distinct correlation in the specific gravity of the wood compared (Table: 10). Even the local volume tables stem/hectare per species, diameter class and ploidy level showed no distinct correlation. Though in some cases higher specific gravity was observed in the ploidy species but this could not be clearly defined.

Given that different environmental factors operate, these imply that hundreds of stands have to be investigated where the varieties of a species exist in order to find if there is any relationship.

Table: 10 Correlation of local volume tables stem/hectare per species and diameter class between ploidy level and specific gravity of wood of some plant species in Goa have been investigated.

Sr. No.	Taxon		*Chromos. Number (2n)	*Sp. gr.	Diameter class (cm) 15 to 20	21 to 25	26 to 30	31 to 35	36 to 40	41 to 50	51 to 60	61 to 70
1.	*Tectona grandis* L.	a)	24	0.6,0.7	5.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		b)	36	0.6,0.7	5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.	*Terminalia Chebula* Retz.	a)	14	0.85	0.0	0.0	0.0	3.1	0.0	0.0	0.0	3.3
		b)	18	1.01	0.0	0.0	0.0	3.5	0.0	0.0	0.0	4.2
3.	*Strychnos nux-vomica* L.	a)	24	0.86	8.0	2.8	0.0	0.4	0.63	0.2	0.1	0.1
		b)	44	0.86	10.6	3.3	1.5	0.9	0.3	0.0	0.1	0.0
4.	*Syzygium cumini* (L) Skeels.	a)	33	0.67	84.2	0.0	3.4	0.0	0.0	0.0	0.0	0.0
		b)	55	0.75	93.1	0.0	3.6	0.0	0.0	0.0	0.0	0.0
5.	*Gmelina arborea* Roxb.	a)	36	0.47	56.0	14.1	0.0	0.0	0.0	0.0	0.0	0.0
		b)	38	0.47	55.1	14.6	0.0	0.0	0.0	0.0	0.0	0.0

1.6.4 DISCUSSION

According to a personal communication (Letter No. 9-17/RIL/DGTP/93 dated 4.1.1993 with the Indian Council of Forestry, Forest Research Institute, Dehra Dun, Otsuka *et al*., (1964) reported that 21 year old tetraploid *Pinus thunbergii* in Japan had shorter tracheids with thick walls than diploid but information on wood density/sp. gravity is lacking.

The doubling of the chromosome complement often produces physiological changes which are comparable with those produced by gene mutations. The cell size in polyploids is usually greater, and body size is frequently bigger although by no means always increased. (Dobzhansky, 1968)

As the natural forest resources are fast declining the genetic diversity is also diminishing. There are many indigenous tree species though having been used traditionally as timber species for a long time, they have not been investigated especially in their timber values.

It is high time, efficient quick determining methods were evolved to bring out information on the timber values of these species because some of the species are going to be threatened no sooner may be endangered and get extinct from the wild state.

It remains at the hands of the foresters and scientists to take up this challenge sooner and not later.

P A R T II

VEGETATION MAPPING OF CASE STUDY "W"

2.1. LOCATION AND DESCRIPTION OF CASE STUDY AREA" W".

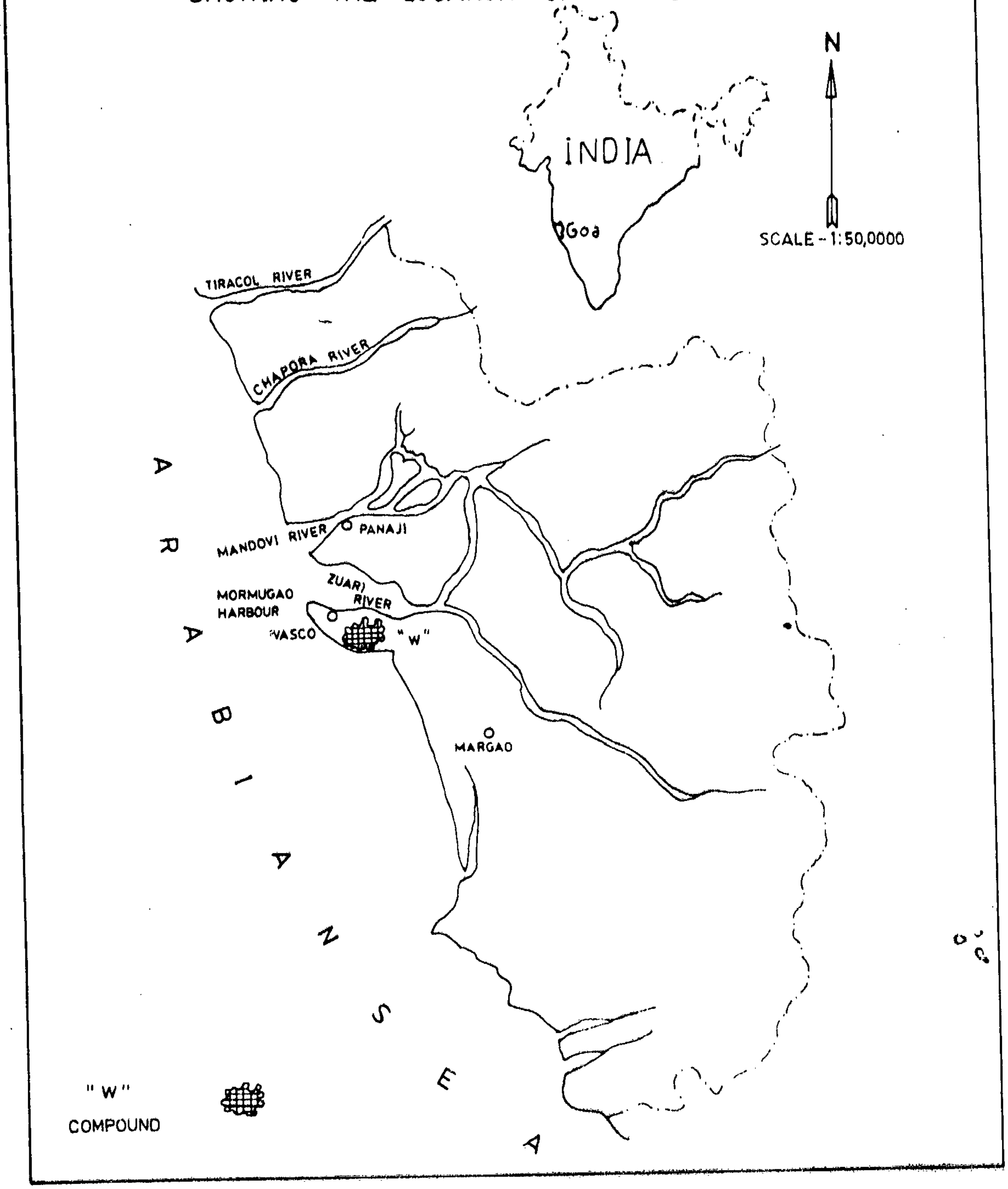
Case study "W" is a fertilizer manufacturing factory situated on the Margao-Vasco main road, about 7 km from the Vasco city centre. The "W" case study area is intersected by the main road and is a vast land of about 558 hectares (sq. km. 5.58). It lies at Latitude 15° 22′ 42" N and 15° 24 ′ 6" N Longitude: 73° 51′ 24" E and 73° 55′ 22.8" E (fig.16a). The west zone of case study "W" is bordered by Dabolim National Airport, to the south by a railway track passing along the shores of the Arabian Sea, but only a small portion touches the sea; just at the railway loading point to the north it is bordered by the Zuari river and to the East by a lake; the lake supplies water for the factory needs, its residents and surrounding villages.

To the East of case study "W" (non-protected & non-fenced area) is a vast area (of about 200 hectares) with very scarce vegetation which is seen as patches of grassland interrupting a rocky plateau. Towards the West (protected & fenced area), vegetation starts to build up forming an open scrub jungle mixed with *Acacia auriculiformis* plantation. Real dense scrub is observed on the extreme west end near the colony area. The rocky plateau is interrupted by grasses like *Iseilema laxum*, *Heteropogon contortus* and *Ischaemum conjugatum*.

About half portion of case study "W" is enclosed with a compound wall, entrance is possible through some four gates situated at different strategic positions. The gates are referred to as 1st,2nd,3rd and 4th as it is given in the text frequently (Fig.16b.)

The case study "W" area is generally of slanting slope (5° -10°) with the exception of a steep slope that exist at the railway loading point(30° - 35°) facing the Arabian Sea. Another steep slope exist just outside the boundary of case study "W" facing the Airport. According to the management′s official note, case study "W" came into

Fig.16a. MAP OF GOA SHOWING THE LOCATION OF "W" COMPOUND



operation in 1972 however, protective fencing with a compound wall and plantation work started in 1984 i.e. about 12 years later.

The annual rainfall at case study "W" area is within the range of 1750mm to 3000mm. The monsoon rains, which initially are coupled with thunderstorm, start in the mid-June. The rainfall increases gradually and reaches the peak point in mid July(~1000mm). The rainfall begins to decline in the end of August and ends in October with spits. The temperature are lowest in the months of December and January measuring 17 ± 2 °C respectively.

The relative humidity is within the range of 81% to 95%, being the highest in the month of September and lowest in January. The soils are generally lateritic with pH range of 5.3 to 6.2.

The case study "W" constitute the soil series of Netorlim series and small patches of Zaimolo series. The Zaimolo series consists of brown to dark brown or yellow-brown lateritic soils of alluvial origin, found on gentle slopes, while Netorlim series is the usual red-brown laterite covering large part of the case study "W". (Govindarajan et. al., 1974).

It is widely claimed by the management that the entire area was a barren rocky plateau constituted of laterite but actually lateritic soil stretches across over seventy per cent of Goa's soil surface stratum, though it might appear to be deeper in the case study "W" than many other parts of Goa (personal observation).

2.1.1. Purpose of vegetation mapping

The initial purpose of the management was to know what species names are found in the compound at case study "W", their Botanical local names.

However earlier investigation carried out by the author in the case study area the vegetation distribution using Aerial photographs

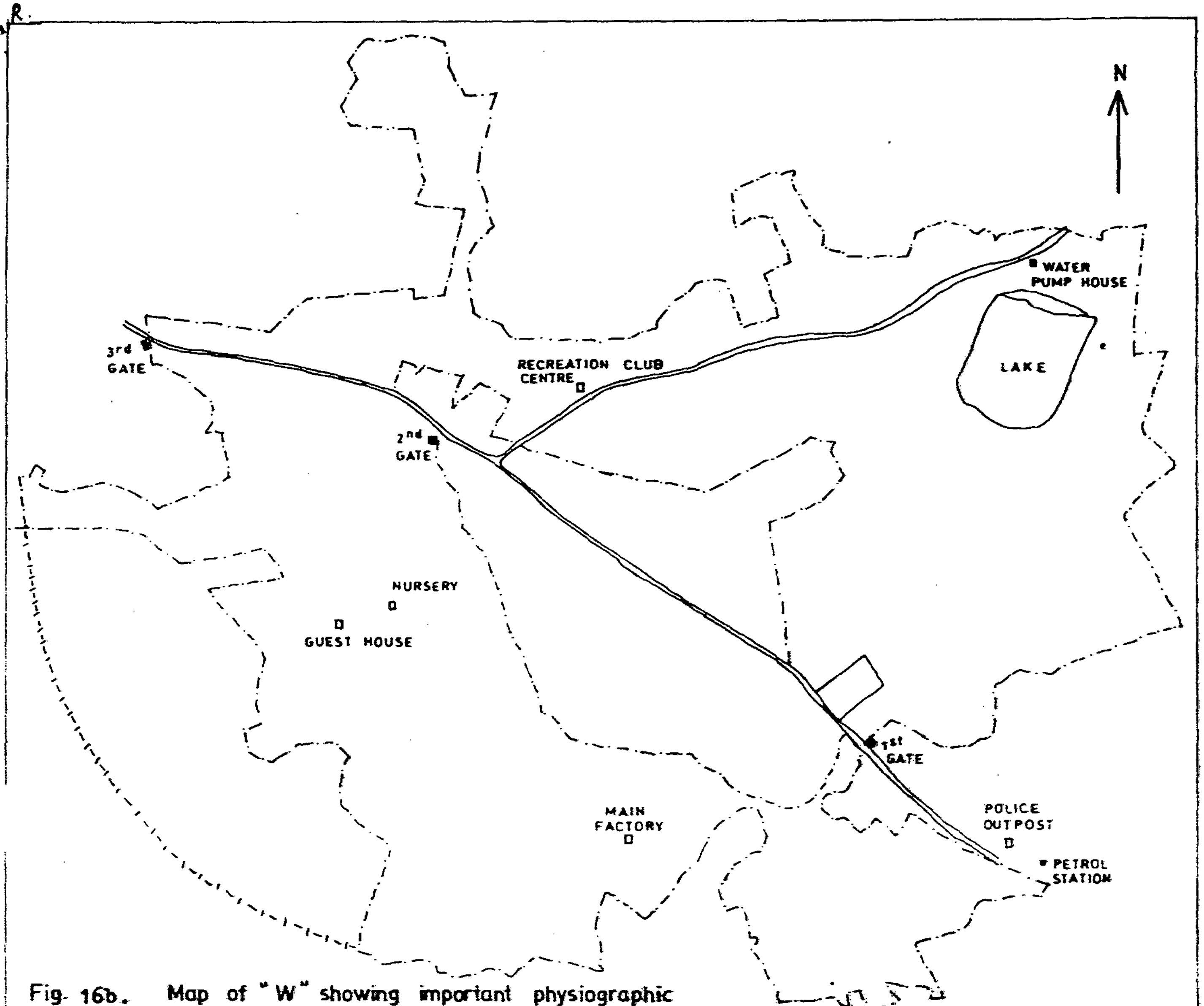


Fig. 16b. Map of "W" showing important physiographic places for demarcating the vegetation mapping.

of Oct. 1960 and Oct. 1991 showed gradual general improvement. The author informed the case study "W" management about this who became much more eager of wanting to know the exact figure of individual plants in the compound. This led to the interest of tree - shrub counting, in order to get a concerted quantified data base.

Tree census is quite a new area of science where quantified data is required whenever an industrial unit is operating as a clear proof whether they are trying to move in phase contrast to restoring the environment or not.

Computerisation of data on plant species will assist in specifying planting schemes for a new developments. The selection of alternative suitable planting material is facilitated by using computerised data already in the printed short-list with computerised data it is possible to give a more concerted effort in evolving a proper plan on what kind of species could be planted to be in conformity with the local flora viz. Associations, Consociations and Societies.

2.2 INTRODUCTION

2.2.1. Qualitative Analysis

The universe is not wholly described in quantitative terms. It is replete with qualitative characteristics which are of fundamental importance but for which there is no numerical expression, and these characteristics must be kept clearly in the foreground of any comprehensive mental picture of natural vegetation.

We should always, bear in mind that vegetation, like a kaleidoscope offers a constantly changing series of patterns, even if the changes are sometimes slow. The universal cycle of birth, death and reproduction makes this inevitable (McLean & Ivimey - Cook, 1973). Once the entitation or subdivisioning of the vegetation cover has been clarified (through qualitative techniques), the communities are essentially established. This is the reason why a thorough reconnaissance and familiarization before sampling is very important. Subsequent sampling and data collection will merely derive more detailed information on these communities, irrespective of one's choice for semiquantitative or quantitative methods for description (Muller - Dombois and Ellenberg, 1974).

2.2.2. Quantitative analysis

Since the realization a large degree of error is inherent in subjective evaluation of abundance, ecologists have become increasingly conscious of the necessity of using quantitative measures to describe vegetation (Kershaw, 1973).

2.2.3. Soil analysis

The establishment of network of intercorrelation between vegetation and environmental variables is a very useful method for studying the complexities of soil-plant relationships and seeking to explain vegetation distribution patterns. However this study also shows how the testing of what may seem to be a relatively straight forward set of hypothesis on an unexceptionally area of woodland, may lead to the generation of a totally new set of ideas requiring further work to develop and test.

In regions of very heavy rainfall (like in Goa) the water that penetrates the soil usually leaches away the soil nutrients as fast as they are formed and thus the soil is impoverished (Dice,1952). Therefore, soil analysis is important wherever vegetation mapping is carried out.

2.2.4. Aerial photographs

Vegetation mapping has become very much easier during the last few decades with the advances in Aerial photography. Vegetation units defined by their total floristic composition cannot always be clearly recognized on aerial photographs because the structure visible on them is primarily conditioned by the dominant species and their developmental status (Mueller Dombois and Ellenberg,1974).In any case it is always necessary to accompany aerial photographs during mapping to achieve "a calibration" of the field variation pattern of plant communities.

2.3. MATERIALS & METHODS

2.3.1. Qualitative Analysis

First, several botanical surveys were carried out in the case study "W" to acquaint oneself with the general topography and plant stratification. By using a pedometer "Kilometer Zahler " (Germany), the area size could be approximated. Official topographic map sheets of case study "W" were used to confirm the actual field size and location. Spots with special physiographic or topographic demarcations were identified and noted specially the Zuari lake, pump house, factory premises , residential quarters, old and new E-Colony, guest house, officers' bungalow, workers' residences, the hostel, the nursery, Mango orchard near gate no. 3, and the railway station loading point. The degree of slope, relative humidity, temperature and wind velocity were determined by Abney level, a clinometer a whirling psychrometer, maximum and minimum thermometer and anemometer respectively. Tall trees and other specimen on the slopes were examined at a closer view using a binocular.

The plant species which were found in flowering or fruiting condition were photographed using a field camera (SLR). During the subsequent botanical surveys, rough sketch maps and mapping tables were prepared and ground truth data collected. Plant collection of individual species representatives was carried out using a vasculum and a plant press, for proper identification in the labaratory. The herbarium was processed as per Lawrence's methods (1951) and deposited in the Botany Department S.P. Chowgule College for future references. Continuous seasonal monitoring of the vegetation was carried out throughout the year. The method used in the descriptive aspect of the vegetation are as those of Ellenberg & Mueller - Dombois (1969) in the tentative physiognomic - ecological classification of plant communities. The Cooke's flora of Bombay

Presidency was frequently referred for taxonomic description of the plant species with minor modifications. The latest taxon and its synonyms were referred to wherever necessary (Rao, 1985 - 86).

2.3.2. Quantitative analysis

Quadrat sampling was done at case study "W" compound and the actual ground truth data was obtained for the entire area where vegetation exists.

Minimal Unit Area was determined by the species-area curve method of Oosting (1958) to get the suitable quadrat size for sampling.After obtaining the Minimal unit Area 30.5m x 30.5m quadrats were sampled serially for the entire "W" case study area of "W" but not in the traditional random sampling method, because the essence of vegetation mapping is to cover the entire area under study.Though the Minimal Unit Area was determined from the natural community, the same was used in the artificial plantation for convenience. Individual tree and shrub count was carried out throughout the case study "W" not only for the cultigens, but also for the naturally occurring plant species.The counting was done in the natural habitats which also involved mapping the species in their exact location per quadrat.These were prepared later prepared into sketch maps and tables.

It must be noted that the ground truth data collected at case study "W" was initially meant for dimensiosnal ordination as computer accessory facilities were not available it was not possible for that purpose.

Formulae applied in the quantitative analysis were as per Kershaw (1973) and Mueller - Dombois and Ellenberg (1974) .

Frequency is the percentage occurence of a species in the total sample (Kershaw, 1973).

Density is the total number of individual of a species relative to the total area examined (Mueller - Dombois,1974)

Doominance = basal area cover (Mueller - Dombois and Ellenberg,Loc. cit).

$$\text{Relative Frequency} = \frac{\text{Frequency of a species}}{\text{sum of frequency of all the species}} \times 100$$

$$\text{Relative Density} = \frac{\text{No. of individuals of a species}}{\text{Total No. of individuals of all species}} \times 100$$

$$\text{Relative Dominance} = \frac{\text{Dominance of a species}}{\text{Sum of Dominance of all the species}} \times 100$$

Now, from these values a Relative Importance Value was derived (Mueller - Dombois & Ellenberg, Loc. cit) by summing up the values of Relative Frequency, Relative Density and Relative Dominance.

Systematic sampling usually gives a more accurate mean of the population density than random sampling of equal intensity and is, therefore to be preferred in many practical ecological Surveys such as resource surveys. Although, random sampling will usually be most desirable for ecological studies, because of the possibility of measuring the sampling error, nevertheless, in some instances systematic sampling is opted to, in which the samples are taken evenly, specified distances a part over the area rather than at random (Dice, 1952). Therefore systematic sampling was used in the case study "W".

2.3.3 Soil analysis.

Soil samples were collected within case study " W" from a depth of 30 cm layer and from areas having conspicuous vegetation pattern or where the plant species showed relative poor growth or exceptionally good performance.

The soil samples were collected from seven different localities of case study "W" namely :

1. The area between the factory and the second gate on the right hand side of the road from the factory.
2. Area close to the second gate at approximately 50 mts. distance from the gate.
3. Area around recreation club at a radiator of 100 m.
4. The mango orchard area on the left hand side of the road from the third gate about 100 m distance.
5. Area around Jacob's circle on the left hand side of the road from 3rd gate.
6. Area around Officer's bungalows and sports ground area.
7. Fenced area which encircles the guest house and the nursery.

In each case 3 to 4 soil samples were collected per site at a spacing of about 40 mts. The soils were then thoroughly mixed to provide a composite sample representing each site. A little of the soil samples representatives was utilized in the physical analysis and for pH. The rest of the composite sample was air dried for 4 days in shallow alluminium trays, ground using pestle and mortar, then screened through 2mm mesh sieves. The samples were sent for chemical analysis at the Agricultural Development Laboratory, Bangalore - India, by AAS method. All the soil samples were analysed for their Specific gravity, Water holding capacity, and Electrical conductivity as described in by Piper (1942) and pore space (Pandeya et al., 1968). An attempt was made to correlate the plant species distribution and the soil status by using chi-square values obtained from contigency tables based on species frequency (Table : 17).

2.3.4 Aerial photographs

The Howard and Mitchell method (1985) of Aerial photographs interpretation was followed which involved examining stereopairs of Aerial Photographs under a mirror stereoscope model No.2 Serial No. Ø528 (Indian). The overlapping vertical panchromatic prints were viewed in pairs, to produce stereoscopic images.

The vegetation details were interpreted by tracing them on sketch maps. Only two aerial photographs covered the total area of case study "W" viz. No. F5 2135 No. F5 2136 - Goa 1/8 MA 1Ø6Ø/25ØØM.

Oblique non-stereoscopic aerial photographs dated April and october 1991 , were also acquired which were used in the vegetation interpretation by using magnifying lenses of varying powers.

Some estimation was done on the number of mature trees from the aerial photographs . Average size of individual trees were estimated from the photographs which was corelated later with the ground truth data obtained.

2.4 OBSERVATIONS

2.4.1. Qualitative analysis

The vegetation is made up of one formation type comprising: Careya arborea, Lannea coromandelica, Ficus rumphii, Bombax ceiba, and Sterculia urens.

Two Association types are observed comprising; 1. Bridelia retusa, Ficus rumphii, Careya arborea. 2. Lannea coromandelica, Calycopteris floribunda, Ziziphus xylopyrus and Grewia umbellifera.

Consociation types:

1. Careya arborea, Ziziphus xylopyrus, Calycopteris floribunda.
2. Lannea coromandelica, Ervatamia heyneana, Holarrhena antidysenterica, Bridelia scandens.
3. Buchanania lanzan, Holarrhena antidysenterica, Microcos paniculata.
4. Ficus rumphii, Terminalia paniculata, Ervatamia heyneana, Acacia chundra.
5. Bombax ceiba, Ficus rumphii, Ervatamia heyneana Holarrhena antidysenterica, Abrus precatorius.
6. Bridelia retusa, Acacia chundra, Sterculia urens, Randia dumetorum, Ziziphus rugosa.
7. Alstonia scholaris, Ficus asperrima, Mallotus alba, Chromolaena odoratum.

Types of vegetation at case study "W" may be classified as; Patches of grassland, scattered mixed scrub and relatively dense scrub which is mainly composed of about 50% exotic species.

a. Vegetation between third gate (West zone) and the Jacob's circle.

Near the 3rd gate is a large mango orchard comprising about 400 mango trees which appear to be well spaced(10 m x 10 m spacing) .

Along the roadside is a well spaced avenue comprising of mainly

Delonix regia , *Peltophorum pterocarpum* and occasionally *Eucalyptus globulus* and *Bougainvillea spectabilis*.

Dominant trees are *Careya arborea*, *Bridelia retusa*,while the co-dominants are *Ziziphus xylopyrus* and *Calycopteris floribunda* as the naturally occurring species.

Towards the upper portion of this area dominant species observed are *Buchanania lanzan* and *Bombax ceiba* whereas the lower tier is composed of *Ervatamia heyneana*, *Bridelia scandens*, and *Microcos paniculata*. Several hundreds of tree plantation of *Acacia auriculiformis* and *Anacardium occidentale* are also observed. In most areas the species appeared to be stunted in growth.

b. Vegetation in the fenced (enclosing guest house) area.

Cultivated and naturally occurring plants are found in one to one proportion. Major plantation work is comprised of *Acacia auriculiformis* and *Anacardium occidentale* and occasionally *Sesbania grandiflora* (Fig. 18).

The dominating naturally occurring species are *Bridelia retusa*, *Lannea coromandelica* and *Ficus rumphii*.

Lower tier is of *Calycopteris floribunda* and to a lesser extent *Grewia umbellifera*. The fencing has helped to enhance a healthy growth of a relatively thick scrub forest.

c. Vegetation around old club and officers' bungalow area.

Very scanty vegetation is observed around the old club and officers' bungalow area. It is an open grassland intercepted by barren rock.Several species have been introduced in this region mainly *Acacia auriculiformis*, *Eucalyptus globulus*, *Samanea saman*, *Erythrina indica*, *Leucaena leucocephala* and to a lesser extent *Cocos nucifera*.

Around the officer's bungalow are numerous species of *Peltophorum pterocarpum*, *Casuarina aquisetifolia* and *Bougainvillea sp.* and

Ziziphus mauritiana showing good performance.

d. Vegetation around "B" colony and sports ground area.

The entire area which is a plateau has been introduced with thousands of Australian Acacia and few tens of *Tamarindus indica* trees. Occasional naturally occurring species are *Lannea coromandelica*, *Bombax ceiba*, *Acacia chundra* , *Terminalia paniculata* and *Alstonia scholaris* as dominants.

Ground flora is scanty more specially in the monocultured plantation of *Acacia auriculiformis* near the sports ground ; only with patches of grass which emerge during the monsoon.

e. Vegetation from the 2nd gate to the administration block.

Entire strips along both sides of the road have been planted with mainly *Acacia auriculiformis* mixed with *Anacardium occidentale*. The elevated portion is a dense scrub comprising of mainly *Acacia chundra*, *Ficus rumphii*, *Bridelia retusa* and *Ziziphus rugosa*.

f. Vegetation within the factory area.

The area is mainly covered by a pure plantation of *Acacia auriculiformis*.

On the left hand side of the road leading to the factory, many young saplings of *Alstonia scholaris* have been planted.

The factory avenue from the first gate is densely decorated with many *Croton variegatum* and *Polyalthia longifolia* plants whereas at the administration block, avenue trees are conspicuous like *Cordia sebestena*. *Tabebuia argentea* , *Melia azedarach* and *Terminalia cattapa* and *Spathodea campanulata* (Fig.17 b), which shows complete brick red leaves that are about to be shed off in summer season.

The diversity of poaceae family members is much less in the plantation of case study "W" than at the adjoining scrub forest.

Table: 11. Simplified artificial key to the families of flowering plants native to or naturalised in case study "W".

1. Stem with scattered vascular tissue, flowers usually 3 merous; venation generally striate; cotyledon 1 .... Group 6 (Monocots)

1. Stem with vascular tissue, forming one or more rings; central pith present or replaced by wood; flowers 4-5 merous; venation reticulate; cotyledons generally 2.....Dicots.

2. Perianth absent (achlamydeae) or of one whorl (monochlamydeae)........Group 5

2. Perianth biseriate or multiseriate.

3. All or most lobes of inner whorl of perianth entire free.

4. Ovary superior.

5. Stamens more than 16 or indefinite..... Group 1

5. Stamens 10, or less definite .... Group 2

4. Ovary inferior.............. Group 3

3. Lobes of inner whorl of perianth united ......Group 4

Group 1

Dicots with 2 or more whorls of perianth lobes, at least inner whorl free; stamens more than 16; ovary superior

1. Ovary apocarpous

2. Stamens inserted on hypanthium (perigynous) ....Rosaceae

2. Stamens inserted on receptacle (hypogynous)....Annonaceae

1. Ovary monocarpellary or syncarpous

3. Stamens inserted on hypanthium.................Lythraceae

3. Stamens inserted on receptacle

4. Leaves opposite ....Clusiaceae

4. Leaves alternate

5. Stamens monadelphous, forming a column

6. Anthers monothecous ....Malvaceae

6. Anthers dithecous ....Sterculiaceae

5. Stamens not forming a column ....Bombacaceae

7. Ovary stipitate

8. Placentation axile ....Tiliaceae

8. Placentation parietal ....Capparaceae (Capparidaceae)

7. Ovary sessile

9. Succulent herbs, sepals 2-3 ....Portulacaceae

9. Woody shrubs, sepals 5 ....Ochnaceae

Group 2

Dicots with 2 or more whorls of perianth at least the inner free; stamens 10 or fewer; ovary superior.

1. Ovary 1-locular

2. Flowers 3-merous; unisexual .... Menispermaceae

2. Flowers 5-merous; bisexual

3. Succulent herbs, leaves simple, fruit - circumscissile capsule .... Portulacaceae

3. Trees, shrubs or herbs, leaves pinnate, fruit - a pod

4. Flowers dense, globose symmetrical, petals valvate stamens definite or indefinite .... Mimosaceae

4. Flowers lax, bilaterally symmetrical petals imbricate, stamens indefinite, 10 or fewer.

5. Corolla ascending imbricate, upper petal innermost .... Caesalpiniaceae

5. Corolla descending imbricate, upper petal outermost .... Fabaceae

6. Androphore or gynophore present

7. Plants with tendrils .... Passifloraceae

7. Plants without tendrils but with hooked thorns .... Capparaceae

6. Androphore or gynophore wanting

1. Ovary 2 - or more - locular

8. Leaves compound

9. Plants climbing stipulate .... Sapindaceae

9. Plants erect exstipulate .... Meliaceae

8. Leaves simple .... Balsaminaceae

<u>Group 3</u>

Dicots with 2 or more whorls of perianth at least inner free; ovary inferior or enclosed in hypanthium.

1. Leaves opposite; fruit fleshy .... Myrtaceae

1. Leaves alternate, fruit woody .... Lecythidaceae

2. Straggling or scandent shrubs or trees; locule 3; ovule solitary ..... Rhamnaceae

2. Erect arborescent trees; locule 1; ovules many .... Flacourtiaceae

3. Woody plants

4. Plants with resinous or caustic sap (mucilage) fruit drupe .... Anacardiaceae

4. Plants not as above, fruits otherwise.

3. Herbaceous plants

5. Leaves cauline with pinnate venation, anthers longitudinary dehiscent ..... Onagraceae

5. Leaves basal or opposite, with palmate venation; anthers poricidal .... Melastomataceae

<u>Group 4</u>

Dicots with gamopetalous corolla

1. Stamens more than corolla lobes

2. Trees; sap milky .... Sapotaceae

1. Stamens as many as corolla lobes or fewer

2. Herbaceous climbers; sap clear .... Cucurbitaceae

3. Ovary inferior

4. Anthers united around style (Syngenesious) ... Asteraceae

4. Anthers free .... Rubiaceae

3. Ovary superior

5. Ovary 4-lobed; gynobasic arising from between the lobes of the ovary .... Lamiaceae

5. Ovary entire; style apical

6. Fruit loculicidal capsule .... Acanthaceae

6. Fruit not as above drupaceous .... Verbenaceae

7. Leaves alternate

8. Corolla plicate if not, style branched .... Convolvulaceae

8. Corolla imbricate, narrowly tubular; style unbranched .... Solanaceae

7. Leaves opposite rarely alternate

9. Carpels united at stigmatic disc, pollen aggregated into tetrads or pollinia ... Asclepiadaceae

9. Carpels united by styles; pollen not as above .... Apocynaceae

10. Fleshy herbaceous plants, corona corolline fimbriate .... Scrophulariaceae

10. Woody herbaceous plants, corolline corona absent or if present not fimbriate .... Gentianaceae

11. Fruit; drupaceous with persistent calyx .... Verbenaceae

11. Fruit; a berry, calyx not persistent ... Loganiaceae

Group 5

Dicots with flowers devoid of perianth (achlamydeous) or with one perianth whorl (monochlamydeous)

1. Perianth absent, inflorescence cyathium .... Euphorbiaceae

1. Perianth present, inflorescence simple
2. Ovary 2-6 locular
2. Ovary monolocular
3. Stamens twice the number of perianth lobes .... Combretaceae
3. Stamens equal to or fewer than perianth lobes
4. Fruit a circumscissile dehiscent ...... Lythraceae
4. Fruit not as above, indehiscent ..... Nyctaginaceae
5. Flowers bisexual
6. Perianth scarious .... Amaranthaceae
5. Flowers unisexual or polygamous....... Ulmaceae
6. Perianth not scarious
7. Plants with milky latex, flowers in a syconium or on hypanthodium .... Moraceae
7. Not like above, flowers in catkins...... Casuarinaceae

Group 6

Monocots

1. Perianth petaloid, at least in part
2. Flowers unisexual
3. Inflorescence umbellate, tendriliferous...... Smilacaceae
3. Inflorescence various, twining ..... Dioscoreaceae
2. Flowers pistillate or bisexual ...... Commellinaceae
1. Perianth not petaloid, often reduced to scales or bristles or absent
4. Woody plants usually trees
5. Leaves pinnate or palmate ..... Arecaceae
5. Leaves entire
4. Plants usually, not woody, herbaceous
6. Inflorescence; a solitary head on spirally ribbed peduncle............Eriocaulaceae

7. Leaves tristichous, not ligulate, culms triangular, anthers basifixed .... Cyperaceae

7. Leaves distichous, ligulate.culms cylindrical, anthers versatile.... Poaceae

Descriptive note on some important tree species found at case study "W".

1. **Acacia auriculiformis**, A. Cunn ex Benth.

This is the most common tree species that has been put for plantation work at case study "W" and other social forestry schemes in Goa.

A medium tree. Leaves are the modified phylloclades which give a false greenery throughout the year. Flowers many appearing in medium spikes, yellow. Seeds black, almost cylindrical, attached to the Zig-Zag integuments in the pods.

Propagated by seeds which are shown in the rains.

2. **Acacia chundra**, (Roxb) Willd. Rao (1985) Fl. G.D. Dam.Dadr. and Nagarhav. 1:151.

An armed medium sized tree closely resembling **Acacia Catechu** but found to be distinct species from its floral aspects. (e.g. Glabrous rhachis, calyx, and corolla) Flowers milky, dirty-white in globose spikes. Pods membranous, 3 - 4 seeded. Seeds semi-cylidrical, glabrous, dark-brown.Propagated by seeds.

3. **Alstonia scholaris**, Br. Cooke (1904) Fl. Bombay 1:194

A large handsome evergreen tree butress stem, Bark greyish, rough, exuding latex if injured. Leaves whorled, dark green, shinning,tapering on the stalk. Flowers light green on long stalks radiating from a common center in umbellate clusters, villous, strongly odorous at night. Fruits hanging in bunches of slender podlike sticks. Propagation by seeds and young shoots.

4. **Bauhinia purpurea**, L. Cooke (1903) Fl. Bombay 1:462.

TABLE:12 a. List of important tree-shrub species found at case study "W"

Sr. No.	Taxon	Habit	Family
1.	Abrus precatorius, L.	(S) (N.O.)	Fabaceae
2.	Acacia auriculiformis, A. Cunn.	(T) (C)	Mimosaceae
3.	Acacia arabica, Willd	(S) (N.O.)	Mimosaceae
4.	Acacia chundra, Roxb.	(T) (N.O.)	Mimosaceae
5.	Achras sapota, L.	(T) (C)	Sapotaceae
6.	Adenanthera pavonina, L.	(T) (C)	Mimosaceae
7.	Adhatoda vasica, Nees	(S) (N.O.)	Acanthaceae
8.	Allamanda cathartica, L.	(S) (C)	Apocynaceae
9.	Allophyllus cobbe, R. Br.	(T) (N.O.)	Sapindaceae
10.	Alstonia scholaris, L. R. Br.	(T) (N.O.)	Apocynaceae
11.	Anacardium occidentale, L.	(T) (C)	Anacardiaceae
12.	Artocarpus heterophyllus, Lamk.	(T) (C)	Moraceae
13.	Azadirachta indica, Juss.	(T) (C)	Meliaceae
14.	Bauhinia parpurea L.	(T) (C)	Caesalpiniaceae
15.	Bauhinia variegata, L.	(T) (C)	Caesalpiniaceae
16.	Barringtonia racemosa, (L) Spreng	(T) (N.O)	Myrtaceae
17.	Bombax ceiba, Mill	(T) (N.O)	Bombacaceae
18.	Bougainvillea spectabilis, Willd.	(S) (C)	Nyctaginaceae
19.	Bridelia retusa, Spreng	(T) (N.O)	Euphorbiaceae
20.	Bridelia scandens (Roxb.) Spreng.	(T) (N.O)	Euphorbiaceae
21.	Buchanania lanzan, Spreng	(T) (N.O)	Alacardiaceae
22.	Caesalpinia pulcherrima, Swartz	(T) (C)	Caesalpiniaceae
23.	Callicarpa tomentosa	(T) (N.O)	Verbenaceae
24.	Callistemon lanceolatus DC	(T) (C)	Myrtaceae
25.	Calycopteris floribunda Lamk	(S) (N.O)	Combretaceae

26.	Carica papaya, L.	(T)	(C)	Caricaceae
27.	Careya arborea, Roxb	(T)	(N.O)	Myrtaceae
28.	Cassia siamea Lamk.	(T)	(C)	Caesalpiniaceae
29.	Cassia fistula,	(T)	(C)	Caesalpiniaceae
30.	C. glauca Lamk	(T)	(C)	Caesalpiniaceae
31.	C. javanica L.	(T)	(C)	Caesalpiniaceae
32.	Casuarina equisetifolia L.	(T)	(C)	Casuarinaceae
33.	Clerodendrum thomsonae, Balf	(S)	(C)	Verbenaceae
34.	Cocos nucifera L.	(T)	(C)	Arecaceae
35.	Croton variegatum, BL.	(S)	(C)	Eurphorbiaceae
36.	Cordia sebestena L.	(T)	(C)	Boraginaceae
37.	Dalbergia sissoo, Roxb.	(T)	(C)	Fabaceae
38.	Delonix regia, Ratin	(T)	(C)	Caesalpiniaceae
39.	Emblica officinalis, L	(T)	(C)	Eurphorbiaceae
40.	Ervatamia coronaria, Stapt	(S)	(C)	Apocynaceae
41.	Ervatamia heyeana, (Wall) Cooke	(T)	(N.O)	Apocynaceae
42.	Erythrina indica Lamk.	(T)	(C)	Fabaceae
43.	E. stricta Roxb	(T)	(C)	Fabaceae
44.	Eucalyptus globulus, Labill	(T)	(C)	Myrtaceae
45.	Ficus benghalensis L.	(T)	(N.O)	Moraceae
46.	F. glomerata, Roxb	(T)	(N.O)	Moraceae
47.	F. asperrima Roxb.	(T)	(N.O)	Moraceae
48.	F. Rumphii, Blume	(T)	(N.O)	Moraceae
49.	F. elastica, Roxb	(T)	(C)	Moraceae
50.	Flacourtia montana, Graham	(T)	(N.O)	Flacourtiaceae
51.	Gmelina arborea, Roxb	(T)	(N.O)	Verbenaceae
52.	Grewia tiliaefolia, Vohl	(T)	(N.O)	Tiliaceae
53.	G. umbellifera, Bedd	(T)	(N.O)	Tiliaceae
54.	Hamelia patens, Jacq	(S)	(C)	Rubiaceae
55.	Helicteres isora L.	(T)	(N.O)	Sterculiaceae

56.	Heterophragma quadrangulare(Roxb)K.Schum	(T)	(N.O)	Bignoniaceae
57.	Hibiscus roseus, Thore	(S)	(C)	Malvaceae
58.	Holarrhena antidysenterica (Roth) DC	(S)	(N.O)	Apocynaceae
59.	Ichnocarpus frutescens (L) R.Br.	(S)	(N.O)	Apocynaceae
60.	Lannea coromandelica(Hout) Merr	(T)	(N.O)	Anacardiaceae
61.	Lawsonia enermis L.	(T)	(C)	Lythraceae
62.	Leucaena leucocephala, (Lampk) de Vit	(T)	(C)	Mimosaceae
63.	Lagerstroemia flos-reginae, Retz.	(T)	(C)	Lythraceae
64.	L. parviflora, Roxb.	(T)	(C)	Lythraceae
65.	L. thorelli, Gag.	(T)	(C)	Lythraceae
66.	Mallotus albus, auct.	(T)	(N.O)	Euphorbiaceae
67.	Mangifera indica, L.	(T)	(C)	Anacardiaceae
68.	Melia azedarach L.	(T)	(C)	Meliaceae
69.	Memecylon umbellatum, Burm	(S)	(N.O)	Melastomataceae
70.	Microcos paniculata, L.	(S)	(N.O)	Tiliaceae
71.	Millingtonia hortensis, L.	(T)	(C)	Bignoniaceae
72.	Mimusops elengi, L.	(T)	(N.O)	Sapotaceae
73.	Moringa eleifera Lamk.	(T)	(C)	Moringaceae
74.	Mussaenda frondosa L.	(S)	(C)	Rubiaceae
75.	Nerium odorum, Soland	(S)	(C)	Apocynaceae
76.	Ochna obtusta, Dc.	(S)	(N.O)	Ochnaceae
77.	Peltophorum pterocarpum, Dc. Backer	(T)	(C)	Caesalpiniaceae
78.	Phyllanthus reticulatus, Poir	(S)	(N.O)	Surphorbiaceae
79.	Pithecellobium dulce, Benth	(T)	(C)	Mimosaceae
80.	Plumeria rubra, L.	(T)	(C)	Apocynaceae
81.	Polyalthia longifolia, Lamk	(T)	(C)	Annonaceae
82.	Polyalthia longifolia L var pendula Lamk.			(T) (C)
83.	Psidium guajava, L.	(T)	(C)	Myrtaceae
84.	Quisqualis indica L.	(T)	(C)	Combretaceae
85.	Randia dumetorum, Lamk.	(S)	(N.O)	Rubiaceae

86.	R. uliginosa Dc.	(S)	(N.O)	Rubiaceae
87.	Rosa indica L.	(S)	(C)	Rosaceae
88.	Roystonea regia Cook.	(T)	(C)	Arecaceae
89.	Ceiba pentandra, Gaert.	(T)	(C)	Bombacaceae
90.	Samanea saman, Willd	(T)	(C)	Mimosaceae
91.	Sapium insigne, Benth	(T)	(N.O)	Euphorbiaceae
92.	Saraca indica, L.	(T)	(C)	Caesalpiniaceae
93.	Spathodeca campanulata, Beauv.	(T)	(C)	Bignoniaceae
94.	Sterculia urens. Roxb	(T)	(N.O)	Sterculiaceae
95.	Strychnos collubrina L.	(T)	(N.O)	Loganiaceae
96.	S. nux-vomica, L.	(T)	(N.O)	Loganiaceae
97.	Syzygium cumini, (L) Skeels	(T)	(N.O)	Myrtaceae
98.	Tabebuia argentea (B & S) Britt.	(T)	(C)	Bignoniaceae
99.	Tamarindus indica, L.	(T)	(C)	Caesalpiniaceae
100.	Terminalia arjuna. (Roxb) Wt. & Arn	(T)	(N.O)	Combretaceae
101.	T. bellirica, Gaert.	(T)	(N.O)	Combretaceae
102.	T. Catappa, L.	(T)	(C)	Combretaceae
103.	T. Paniculata, Roth	(T)	(N.O)	Combretaceae
104.	T. tomentosa, (D.C) Wt.	(T)	(N.O)	Combretaceae
105.	Thespesia populnea Soland	(T)	(C)	Malvaceae
106.	Thevetia peruviana Schum.	(S)	(C)	Apocynaceae
107.	Trema orientalis, (L) Br.	(T)	(N.O)	Ulmaceae
108.	Vinca rosea, L.	(S)	(C)	Apocynaceae
109.	Wagatea spicata, Dalz.	(S)	(N.O)	Caesalpiniaceae
110.	Ziziphus mauritiana, Lamk	(T)	(N.O)	Rhamnaceae
111.	Z. oenoplia, Mill	(S)	(N.O)	Rhamnaceae
112.	Z. rugosa, Lamk.	(S)	(N.O)	Rhamnaceae
113.	Z. Xylopyrus Sedgw	(T)	(N.O)	Rhamnaceae
114.	Annona reticulata L.	(T)	(C)	Annonaceae
115.	Garcina indica, Choiss	(T)	(N.O)	Clusiaceae

Table: 12b. List of herbaceous plant species found at case study "W".

Sr. No.	Taxon	Sr. No.	Taxon	Sr. No.	Taxon	Sr. No.	Taxon
1.	Abutilon indicum	23.	Crotalaria filipes	45.	L. cuspidata	67.	Sesamum mulayanum
2.	Acanthospermum hispidum	24.	Commelina attenuata	46.	L. prostrata	68.	Sesbania bispinosa
3.	Achyranthes aspera	25.	Dactyloctenium aegyptium	47.	Lepidagathis species	69.	Sida rhombifolia
4.	Alysicarpus bupleurifolius	26.	Desmodium triquetrum	48.	Ludwigia parviflora	70.	Smilax zeylanica
5.	Aerva lanata	27.	D. polycarpum	49.	Malvastrum coromandelianum	71.	Smithia conferta
6.	Aeschynomene aspera	28.	Dioscorea bulbifera	50.	Merremia emarginata	72.	Solanum nigrum
7.	Ageratum conyzoides	29.	Eriocaulon diannae	51.	M. tridentata	73.	Spermacoce hispida
8.	Alternanthera sessilis	30.	Euphorbia hirta	52.	M. vitifolia	74.	S. verticillatus
9.	Amaranthus viridis	31.	Euphorbia notoptera	53.	Mimosa pudica	75.	Tephrosia tinctoria
10.	Andrographis paniculata	32.	Evolvulus alsinoides	54.	Mussaenda laxa	76.	Ternanus labialis
11.	Anisochilus verticillatus	33.	Geissaspis tenella	55.	Naregamia alata	77.	Tricholepis glaberrima
12.	Atylosia scarabaeioides	34.	Hedyotis herbacea	56.	Neuracanthes sphaerostachyus	78.	Tridax procumbens
13.	Atylosia crassa	35.	Hemidesmus indicus	57.	Osbeckia truncata	79.	Urena lobata
14.	Canscora decurrens	36.	Heteropogon contortus	58.	Passiflora foetida	80.	Vernonia cinerea
15.	Canscora diffusa	37.	Hyptis suaveolens	59.	Phaseolus mungo	81.	Dioscorea wallichii
16.	Cassia absus	38.	Ipomoea sepiara	60.	Phyllanthus fraternus	82.	Impatiens kleinii
17.	Celosia argentea	39.	I. campanulata	61.	Physalis minima	83.	Cleome viscosa
18.	Chromolaena odorata	40.	Ischaemum conjugatum	62.	Portulaca oleracea		
19.	Cleome viscosa	41.	Iseilima laxum	63.	Rauvolfia serpentina		
20.	Clitoria ternatea	42.	Ixora coccinea	64.	Rungia linifolia		
21.	Crotalaria pallida	43.	Lantana camara	65.	R. pectinata		
22.	C. epunctata	44.	Lepidagathis cristata	66.	Russelia juncea		

Medium sized deciduous tree with crooked branches. Leaves characteristically two equal lobes, heart-shaped. Flowers purple-pink, in few flowered clusters at the end of branches, which appear in March-April when the leaves have fallen off.

Propagation: seeds sown in the monsoon. Seedlings appear in 7 - 10 days and are transplanted during rains. One of the trees which flowers in winter.

5. **Bombax ceiba** , L.Rao (1985)Fl. G.D.Dam. Dadr. and Nagarhav 1:44 .

A tall deciduous tree, butressed at base branches covered with stout, conical prickles, which are spreading. Leaves alternate, (5-7) digitate, bright green. Flowers crimson red , cup-shaped on branched terminals. Leafless at bloom. Fruit; ovoid capsule, which is angled. Seeds many, covered with soft silky cotton.

6. **Bridelia retusa** , Spr. Cooke (1906) Fl.Bombay 3:68.

Medium sized tree with woody thorns at the trunk base. Leaves numerous, obtuse,lanceolate, occasionally rounded at the apex. Flowers yellow-green, dioceous, crowded in dense axillary clusters. Fruits; drupe fleshy,purple-black with persistent calyx.

7. **Buchanania lanzan**, Spreng. Cooke (1903) Fl.Bombay 1:293.

Medium tree very frequent in the case study "W". Trunk straight, plant branches clothed with silky hair. Leaves alternate, thickly coriaceous, oblong, obtuse occasionally retuse. Flowers small (0.7 cms across) green-white.

Fruits; lentiform drupe with a hard stone seed.

8. **Cordia sebestena**, L. Cooke (1904) Fl. Bombay Pres.2:268.

A small tree 4-8 mts high, with rough coarse,ovate, elliptic leaves, 12-14 cms long, with abundant large sized showy scarlet flowers (Fig). Fruits; drupes, pure white when ripe , 3.7 x 1.8 cms. in size; (most abundant ornamental tree around case study " W " administration block) the species is a native of Cuba though ocassionally cultivated in many places in Goa (Fig.19b).

9. **Dalbergia sissoo** , Roxb. Cooke (1903 Fl.Bombay 1:421.

A tall straight, deciduous tree, up to 20 meters high. Bark greyish marked with short irregular cracks and peels of thin longitudinal flakes. Leaves compound alternate, divided into 5 to 7 rounded leaflets measuring 3-7 by 2-5 cms. Flowers white small in axillary clusters. Fruits; Pods flat, oblong, 1 to 4 seeded.

10. **Erythrina indica**, Lamk. Cooke (1903) Fl. Bombay 1:390.

Medium sized deciduous tree upto 20 mts. high. Upper portion of branches with small dark prickles. Leaves tri-foliate;leaflets triangular, middle terminal leaflets larger than the other two. Flowers crimson red on long stalk, often visited by noisy birds and insects (Fig.18c).

11. **Eucalyptus globulus**, Labill. Rao (1985) Fl. G.D.Dam.Dadr.& Nagarhav.1:170.

Evergreen aromatic tree, indigenous to Australia. Tallest trees of the genus are known to exceed 100 mts. in height. Hybrids are cultivated for their oil (from leaves and wood). Tall slender tree sparsely clothed with smooth, brown peeling bark. Leaves simple sickle shaped in a lateral plane, smooth, dull green. Flowers in drooping clusters at the ends of the branches.Fruits; conical with a flat cap.

12. **Lannea coromandelica**, (Hout) Merrill Syn. **Odina woodier** Roxb. Rao (1985) Fl.G.D.Dam.Dadr.& Nagarhav. 1:94.

Deciduous medium sized tree about 10 mts. high Stem, smooth, ash coloured. Masses of gum exudes from wounds of cracks. Leaves compound alternate. Flowers yellow-purple clustered; male and female alike. Fruit kidney shaped, red when ripe, 1 1/2 cm.. A handsome tree is full foliage and eyesore when leafless. It is the most abundant naturally occurring species in the case study " W ".

13. **Leucaena leucocephala**, (Lamk.) de Wit. Rao (1985) Fl. G.D.Dam.Dadr.& Nagarhav 1:156.

Medium sized sub-erect occasionally branching from the base. Leaves bipinnate,10-15 pairs. Flowers milky white in a globose spike at the terminal branches; profusely flowering and fruiting. Fruits papery, copper-brown pods measuring 12.5 by 1.8 cms. Seeds 12-20.

14. **Melia azedarach**, L. Cooke (1902) Fl. Bombay 1:218.

A fast growing semi-deciduous, moderate sized tree up to 13 mts. high. Bark grey-brown, marked with long shallow vertical fissures. Leaves alternate, tripinnate, bright green. Leaflets lens-shaped with toothed margin. Unequal at base. Flowers lilac, honey centered in long axillary panicles. Fruit: fleshy globular, with four tiny seeds in heart shaped.

Indigenous to Baluchistan, but naturalized all over India and to many tropical countries. Several forms of the tree are reported varying in size and colour (Bole and Vaghani, 1986).

15. **Peltophorum pterocarpum**, (DC) Backer. Rao (1985) Fl. G.D.Dam.Dadr.& Nagarhav 1:149.

A large semi-evergreen tree up to 30 mts. high with grey smooth bark. Leaves: bipinnate dark green 30 cms long with 15-20 pairs of leaflets, each with 20-30 pinnae, which are semideciduous. Flowers pyramid shaped, clustered, pale-yellow, fragrant, rather irregular. Fruits: brown copper, pods persistent on the tree, throughout the year. A fairly fast growing tree. Propagated from seed and cutting.

16. **Polyalthia longifolia** , (Sonner) Tw. Enum. Rao (1985) Fl.G.D.Dam.Dadr.& Nagarhav 1:5.

A tall handsome evergreen tree, branches glabrous, slender. Leaves membranous, narrowly lanceolate, tapering to a fine point,with undulating margins. Flowers: 2.5 cm across, yellow-green, star shaped, in fascicles, umbellate. Fruits: egg-shaped, drupe about 1.8 cm long.

E X P L A N A T I O N   O F   P L A T E

Photographs of some ornamental cultigens found at case study "W"

Fig 17a. _Roystonea regia_ (royal palm) and _Polyathia longifolia_ var _pendula_ at the background whole plant close to the nursery and guest house.

Fig 17b. _Spathodea campanulata_ (African tulip) showing flowering portion at the recreation club area.

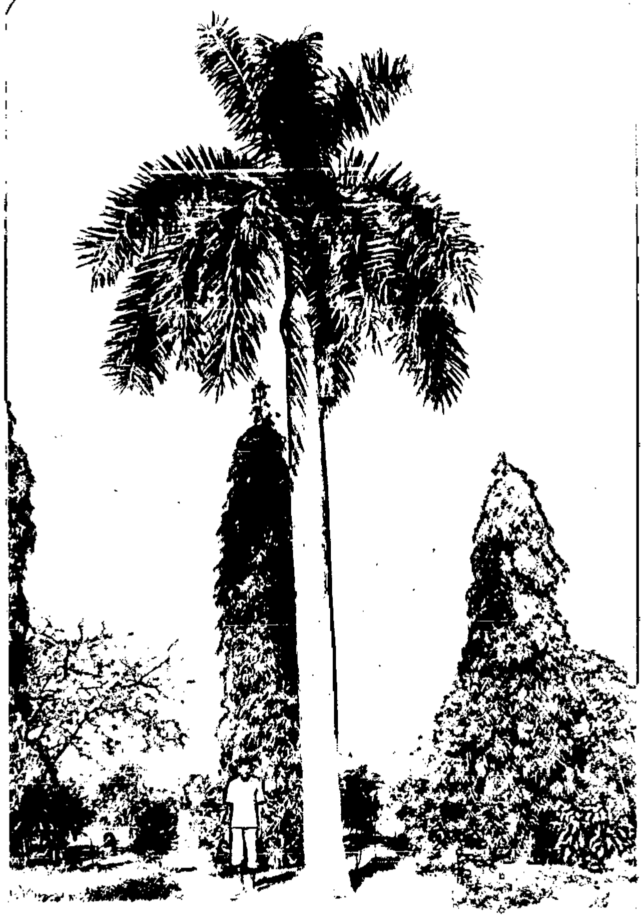


Fig. 17a

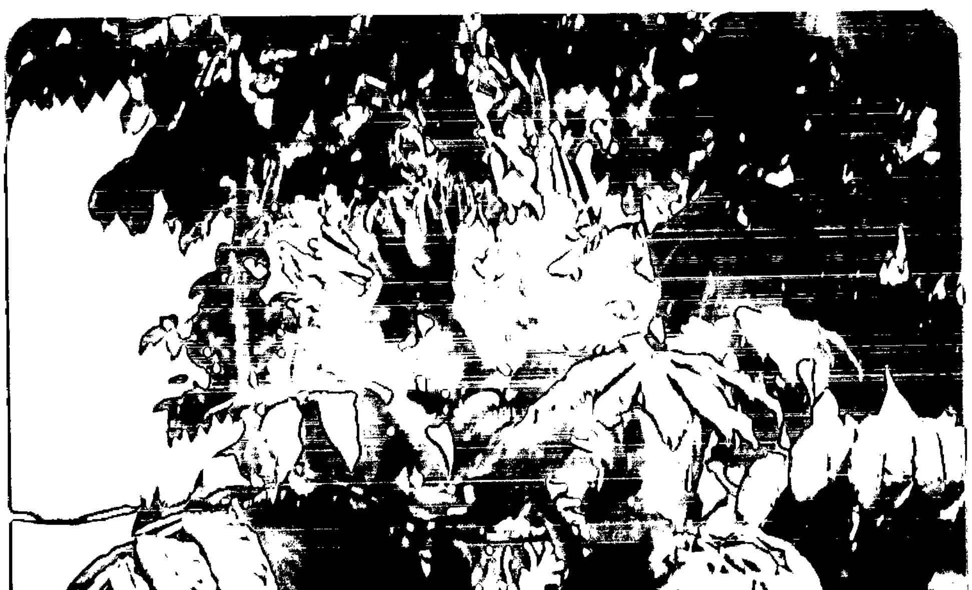


Fig. 17b

Seeds orbicular-ovoid, shiny.

17. **Polyalthia longifolia**, (Sonner) Thw. Var pendula.

Considered scared and often planted near temples. Its habit is the same as former species except the branches are drooping. Propagated by seeds sown in the heavy monsoon rainfall.

The tree gives a very good protection from sun heat, dust and acts as a wind-breaker. Excellent tree for border planting in parks and homes. Proper spacing is required (4.5 mts. apart) for better growth performance.

18. **Roystonea regia**, C. F. Cook. Bole and Vaghani (1985) Field guide to common trees of India.

One of the stateliest of all palms reaching up to 20 mts. height and 0.6 m in diameter at base. Somewhat thickened towards the upper middle portion giving a tree a bottle shape appearance. Trunk smooth light grey with ring like markings. Leaves feathery 2-4 mts. long, similar to those coconut palms; the difference lies in the basal sheath which is tubular and much larger. Flowers in 3-4 clusters enclosed by two white, boat shaped spathes. Male flower longer than female flower. Fruits: egg-shaped. A native of West Indies commonly planted in parks and gardens. A graceful avenue tree (Fig.17 a).

19. **Samanea saman**, Merrill. Syn **Entherolobium saman** Prain. Bole & Vaghani, (1985) Field Guide to common trees of India.

A large deciduous tree about 18 mts. high with canopy of 20-25 mts. Leaves bipinnate dark green up to 35 cm long leaflets 8-10 pairs opposite, oblique. Leaves shade early in the cold season for a short time. Flowers in globose heads, white-pink. Fruits: Pods, straight, papery flattened smooth. A native of Brazil. Cultivated as an ornamental.

Easily propagated by seed sown in rainy season. Can also be

EXPLMNATION OF PLATE

Photographs of some cultigens found at case study "W"

Fig 18a. Saraca indica (Ashoka plant) showing flowering portion.

Fig 18b. Sesbania grandiflora (Agathi plant) showing flowering portion.

Fig 18c. Erythrina indica (Indian coral tree) showing flowering portion, the species is completely leafless at bloom.

Fig. 18a.

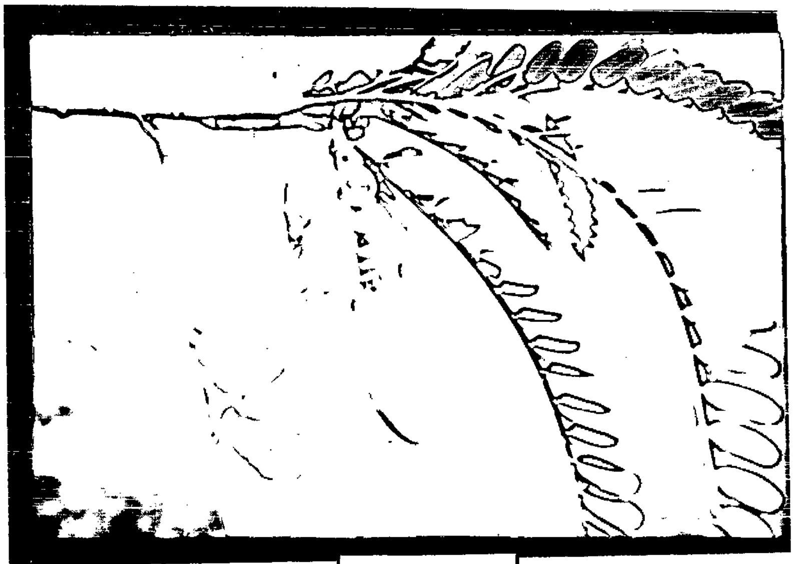


Fig. 18b.

Fig. 18c.

propagated by cuttings. It is a fast growing plant species. NB:Extremely gigantic specimen are found along all approach roads to the major towns of Goa viz. Panaji, Margao, Vasco,Mapusa, and Ponda which offer a dense shade cover.

20. **Saraca indica**, (Roxb)L.Cooke(1903)Fl. Bombay 1:456.

A medium sized evergreen tree up to 10 mts. height, with a warty surfaced trunk.

Leaves paripinnate with 4-6 leaflets. Oblong lanceolate gracefully pendate, copper coloured when young. Flowers in dense panicles, scarlet orange often arising from the upper stem portion. Fruits: flat pods 15 by 4 cm, leathery with 2-5 compressed seeds.It is can be propagated easely by seeds and cuttings (Fig.18a).

21. **Sterculia urens**, Roxb. Cooke (1901) Fl. Bombay 1:131.

A medium tree sized about 10 mts high with powdery, papery exfoliating bark. The tree is leafless in cold season and, the whitish bark gives it a grotesque appearance. Leaves 5-lobed with velvet touch. Flowers: light yellow with purple throat , star-shaped, odouriferous. Fruits: woody, crimson, with bristly stinging hair.

22. **Tabebuia argentea**, (B & S) Britt.

Small to medium sized tree with digitate alternate leaves. Flowers large, funnel-shaped arranged in groups on a common peduncle (Fig 19a) and beautiful pale mauve colour. Fruits: is a capsule terminated by a persistent style. Seeds flat, winged.

A native of mexico, the species is found suitable in a wide range of habitats. Propagation can be done by seeds during the monsoon.

23. **Terminalia paniculata**, Roth. Cooke (1903) Fl. Bombay 1:510.

Medium sized tree, quite frequent on the slopes of " W ". Leaves subopposite, oblong-lanceolate, shortly acuminate roundcordate with sessile glands at base beneath. Flowers pale white, on branched spikes. Fruits: brown-red, unequally 3-winged, densely crowded on the

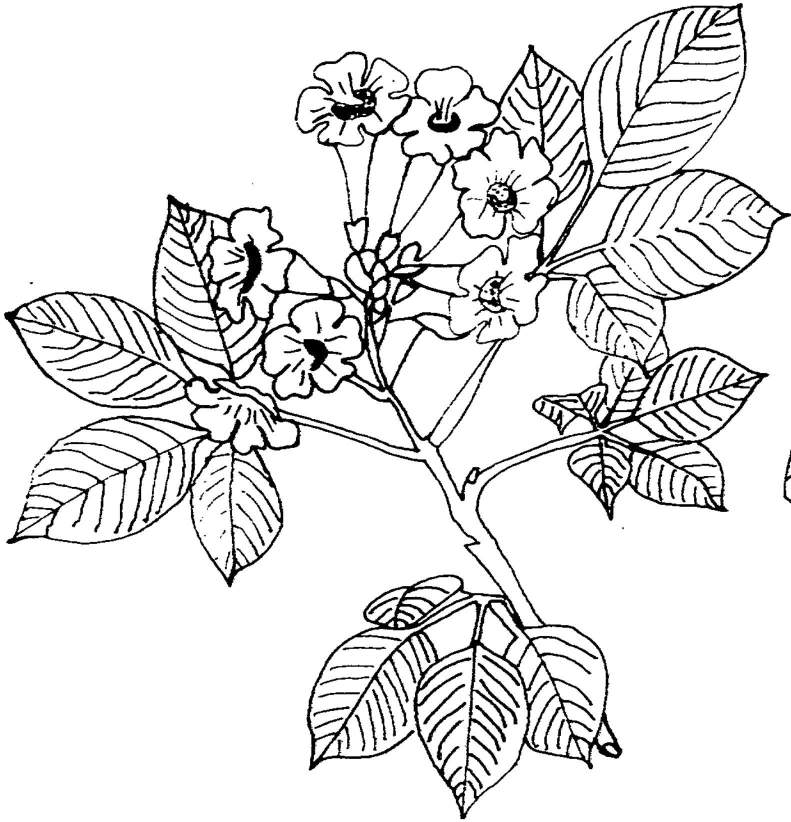


Fig 19a. *Tabebuia argentea* (B.&Schum) Br.

A flowering twig.

Fig 19b. *Cordia sebestena* L.

A flowering twig.

Some cultivated plant species found at case study " W " terminal branches, giving the tree brown-red colour.

24. **Trema orientalis**, Blume. Cooke (1907) Fl. Bombay 3:129.

Small trees almost evergreen reaching 10 mts. in height. Trunk straight. Leaves oblique with an elongated point, margin serrate, rough above pubescent below . Flowers small, monoecious or dioecious, in clusters, light green. Fruits: round 0.5 cm in diam., black.

25. **Ziziphus mauritiana**, (Lamk.) Rao(1985) Fl.G.D.Dam.Dadr.& Nagarhav.1:80.

A small evergreen tree, variable in size up to 10 mts. in height. Leaves variable oblong elliptic, ovate, serrate with 2 stipular spines, one of which is hooked. Flowers small, green-yellow. Fruits: drupe with one hard seed.

26. **Ervatamia heyneana**, (Wall.) Cooke,(1904)Fl.Bombay 2:134.

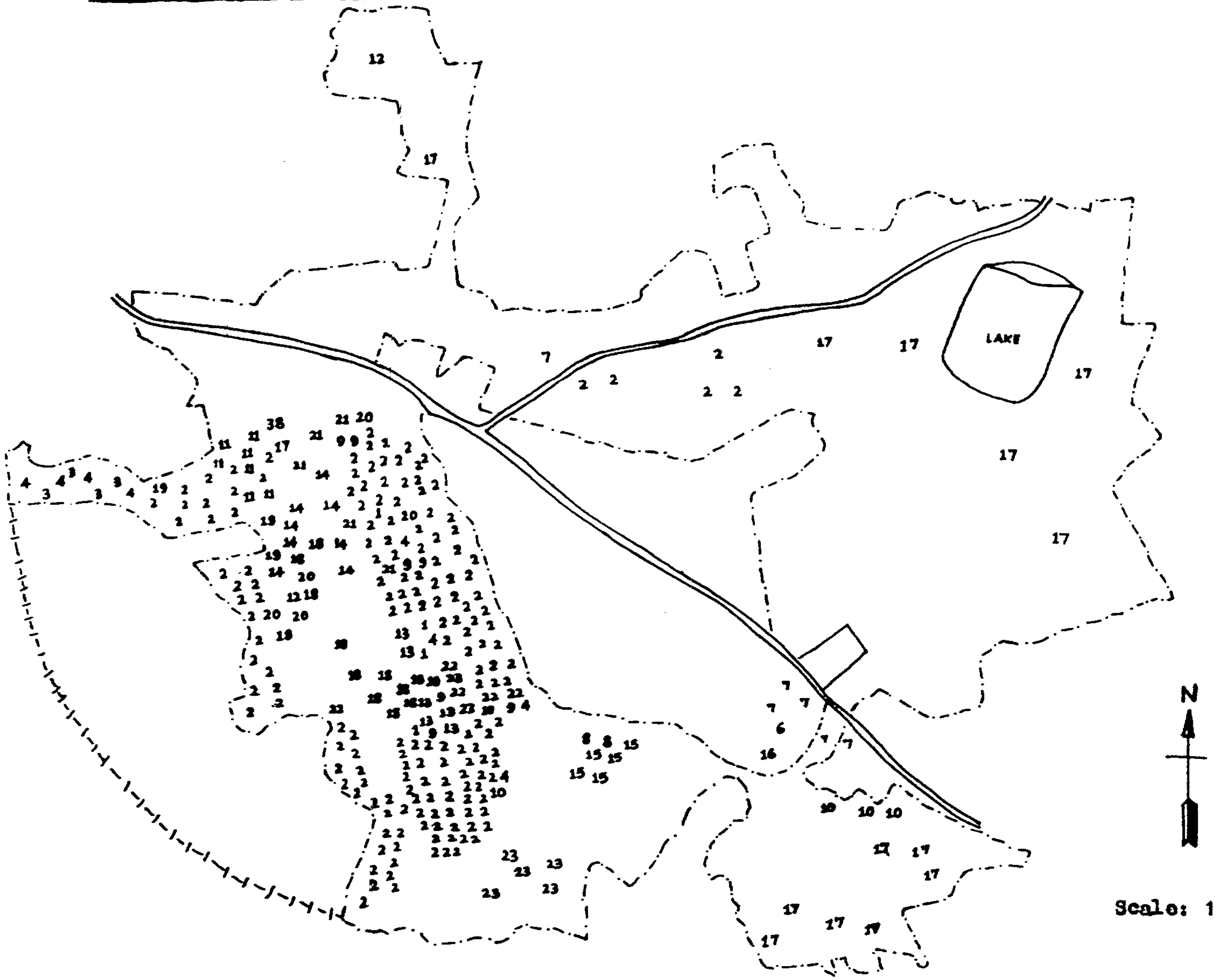
A shrub becoming a small tree under the favourable conditions.Stem bark rough. Leaves light green coriaceous oblonglanceolate, shortly acuminate glabrous. Flowers of many peduncled cymes,rotate,white; corolla lobes overlapping to the right. Fruit: of paired follicles, orange-yellow when ripe, curved and subsessile. Seeds long surrouded by red pulp. It is among the most common species in the case study " W ".

Distribution maps have been prepared to show the actual locality of the taxon in the case study area.

Table:13. List of common lithophytes at case study "W" area

Taxon	Nature of propagation
1. **Alstonia scholaris** (L) R. Br.	Seeds & shoots
2. **Sterculia urens** Roxb.	Seeds & shoots
3. **Bombax ceiba** Mill.	Seed
4. **Careya arborea** Roxb.	Seed
5. **Ficus rumphii** Blume	Shoots & stumps
6. **Ficus benghalensis** L.	shoots & stumps
7. **Lannea coromandelica** (Hout.) Merr.	Shoots & seeds

TAXON DISTRIBUTION AT "W" COMPOUND.



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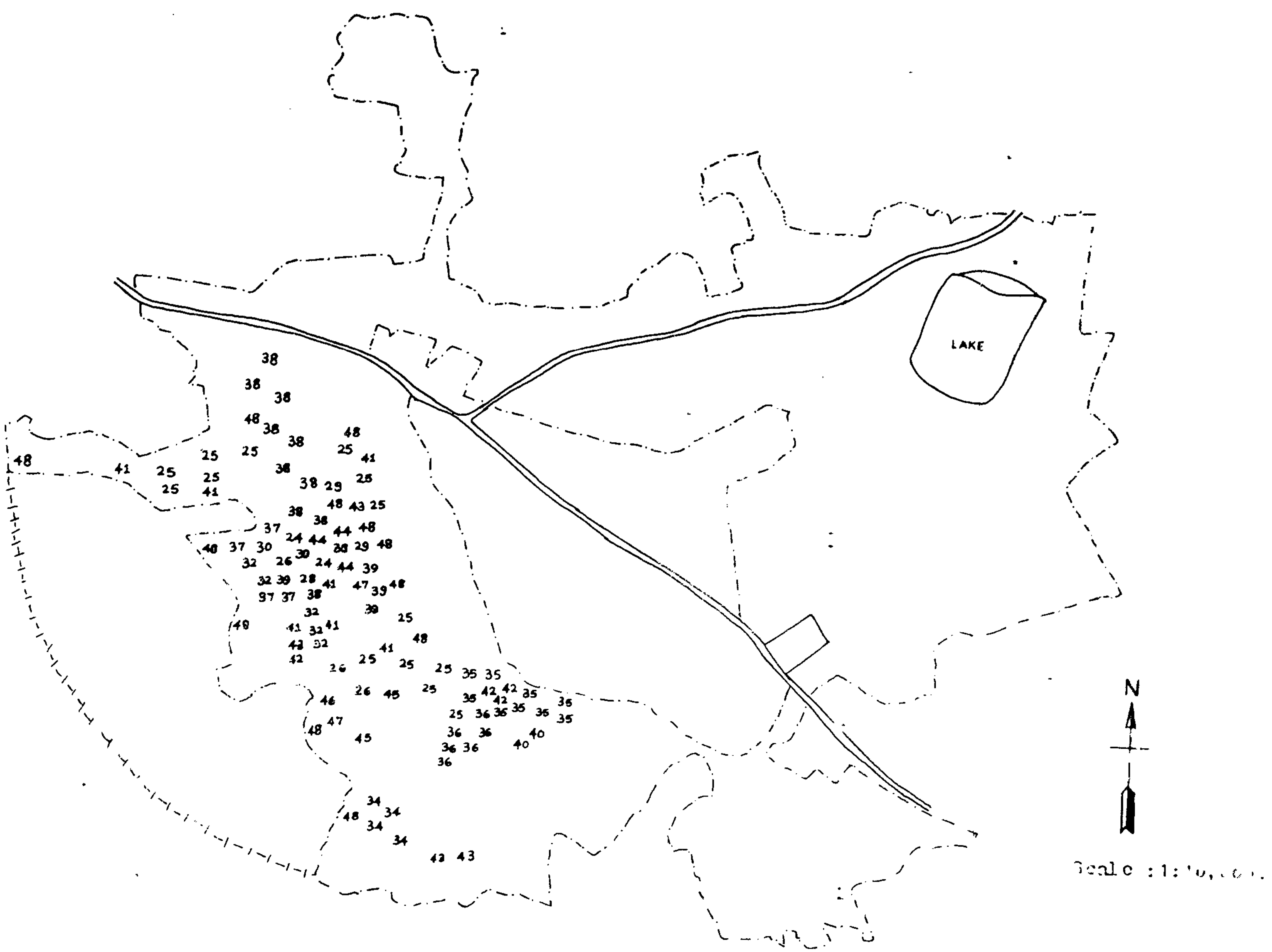
EXPLANATION OF PLATE

Taxon on distribution map of important plant species at case study "W".

Sr. No. on Map	Taxon
1.	*Abrus precatorius* L.
2.	*Acacia auriculiformis*
3.	*Acacia arabica* Willd.
4.	*Acacia chundra* Roxb.
5.	*Achras sapota* L.
6.	*Adenanthera pavonina* L.
7.	*Adhatoda vasica* Nees.
8.	*Allamanda cathartica* L.
9.	*Allophylus cobbe* R. Br.
10.	*Alstonia scholaris* (L.) R. Br.
11.	*Anacardium occidentale* L.
12.	*Artocarpus heterophyllus* Lam.
13.	*Azadirachta indica* Juss.
14.	*Bauhinia purpurea* L.
15.	*Bauhinia variegata* L.
16.	*Barringtonia racemosa* (L.) Spreng.
17.	*Bombax ceiba* Mill.
18.	*Bougainvillea spectabilis* Willd.
19.	*Bridelia retusa* Spreng.
20.	*Bridelia scandens* (Roxb) Spreng.
21.	*Buchanania lanzan* Spreng.
22.	*Caesalpinia pulcherrima* Swartz.
23.	*Callicarpa tomentosa* Murr.

TAXON DISTRIBUTION AT "W" COMPOUND -GOA.



EXPLANATION OF PLATE

Taxon on distribution map of important plant species at case study "W".

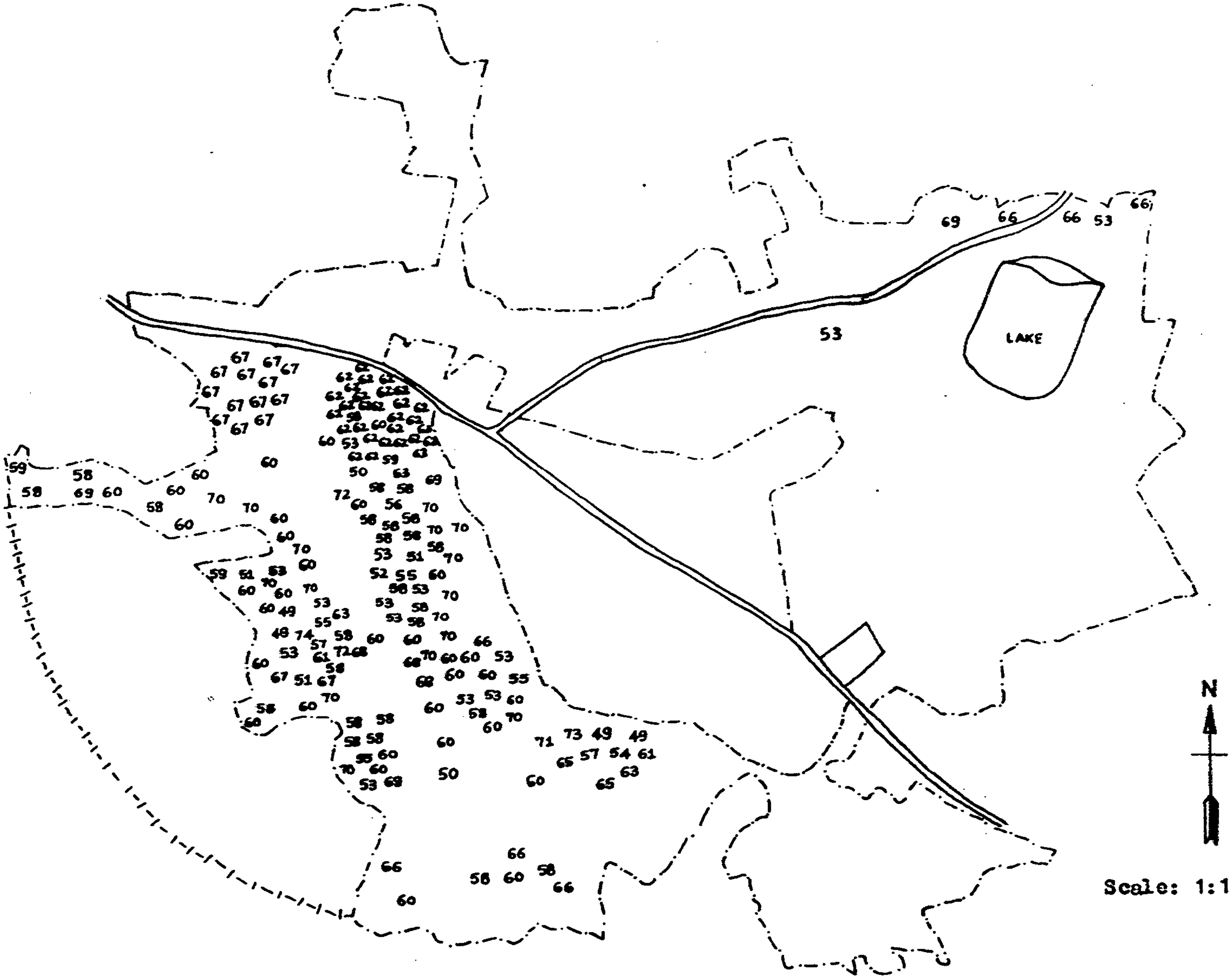
Sr. No. on Map	Taxon
24.	*Callistemon lanceolatus* DC.
25.	*Calycopteris floribunda* (Roxb.) Poir.
26.	*Carica papaya* L.
27.	*Careya arborea* Roxb.
28.	*Cassia angustifolia* Vahl.
29.	*Cassia fistula* L.
30.	*Cassia glauca* Lam.
31.	*Cassia javanica* L.
32.	*Casuarina equisetifolia* L.
33.	*Clerodendrum thomsonae* Balf.
34.	*Cocos nucifera* L.
35.	*Codiaeum variegatum* Bl.
36.	*Cordia sebestena* L.
37.	*Dalbergia sissoo* Roxb.
38.	*Delonix regia* Ratin.
39.	*Emblica officinalis* L.
40.	*Ervatamia coronaria* Stapf.
41.	*Ervatamia heyneana* (Wall) Cooke.
42.	*Erythrina indica* Lam.
43.	*Erythrina strictus* Roxb.
44.	*Eucalyptus globulus* Labill.
45.	*Ficus benghalensis* L.
46.	*Ficus glomerata* Roxb.
47.	*Ficus asperrima* L.
48.	*Ficus rumphii* Blume.

E X P L A N A T I O N O F P L A T E

Taxon on distribution map of important plant species at case study "W".

Sr. No. on Map	Taxon
49.	*Ficus elastica* Roxb.
50.	*Flacourtia montana* Graham.
51.	*Gmelina arborea* Roxb.
52.	*Grewia tiliaefolia* Vahl.
53.	*Grewia umbellifera* Bedd.
54.	*Hamelia patens* Jacq.
55.	*Helicteres isora* L.
56.	*Heterophragma quadrangularis*
57.	*Hibiscus roseus* Thore.
58.	*Holarrhena antidysenterica* (Roth) DC.
59.	*Ichnocarpus frutescens* (L) R.Br.
60.	*Lannea coromandelica* (Hout.) Merr.
61.	*Lawsonia alba* L.
62.	*Leucaena leucocephala* (Lam.) de Wit.
63.	*Lagerstroemia speciosa* (L.) Pers.
64.	*Lagerstroemia parviflora* Roxb.
65.	*Lagerstroemia thorelli* Gag.
66.	*Macaranga peltata* Muell.
67.	*Mangifera indica* L.
68.	*Melia azadirachta* L.
69.	*Memecylon umbellatum* Burm.
70.	*Microcos paniculata* L.
71.	*Millingtonia hortensis* L.
72.	*Mimusops elengi* L.
73.	*Moringa oleifera* Lam.
74.	*Mussaenda frondosa* L.

TAXON DISTRIBUTION AT "W" COMPOUND - GOA.



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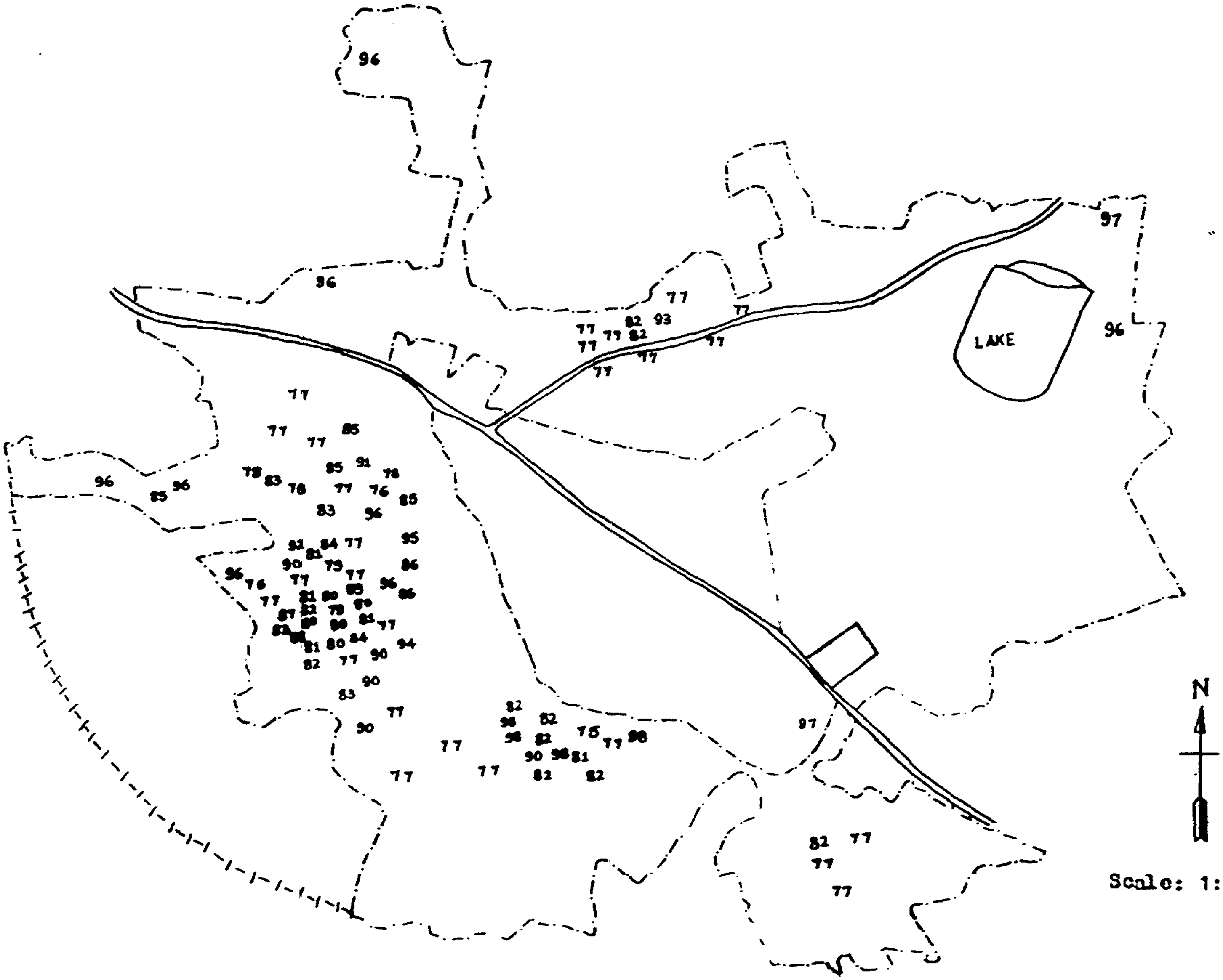
TAXON DISTRIBUTION AT "W" COMPOUND - GOA.



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E X P L A N A T I O N   O F   P L A T E

Taxon on distribution map of important plant species at case study "W".

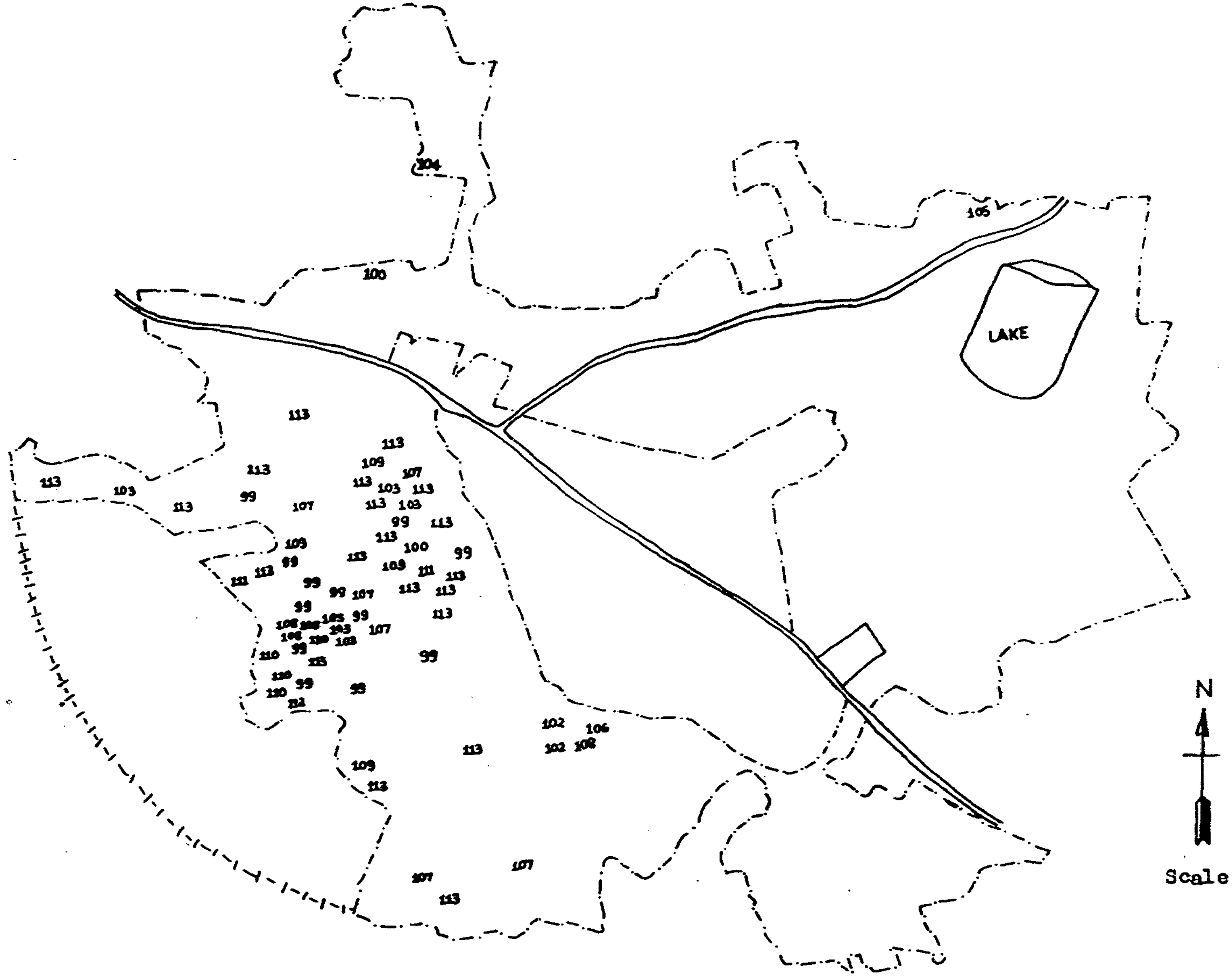
Sr. No. on Map	T a x o n
75.	*Nerium odorum* Soland.
76.	*Ochna obtusata* DC.
77.	*Peltophorum pterocarpum* (DC) Backer.
78.	*Phyllanthus reticulatus* Poir.
79.	*Pithecellobium dulce* Benth.
80.	*Plumeria rubra* L.
81.	*Polyalthia longifolia* Lam.
82.	*Polyalthia Longifolia* Var pendula.
83.	*Psidium guajava* L.
84.	*Quisqualis indica* L.
85.	*Randia dumetorum* Lam.
86.	*Randia uliginosa* DC.
87.	*Rosa indica* L.
88.	*Roystonea regia* Cook.
89.	*Ceiba pentandra* Gaert.
90.	*Samanea saman* Willd.
91.	*Sapium insigne* Benth.
92.	*Saraca indica* L.
93.	*Spathodea campanulata* Beauv.
94.	*Sterculia urens* Roxb.
95.	*Strychnos collubrina* L.
96.	*Strychnos nux-vomica* L.
97.	*Syzygium cumini* (L) Skeels.
98.	*Tabebuia argentea* (B & S) Britt.

EXPLANATION OF PLATE

Taxon on distribution map of important plant species at case study "W".

Sr. No. on Map	Taxon
99.	Tamarindus indica L.
100.	Terminalia arjuna (Roxb.) Wt & Arn.
101.	T. bellerica Gaert.
102.	T. catappa L.
103.	T. paniculata Roth.
104.	T. tomentosa (D.C) Wt. & Arn.
105.	Thespesia populnea Soland.
106.	Thevetia peruviana Schum.
107.	Trema orientalis (L) Br.
108.	Vinca rosea L.
109.	Wagatea spicata Dalz.
110.	Ziziphus mauritiana Lam.
111.	Ziziphus oenoplia Mill.
112.	Ziziphus rugosa Lam.
113.	Z. xylophyrus Lam.

TAXON DISTRIBUTION AT "W" COMPOUND - GOA.



Scale:1:10,000.

b) Species diversity

The study of plant species diversity at case study "W" reveals that the total number of trees and shrubs was 97, the total number of trees is 50; the indigenous being, 26 and 24 exotics.

The total plant species diversity at case study "W" was 179

2.4.2. Quantitative analysis

A total of five hundred and ninety six quadrats were sampled out of which represented the entire area where vegetation existed at the case study " W " area. Ground truth data on some of the areas botanically surveyed is given in the table 14 a,b.c,d,and e.

Plants species with highest frequency were Ziziphus xylopyrus Lannea coromandelica, Holarrhena antidysenterica, Calycopteris floribunda, Ziziphus rugosus, Acacia chundra, Ervatamia heyneana, and Microcos paniculata.

Species with the highest dominance were found to be Trema orientalis, Holarrhena antidysenterica, Ficus asperrima, Acacia chundra, Artocarpus heterophyllus, Helicteres isora and Heterophragma quadriloculare.

Maximum density was noted in Ziziphus xylopyrus, Holarrhena antidysenterica, Acacia chundra, Ficus asperrima, Lannea coromandelica, Microcos paniculata and Ervatamia heyneana.

Table :14. Ground truth data of some quadrats sampled in the case study "W".

Unit Area: 30.5m x 30.5m.

N.B: N.V. means no vegetation was found in the specific quadrats .

Table 14 a Ground truth data for quadrats sampled on the left hand side of the road close to the third gate. Total No. of Quadrats sampled = 36.

Sr. No.	Taxon Quadrat No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	29 to 36
1.	Anacardium occidentale	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	3	2	-	1	1	1	---
2.	Bridelia scandens	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13	-	-	6	---
3.	Buchanania lanzan	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	---
4.	Calycopteris floribunda	-	8	-	-	2	-	2	-	-	-	-	-	3	2	-	2	-	-	-	-	-	3	---
5.	Careya arborea	2	3	-	-	-	-	2	1	-	-	4	-	3	-	-	-	-	-	1	2	2	-	---
6.	Delonix regia	-	-	3	3	2	-	-	-	-	2	3	-	-	-	-	3	3	-	-	-	13	-	---
7.	Ervatamia heyneana	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-	---
8.	Eucalyptus globulus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	---
9.	Ficus rumphii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1
10.	Grewia umbellifera	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	---
11.	Mangifera indica	-	-	8	5	7	20	-	-	20	15	10	22	-	-	14	8	8	13	-	10	27	-	10 ± 5
12.	Peltophorum pterocarpum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2 ± 2
13.	Randia dumetorum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	---
14.	Samanea saman	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	---
15.	Terminalia paniculata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	---
16.	Ziziphus rugosa	-	-	3	-	-	-	-	1	-	-	4	-	-	-	1	-	1	-	-	-	-	2	2 ± 1
17.	Ziziphus Xylophyra	-	-	1	2	2	1	-	-	-	-	-	-	3	1	-	-	-	-	-	-	1	-	---
18.	Holarrhena antidysenterica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20	---

Table: 14 b. Ground truth data for quadrats sampled from left hand side bordering the nursery adjacent to the colony road. total no. of quadrats sampled = 46.

Sr. No.	Taxon Quadrat No.	1 TO 18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34 TO 46
1.	Acacia auriculiformis	35 ± 6	4	45	-	4	25	-	50	39	36	40	66	96	52	122	28	31.0 ± 5
2.	Acacia chundra	--	3	4	-	-	-	-	-	-	-	-	-	7	-	-	-	--
3.	Bridelia retusa	--	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	--
4.	Bridelia scandens	--	-	-	-	-	-	-	-	-	-	-	1	3	-	1	-	--
5.	Bougainvillea spectabilis	--	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	--
6.	Calycopteris floribunda	--	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	--
7.	Careya arborea	--	2	-	-	-	-	-	-	-	-	-	-	-	1	-	-	--
8.	Delonix regia	--	-	-	-	-	-	-	-	-	-	-	-	5	-	-	3	--
9.	Dalbergia sissoo	--	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	--
10.	Ervatamia heyneana	1 ± 1	2	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-
11.	Eucalyptus globulus	--	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	--
12.	Ficus rumphii	1 ± 1	3	6	-	-	3	5	-	-	-	-	-	2	-	-	-	--
13.	Flacourtia montana	--	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	--
14.	Holarrhena antidysenterica	--	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	--
15.	Ixora coccinea	1 ± 1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	--
16.	Lannea coromandelica	2 ± 1	6	1	-	-	-	-	-	-	-	-	3	1	-	-	-	--
17.	Leucaena leucocephala	--	-	-	-	-	1	2	-	-	-	-	3	1	-	-	2	--
18.	Microcos paniculata	--	2	-	-	2	5	9	9	-	-	5	-	-	6	-	-	--
19.	Peltophorum pterocarpum	--	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	--
20.	Randia dumetorium	--	-	-	-	-	-	-	-	-	-	-	-	3	-	-	1	--
21.	Samanea saman	--	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	--
22.	Tamarindus indica	--	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	--
23.	Zizyphus rugosa	1 ± 1	1	-	-	-	-	-	-	-	-	-	-	1	-	3	-	--

Table: 14 c. Ground truth data for quadrats sampled from the L.H.S. of the Road to the officer's Bungalow. Total no. of quadrats sampled = 43.

Sr. No.	Taxon Quadrat No	1 to 6	7	8	9	10	11	12	13	14	15	16 to 31	32	33	34	35	36	37	36	37	38	39	40	41 to 43
1.	Acacia auriculiformis	7.8.0 ± 7	90	80	75	180	78	55	35	40	48	31 ± 5	-	23	8	-	-	-	-	-	-	25	-	---
2.	Acacia chundra	---	-	-	-	-	3	2	-	5	6	---	-	-	-	-	-	-	-	-	-	-	-	---
3.	Bridelia retusa	---	-	-	-	4	-	-	-	-	-	---	-	-	-	-	4	-	-	-	-	-	-	---
4.	Buchanania lanzan	---	-	2	1	-	-	-	-	-	-	---	-	-	-	-	-	-	-	-	-	-	-	---
5.	Careya arborea	---	-	-	-	1	-	-	-	1	1	---	-	-	-	-	-	-	-	-	-	-	-	---
6.	Ervatamia heyneana	1 ± 1	-	-	-	-	-	-	-	-	-	---	-	-	-	-	-	-	-	-	-	-	-	---
7.	Ficus rumphii	2 ± 1	-	-	-	-	-	1	-	1	-	---	-	-	-	-	-	-	-	-	-	-	-	---
8.	Grewia umbellifera	---	-	2	-	4	-	-	-	2	2	---	-	-	2	3	-	2	-	3	5	2	2	1 ± 1
9.	Holarrhena antidysenterica	---	40	30	20	10	38	50	15	25	20	---	-	-	-	-	-	-	-	-	-	-	-	---
10.	Leucaena leucocephala	2 ± 1	1	-	-	-	6	-	5	-	-	1 ± 1	-	1	-	-	-	8	-	4	-	2	-	---
11.	Lannea coromandelica	1 ± 1	1	-	-	-	-	1	1	12	4	2 ± 1	-	-	-	-	6	-	-	-	-	-	-	1 ± 1
12.	Microcos paniculata	1 ± 1	-	-	-	-	-	-	-	-	-	---	80	-	-	-	-	-	-	-	-	-	-	---
13.	Mangifera indica	---	-	-	-	-	-	-	2	1	2	---	-	-	-	-	1	3	-	-	-	2	-	3 ± 1
14.	Peltophorum pterocarpum	3	-	-	-	-	-	-	-	-	-	4 ± 1	-	-	-	-	-	-	-	-	-	-	-	---
15.	Polyalthia Longifolia	1 ± 1	-	-	-	-	-	-	-	-	-	---	-	-	-	-	4	-	-	-	-	2	-	---
16.	Randia dumetorium	1 ± 1	-	-	-	-	-	-	-	-	-	---	-	-	-	-	-	1	-	-	-	-	-	---
17.	Sterculia urens	1 ± 1	-	-	-	1	-	2	-	-	-	---	-	-	-	-	-	-	-	-	-	-	-	---
18.	Terminalia paniculata	---	-	-	-	-	-	-	-	-	-	---	-	-	-	-	-	-	-	-	-	-	-	---
19.	Tamarindus indica	4 ± 1	10	-	5	-	-	-	-	-	-	3 ± 2	-	-	-	10	9	6	2	-	4	3	-	---
20.	Trema orientalis	---	1	-	-	-	-	-	-	-	-	---	-	-	-	-	-	-	-	-	-	-	-	---

Table : 14 d. Ground truth data for quadrats sampled at the fenced area of the nursery on the L.H.S. of the road entering the guest house close to private property on the right hand side of the road from the third gate. Total no. quadrats sampled = 44.

Sr. No.	Taxon	1	2	3	4	5 to 7	8	9	10	11 to 15	16	17	18	19	20 to 31	32	33	34	35	36	37	38	39	40	41	42	43	44
1.	Abrus precatorius	-	-	-	-	---	-	-	-	N.V.	-	-	-	-	---	-	-	1	-	3	-	2	-	1	-	1	3	-
2.	Acacia auriculiformis	11	23	25	34	60 ± 5	40	4	3	---	16	4	40	38	23 ± 4	20	29	11	3	38	30	53	16	10	-	-	-	-
3.	Acacia Chundra	-	-	-	-	---	-	-	-	---	-	-	-	-	---	-	-	-	2	8	8	-	-	-	-	-	-	-
4.	Anacardium occidentale	27	6	8	15	4	12	2	2	N.V. ---	5	5	-	14	2	-	4	2	2	8	8	5	8	15	5	5	20	-
5.	Bauhinia variegata	-	-	-	-	---	-	-	-	---	-	-	-	2	2	-	-	-	-	-	-	-	-	-	-	10	6	-
6.	Bridelia retusa	10	10	3	4	2	-	-	-	---	2	-	-	-	2	5	2	-	9	-	1	4	-	-	-	-	-	-
7.	Bridelia scandens	-	-	-	2	---	-	-	-	---	-	-	-	-	---	-	2	3	2	-	-	-	1	2	-	-	-	-
8.	Bougainvillea spectabilis	4	2	-	3	---	2	3	-	---	3	-	-	-	---	-	-	-	-	-	-	-	2	-	-	-	6	-
9.	Buchanania lanzan	4	-	-	-	1	-	-	-	---	1	-	3	-	---	-	5	-	6	7	2	3	-	1	-	-	-	-
10.	Bombax ceiba	7	1	-	1	---	2	-		---	-	3	-	-	---	-	-	1	-	2	-	-	-	1	-	-	-	1
11.	Careya arborea	2	4	-	-	---	3	-	1	---	-	-	-	4	---	2	3	-	-	-	-	-	1	1	2	-	3	-
12.	Cassia glauca	-	-	-	-	---	2	1	-	---	-	-	-	-	---	-	-	-	-	-	-	-	-	-	-	-	-	-
13.	Calycopteris floribunda	7	5	4	5	3	3	1	2	---	-	1	5	-	5	4	-	12	10	7	5	6	-	11	3	4	-	-
14.	Calli stemon lanceolata	-	-	-	-	---	25	12	-	---	-	-	-	-	---	-	-	-	-	-	-	-	-	-	-	-	-	-
15.	Delonix regia	6	-	-	3	3	4	8	-	---	1	1	-	5	---	-	5	15	-	-	-	5	6	-	1	-	-	-
16.	Dalbergia sissoo	-	-	-	-	---	-	-	-	---	-	-	-	-	---	-	-	-	-	-	-	-	-	-	10	7	-	-
17.	Ervatamia heyneana	3	3	3	-	4	3	-	-	---	-	3	3	6	2	3	2	9	8	5	1	2	-	-	4	5	3	-
18.	Ficus rumphii	6	-	2	3	---	-	2	-	---	1	2	-	-	---	1	1	3	6	-	-	-	-	-	4	10	3	-
19.	Grewia umbellifera	4	8	4	10	---	3	3	-	---	-	-	-	3	---	-	2	-	4	4	5	4	3	-	2	-	-	-
20.	Holarrhena antidysenterica	-	-	6	-	---	-	-	-	---	-	-	-	7	---	-	-	-	10	8	12	-	-	-	-	10	8	-
21.	Lannea coromandelica	1	3	3	1	3	2	-	1	---	2	3	1	5	---	2	2	4	10	5	8	-	2	-	3	3	3	3

Table: 14 e. Ground truth data for quadrats on the R.H.S. of the road; 2nd gate entrance to the factory. total no. of quadrats sampled = 74.

Sr. No.	Taxon	1 to 20	21	22	23 to 49	50 to 55	56	57	58	59	60	61	62	63	64	65	66	67	68	69 to 74
1.	Acacia auriculiformis	50 ± 8	90	150	---	60 ± 6	45	-	-	-	-	-	-	-	-	-	-	-	-	---
2.	Acacia chundra	---	31	15	---	2 ± 1	-	-	-	-	2	-	-	-	2	-	4	-	2	6 ± 3
3.	Alstonia scholaris	---	-	-	---	---	-	-	2	-	-	-	-	-	1	-	1	-	-	---
4.	Bombax ceiba	---	-	-	---	---	-	-	-	-	-	-	4	-	-	4	-	-	2	1 ± 1
5.	Anacardium occidentale	3 ± 1	-	-	---	3 ± 1	-	-	-	-	-	-	-	-	-	-	-	-	-	---
6.	Calycopteris floribunda	---	-	-	---	---	-	-	-	-	2	-	-	-	4	-	-	3	-	1 ± 1
7.	Careya arborea	---	-	-	---	---	-	-	2	-	-	-	-	-	1	-	-	-	1	---
8.	Ervatamia heyneana	---	-	-	---	---	-	-	-	14	-	16	-	10	-	-	-	6	2	---
9.	Emblica officinalis	---	-	5	---	---	-	-	-	-	-	-	-	-	-	-	-	-	-	---
10.	Ficus rumphii	---	-	1	---	---	1	1	-	-	2	-	2	-	2	-	1	1	-	---
11.	Grewia umbellifera	---	6	-	1 ± 1	---	-	4	-	-	-	-	-	-	-	-	-	-	-	---
12.	Holarrhena antidysenterica	---	-	-	25 ± 5	5 ± 1	24	30	25	20	25	28	23	5	-	-	15	18	12	---
13.	Lannea coromandelica	---	-	5	---	---	3	2	1	2	2	1	3	3	3	2	10	5	-	---
14.	Leucaena leucocephala	---	150	90	5 ± 2	4	-	-	-	-	-	-	-	-	-	-	-	-	-	---
15.	Microcos paniculata	---	-	-	4 ± 1	1	4	6	4	2	1	1	-	-	1	1	-	2	-	---
16.	Peltophorum pterocarpum	3 ± 1	-	-	---	---	-	4	-	6	-	2	-	-	-	-	-	-	-	---
17.	Samanea saman	---	-	2	---	---	3	2	1	-	-	-	-	-	-	-	-	-	-	---
18.	Sterculia urens	---	-	-	---	---	-	-	1	-	-	1	-	3	-	8	-	-	-	---
19.	Terminalia paniculata	---	-	-	1 ± 1	---	-	4	3	3	3	1	-	-	-	4	-	-	-	---
20.	Tamarindus indica	---	-	-	2 ± 1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	---
21.	Ziziphus rugosa	---	-	-	---	---	-	-	-	1	-	-	-	-	2	-	3	-	4	---
22.	Ziziphus xylophyrus	---	-	-	---	1	1	-	-	-	-	-	2	-	-	-	-	-	-	---

Table: 15 a.Frequency, dominance,and density of plant species in the case study "W".

Sr. No.	Taxon	Frequency	Dominance	Density	Relative Frequency	Relative Dominance	Relative Density
1.	Abrus precatorius	5.96	2.65	0.16	0.844	0.21	0.564
2.	Acacia chundra	21.7	8.77	1.91	5.66	15.6	49.67
3.	Artocarpus heterophyllus	4.20	4.66	0.20	0.15	8.9	0.175
4.	Alstonia scholaris	8.78	1.82	0.16	2.23	5.93	1.029
5.	Allophyllus cobbe	2.0	0.03	1.47	0.049	0.067	0.025
6.	Acacia arabica	8.8	1.00	0.088	0.198	0.54	0.050
7.	Bombax ceiba	10.8	1.68	0.18	2.98	3.19	1.268
8.	Bridelia retusa	17.8	1.93	0.34	2.33	0.42	1.029
9.	Bridelia scandens	18.5	1.74	0.32	2.93	5.02	1.431
10.	Buchanania lanzan	17.2	2.06	0.31	2.68	4.51	1.217
11.	Calycopteris floribunda	30.2	3.04	0.92	6.70	2.14	1.305
12.	Capparis monii	3.03	2.0	0.06	0.049	0.03	0.025
13.	Careya arborea	18.5	0.31	1.66	6.06	10.1	2.55
14.	Celastrus paniculata	9.09	3.33	0.30	0.15	0.099	4.331
15.	Ervatamia heyneana	19.6	2.92	0.57	5.86	0.335	4.33
16.	Ficus asperrima	11.1	9.33	1.04	0.15	0.60	0.351
17.	Ficus glomerata	13.9	0.88	0.116	0.29	1.37	0.062
18.	Ficus rumphii	24.0	1.33	0.32	7.15	4.64	2.397
19.	Flacourtia montana	5.98	1.60	0.095	0.49	0.17	0.2
20.	Gmelina arborea	3.09	3.0	0.03	0.15	1.65	0.037
21.	Grewia tiliaefolia	2.97	2.33	0.069	0.15	1.362	0.087
22.	Grewia umbellifera	16.2	1.84	0.298	4.37	0.173	2.03
23.	Helicteres isora	8.11	3.0	0.243	0.447	0.079	0.34
24.	Heterophragma quadriloculare	2.32	3.0	0.069	0.049	0.062	0.037
25.	Holarrhena antidysenterica	23.4	21.3	4.98	7.0	6.54	37.7
26.	Ixora arborea	8.77	2.88	0.25	1.24	1.11	0.9

27.	Ixora coccinea	15.5	2.28	0.35	0.25	0.05	0.2
28.	Lantana camara	3.6	1.75	0.063	10.68	7.27	6.679
29.	Lannea coromandelica	35.8	2.47	0.88	0.198	0.002	0.087
30.	Lagerstroemia lanceolata	4.65	1.0	0.046	0.099	0.377	0.025
31.	Mimusops elengi	11.1	1.33	0.148	0.049	0.091	0.012
32.	Microcos paniculata	20.6	2.98	0.614	0,347	0.026	0.175
33.	Memecylon umbellatum	2.22	1.0	0.025	5.36	0.139	4.04
34.	Memecylon wightii	4.0	2.0	0.08	0.15	2.61	0.05
35.	Phyllanthus reticulatus	2.32	2.0	0.046	0.049	0.026	0.025
36.	Randia dumetorum	12.7	2.12	0.27	2.78	0.06	1.5
37.	Sapium insegne	2.41	1.2	0.03	0.496	0.049	0.15
38.	Sterculia urens	12.3	1.38	0.17	1.84	2.47	0.64
39.	Strychnos nux-vomica	2.16	1.0	0.021	0.198	0.172	0.05
40.	Terminalia bellirica	3.2	1.75	0.056	0.198	0.661	0.087
41.	Terminalia chebula	3.03	1.0	0.03	0.049	1.38	0.012
42.	Terminalia paniculata	12.79	2.06	0.263	3.53	0.157	1.83
43.	Trema orientalis	3.48	11.0	0.392	0.596	2.06	1.69
44.	Vanguera spinosa	4.44	1.0	0.044	0.099	0.014	0.025
45.	Ziziphus mauritiana	11.27	1.97	0.22	1.94	1.82	0.96
46.	Ziziphus oenoplia	2.96	1.75	0.051	0.918	0.0004	0.087
47.	Ziziphus rugosa	24.03	1.71	0.41	6.75	0.134	2.92
48.	Ziziphus xylopyrus	46.04	2.22	1.03	2.88	3.57	1.62

Sr. No.	Taxon	I.V.I	Sr. No.	Taxon	I.V.I
1.	Abrus precatorius	1.61	25.	Holarrhena antidysenterica	51.21
2.	Acacia chundra	70.98	26.	Ixora arborea	3.25
3.	Acacia arabica	0.79	27.	Ixora coccinea	0.597
4.	Alstonia scholaris	6.62	28.	Lantana camara	0.287
5.	Artocarpus heterophyllus	9.25	29.	Lannea coromandelica	24.63
6.	Allophylus cobbe	0.141	30.	Lagerstroemia lanceolata	0.50
7.	Bombax ceiba	6.44	31.	Memecylon umbellatum	0.15
8.	Bridelia retusa	9.37	32.	Memecylon wightii	0.54
9.	Bridelia scandens	3.78	33.	Microcos paniculata	9.54
10.	Buchanania lanzan	8.4	34.	Mimusops elengi	2.8
11.	Calycopteris floribunda	10.15	35.	Phyllanthus reticulatus	0.10
12.	Capparis moonii	0.11	36.	Randia dumetorum	4.33
13.	Careya arborea	18.67	37.	Sapium insegne	0.89
14.	Celastrus paniculata	0.37	38.	Sterculia urens	4.94
15.	Ervatamia heyneana	10.52	39.	Strychnos nux-vomica	0.42
16.	Ficus asperrima	1.1	40.	Terminalia bellirica	0.94
17.	Ficus glomerata	1.73	41.	Terminalia chebula	1.44
18.	Ficus rumphii	21.34	42.	Terminalia paniculata	5.52
19.	Flacourtia montana	0.86	43.	Trema orientalis	4.34
20.	Gmelina arborea	2.03	44.	Vanguera spinosa	0.13
21.	Grewia tiliaefolia	0.598	45.	Ziziphus mauritiana	4.72
22.	Grewia umbellifera	6.57	46.	Ziziphus oenoplia	0.28
23.	Helicteres isora	0.86	47.	Ziziphus rugosa	9.81
24.	Heterophragma quadriloculare	0.15	48.	Zipiphus xylopyrus	8.06

The species with the highest relative frequency were *Lannea coromandelica*, *Acacia chundra*, *Calycopteris floribunda*, *Careya arborea*, *Ervatamia heyneana*, *Ficus rumphii*, *Holarrhena antidysenterica*. The lowest relative frequency was observed with *Vanguera spinosa*, *Heterophragma quadriloculare*, *Allophyllus cobbe*, *Capparis moonii*, *Memecylon umbellatum* and *Phyllanthus reticulatus*.

The species with the highest relative dominance were *Acacia chundra*, *Artocarpus heterophyllus*, *Alstonia scholaris*, *Bridelia retusa*, *Careya arborea*, *Holarrhena antidysenterica* and *Lannea coromandelica*.

The lowest relative dominance was observed with *Capparis monii*, *Lantana camara*, *Memecylon umbellatum*, *Vanguera spinosa* and *Ziziphus oenoplia*.

The species with the highest relative density were *Acacia chundra* and *Holarrhena antidysenterica* which were extremely high compared to other species in the area. The lowest relative density was observed in *Gmelina arborea*, *Heterophragma quadriloculare*, *Memecylon umbellatum* and *Terminalia chebula* (Table: 15a).

The plant species with the highest importance value index were *Acacia chundra*, *Holarrhena antidysenterica*, *Careya arborea*, *Lannea coromandelica* and *Calycopteris floribunda* whereas the species with the lowest importance value index were *Allophyllus cobbe*, *Capparis monii*, *Celastrus paniculata*, *Heterophragma quadriloculare*, *Memecylon umbellatum*, *Phyllanthus reticulatus*, *Strychnos nux-vomica*, *Vanguera spinosa* and *Ziziphus oenoplia* (Table: 15b).

2.4.3. Soil Analysis

The pore space (%) was found within the range of 24% and 39.2% in all soils at case study "W". The pore space (%) was lowest in soil samples collected at area between factory and the second gate on the left hand side of the road. 26.3 % and the mango orchard 24%. The highest pore space(%) was found in soil samples from the second gate (38%) and the recreation club area 39.2%.

The water holding capacity was within the range of 45% to 68%, the lowest being at the left hand side of the road(45%) and highest at the dense scrub 68%.

Moisture content(%) was within the range of 11% to 20.4% in all the soil samples, the lowest being at the dense scrub area and highest at the area surrounding the sports ground (Table:16a).

The pH of the soil samples of case study "W" was within the range of 5.3 to 6.2, the lowest being at the area with clay soil found around the entire fenced area which encloses the nursery, and the highest in the soil samples from the area between 2nd Gate on the left hand side of the road. Generally the soils are strongly acidic, medium acidic to slightly acidic. Electrical conductivity (ds/m) range was 0.03ds/m to 0.19ds/m, the lowest being at the dense scrub forest near Jacob's circle and the highest being with the soil samples from the recreation club area.

Organic carbon % was found in all soil samples to be more 1.2%. Available phosphorus (Kg/Acre) was within the range of 2 to 725 Kg/Acre, the lowest being at the area between second gate and the factory on the left hand side of the road and, the highest being at the recreation club area. The available potassium (Kg/Acre) was within the range of 64 to 134 Kg/Acre, the lowest being at the second gate area on the left hand side of the road and highest at the recreation club area(Table:16b).

Available calcium was within the range of 1.5 to 5.5 mg/100g, the lowest being at the nursery area and the highest at the area between factory and 2nd Gate on the left hand side of the road(Table:16c).

Table:16 a. Physical soil analysis of case study "W".

Sr No.	Pore space %	Water holding capacity %	Moisture content %
1.	26.3	48	20
2.	38	45	12
3.	39.2	65	14
4.	24.0	62	13
5.	36.4	68	11
6.	32	48	20.4
7.	33.5	58	16

Table: 16 b. Chemical soil analysis of case study "W"

Survey No. of the field & locality	1 Between Factory 2nd gate left hand side of road	2 Area close to the 2nd gate Right hand side of the road	3 Jai-Kisaan recreation Club area	4 Mango orchard area	5 Dense Scrub area close to Jacob's Circle	6 Area close to the sports ground	7 Nursery area
Texture of the soil	Orange brown loam	Gray Gravel loam	Mixed humus loam	Clay loam	Clay soil	Gravel	Clay
pH in water 1:2.5	6.2	5.8	5.9	5.9	6.1	5.7	5.3
E.C.* dS/m	0.04	0.04	0.19	0.05	0.03	0.06	0.03
Organic carbon (%)	>1.2	>1.2	>1.2	>1.2	>1.2	>1.2	>1.2
Available phosphorus (Kg/acre)	2.0	4.0	>25.0	3.0	6.0	2.0	5.0
Available Potassium (kg/acre)	86.0	64.0	134.0	128.0	106.0	108.0	72.0
Available Calcium mg/100g of soil	5.50	3.25	2.50	5.00	5.00	2.50	1.50

* Previously expressed as millimhos per centimeter (mmho/cm). Since 1S = 1mho, ds/m = 1mmho/cm. (Brady,1984) therefore units expressed here are in decisiemens per meter (ds/m).

Table: 16 c. Chemical soil analysis-micronutrients status (ppm) at case study "W".

Survey No.	1	2	3	4	5	6	7
Zn	1.3	2.65	3.13	Ø.79	Ø.72	Ø.87	Ø.7
Cu	1.4	2.Ø	1.6	2.2	2.Ø	1.6	1.5
Fe	1Ø.Ø	32.8	24.4	15.4	14.5	23.6	18.Ø
Mn	8.7Ø	24.8	8.9	6.5	4.5	9.Ø	5.4
Al	8.9Ø	1Ø.75	3Ø.Ø7	12.77	2.65	1Ø.75	22.9
Mg (mg/1ØØgm of soil)	1.ØØ	Ø.5Ø	1.ØØ	Ø.25	Ø.25	3.5Ø	1.5Ø
Loss on ignition by wt. %	15.25	15.74	15.Ø	12.1	28.75	29.Ø	13.7

The picture thus emerges is that the soils of the case study area "W" were relatively dry and acidic with deficiency in Phosphorus and Zinc content. The soils are very much mineral rather than organic soils.

Soils and plant distribution:

Chi-square values obtained from contigency tables based on species frequencies in stands having levels of an environmental factor greater than or less than the mean level for all stands (Table 17).

The sign in brackets indicates whether the species has a higher frequency in stands with high levels of the environmental factor than expected on the basis of random occurrence (Positive association, +), or vice versa (negative association, -), Asterik code of significant levels.

Table 17. Showing positive and negative correlation between plant species' frequency and soil nutrients status along with pH.

Taxon	Frequency	Zn (ppm)	Cu (ppm)	Al (ppm)	pH
1. Lannea coromandelica	35.8	1.3(+)	1.4(-)	8.9(-)	5.9(+)
2. Ervatamia heyneana	19.6	1.3(+)	1.4(+)	10.75(+)	5.7(-)
3. Holarrhena antidysenterica	23.4	2.65(-)	2.0(-)	30.07(+)	6.1(+)
4. Careya arborea	18.5	3.13(-)	1.6(+)	12.77(-)	5.3(-)
5. Grewia umbellifera	16.2	0.72(+)	2.0(+)	2.65(-)	5.3(-)
6. Gmelina arborea	3.09	0.79(+)	2.2(-)	10.75(-)	5.7(+)
7. Microcos paniculata	20.6	0.87(-)	0.72(+)	2.65(-)	6.1(+)
8. Memecylon umbellatum	2.22	0.7(+)	1.5(-)	22.9(-)	5.8(+)
9. Acacia chundra	21.7	1.3(-)	1.4(-)	8.9(-)	5.9(-)
10. Ficus rumphii	24.0	0.79(-)	2.2(+)	10.75(-)	6.1(-)
11. Calycopteris floribunda	30.2	0.72(-)	2.0(-)	2.65(+)	5.9(+)
12. Allophyllus cobbe	2.00	0.87(-)	1.6(-)	12.77(-)	5.3(+)
13. Capparis monii	3.03	0.72(-)	2.0(-)	2.65(-)	5.8(-)

EXPLANATION OF PLATE

Aerial photographs showing the vegetation at the case study "W" (Date: Nov.1991; scale 1cm-100mts on ground approximately)

Fig 22a. Showing areas close to the factory (the factory premises is in the extreme north west of the aerial photograph); the Vasco-Margao national highway road is seen running from the south west of the aerial photograph, several residential areas are seen along the roadsides (especially in the lower portion). The extreme north of the aerial photo; is the fenced area with dense scrub. The entire eastern portion of the photograph is the denuded rocky plateau.

Fig 22b. Showing the unfenced area where it seems vegetation has been cleared deliberately, because areas adjoining the case study "W" (at the background) have got relatively dense scrub. The upper left portion of the aerial photograph shows the lake of the case study "W" which supply most of the water requirements.

2.4.4 Aerial photographs.

As mentioned previously "W" was established in 1972 but the aerial photographs depict the condition of vegetation twelve years prior to the establishment (Fig.20).

Generally scrub vegetation was observed adjacent to the slopes. On the south side of the rail track going to Vasco lies a deep valley which appears to be outside the present boundary of case study "W" compound. An estimation of about ten thousand coconuts, Cocos nucifera trees (confirmed later by ground truth data) was observed along a stretch of groves of hardly 1 k.m.

The area on the extreme south-east of case study "W" had scattered vegetation of scrub forest dominated by shrubs, lianas, and climbers.

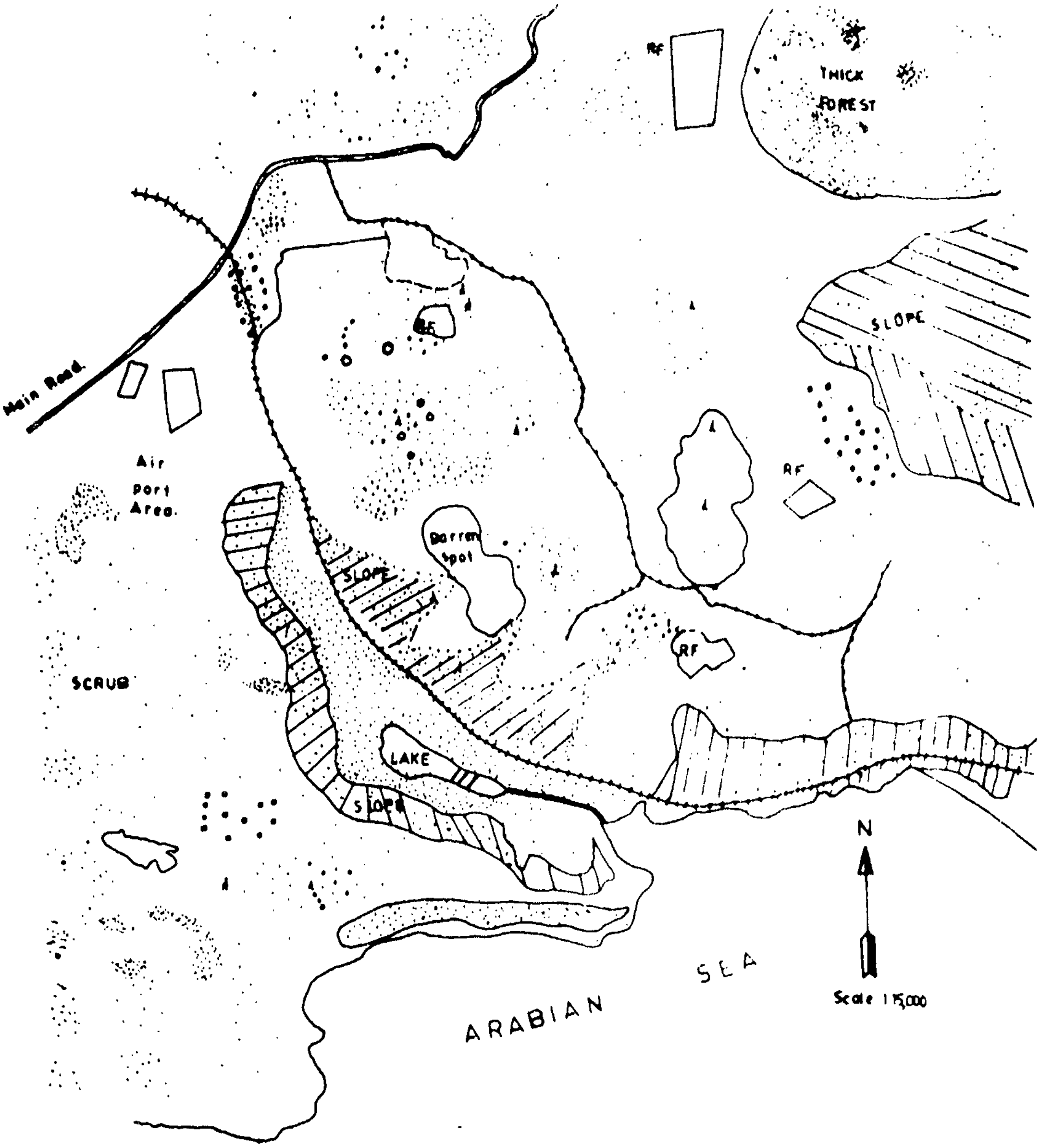
Dominant tree species were Ficus rumpii , Lannea coromandelica and Anacardium occidentale.

Large trees were visible on the slopes areas facing the sea shores. All flat areas, presumably rocky plateau today, had some dense scrub vegetation cover (Fig.21).

Occasionally large gigantic trees were observed like Ficus Benghalensis which had dense canopy covering large areas as the result were easily distinguishable.

The aerial photographs which had been taken in the post monsoon did really depict a dense vegetation; a clear indication that vegetation was relatively dense in the early 1960's as compared to the aerial photographs of 1991 (Fig.22a and 22b).

Many trees species for example were situated on the now abandoned reservoir, over 800 trees but now hardly five trees exist at the same spot. The area now appears to be a barren rocky plateau.



KEY:

Rail.

Sec. Road.

Human settlements.

trees

Fig. 20. Vegetation land cover at case study 'W' and surrounding areas as depicted from Aerial photographs Nos. F5 2136. dt. Oct.'50.

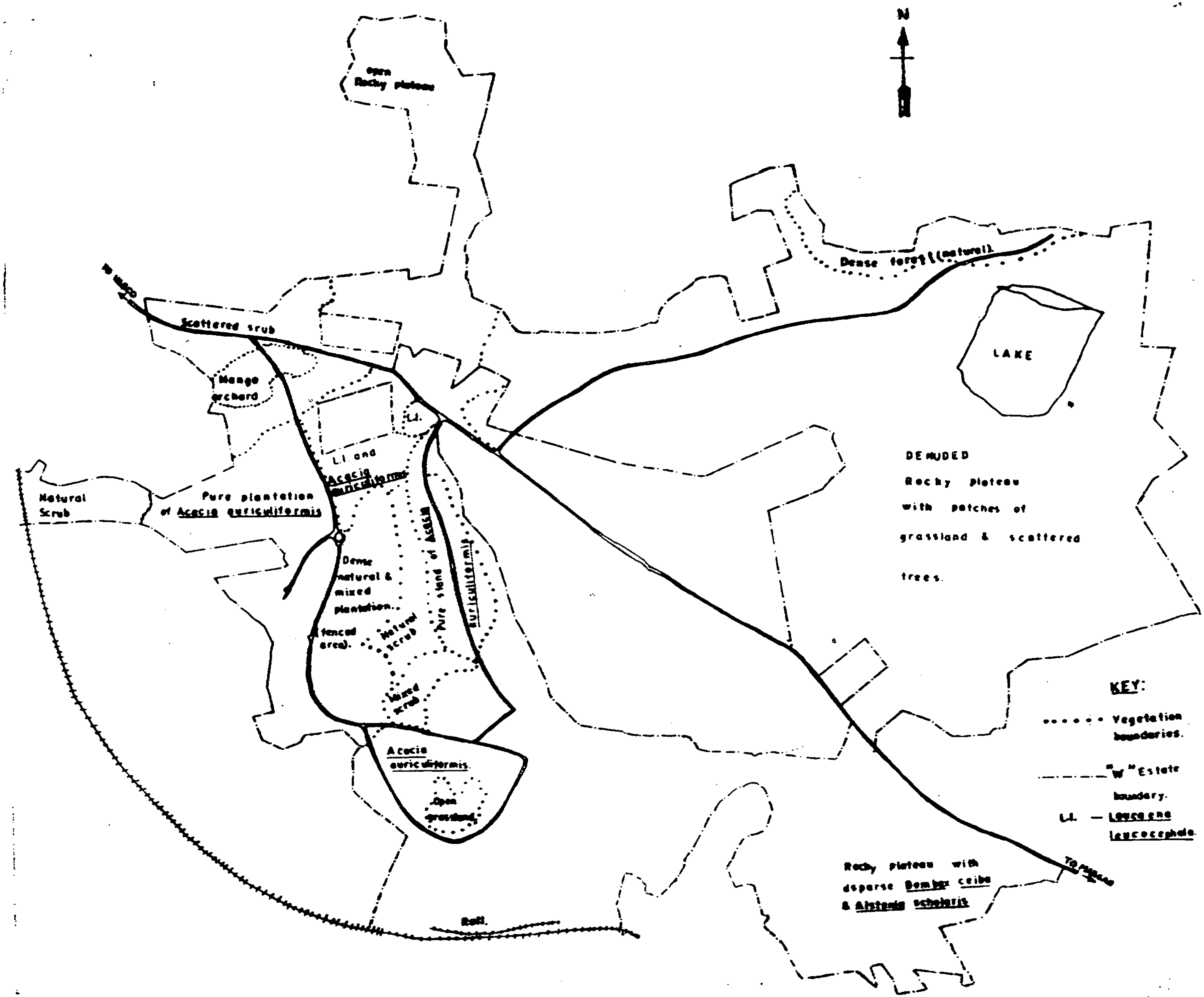


Fig. 21. Vegetation land cover at case study " W " as interpretated from ground truth data (1991-92).

2.5 DISCUSSION

2.5.1. Qualitative analysis of vegetation

It is interesting to note that in some cases the scrub is impenetrable due to lianas like Smilax Zeylanica Calycopteris floribunda , Wagatea spicata . Due to favourable conditions here, some shrubs have developed into small to medium trees especially Ziziphus xylopyrus, Z. oenoplia, Ervatamia heyneana and Holarrhena antidysenterica.

The main reason in the case study "W" being a well protected area. (both by security personnel and wall fencing) has stood to be an ideal habitat for some shrubs to have grown to medium trees. Lack of scarcity of epiphytes is a clear indication that this area was devoid of a luxuriant forest type of vegetation cover or it may be due to environmental disturbance. Lack of Hydnocarpus laurifolia is conspicuous in this area, probably because it prefers hilly sites.

The young monocultured plantation constituting Acacia auriculiformis has greatly modified the vegetation landscape from its original form .The sites which previously were semi-deciduous scrub with low stratification but now appears to be evergreen medium scrub. The greenery is attributed by the phylloclades which are persistent throughout the year.

The glamour of beautiful birds population like the peacock around the protected compound and freely moving large monkey population gives some hope that this formerly called " a rocky plateau " is slowly turning to a balanced ecosystem _ where both plant and animal communities could co-exist and replenish for their nourishment.

Only. and unfortunately, the " sweet " fruit bearing trees will have hard times to regenerate naturally ;for example the mango plantations.Case study "W" administration has made tremendous efforts in planting several exotic tree species in the compound. The survey showed exotic species introduced outnumbered the local species found here. This is one of the industries and allied complexes that has made some efforts to improve its greenery, unlike most other similar institutions where there has been a gradual degradation even in,the fence - protected area. A good example citation is the way management carefully excavated a huge Bombax ceiba tree (about 15 mts. high) from the middle of the now present sports ground and transplanted it outside the field. The tree is performing well, this is a clear indication of enviromental awareness of the management of case study "W" community.

The vegetation aspect is taking a different shape in landscape ; the introduced exotic species and weed species are gradually increasing in frequency displacing the indigenous flora. This is most common at the areas close to the residential quarters. For example Leucaena leucocephala though initially located at one spot near the second gate, has now sporadically spread to almost all spots with abundant water supply in the case study area.

2.5.2 Quantitative analysis

The relative frequency was highest in Lannea coromandelica probably due its fast growth and profuse flowering and fruiting and also due to its frequent regeneration through the rootstalks.

On the other hand, species with low frequency like Memecylon umbellatum and Phyllanthus reticulatus bear few fruits which are eaten by birds and mammals like monkeys rendering the dispersal at far off distances (outside the case study area).

The highest relative dominance observed in Acacia chundra is as a result of its large size as compared to other species and it is frequently found in clumps, which is not a common characteristic in Acacia tree species. This is clearly reflected for its having the highest relative density.

Memecylon umbellatum and Terminalia chebula which are very rare and were observed as being accidentals having the lowest relative density.

The importance value index which is a combination of all the characteristics shows that species showing the highest importance value index form the actual consociations of the case study "W". Therefore the association is of Acacia-Holarrhena-Careya-Lannea type. These dominants modify the ground flora in many ways for example under Careya arborea due heavy litter and rainfall, a number of herbaceous species tend to grow underneath .

Despite the enormous efforts and finance used in planting large amount of trees, little is known how many survive.

The case study "W" according to the official records had planted over 1.5 lakhs tree saplings in the last eight years.

When vegetation mapping was carried out, it was found from the ground truth data survey that the total number of tree-shrub individuals were found to be about 30 thousand which accounts for the naturally occurring and cultivated species.

The species were sampled from five hundred and ninety six quadrats which represented the total area where vegetation existed in the case study "W" .

The findings indicate probably partially incomplete records and poor survival of some of the species, or this may imply that the mortality rate was high and no post-plantation records were maintained to check on their performance. Vegetation mapping had greatly enhanced the finding out of the present status of the plantation work and also helped in the selecting probable suitable adaptive species to be used in the future work.

Burrows (1990) states that dominant plant species usually form most of the biomass on a site make most demands on the resources of the site and control site conditions for other species. They are strong competitors, often limiting or totally excluding other species which potentially could occupy a site.

Dominants and other relatively large plants in forest or scrub, may provide sites for the growth of epiphytes and support for weak stemmed plants. Their presence will also favour species which require shaded conditions or deep litter layers for their survival.

2.5.3. Soil Analysis

Soil types with characteristic profiles occur in different climatic and vegetation zones of the world, but local conditions such as rock type, topography or drainage profoundly influence the soils of particular sites. Soil profile in any locality therefore, vary in their morphology according to many specific site conditions (Burrows, Loc.cit.).

From the chemical soil analysis it was found that one area i.e. recreation club area which was a completely denuded rocky plateau with no vegetation at all was having sufficient nutrients requirements for the normal plant growth. Thus it appeared this area was only interfered by biotic factors . Moreover, from earlier observations made from aerial photographs dated October 1960 showed that vegetation existed in this locality.

Several species were observed as being stunted in growth at the mango orchard and nursery areas as compared to the same species which showed normal growth in all other areas. Some species like <u>Acacia auriculiformis (Fig.23a and 23b), Samanea saman</u> and <u>Delonix regia</u> were found to be stunted in growthespecially at the sposts which were deficient in Zinc.

There was a marked correlation in zinc deficiency in these soils

E X P L A N A T I O N   O F   P L A T E

Photographs showing changes in growth forms due to mineral nutrient deficiency: sites with zinc deficiency might have caused stunted growth in *Acacia auriculiformis*.

Fig 23a. *Acacia auriculiformis*, whole plant showing healthy growth in the presence of sufficient zinc sites (above 1ppm)

Fig 23b. *Acacia auriculiformis* whole plant of similar age, showing stunted growth in the zinc deficiency sites at case study "W"

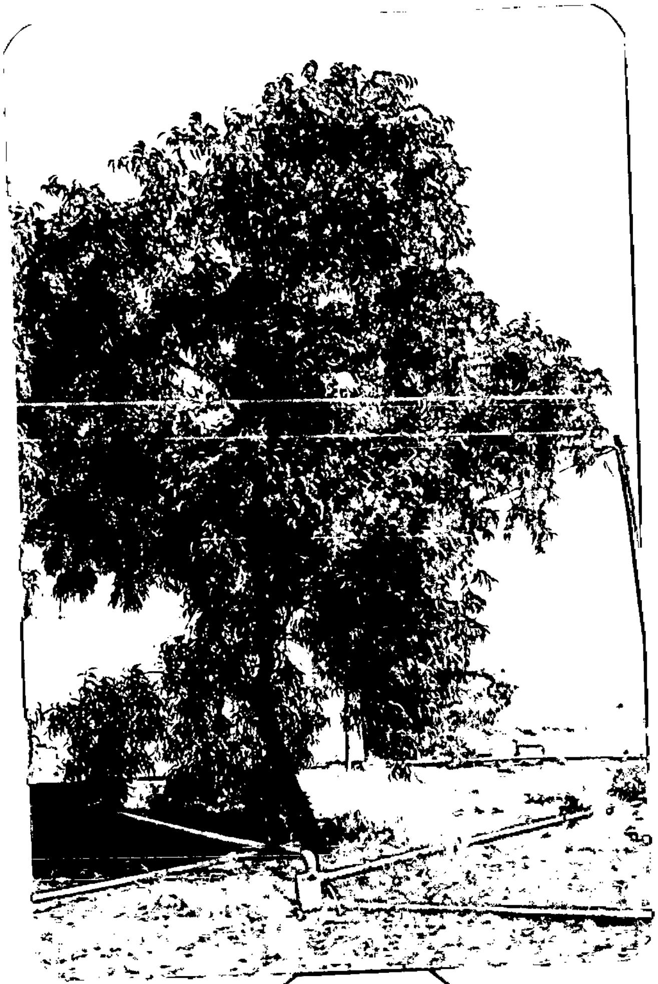


Fig. 23a

Fig.23b

E X P L A N A T I O N O F P L A T E

Photographs showing changes in growth forms due to mineral nutrient deficiency: sites with zinc deficiency might have caused stunted growth in _Acacia auriculiformis_.

Fig 23a. _Acacia auriculiformis_, whole plant showing healthy growth in the presence of sufficient zinc sites (above 1ppm)

Fig 23b. _Acacia auriculiformis_ whole plant of similar age, showing stunted growth in the zinc deficiency sites at case study "W"

(Table 17) and the distribution of some plant species. This was confirmed after doing the chemical soil analysis.Zinc deficiency is generally associated with retarded growth, small narrow and mottled strap-like leaves with undulated marginal, followed by general chlorosis of upper foliage which in severe cases turn brown and necrotic (Viets,1951).

Some effects of zinc deficiency on plant growth are apparently incident to the reduction of auxin contents. Leaves of zinc deficient plants are often lower in moisture content and growth of plants change simultaneously with zinc deficiency. Within two days after the zinc was added to the zinc deficient plants, the water content of the plant increased and growth was resumed.Some of the visual symptoms of zinc deficiency are therefore, directly related to the vital role in auxin production.Zinc deficiency frequently occurs in the soils containing abnormal high concentration of soluble total phosphates, its magnitude in plants increased with the increase of phosphorus in soil.The reduced content of zinc and zinc deficiency symptoms with increased level of phosphorus may possibly be attributed to the dilution effect (Kanwar and Thakur,1973).

Seats and Jurinak (1957) stated that zinc interacts with phophate radical to form insoluble phosphate complex, which lowers the availability of zinc thus creating more deficiency. Phosphorus is one of the most important limiting factors for plant growth, and its availibility in soils seems likely to be a key factor controlling the rate and the direction of long-term vegetation change (Burrows, 1990)

The soils at the case study "W" which had rather low phosphorus may be as result of the lateritic soils which has been long exposed to leaching during the monsoon rains. Generally phosphorus has been observed to be deficient in many soils of the Western Ghats' (Goa) as was found by Govindarajan et.al., (1974).

In this case study phosphorus which was found to be below the normal requirements for the plant growth may have been attributed by the intensive clearance of vegetation cover.

Soil may become polluted as a result of the deposition of material from the atmosphere or from the addition of agricultural chemicals. In some ways, agricultural chemicals are the most insidious because they are applied for a "good reason"; commonly they are very complex substances which requires specialized equipment and skills to detect (Burrows,1990).

This may be particularly so in the case study "W" especially at spots close to the playing ground where most of the effluent water from the factory is discharged. The excess discharge may prove futile to the vegetation development at these sites.

2.5.4 Aerial photographs.

Based on the aerial photographs of Oct. 1960 (on the unprotected zone) with those of 1991, this area used to harbour about one lakh trees and shrubs but presently hardily 300 exist. The reason may have been due to the encroachment of many skilled and unskilled allied workers to the case study "W" industry who resided at this spot.The workers relied on fuel wood for their domestic energy therefore , they had to cutdown most of the trees and shrubs found in this locality.

Presently their are about ten thousand people (of low to medium income) within the proximity of the case study which means that this has been the main cause of threat to the vegetation cover more especially in the unprotected zone.On the other hand ,vegetation improved imensely in the protected zone ; this was because more plantation work had been carried out in addition to getting protection from biotic interferences.

2.6. Forest fires

Fire is probably the most important destructive phenomenon affecting natural and semi-natural vegetation.

Fire has a strong influence in some deciduous forests of east north America.It is a much stronger force in the ecology of grasslands (Vogl, 1974); tropical and subtropical savannahs (Walker,1982), the Mediterranean scrub vegetation types throughout the world (Castri, et al., 1981); much of the vegetation of Australia(Gill et al., 1981); heathland types throughout the world (Specht,1979); and most of the gymnosperm forest of North America and Siberia(Seitz, 1986). The plants in most fireprone vegetation are evergreen perennials or grasses that die down during a dry season (Burrows,Loc.cit).

Forest fires as in any part of the Western Ghats erupt from time to time. The fires destroy a large number of plant species to illustrate this as an example, is when fire broke out at the case study "W" on 12th Nov 1991 at 12:45 p.m. The fire spread out along the administration offices and the "E" colony area in the case study "W" destroying about 4,928 plant species in an area of about one hactare within 30 minutes. Among the most damaged Lannea coromandelica 196, Holarrhena antidysenterica 1820, Ervatamia heyneana 54, Terminalia paniculata 28, Calycopteris floribunda 112, Grewia umbellifera 54, Abrus precautorius 28, Buchanania lanzan 28, Acacia auriculiformis 2500, Ficus rumphii 54, and Acacia chundra 28, which were mainly trees and shrubs.

It was observed after one year that some of plant species which were thought to have wilted, sprout again especially Lannea coromandelica, Ervatamia heyneana, Buchanania Lanzan, and Ficus rumphii. These plant species were deep rooted (personal observation) and therefore, probably, they were not damaged adversely in the underground portion as compared to the shallow rooted plant species like *Abrus precatorius* and *Calycopteris floribunda*. In the completely burned sites where none of the species survived, conspicuous invasion of saplings of *Trema orientalis* and *Chromolaena odorata* were noticed. Though some tree species sprouted , ground fires killed most trees except the deep rooted ones.

Vegetation analysed on the burn't site two years later was found to be dominated by trees rather than herbs or soft shrubs, but tree basal area was reduced to about one-fifth of that of unburn't scrub forest tree species composition and had changed by 60% and the regeneration forest was overwhelmingly dominated by *Trema orientalis* seedlings.

Burrows (1990) stated that exogeneous disturbing events, such as fire, logging and grazing, can exaggerate or accelerate the process of nutrient pool degradation.

The resultant vegetation, on soils with depleted nutrient supplies, is low in stature, vigour and biomass compared with that on younger surfaces. It is composed of plants with relatively low nutrient demands.

The species diversity of the vegetation on old soils need not be less than that of more-fertile, younger soils but the species composition is very different.

For future caution it would be advisible to remove the grass at the earliest time after monsoon rains when the grass is still green but not dry. With such minor precaution, fire incidences could be greatly minimised in the case study "W".

2.7 Suggestions given to the case study "W" management.

a) Avenue trees in the effort of beautifying the case study "W".

It is unfortunate that only four conspicuous tree species namely, *Delonix regia* , *Peltophorum pterocarpum* , *Polyalthia longifolia* , and

Eucalyptus globulus have been planted as ornamental avenue trees. More species need to be introduced in order to have such a combination that glamour of blooming flowers is seen alternatively or throughout the year. Owing to their different flowering seasons, a reasonably serial order scheme has been prepared as an example of beautifying the case study area "W" (Table:18).

From the field observations, at case study "W", it was found that monkeys relish the branches, leaves, and flowers of Bauhinia species most , thus, they are often found stunted in growth. The species should be protected with tree guards especially when they are young.

Table: 18. Probable scheme for beautifying case study "W".

SCHEME NO. 1

(Samanea saman)	(Poinciana regia)	(Cassia fistula)
(light pink)	(Scarlet Orange)	(Yellow)

This is a very striking colour scheme, the rich yellow colour of amaltas flowers contrasting with the scarlet-orange colour of gulmohur flowers along with the light pink flowers of the raintree in the month of May when the three species are flowering.

SCHEME NO. 2

Plumeria alba (white & red & red varieties)	Colvillea racemosa (Orange red)	Peltophorum pterocarpum (Golden yellow)

This colour scheme is very effective in October when both these trees are flowering and a colour effect similar to that in Scheme No. 1 is produced.

SCHEME NO. 3

Parkia biglandulosa (Milky)	Grevillea robusta (Yellow)	Jacaranda mimosaefolia (Blue)

Both these trees flower together in April and a beautiful colour effect , which is soothing in the glare of the April sunshine .

SCHEME NO. 4

Butea frondosa	*Erythrina indica*	*Spathodea campanulata*
(Orange Scarlet)	(Scarlet red)	(Orange crimson)

These trees flower in March and they are a blaze of colour especially along the roadsides.

SCHEME NO. 5

Cassia nodosa	*Lagerstroemia parviflora*	*Bombax ceiba*
(Pink - red)	(Pink)	(Pink - red)

The three species flower in May and June when a very mellow colour scheme of pink and red is obtained.

SCHEME NO. 6

Bauhinia variegata	*B. variegata*	*B. Krugii*
(Purple - mauve)	(White)	(Light magenta)

This colour scheme which is composed of three varieties of *Bauhinia variegata* , pink, white, purple-mauve and light magenta *(B. Kurgii)* is recommended for dust-free roads of residential areas. All these Bauhinias blossom in a leafless condition from the middle of February to the middle of March when they look like huge bouquets of pink, white, purple and light magenta flowers. This is a very pleasing colour scheme and is highly recommended.

b)Implementation of more lithophytes.

Lithophytes are in a layman language " rock loving plants"; they are plants which are found to grow well without much stress on laterite rocky soils.

Their roots penetrate deep in to the rock substrate both vertically and laterally and derive their nutrition safely without much competition from other species.

Case study "W" ,like many other places close to the sea coast in Goa is a vast land composed of a thick layer of laterite, therefore, this can be the most suitable site for introducing lithophytes. The following naturally occurring ten trees and shrub species owing to their frequency, abundance , dominancy and with relatively large basal area cover, need to be propagated for the revegetation programmes at case study "W" namely; *Lannea coromandelica*** , *Careya arborea** , *Acacia chundra*** , *Ficus rumphii* , *Holarrhena antidysenterica*** , *Ziziphus rugosa*** , *Bridelia retusa*** , *Grewia umbellifera*** , *Bombax ceiba* , *Calycopteris floribunda*** , Other important species to a lesser extent are *Sterculia urens* , *Alstonia scholaris* and *Buchanania lanzan*.

NB. Asterisk means the species may be useful for fuel wood.Since their is a constant demand for fuel wood in this locality, probably the management should propagate many fuel wood species and transplant them.

c)Monoculture

Though much plantation work has been done by case study "W" there has been only a concentration in a few species namely: (1) Avenue trees *Delonix regia* and *Peltophorum pterocarpum*, (2) A mango orchard comprised of only *Mangifera indica* (3) A pure plantation of *Acacia auriculiformis* in the scrub plateau, residential and areas adjoining the factory and the road leading to the 2nd gate. *Anacardium occidentale* and *Eucalyptus hybrid* are very abundant though the former is found in the wild state also. All these cultigens have got a closely allied Chromosome number range which warrants us to call it a monoculture plantation (because the induced flora was not taken into account to match the " local flora "). A wide spectrum of Chromosome number ranging plant species should be selected, most probably polyploid species for the revegetation work, this will give rise to a balanced ecosystem corresponding with the local natural eco-climatical conditions.

The studies carried out on a natural vegetation which is found in patches reveals an almost balanced polycultured ecosystem like the one found in the other scrub areas of Goa's Western Ghats. The same species from these habitats should be utilised for reforestation at the case study "W".

Fast growing plant species

There is a need to cultivate fast growing and yielding plant species that will also improve the soil fertility.So legume plant species are the most appropriate along with the other indigenous tree species.

Some of the fairly fast growing leguminosae species are;

Erythrina indica, Peltophorum pterocarpum, Samanea saman, Sesbania grandiflora, Leucaena leucocephala, Pithecellobium dulce, Bauhinia purpurea and Dalbergia sissoo.

Some of the fast growing non-leguminous tree species are;

Gmelina arborea, Eucalyptus hybrid, Trema orientalis, Emblica officinalis, Casuarina equisetifolia , and Melia azedarach.

The above mentioned plant species are fast growing , such that bearly within a period of ten years sizable amount of useful timber may be obtained.

PART III

A. VEGETATION MAPPING OF CASE STUDY "X"

B. VEGETATION MAPPING OF CASE STUDY "Y"

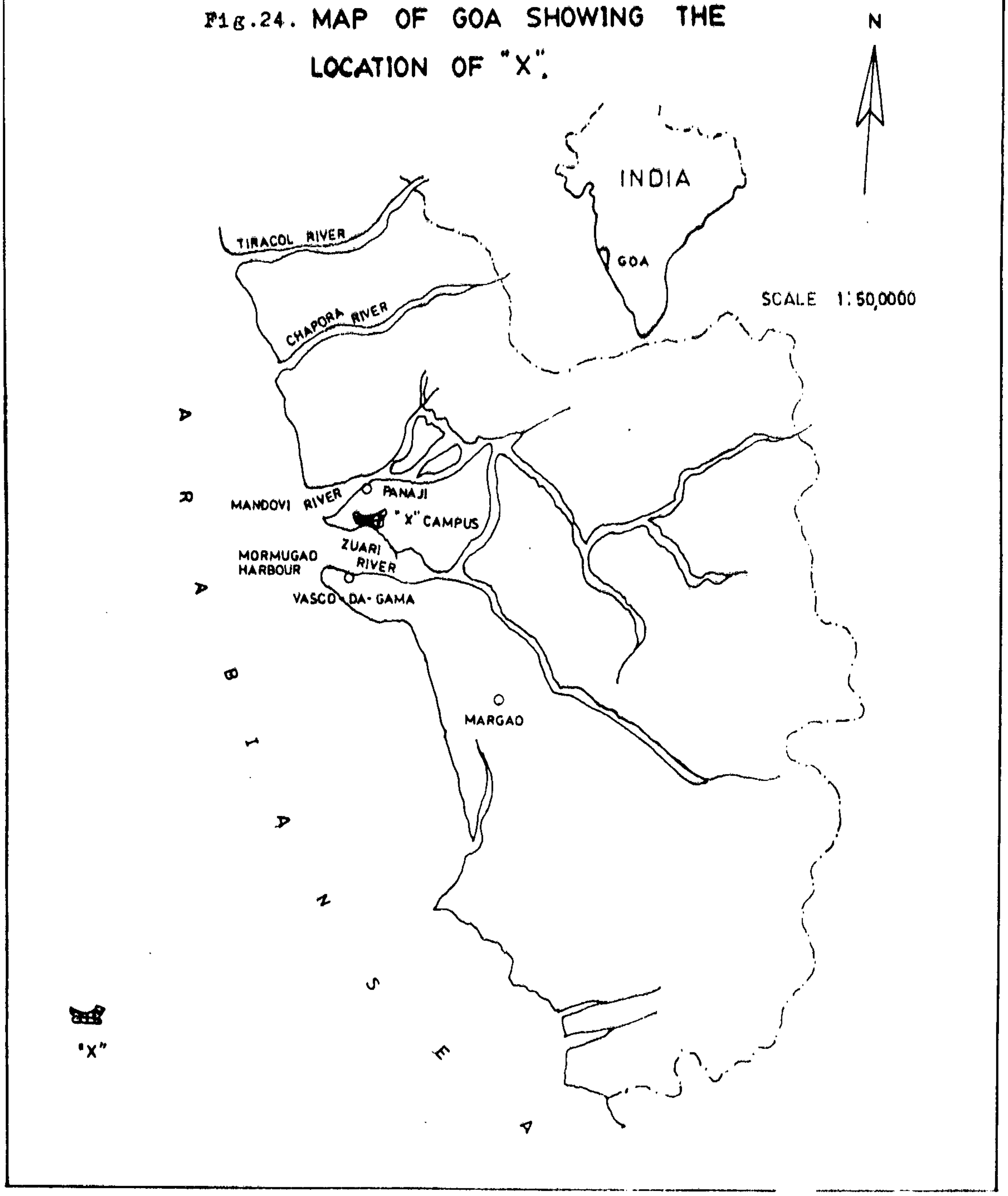
3.1 LOCATION AND DESCRIPTION OF CASE STUDY AREA "X"

The area chosen for the case study is an educational institution and is referred here as "X". It lies on Taleigao plateau close to the coast of Goa. It is situated about 7 km south of the capital city of Goa State - Panaji, at latitude 15° 27′ 11.4" N and 15° 27′ 43.8" N and longitude 73° 50′30" E and 73° 49′30" E (Fig.24).The area is mainly an open rocky plateau with scanty vegetation. The area taken for the study is about 142 hectares, lying at about 60 mts. Above sea level case study. The north-east zone is bordered by a dam, to the south-east bordered by All India Radio Transmission Station to the south-west by Dona Paula and to the north-west by Zuari river (though before the river is a very steep silent valley composed of very thick dense vegetation). The most spectacular topographic demarcations in the case study "X", are the dome-shaped water tanks one being close to All India Radio and the other being close to Dona Paula.

Annual rainfall of Case Study "X" area in the range of 2,400 to 3,400 mm under normal conditions. However, under unfavourable conditions it may come down to 1600 mm, being marked by the rainiest down pour in July when nearly a third of the annual rainfall is received.

Though temperature rises slowly from March and later part of April and May, the hottest period is within the range of 35° to 37°C the area, being closer to the sea coast, is much more pleasant because of the constant blowing in of the sea breeze. Humidity is high in the monsoon being 90% and lower in the winter season being 70% approximately.The soil type is latosol with pH ranging from 6.2 to 6.9. Plant species found in the area marked "X" were not identified earlier. As a result botanical names of the plants were not known to the people who are working in this case study "X", therefore, it was thought that these plants should be identified and vegetation analysis

Fig.24. MAP OF GOA SHOWING THE LOCATION OF "X".



carried out. The aim was to help in selecting seeds of the suitable indigenous plant species within and around the case study "X" for raising in the nursery and also help in the future developments in other plantation works.

3.2 INTRODUCTION:

3.2.1 Qualitative analysis:

Once the entitation or subdivisioning of the vegetation cover has been clarified (through qualitative techniques), the communities are essentially established. This is the reason why a thorough reconnaissance and familiarization before sampling is important. Subsequent sampling and data collection will merely derive more detailed information on these communities, irrespective of one's choice for semi-quantitative or quantitative methods for description. (Mueller - Dombois and Ellenberg, 1974).

3.2.2 Quantitative analysis:

Since the realization that a large degree of error is inherent in subjective evaluation of abundance, ecologists have become increasingly conscious of the necessity of using quantitative measures to describe vegetation (Kershaw, 1973).

3.2.3 Soil analysis at case study "X" :

A detailed investigation of soil chemistry and nutrient levels in relation to the diversity of ground flora is important. When properly verified, these relationships might be used to attempt to improve the diversity of the ground flora in the woodland (Gilbertson, 1985).

3.2.4 Aerial Photographs:

Aerial photographs are capable of extending the ecologist's understanding of many scientifically interesting areas. A single photograph may contain an infinite variety of detail which may be used to study variation in both space and time. The relatively recent development and proliferation of remote sensing systems has opened up hitherto unknown fields for the photo-interpreter. As the potentials of these systems become better understood and we are able to specify and predict accurately the conditions under which to use them, then great strides will be made in the advancement of ecological research (Hubbard and Grimes, 1969).A recent investigation was carried out to interpret the actual vegetation cover that existed in Oct. 1960 and compare the information with recent aerial photographs (Nov. 1991) coupled with ground truth data.

3.3 MATERIALS AND METHODS:

3.3.1. Qualitative analysis:

several botanical surveys were carried out in the case study "X" to acquint oneself with the general topography and plant stratification. By using a podometer "Kilometerzahlor (Germany) the area size could be approximated. Official topographic map sheet of case study "X" were used to confirm the actual field size. Spots with special physiographic or topographic demarcations were identified and noted, especially, the dome-shaped water tank area close to All India Radio, the rocky plateau close to the teaching staff quarters, the mango orchard area, the relatively dense forest behind the hostel, and the second dome-shaped water tank on the approach road to Dona Paula.

The degree of slope, relative humidity, temperature, wind velocity were determined by Abney level, a clinometer, a whirling psychrometer, a maximum and minimum thermometer and anemometer respectively.

Tall trees and other specimen on the slopes were examined at a closer view using a binocular to observe the floral or fruiting portions. The plant specimens which were found in flowering or fruiting condition were photographed using a field camera (SLR).

During the subsequent botanical surveys, rough sketch maps or mapping tables were prepared and ground truth data collected. Plant collection of individual species representatives was carried out using a vasculum and plant press, for proper identification in the Post -Graduate section of the Botany Department, S.P. Chowgule College, Margao-Goa. The herbarium was processed as per Lawrence's Methods (1951) and placed in the Botany Department, S.P. Chowgule College, for future references. Continuous seasonal monitoring of the vegetation was carried out throughout the year.

The method used in the descriptive aspect of the vegetation are as those of Ellenberg & Mueller-Dombois (1969) in the tentative physiognomic - ecological classification of plant communities.

A list of some trees , shrubs and herbs which were found in the case study "X", was prepared (Table 20 & 21). Some elucidation was made on their local names, which were either, in English, Konkani or Marathi, flowering and fruiting season (an important factor to periodicity), Chromosome Numbers (2n) (an important factor to genetic diversity) and their local uses.

3.3.2 Quantitative analysis:

Quadrat sampling was done at case study "X" and the actual ground truth data was obtained for the entire area where vegetation exists.

Minimal Unit Area was determined by the species - Area curve method of Oosting (1958), to get the suitable quadrat size for sampling. After obtaining the Minimal Unit Area (100m x 100m) the quadrats were sampled serially for the entire area, but not in the tradational random sampling method, because the essence of vegetation mapping was to cover the total case study area. The areas where intensive sampling was carried out are: around the guest house and teaching staff quarters, around the north dome shaped tank, around the south dome shaped tank, non-teaching staff quarters and behind the hostel to the areas facing a dam.

Systematic sampling was used in the case study "X". Systematic sampling usually gives a more accurate mean of the population density than random sampling of equal intensity and is, therefore to be preferred in many practical ecological surveys, such as resource surveys.

Although, random sampling will usually be most desirable for ecologic studies, because of the possibility of measuring the sampling error, nevertheless, in some instances the samples are taken evenly, specified distances a part over the area rather than at random (Dice, 1952).

Formulae applied in the quantitative analysis were as per Kershaw (1973) and Mueller-Dombois and Ellenberg (1974) which are similar in nature. Now, from these values a relative important value was derived (Mueller-Dombois & Ellenberg, Loc. cit.) by summing up the values of relative frequency, relative density and relative dominance.

3.3.3 Soil analysis of Case Study "X".

Soil samples were collected within case study "X" compound from a depth of 30cm layer.

The soil samples were collected from areas having conspicuous vegetation pattern or where the plant species showed relatively poor growth or exceptionally good performance.

In each case 5 to 6 soil samples were collected per site at a spacing of about 40 mts.

The soil samples were collected from six different sites of case study "X" namely:

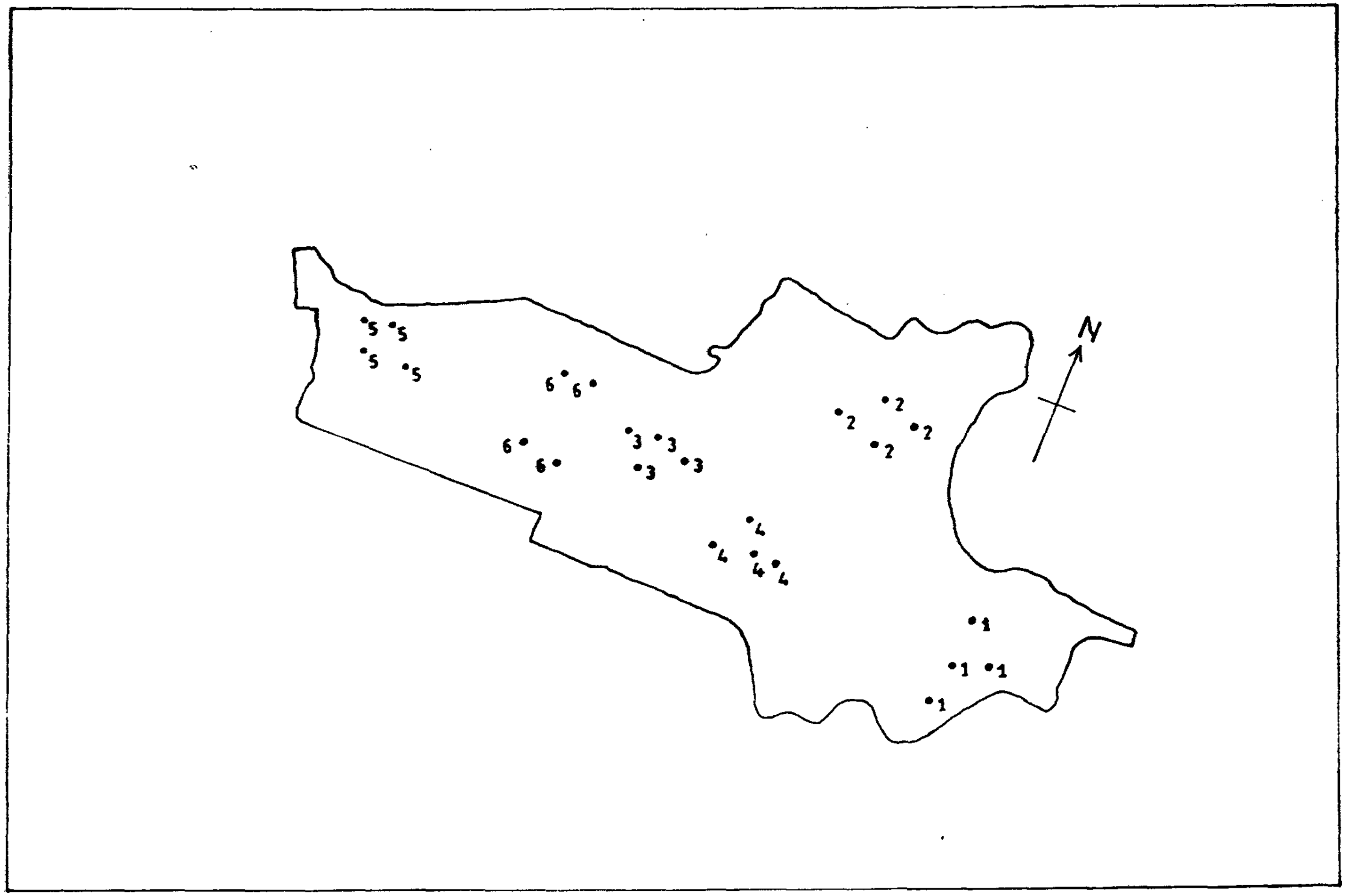


Fig. 25. Map of "X" showing points soil samples were collected for analysis.

1. the scrub forest area which is close to All India Radio,
2. a rocky plateau area which is close to the staff quarter,
3. the mango orchard area which contains transferred soil,
4. a relative dense forest area behind the ladies hostel,
5. the dome shaped tank area close to Dona Paula, and
6. a rocky area near a cross.

The soil samples were then thoroughly mixed to provide a composite sample representing each site.

The composite sample was air dried for 4 days in shallow alluminium trays, ground into fine power using a pestle and mortar then screened through 2mm mesh sieves (Fig. 25).

Fractions of the soil samples were analysed for their specific gravity, water holding capacity and electrical conductivity as described by Piper (1942), Moisture content as per the methods described by Brady (1984), Pore space (porosity) and pH as per the methods described by Pandeya et al., (1968).

The rest of the soil samples were sent for chemical analysis, at the Agricultural Development Laboratory, Bangalore - India, by AAS method.

The pH of the soil samples was measured by using a digital pH meter 335 "Systronicss". The meter was standardized using two buffer solutions. The soil samples were made to be at the same temperature as the buffer solution. (Piper, 1942) (Moore & Chapman, 1986). The soil samples were analysed for their porosity moisture content, and water holding capacity as per the methods of Black (1965) and Piper (1942).

3.3.4 Aerial Photographs

The Howard and Mitchell (1985) method of Aerial photograph interpretation was followed which involves examining stereopairs of aerial photographs under a mirror stereoscope model No.2 serial No. 0528. The overlapping, vertical panchromatic prints were viewed in pairs, to produce stereoscopic images. The vegetation details interpreted were then transferred to a map.

The aerial photographs which were procurred and carefully interpreted are No. F5 2129, No. F5 2130 GOA 1/8 MA 1060/2500 M. Oblique non-stereoscopic aerial photographs were also acquired, which were used in the vegetation interpretation.

3.4 OBSERVATIONS

3.4.1 Qualitative analysis

Natural vegetation of case study "X" can broadly be termed as open scrub woodland which is semi-deciduous and potentially evergreen.

The basic formation is the same as the one found on the Western Ghats of Goa comprised of Bombax ceiba, Careya arborea, Tamarindus indica, Garcinia indica and Caryota urens.

Two distinctive associations are observed, which are mainly governed by steepness of slope and moisture content.

Association 1 : Conspicuous consociations are Bombax ceiba, Careya arborea and Tamarindus indica forming one association.

Association 2 : Dominating consociations on the relatively slopy areas facing the river Zuari are Caryota urens, Garcinia indica Terminalia bellirica and Anacardium occidentale though cultivated, is equally well distributed on the slopes. Within the two Associations six societies are observed as given below.

Societies :

1. Bombax ceiba, Ziziphus rugosa, Microcos paniculata, Memecylon umbellatum, Holarrhena antidysenterica and Heteropogon contortus.

2. Careya arborea, Calycopteris floribunda, Bridelia scandens and

Naregamia alata.

3. Tamarindus indica, Cassia torta and Carissa inermes.

4. Caryota urens, Leea indica, Capparis monii, Chromolaena odorata, Smilax zeylanica and Aristolochia indica.

5. Garcinia indica, Trema orientalis, Clerodendrum ovatum, Allophyllus cobbe, Mussaenda laxa, and Tridax procumbens.

6. Ficus benghalensis, Wagatea spicata, Ziziphus oenoplia, and Cassia tora.

Several pulviotherophytes are found here which are known to be the short lived vascular plants that germinate after fairly heavy rainfall and rapidly complete their cycles of developement. These are Dioscorea bulbifera, Gaissaspis tenella, Cassia tora, Cassia absus, Eriocaulon diannae, Sesamum mulayanum and Smithia conferta.

i) Vegetation in the circle and orchard plantation area :

The circle is decorated with ornamental under shrubs namely the red, yellow and purple Lantana indica and Lantana camara arranged alternatively to the periphery of the circle along with about 23 Casuarina equisetifolia individuals which have been trimmed to form an evenly ball shaped canopy. In the background is a mixture or red and purple Bougainvillea spectabilis plus the dwarfed shrub Cassia biflorus projecting the yellow beautiful flowers in the foreground.

The orchard plantation is a recent development of about 3 years old. The plantation area is about one hectare and is well fenced. Important tree species introduced here are:

Achras sapota, Anacardium occidentale, Artocarpus heterophyllus, Cocos nucifera, Ficus incisus, Mangifera indica, Millingtonia hortensis, Psidium guajava.

Pithecellobium dulce - a thorny tree has been used as a hedge plant surrounding the main office building of the case study "X". In the nursery area male bamboo, Dendrocalamus strictus and Leucaena leucocephala are rather conspicuous.

On the roadsides from the guest house to the second circle, several individuals of the decorative Ficus benjamina var.nuda are observed.

ii) Plantation work between the 1st circle, Pure and Applied Science block Area.

Rarely any natural vegetation exists at this point except very much scattered species like Bombax ceiba, Trema orientalis, Sterculia urens and Euphorbia royleana. A good number of plant species have been planted infront of the science block area. namely, (including their number of individuals) Acacia mangium (02) Bauhinia variegata (10) Acacia auriculiformis (160) Bougainvillea spectabilis (400) Cassia alata (06) Cassia cassia (05) Cassia angustifolia (05) Emblica officinalis (02) Jacaranda mimosaefolia (01) Samanea saman (05) Peltophorum pterocarpum (24) Pongamia pinnata (01) Delonix regia (08) Bombax ceiba (05) Trema orientalis (03) Sterculia urens (01) Euphorbia royleana (32).

Extreme dense population of Bougainvillea spectabilis is observed along the roadsides facing the Science Block.

The castor oil plant, Ricinus communis though usually a cultivated species has invaded areas between the Arts and the Science Blocks forming a population of dense clusters.

Several beautiful ornamental herbs have been planted in the "X" guest house, to name a few : Coleus blumei (Lamiaceae), Aglaonema roobelini (Araceae); Impatiens marianae (Balsaminaceae); Begonia fuscomaculata (Begoniaceae); Dichorisandra reginae (Commelinaceae); Gezania krebsiana (Asteraceae); Sedum compressum (Crassulaceae); Euphorbia pulcherrima (Euphorbiaceae); Sasa fortunei (Poaceae);and Espiscia cupreata (Pandanaceae). Alist of the common trees, shrubs and herb species found in the case study "X" is given in the tables 20 & 21.

Table 19 Simplified Artifical Key to the families of flowering plants native to or naturalised at the case Study "X".

N.B. : With the exception of group5 and group6 the key remains to be the same as in the previous case study "W". (refer to Table 11)

Group 5

Dicots with flowers deviod of perianth (achlamydeous) or with one whorl of perianth (monochlamydeous)

1. Perianth absent, inflorescence cyathium ... Euphorbiaceae
1. Perianth present, inflorescence simple
2. Ovary 2-6 locular
3. Flowers unisexual .... Begoniaceae
5. Flowers bisexual .... Aristolochiaceae
2. Ovary monolocular
4. Plant stem parasitic .... Loranthaceae
5. Stamens twice the number of perianth lobes ... Combretaceae
5. Stamens equal to or fewer than perianth lobes
6. Fruit a circumscissile dehiscent .... Lythraceae
6. Fruit not as above, indehiscent .... Nyctaginaceae
7. Flowers bisexual
6. Perianth scarious .... Amaranthaceae
7. Flowers unisexual or polygamous .... Ulmaceae
8. Perianth not as above, membranous
9. Plants with milky latex, leaves entire simple .... Moraceae
9. Not as above, leaves scaly minute forming sheaths .... Casuarinaceae

Group 6

Monocots

1. Perianth petaloid, at least in part

2. Flowers unisexual

3. Inflorescence umbellate, tendriliferous .... Smilacaceae

3. Inflorescence various, twining .... Dioscoreaceae

2. Flowers pistillate or bisexual

4. Staminodes present .... Orchidaceae

4. Staminodes absent .... Commelinaceae

1. Perianth not petaloid, often reduced to scales or bristles or absent

5. Woody plants usually trees

6. Leaves pinnate or palmate .... Arecaceae

6. Leave entire

5. Plants usually, not as above, herbaceous

7. Inflorescence; a solitary head on spirally ribbed peduncle .... Eriocaulaceae

7. Inflorescence; various but not as above

8. Leaves tristichous, not ligulate, culms triangular, anthers basifixed .... Cyperaceae

8. Leaves distichous, ligulate, culms cylindrical, anthers versatile .... Poaceae.

ii) Descriptive note on important trees & shrubs found in the case study "X"

1. **Acacia torta** (Roxb.) Craib. Rao (1985) Fl. G.D. Dam. Dadr. and Nagarhav. 1:153:

Small tree, 4-6m high. Leaves 6-10cm long, bipinnate, rachis with a few glands between the upper pinnae, 5cm long, with 8-10 pairs. Leaflets in 25-30 pairs, truneate at base, 5x2.5mm, pubescent beneath, with hooked spines.

Spike upto 6cm long, heads 0.8cm across, bracts stipuliform. Corolla white, twice as long as calyx. Pods 12 x 1.2cm, wavy, glabrous, 5-6 seeded.

2. **Caryota urens**, Cooke (1907) Fl. Bombay 3:315:

A lofty unbranched palm, 15-20 mts may sometimes reach 30 mts. Trunk smooth, cylindrical with ring like markings fairly smooth and grey. Leaves : very large bipinnate reaching upto 5-6m in length and 40 cm in breadth. The leaflets are like a fish tail or fin, serrated at the tip. Flowers : The tree flowers after about 10-15 years, the flowers are borne on large branches of heavy pendulous spikes, 3-7 mts long bearing both male and female flowers. Fruits : round about 2cm in diameter, red with 1-2 seeds which appear like areca nut.

3. **Casuarina equisetifolia**, Forst. Cooke (1906) Fl. Bombay 3:161:

Tall, straight erect tree, about 20-25 mts. high resembling a pine tree. Branches numerous, drooping with 6-8 angled needles looking like leaves. Bark rough broad, exfoliating in longitudinal steps. Leaves needle shaped, jointed, covered by triangular scales at the joints. Flowers red in catkins, clustered, appearing on the same or separate tree.

4. **Carissa inermis** Valh. Cooke (1906) Fl. Bombay 2:187.

Erect or scandent spinous woody shrubs. Leaves ovate to elliptic lanceolate 5-9cm long, base rounded or sometimes obtuse or acute, apex acute to slightly acuminate, occasionally emerginate. Cymes terminal. Calyx eglandular, corolla clover shaped, white, tube pubescent within lobes lanceolate, imbricate to the right. Corolla tube 10-20 mm long. Stamens inserted near the top of the tube, filaments short, anthers oblong, apiculate free.

5. **Ervatamia heyneana** (Wall.) Cooke. Fl. Bombay .2:134.

A shrub becoming a small tree under favourable conditions of 5 to 8 mts high. Stem - bark rough. Leaves light green coriaceous, oblonglanceolate, shortly acuminate glabrous. Flowers of many penduncled cymes, rotate, white; corolla lobes overlapping to the right. Fruit: of paired follicles, orange-yellow when ripe, curved and subsessile. Seeds long surrounded by a red pulp. It is among the most common plant species in their case study "X".

6. **Ficus benghalensis** Cooke (1907) Fl. Bombay 3:145.

A huge spreading tree of about 15 mts high, with a large number of hanging roots which extend the growth of the tree indefinitely. Branches of trunk smooth with milky latex. Leaves ovate, smooth, shiny, green buds covered by conical stipules. Flowers inconspicuous, inside figs.

Fruits : fig, turns red and becomes soft at maturity. Seeds numerous. Many varieties of birds tend to visit the tree at the fruiting season.

7. **Holarrhena antidysenterica** Wall. Cooke (1904) Fl. Bombay 1:195.

Shrubs or small trees about 1-2 mts high leaves broadly ovate to elliptic 10-25 cm long pubescent or glabrous base rounded to obtuse, apex accuminate. Inflorescence cymes terminal or lateral corymbose. Corolla white, tube about 10 mm long, pubescent lobes oblong mostly 12-14 mm long. Calyx with small basal glands within. Stamens attached near the base of the tube, filamentous and short. Anther linear, oblong, stigma free not thickened, conical. Fruit : Pair of follicles, somewhat divergent 20-40 cm long, seeds comose.

8. **Microcos paniculata** L. Rao (1985) Fl. G.D. Dam. Dadr. & Nagarhav. 1:55.

Stellately pubescent shrubs reaching 4-5 mts. Leaves alternate, petiole less than 0.8cm, leaf blade to 15 x 15 cm ovate lanceolate, acute, sub-entire, palmately 3 ribbed glabrous, crenate-serrate or lobed. Inflorescence axillary or terminal panicle, buds globose, sepals elliptic, acute, pubescent within free, petals entire glandular in lower portion, stamens many, free borne on short or elongated torus. Ovary 2 locular or 4 locular. Ovules 2 many in each stigma 2-5

Table 20 List of importan tree/shrub species observed during the survey of case study "X".

Key :- Tree(T); scrub (S); Naturally occurring (N.O.); Cultigen (C)

Sr. No.	Taxon	Habit	Family	Common/Local names Marathi & Konkani	Flowering/Fruiting Season	Chromosome No.	Local use if known
1.	Abrus precatorius, L.	(S) (N.O.)	Fabaceae	Gunj	Fl: Aug-Sept; Fr: Oct-Dec	22	Seeds: in jewellery arrangements
2.	Acacia auriculiformis, A. Cunn.	(T) (C)	Mimosaceae	Aust. Acacia	Fl/Fr. Nov-Jan	26	Afforestation
3.	Acacia arabica, Willd	(S) (N.O.)	Mimosaceae	Babhal	Fl: Apr-June; Fr: Aug-Oct.	44	Stem exudate: gum
4.	Acacia torta (Roxb) Craib.	(T) (N.O)	Mimosaceae	Lalkhair	Fl:& Fr: May-Sept.	26	Substitute of A.Catechu
5.	Acacia mangium	(T) (C)		------		26	
6.	Achras sapota L.	(T) (C)	Sapotaceae	Chikku	Fl: & Fr: Aug-Dec.	26	Fruits : eaten
7.	Allophylus cobbe R. Br.	(T) (N.O)	Sapindaceae	------	Fl: Sept-Oct; Fr: Nov.	22-32	Leaves: medicinal
8.	Alstonia scholaris, L.R. Br.	(T) (N.O)	Apocynaceae	Satparni	Fl: Oct-Nov; Fr: Dec.	44	Bark:substitute for quinine,Timber:slates
9.	Anacardium occidentale, L.	(T) (C)	Anacardiaceae	Cashew-nut	Fl: Nov-Feb; Fr:Mar-May	42	Fruits : edible
10.	Artocarpus heterophyllus, Lamk	(T) (C)	Moraceae	Jack-fruit	Fl: & Fr: Feb-Jun.	28-56	Fruits : edible

(Cont....)

11.	Azadirachta indica Juss.	(T) (C)	Meliaceae	Neem	Fl: Apr-May; Fr:Jun-Jul	30	Lvs: Insect repellant
12.	Bauhinia variegata L.	(T) (C)	Meliaceae	Kanchan	Fl: & Fr: Apr-Jul.	28	Leaves : Insect repellant
13.	Bombax ceiba, Mill	(T) (N.O.)	Bombacaceae	Savari	Fr: Jun-Aug; Fl:Feb-Jun Fr: Mar-Apr.	88	Capsule : cotton fibre
14.	Bougainvillea spectabilis, Wild.	(S) (C)	Nyctaginaceae		Fl: & Fr:Almost through out the year.	20,84,51	Ornamental
15.	Bridelia retusa, (Spreng) wild.	(T) (N.O)	Euphorbiaceae	------	Fl: Apr-Oct; Fr:May-Jun	28	----
16.	Bridelia scandens(Roxb) Spreng.	(T) (N.O.)	------	--------	Fl: Nov; Fr: Dec-Jan.	28-28	
17.	Buchanania lanzan, Spreng.	(T) (N.O.)	Anacardiaceae	Chara	Fl: Jan-Mar; Fr:Apr-May	----	Fruit : Edible
18.	Caesalpinia pulcherrima Swartz	(T) (C)	Caesalpiniaceae	Shack Gaban	Fl: & Fr:Almost through out the year	24	Ornamental, wood decoction: tonic, diarrhoea & dysentery
19.	Callistemon lanceolatus DC.	(T) (C)	Myrtaceae	Bottle-brush	Fl:& Fr: Aug-Nov.	22	Ornamental
20.	Calycopteris floribunda,(Roxb.) Peir.	(S) (N.O)	Combretaceae	Ukshi	Fl: Mar-Apr; Fr:Apr-May	48	Leaves : Colic & dyspepsia, young twigs: diarrhoea & dysentery Seeds : Jaundice
21.	Caryota urens L.	(T) (N.O.)	Arecaceae	Bherli-mad	Fl:& Fr: Througout the year.	48,54	Root: Snake bites, Fruit: Ulcers & Jaundice. Leaves : Ropes & Baskets
22.	Careya arborea, Roxb.	(T) (N.O.)	Myrtaceae	Kumbh	Fl: & Fr: Mar-Jun.	26	Timber
23.	Cassia alata L.	(S) (C)	Caesalpiniaceae	Shimai-agase	Fl: & Fr: Mar-May.	12,24,28	Leaves: repeted for skin diseases,veneral diseases insect bites
24.	Cassia fistula,	(T) (C)	Caesalpiniaceae	Indian Laburnum	Fl:& Fr: May-Sept.	24	Ornamental
25.	Cassia javanica L.	(T) (C)	Caesalpiniaceae	-------	Fl: & Fr: Jul-Sept.	28	Ornamental

(Cont.....)

26.	Casuarina equisetifolia L.	(T) (C)	Caesalpiniaceae	Beef Food	Fl: & Fr: Aug-Oct	18	Reclamation
27.	Clerodendrum thomsonae, Balf.	(S) (C)	Verbenaceae	------	Fl: Aug-Sept; Fr: Nov.	42,46,48, 50	Ornamental
28.	Clerodendrum viscosum Vent.	(S) (N.O)	Verbenaceae	-----	Fl: Oct-Jan.	48	Occasionally ornamental
29.	Cocos nucifera L.	(T) (C)	Palmaceae	Coconut	Fl: & Fr:Almost throughout the year.	32	Edible Kernel all parts useful
30.	Codiaeum variegatum, Bl.	(T) (C)	Euphorbiaceae	Crotons	Fl: Nov-Dec; Fr:Jan.	108,112, 116,120	Ornamental
31.	Dalbergia sissoo, Roxb.	(T) (C)	Fabaceae	Sissoo plant	Fl: Aug-Sept; Fr: Oct.	20	Timber
32.	Delonix regia, Rafin.	(T) (C)	Caesalpiniaceae	Gulmohor	Fl: Apr-May; Fr:Jun-Aug	24	Ornamental
33.	Dendrocalamus strictus Roxb.	(T) (C)	Poaceae	Male Bamboo	-------	70,72	Wooden poles
34.	Emblica officinalis, L.	(T) (C)	Euphorbiaceae	Amla	Fl: Mar-May; Fr:Aug-Nov	98-104	Fruit : edible
35.	Ervatamia heyneana, (Wall) Cooke).	(T) (N.O)	Apocynaceae	Nag-Kuda	Fl: Mar-Apr; Fr:Apr-Aug	22	Fruit: Religious significance
36.	Eucalyptus globulus, Labill.	(T) (C)	Myrtaceae	Nilgiri	Fr: Mar-May; Fl:Jun-Jul	20	Leaves: medicinal, carminative, stimulant expectorant, diphoretic, antiseptic
37.	Euphorbia royleana Boiss	(S) (N.O)	Euphorbiaceae	---	Fr: Sept-Oct.	30	Life fencing
38.	Ficus benghalensis, L.	(T) (N.O)	Moraceae	Vad/Banyan	Fl: & Fr: Jan-Apr.	26	Religious significance
39.	Ficus glomerata, Roxb.	(T) (N.O)	Moraceae	Umber/Umbad	Fl: & Fr: Mar-Sept.	26	Fruits:edible,Tree:religious significance
40.	Ficus benjamina L.	(T) (N.O.)	Moraceae	-----	Fl: & Fr: May-Aug.	26	

(Cont.....)

41.	Ficus rumphii Bl.	(T) (W.O.)	Moraceae	Pimpri	Fl: & Fr: Nov-Dec.	26	Wood: Juice, Fruit: emetic & anthelmintic
42.	Ficus asperrima Roxb.	(T) (W.O)	Moraceae	Karvat	Fl: & Fr: Mar-Apr.	26	------
43.	Ficus macrophylla Desf.	(T) (C)	Moraceae	------	Fl: & Fr: Dec-Jan.	26	Ornamental
44.	Flacourtia montana, Graham	(T) (W.O)	Flacourtiaceae	Jagama	Fl: Nov-Dec; Fr:Jan-Apr	22	Fruit : edible
45.	Garcinia indica choisy.	(T) (W.O.)	Clusiaceae	Kokum	Fl: Sept-Jan.	48,54	Fruit : edible.
46.	Gmelina arborea, Roxb.	(T) (W.O.)	Verbenaceae	Shivan	Fl: Mar-May; Fr: Jun	36	Wood : musical instruments
47.	Grewia umbellifera, Bedd.	(T) (W.O.)	Verbenaceae	-----	Fl:Mar-Jul; Fr:Aug-Sept	18-36	Bark : cordage
48.	Helicteres isora L.	(S) (W.O.)	Sterculiaceae	Murud sheng	Fl:Aug-Nov; Fr:Sept-Jan	18,24	Seeds: Medicinal,Gonorrhoea, ulcers, Root -bark decoction : diabetes, diarrhoea,
49.	Heterophragma quadrangulare, (Roxb)K.Schum	(T) (W.O.)	Bignoniaceae	Varas	Fl: Jan-Apr; Fr:Jun-Jul	40	Wood: cheap fuel dysentery, Fruit : Colic, flatulence.
50.	Hibiscus roseus, Thore.	(S) (C)	Malvaceae	Jaswand	Fl: Almost throughout the year	38	Ornamental
51.	Holarrhena antidysenterica, (Roth) DC.	(S) (W.O.)	Apocynaceae	Kudo	Fl: Apr-May; Fr:Aug-Nov	22	Root bark: Dysentery, stomachic, anthelmintic.
52.	Ichnocarpus frutescens (L) R.Br.	(S) (W.O.)	Apocynaceae	Krishnasarwa	Fl: Oct-Nov; Fr: Dec.	20	-----
53.	Jacaranda mimosaefolia d. Don.	(T) (C)	Bignoniaceae	------	Fl: & Fr:	36	Ornamental
54.	Lannea coromandelica (Hout.) Merr.	(T) (W.O.)	Anacardiaceae	Moi	Fl: Feb-Mar; Fr:Mar-Jun	28-40	Bark : Bone fracture, astingent
55.	Lawsonia alba, L.	(T) (C)	Lythraceae	Mehendi	Fl: & Fr: Jan-Aug.	---	Leaves : Dye

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(Cont.....)

56.	Leucaena leucocephala, (Lamk) de Wit.	(T) (C)	Mimosaceae	Vilayati babul	Fl: Jul-Oct; Fr: Nov	36-104	Reclamation
57.	Mallotus albus, auct.	(T) (N.O.)	Euphorbiaceae	-----	Fl: & Fr: Nov; Fr: Dec-Jan	27-72	Leaves: used as wrappers
58.	Mangifera indica, L.	(T) (C)	Anacardiaceae	Mango tree	Fl: Dec-Jan; Fr:Mar-May	40	Fruit: edible
59.	Melia azadirach L.	(T) (C)	Meliaceae	Persian Lilac	Fl: Apr-May; Fr:Jun-Jul	28	Leaves: Medicinal, anthelmintic; Fruit: purgative, emollient Flowers : stimulant. tonic, stomachic.
60.	Memecylon umbellatum	(S) (N.O.)	Melastomataceae	Anjan	Fl: Jan-Mar; Fr:Apr-May	14-28	Stem : Fuel wood
61.	Microcos paniculata, L.	(S) (N.O.)	Tiliaceae	Hasale	Fl:May-Oct; Fr:Sept-Nov	18-36	Fruit : edible Leaves : Jaundice treatment
62.	Mimusops elengi, L.	(T) (N.O.)	Sapotaceae	Bakul	Fl: Nov-Dec; Fr:Jan-Mar	24	Ornamental, fragrant flowers : garlands
63.	Moringa oleifera Lamk.	(T) (C)	Moringaceae	Shevaga	Fl: Dec-Feb; Fr:Mar-May	28	Leaves and fruits : vegetable
64.	Mussaenda frondosa L.	(S) (C)	Rubiaceae	------	Fl: & Fr: Aug-Nov.	22	Ornamental
65.	Mussaenda laxa (H.K.)Gamble.	(S) (N.O.)	Rubiaceae	-----	Fl:Aug-Sept; Fr:Nov-Jan	22	---
66.	Ochna obtusata, DC.	(S) (N.O)	Ochnaceae	------	Fl: Apr-May; Fr: Jun	24-48	---
67.	Peltophorum pterocarpum, DC. Backer	(T) (C)	Caesalpiniaceae	Copper-pod Tree	Fl: Feb-Mar; Fr: Apr.	26-28	Ornamental
68.	Pithecellobium dulce, Benth	(T) (C)	Mimosaceae	Vilayati chinch	Fr: Aug; Fl: Jan-Feb. Fr: Mar-May	26	Fruits : edible
69.	Plumeria rubra, L.	(T) (C)	Apocynaceae	Pandhara chafa	Fl: Mar-May; Fr: May	36	Ornamental
70.	Pongamia pinnata (L.) Pierre	(T) (C)	Fabaceae	Karanj	Fl: Apr-Jun; Fr:Through out the year.	20,22	Seeds Oil : Skin diseases

(Cont...)

71.	Polyathia Longifolia, Var pendula Lank	(T) (C)	Fabaceae	Karasj	Fr: Jun; Fl: Apr-May	18	Ornamental Leaves : religious festivals
72.	Psidium guajava, L.	(T) (C)	Myrtaceae	Peru	Fl:Sept-Oct; Fr:Nov-Dec	22	Fruits : edible
73.	Quisqualis indica L.	(S) (C)	Combretaceae	Rangoon creeper	Fl: & Fr: May-Jul	22,24,26	Ornamental
74.	Randia dumetorum, Lank	(S) (N.O)	Rubiaceae	Gela	Fl: Mar-May; Fr:Aug-Nov	22	Fruits : fish poison
75.	Rosa indica L.	(S) (C)	Rosaceae	Rose	-----	14	Ornamental, flowers : garlands
76.	Roystonea regia, Cook.	(T) (C)	Arecaceae	Bottle Palm	Fl:Throughout the year	36	Ornamental
77.	Ceiba pentandra, (L.) Gaerth	(T) (C)	Bombacaceae	Silk Cotton	Fl: Mar; Fr: Apr-May	72-80	Capsule : silk cotton
78.	Samanea saman, Willd.	(T) (C)	Mimosaceae	Rain tree	Fl: Apr; Fr: Jun	26	Shade giving tree
79.	Sapium insigne, Benth.	(T) (N.O.)	Euphorbiaceae	-----	Fl: Jan-Feb; Fr: Apr	36	----
80.	Sterculia ureas, Rox.	(T) (N.O.)	Sterculiaceae	Caraya-gum	Fr: Jan-Feb; Fl:Oct-Dec Fr: Jan-May.	40	Gum : stem exudate
81.	Strychnos nux-vomica L.	(T) (N.O.)	Sterculiaceae	Kalaro	Fl: Mar-Apr; Fr: Aug	24	Seeds : Medicinal dyspepsia, diseases of the nervous system.
82.	Syzygium cumini (L) Skeels.	(T) (N.O.)	Myrtaceae	Jambhul	Fl: Mar-May; Fr: May.	44	Fruits : edible
83.	Tamarindus indica L.	(T) (C)	Caesalpiniaceae	Chinch	Fl: Apr-May; Fr:May-Jun	24	Pods : edible
84.	Terminalia arjuna (Rorb.) Wt & Arn.	(T) (N.O.)	Combretaceae	Arjuna	Fl: Apr-May; Fr: Jun.	24	Bark decoction:heart diseases & Gonorrhea
85.	T. bellerica Gaert.	(T) (N.O.)	Combretaceae	Beheda	Fl:Mar-May; Fr:Sept-Nov	26	Seeds : edible

(Cont.....)

86.	T. catappa L.	(T) (C)	Combretaceae	Badam	Fl: Apr-May; Fr: Aug	24	Seeds : edible
87.	T. paniculata Roth.	(T) (W.O.)	Combretaceae	Kindal	Fl: Sept-Nov; Fr: Dec	14-43	Timber
88.	Thespesia populnea soland.	(T) (C)	Malvaceae	------	Fl: & Fr: Nov-Jan	26	Hedge plant
89.	Trema orientalis (L) Br.	(T) (W.O.)	Ulmaceae	Gol	Fl: Nov-Dec; Fr: Jan	20-40	Wood
90.	Vinca rosea L.	(S) (C)	Apocynaceae	Sadaphuli	Fl: Almost throughout the year.	16,32	Ornamental
91.	Wagatea spicata Dalz.	(S) (W.O.)	Caesalpiniaceae	-----	Fl: Nov-Dec; Fr:Jan-Feb	---	-----
92.	Ziziphus mauritiana Lamk.	(T) (W.O.)	Rhamnaceae	Bori	Fl:Sept-Nov; Fr:Nov-Mar	24,48,96	Fruits : edible
93.	Ziziphus oenoplia Mill.	(S) (W.O.)	Rhamnaceae	------	Fl: Aug-Oct; Fr: Nov	20,48	-----
94.	Ziziphus rugosa Lamk.	(S) (W.O.)	Rhamnaceae	Chunna	Fl: Dec-Mar; Fr:Apr-May	20,96	Fruits: edible
95.	Carissa inermis Vahl.	(S) (W.O.)	Apocynaceae	------	Fl: Jan-Feb; Fr: Mar	22	Fruits : edible
96.	Carissa congesta Wt.	(S) (W.O.)	Apocynaceae	-----	Fl: Dec-Feb; Fr:Mar-May	22	Fruits : edible
97.	Annona reticulata L.	(S)	Annonaceae	Bull's heart	Fl: May-Jun; Fr:Jun-Jul	14	Fruits : edible

Table 21 Herbaceous / ground flora found in case study 'X'.

Sr. No.	Taxon	Habit	Family	Common/Local names Marathi & Konkani	Flowering/Fruiting Season	Chromo- -some No.	Local use if known
1.	Abutilon indicum, Sweet	(H.O.)	Malvaceae	-----	Fl: & Fr:Almost through out the year	36	------
2.	Achyranthes aspera, L.	(H.O.)	Amaranthaceae	Aghada	Fl: Sept; Fr: Oct-Nov	14	Leaves: Diarrhoea Flowers : Snakebite Seeds : expectorant
3.	Alysicarpus bupleurifolius, DC.	(H.O.)	Fabaceae	------	Fl:Sept-Oct; Fr:Nov-Dec	16	----
4.	Aerva lanata Juss.	(H.O.)	Amaranthaceae	Kapurphuti	Fl: Sept; Fr: Oct. Fr: Dec-Jan.	16	-----
5.	Ageratum conyzoides, L.	(H.O.)	Asteraceae	------	Fl: & Fr:almost through out the year	20	-----
6.	Alternanthera sessilis, Br	(H.O.)	Amaranthaceae	------	Fl: & Fr: Aug-Apr	34	------
7.	Amaranthus viridis, L.	(H.O.)	Amaranthaceae	Ran-bhaji	Fl: & Fr: Sept-Nov	34	-----
8.	Andrographis paniculata, Nees.	(H.O.)	Acanthaceae	Kirayata	Fl: Dec; Fr: Jan-Feb	28	Plant: Bitter tonic febrifuge
9.	Anisochilus verticillatus, Hk.F.	(H.O.)	Lamiaceae	-----	Fl: Aug-Oct; Fr: Oct	---	-----
10.	Aristolochia indica, L	(H.O.)	Aristolochiaceae	Sapasan	Fl: Oct-Nov; Fr:Dec-Jan	12	Roots:antidote for snakebite
11.	Atylosia scarabaeoides, Benth.	(H.O.)	Fabaceae	-----	Fl: Jan-Oct; Fr:Nov-Dec	22	-----
12.	Canscora decurrens, Dalz.	(H.O.)	Gentianaceae	-----	Fl: Oct-May; Fr:Jan-May	72	-----
13.	Canscora diffusa, Dalz.	(H.O.)	Gentianaceae	-----	Fl: & Fr: Mar-Nov.	72	-----
14.	Cassia absus, L.	(H.O.)	Caesalpiniaceae	------	Fl: & Fr: Aug-Nov.	26,28,56	-----
15.	Celosia argentea, L.	(H.O.)	Amaranthaceae	Kurdu	Fl: & Fr: Aug-Nov.	36	Young plant: vegetable

(Cont...)

16.	Chromolaena odorata, (L.) King & Robin	(N.O.)	Asteraceae	-----	Fl: Nov-Dec; Fr:Jan	58	---
17.	Cleome viscosa, L.	(N.O.)	Capparidaceae	-----	Fl: & Fr: Apr-Jan	----	---
18.	Clitoria ternatea, L.	(C)	Fabaceae	Gokaara	Fl:& Fr: Jan-Nov.	16	Ornamental, Root-bark:irritation of the bladder & urethra Lvs: fever
19.	Crotalaria pallida aiton.	(N.O.)	Fabaceae	------	Fl: Aug; Fr: Sept-Oct	16-32	---
20.	Crotalaria epunctata, Grah.	(N.O.)	Fabaceae	------	Fl: Jul-Aug; Fr: Oct	16-32	---
21.	Commelina attenuata, Koen.	(N.O.)	Commelinaceae	------	Fl: & Fr: Sept-Oct	48	--
22.	Dactyloctenium aegyptium, Willd.	(N.O.)	Poaceae	------	Fl: & Fr: Aug-Sept	20,34,36,40, 48	Used as an orchard grass
23.	Desmodium triquetrum, DC.	(N.O.)	Fabaceae	------	Fl: Oct-Nov; Fr:Nov-Dec	22	--
24.	Desmodium polycarpum, DC.	(N.O.)	Fabaceae	------	Fl: & Fr: Sept-Oct	20-22	--
25.	Dimeria woodrowii, Stapf.	(N.O.)	Poaceae	------	Fl: & Fr: Aug-Sept	--	--
26.	Dioscorea bulbifera, L.	(N.O.)	Dioscoreaceae	Karande	Fl: & Fr: Aug-Nov	36,40,54,60 98-100	Bulbils & tubers : edible
27.	Eriocaulon dianae, Fyson	(N.O.)	Erioca...	-------	Fl: & Fr: Aug-Sept.	34-64	-
28.	Euphorbia hirta, L.nn Vent.	(N.O.)	Euphorbiaceae	------	Fl: & Fr:Almost through out the year.	12,20	-
29.	Euphorbia notoptera, Boiss	(N.O.)	Euphorbiaceae	------	Fl: Oct-Nov; Fr: Dec	12-200	-
30.	Evolvulus alsinoides, L.	(N.O.)	Convolvulaceae	Shankapushpi	Fl: Nov-Dec; Fr: Jan.	26	Plant : memory,tonic

(Cont.....)

31.	Geissaspis tenella, Benth	(N.O.)	Fabaceae	-----	Fl: Jun; Fr: Aug	--	---
32.	Hedyotis herbacea, L.	(N.O.)	Rubiaceae	Paripat	Fl: & Fr: Jun-Aug	12-48	Plant: Medicinal
33.	Hemidesmus indicus, L.	(N.O.)	Periplocaceae	Dudhsheri	Fl:Sept-Dec; Fr:Jan-Apr	22	Roots:
34.	Heteropogon contortus, L.	(N.O.)	Poaceae	-----	Fl: & Fr: Aug-Sept	20,40,60,80, 44	Fodder
35.	Hyptis suaveolens, L.	(N.O.)	Lamiaceae	-----	Fl: & Fr: Aug-Nov	28	---
36.	Impatiens Kleinii Wt & Arn..	(N.O.)	Balsaminaceae	-----	Fl: & Fr: Aug-Oct	28-84	----
37.	Ipomoea sepiara, Koen.	(N.O.)	Convolvulaceae	------	Fl: Aug-Sept; Fr: Oct	30	-----
38.	Ipomoea campanulata, Auct.	(N.O.)	Convolvulaceae	-----	Fl: Jun-Jul; Fr: Aug	--	---
39.	Ischaemum conjugatum, Roxb.	(N.O.)	Poaceae	----	Fl: & Fr: Aug-Sept	18-72	Fodder
40.	Iseilema laxum, Hack.	(N.O.)	Poaceae	------	Fl: & Fr: Aug-Sept	8,24,28	Fodder
41.	Ixora brachiata, Roxb.	(N.O.)	Rubiaceae	------	--------	----	-----
42.	Ixora coccinea, L.	(N.O.)	Rubiaceae	Pitkuli	Fl: Nov-Dec; Fr: Feb	22	Can be ornamental
43.	Lantana camara, L.	(N.O.)	Verbenaceae	Ghaneri	Fl: & Fr:Almost through out the year.	22,33,44,66	----
44.	Leea indica (Burm.) Merill.	(N.O.)	Leeaceae	---	---	---	---
45.	Lapidagathis cristata, Willd.	(N.O.)	Acanthaceae	------	Fl: Nov-Dec; Fr:Mar-Apr	22	------

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(Cont...)

46.	L. prostrata, Dalz	(N.O.)	Acanthaceae	------	Fl: Nov-Dec; Fr:Mar-Apr	22	-------
47.	Ludwigia parviflora, Roxb	(N.O.)	Onagraceae	-----	Fl: & Fr: Aug-Nov	18-48	-----
48.	Malvastrum coromandelianum, L.	(N.O.)	Malvaceae	------	Fl: Aug; Fr: Sept	24	----
49.	Merremia tridentata, L.	(N.O.)	Convolvulaceae	-----	Fl:Aug-Sept; Fr:Nov-Dec	28-58	----
50.	Merremia vitifolia, Burm	(N.O.)	Convolvulaceae	------	Fl: & Fr: Nov-Mar	28-58	----
51.	Mimosa pudica, L.	(N.O.)	Mimosaceae	Lajalu	Fl: & Fr: Sept-Jan	52	Leaves: pain on hips & kidney
52.	Mussaenda laxa, Hk. Gamble	(N.O.)	Rubiaceae	Shervan	Fl: & Fr: Apr-Nov	22	Sometimes ornamental
53.	Naregamia alata, Wt & Arn.	(N.O.)	Meliaceae	------	Fl: Aug-Oct; Fr:Oct-Dec	--	Plant: bark of root: expectorant bronchitis
54.	Neuracanthes sphaerostachyus, Dalz.	(N.O.)	Acanthaceae	Ghosvel	Fl: Aug-Nov; Fr: Oct onwards	--	---
55.	Osbeckia truncata, Wt. & Arn.	(N.O.)	Melastomataceae	-----	Fl: Aug-Nov; Fr: Nov	20-40	---
56.	Passiflora foetida, Linn.	(N.O.)	Passifloraceae	-----	Fl: & Fr: Apr-Aug	13,20	----
57.	Phaseolus mungo, L.	(N.O.)	Fabaceae	-----	Fl:Jul-Aug; Fr: Sept	22	Seeds & leaves: edible
58.	Phyllanthus fraternus, Webster.	(N.O.)	Euphorbiaceae	Bhuiavali	Fl: Aug-Nov; Fr:Nov-Mar	14-156	---
59.	Physalis minima, L.	(N.O.)	Solanaceae	Chirputi	Fl: & Fr: Aug-Nov	48	Fruits : edible
60.	Portulaca oleracea, L.	(N.O.)	Portulacaceae	Cholchi bhaji	Fl: & Fr:Almost through out the year	14,18,45,54, 52	Leaves: vegetable

(Cont...)

61.	Rauwolfia serpentina, Benth.	(N.O.)	Apocynaceae	Sarpagandhi	Fl: Apr; Fr: Nov	20	Roots: antidote for snake bite
62.	Rungia linifolia, Nees.	(N.O.)	Acanthaceae	-----	Fl:Sept-Oct; Fr:Nov-Dec	20	-----
63.	Rungia pectinata, Nees.	(N.O.)	Acanthaceae	------	Fl: & Fr: Nov-Mar.	---	---
64.	Russelia juncea, Zucc.	(C)	Scrophulariaceae	------	Fl: Almost throughout the year	20	-----
65.	Sesamum mulayanum, Nair.	(N.O.)	Pedaliaceae	Jangli Till	Fl: Oct	26-64	Seeds: used locally
66.	Sesbania bipinosa, (Jacq) Steud.	(N.O.)	Fabaceae	Tadnad	Fr:Aug-Sept; Fr:Oct-Nov	12	Plant : Religious purpose
67.	Sida rhombifolia, L.	(N.O.)	Malvaceae	------	Fl: Oct-Nov; Fr:Nov-Dec	14	----
68.	Smilax zeylanica, L.	(N.O.)	Smilacaceae	Ghotvel	Fl:Aug-Sept; Fr:Aug-May	26-60	Tender leaves : vegetable
69.	Smithia conferta, Sm.	(N.O.)	Fabaceae	------	Fl: & Fr: Aug-Nov	32	----
70.	Solanum nigrum, L.	(N.O.)	Solanaceae	------	Fl: Sept-Jan; Fr: Feb	24,36,48,72, 96, 144	Leaves : vegetable
71.	Spermacoce hispida, L.	(N.O.)	Rubiaceae	----	Fl: Aug-Sept; Fr: Oct	28	---
72.	Spermacoce verticillatas, L.	(N.O.)	Rubiaceae	------	Fl: & Fr: Aug-Nov	56	----
73.	Tephrosia tinctoria Pers.	(N.O.)	Fabaceae	------	Fl: & Fr: Sept-Nov	22	Seeds : Laxative
74.	Teramnus labialis, Spr.	(N.O.)	Fabaceae	Ran-Udid	Fl: Oct-Nov; Fr: Nov	28	---
75.	Tricholepis glaberrima, DC.	(N.O.)	Asteraceae	-----	Fl: Oct-Nov; Fr: Dec	16-32	----

(Cont....)

76.	Tridax procumbens, L.	(N.O.)	Asteraceae	-----	Fl: & Fr:Almost through out the year	36	----
77.	Urena lobata, L.	(N.O.)	Malvaceae	------	Fl: Oct-Nov; Fr:Nov-Mar	28	----
78.	Vernonia cinerea, Less.	(N.O.)	Asteraceae	-----	Fl: & Fr: Aug-Nov	18	----
79.	Dendrophthoe falcata, (L.) Etting.	(N.O)Aerial Parasite	Loranthaceae	Vendal Bendram	Fl: Apr-May; Fr:Nov-Jul	18	----
80.	Acampe praemorsa, Blatt & Mec.	(N.O.) Epiphytic orchid	Orchidaceae	Kanphodes	Fl:Sept-Oct; Fr:Nov-Dec	Range 40-56	----
81.	Capparis moonii, Wt.	(N.O.)Woody climber	Caparidaceae	-------	Fl: Dec-Jan; Fr:Feb-Apr	Range 24-85	----
82.	Ricinus communis, L.	(S) (N.O.)	Euphorbiaceae	Castor oil plant	-----	20	-----

lobed, fruit entire drupaceous with 1-4 pyrenes.

9. **Terminalia paniculata** Roth Cooke (1903) Fl. Bombay 1:510.

Medium sized tree of about 8-12 mts high, quite frequent on the slope of case study "X". Leave sub-opposite, oblong-lanceolate, shortly acuminated round-cordate with sessile gland at base. Flowers pale white, on branched spike.

Fruit : brown unequally 3-winged, densely crowded on the terminal branches, giving the tree a brown-red colour.

10. **Ziziphus mauritiana** L. Rao (1985) Fl. GG.D. Dam, Dadr, & Nagarhav 1:80.

A small evergreen tree, variable in size upto 10 mts. in height. Leaves variable oblong-elliptic, ovate, serrate with 2 stipular spines, one of which is hooked. Flowers small green-yellow in small axillary clusters.Fruit : drupes with one hard seed.

11. **Ziziphus rugosa** Lamk. Cooke (1902) Fl. Bombay 1:258.

Armed pubescent shrub of about 2-5 mts high, often scandent or climbing. Leaves broadly elliptic, subcordate below, pubescent beneath. Flowers light green in long- peduncled tomentose cymes, apetalous. (is the only species in the genius with such characteristic). Drupes fleshy, oblong, white, measuring 1-1.5cm.

12. **Pithecellobium dulce**, Benth. Cooke (1903) Fl. Bombay 1:185.

A moderately large evergreen tree, 6-9 mts high, armed with short, straight stipular thorns. Bark smooth, lenticellate with horizontal raised ridges, often covered with woody prickles. Leaves pinnate, sub-coriaceous, obtuse glaucescent. Flowers white, sessile in small heads. Fruit pod, 10-13 x 1.3 cm, fleshy, coriaceous twisted.

N.B. The Botanical decription of Acacia auriculiformis, A Cunn ex Benth, Alstonia scholaris, (L.) R. Br.(Fig.27a), Bombax ceiba. Linn.. (Fig.27b) Lannea coromandelica Merrill. Melia azedarach L.. Peltophorum Pterocarpum Becker. Samanea saman Merrill. Sterculia

EXPLANATION OF PLATE

Photographs showing dominant naturally occurring plant species at case study "X"

Fig 27a. _Bombax ceiba_ flowering portion, leafless at bloom.

Fig 27b. Alstonia scholaris flowering portion.

Fig. 27a

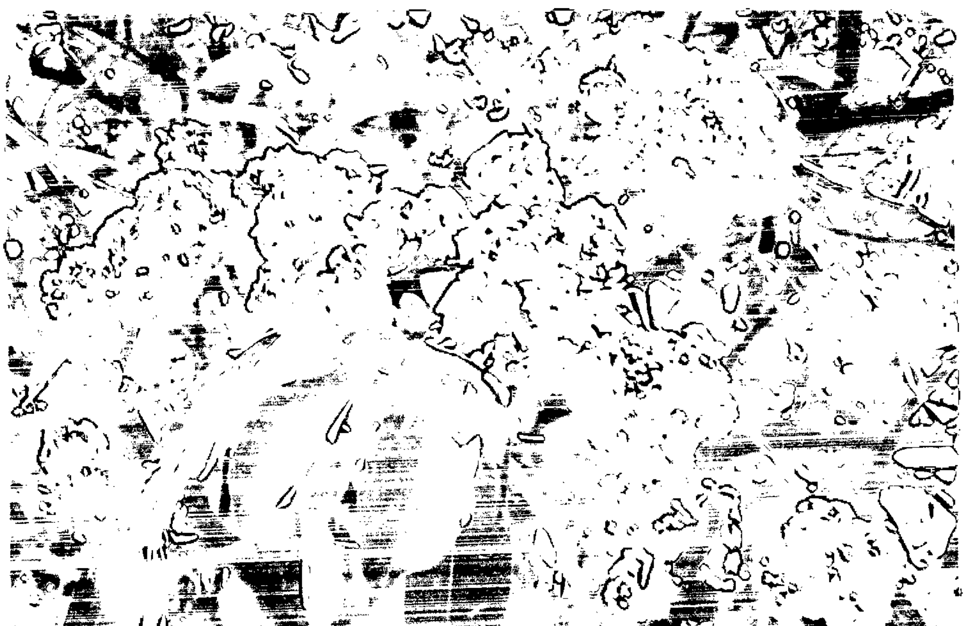


Fig. 27b

urens Roxb, and Trema orientalis Blume., are not given here, because they have been described in the previous text (though they are among the most important plant species in the case study "X").

Common lithophytes at case study "X":

Species' site preference is an important factor while considering the selection plants species for afforestation work. The following species have been found to be frequent within the rocky plateau of case study "X"; Alstonia scholaris R.Br., Sterculia urens Roxb.,Bombax ceiba L.,Lannea coromandelica L.,and Ziziphus rugosa Lam.

Table: 22 A list of fast growing tree species located at case study "X".

Sr.No.	Taxon	Family
1.	**Leucaena leucocephala (Lam.) de Wit.**	Mimosaceae
2.	**Samanea saman** Wild	Mimosaceae
3.	**Peltophorum pterocarpum** L.*	Caesalpiniaceae
4.	**Acacia auriculiformis** L.	Mimosaceae
5.	**Trema orientalis** L.*	Euphorbiaceae
6.	**Bauhinia variegata** L.*	Caesalpiniaceae
7.	**Pithecellobium dulce** Benth	Mimosaceaepa

Other fast growing species observed elsewhere in Goa.

Sr.No.	Taxon	Family
1.	**Sesbania grandiflora** L.	Fabaceae
2.	**Erythrina indica** Lam.	Fabaceae
3.	**Adenanthera pavonina** L.	Mimosaceae
4.	**Dalbergia sissoo** Roxb.	Mimosaceae

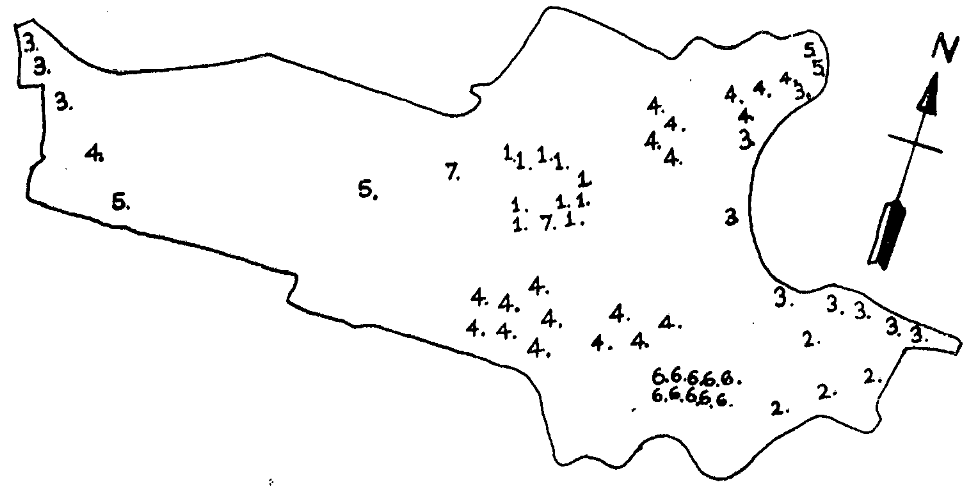
* Non-nodulating species.

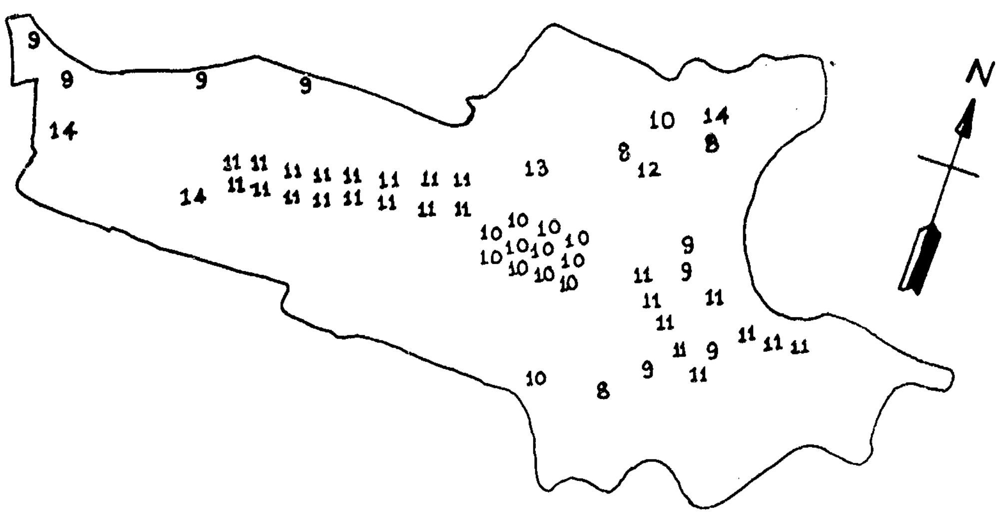
EXPLANATION OF PLATE

Taxon on distribution map of important plant species at case study "X".

Sr. No. on Map	Taxon
1.	Acacia auriculiformis A. Cunn.
2.	Acacia chundra Roxb
3.	Alstonia scholaris (L.) R. Br.
4.	Bombax ceiba Mill.
5.	Careya arborea Roxb.
6.	Casuarina equisetifolia L.
7.	Delonix regia Ratin.
8.	Ficus benghalensis L.
9.	Lannea coromandelica (Hout.) Merr.
10.	Mangifera indica L.
11.	Peltophorum pterocarpum (DC) Backer.
12.	Polyalthia longifolia Lam.
13.	Samanea saman Willd.
14.	Sterculia urens Roxb.

TAXON DISTRIBUTION AT CASE STUDY "X"





Scale : 1: 30,000 (Approximately).

EXPLANATION OF PLATE

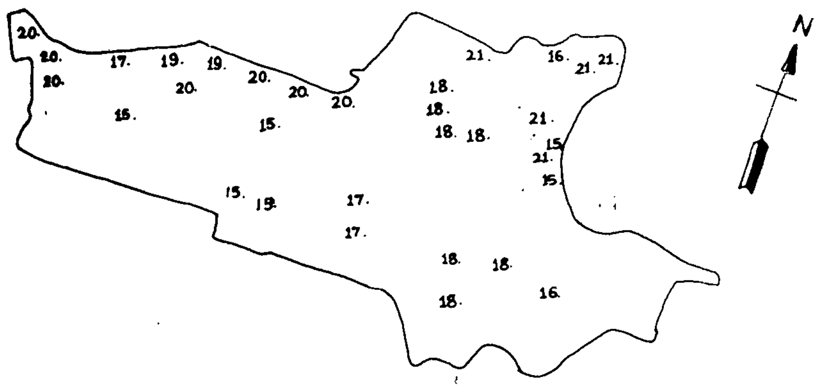
Taxon on distribution map of important plant species at case study "X".

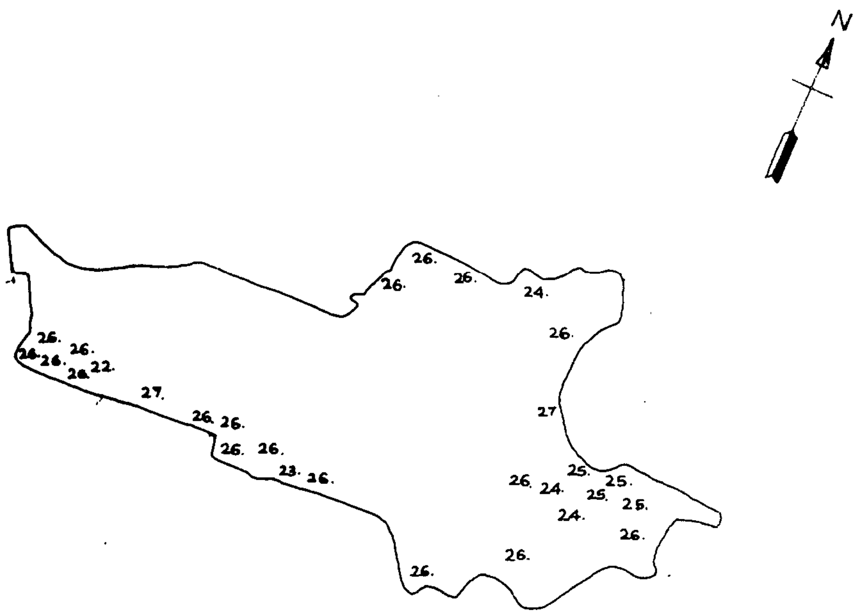
Sr. No. on Map	Taxon
15.	Tamarindus indica L.
16.	T. paniculata Roth.
17.	Trema orientalis (L) Br.
18.	Ziziphus mauritiana Lam.
19.	Ervatamia heyneana (Wall) Cooke.
20.	Carissa inermis Vahl.
21.	Caryota urens L.
22.	Holarrhena antidysenterica (Roth) DC.
23.	Microcos paniculata L.
24.	Ziziphus rugosa Lam.

.. Taxon on distribution map of some important herbaceous **medicinal** plant species.

25.	Aristolochia indica L.
26.	Dioscorea bulbifera L.
27.	Leea indica Burm.

TAXON DISTRIBUTION AT CASE STUDY "X"





Scale : 1: 30,000 (Approximately).

Plant species diversity

The simplest index of diversity is the total number of species usually of a specific taxon under investigation, inhabiting a particular area.

The study of plant diversity in case study "X" area reveals that:

Total number of Trees and Shrubs ....93, Total number of Trees ....76, (for both cultivated and the naturally occurring) The total number of the naturally occurring trees is ..... 51, Total number of vascular plants .....168 (Entire plant community including herbs) therefore plant species diversity is 168.

Holarrhena antidysenterica tends to form dense clusters. The capacity of plants to form dense groups is dependent upon the number of seeds produced, their mobility, a survival and germination, the survival of seedlings and their ability and those of mature plants to survive intense competition (Hanson, 1950; Puri et al., 1968). The same case has been observed for Microcos paniculata, a species that is cherished for its ripe drupe by the local people has been spared from cutting thus it is quite abundant and frequent in the case study "X" .

The dense natural population of Bombax ceiba around the main office building is an indication that this is the real adapted species of this area. It would be better to propagate it in large scale for plantation work in the case study area.

The presence of the plant species like Aristolochia indica (a twining herb) which is very rare in other places and highly reputed for its medicinal values is rather interesting .

Even the growth of grass which is normal during monsoon is burnt out as it is considered to be a threat to the growth of trees. It is, therefore, obvious that such activities cannot allow any animal life on the land. Even the insects and worms who burrow and fertilize the earth are destroyed in these devastating fires. Careya arborea and

Microcos paniculata appear quite resistant to fire the moment the plant gets burnt, a new shoot emerges in two weeks' time.

3.4.2. Quantitative analysis

A total of 37 quadrats were mapped out for the actual spot where the individual plants of each species was located.

From the quantitative analysis of case study "X" vegetation, it was found that plant species with the highest frequency were Microcos paniculata, Calycopteris floribunda, Memecylon umbellatum, Bombax ceiba, Euphorbia royleana, Holarrhena antidysenterica and Abrus precatorius in the descending order. Plant species with the lowest frequency were Randia dumetorum, Leea indica and Syzygium zeylanicum respectively.

Dominance was strikingly high in Calycopteris floribunda, Holarrhena antidysenterica, Microcos paniculata and Memecylon umbellatum. The lowest dominance was recorded in Acacia torta, Alstonia scholaris, Artocarpus heterophyllus, Randia dumetorum and Terminalia arjuna.Plant species with the highest density were Calycopteris floribunda, Holarrhena antidysenterica and Microcos paniculata whereas the ones with the lowest density were Terminalia arjuna, Alstonia scholaris and Leea indica.

The plant species with the highest relative frequency were Abrus precatorius, Bombax ceiba, Calycopteris floribunda, Euphorbia royleana, Microcos paniculata and Memecylon umbellatum, and Euphorbia royleana.

The plant species with the highest relative dominance were Bombax ceiba, ficus rumphii, Ficus benghalensis, Calycopteris floribunda, Careya arborea and Holarrhena antidysenterica.

The relative density was generally low in most species except Calycopteris floribunda, Leea indica and Microcos paniculata, which were found to be the highest.

The importance value index was found to be highest in _Sterculia urens_, _Strychnos nux-vomica_, _Ziziphus rugosa_, _Leea indica_, _Microcos paniculata_ and _Calycopteris floribunda_. The lowest importance value index was observed in _Ziziphus glaberrima_, _Acacia torta_, and _Syzygium zeylanicum_.

The results of the sampling showed that there were about 9,161 tree-shrub species in the case study area. The major aspect is the existence of a relatively dense forest cover in the areas adjoining the case study "X" but not within it.

Table 22 a Ground truth data of case study "X". Unit Area : 100 m x 100m

Sr. No.	Taxon / Quadrat No.	Quadrats close to Guest House & staff quarters																
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1.	Abrus precatorius	3	4	3	-	-	3	-	2	1	-	-	-	7	12	24	5	4
2.	Acacia torta	-	-	-	3	-	2	1	1	-	-	-	-	-	11	16	32	-
3.	Anacardium occidentale	3	3	4	-	2	3	4	-	4	5	-	-	-	4	5	12	4
4.	Bambusa arundinaceae	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-
5.	Bombax ceiba	4	3	5	4	4	3	3	4	4	2	3	1	-	7	8	-	4
6.	Calycopteris floribunda	28	22	36	32	28	31	19	20	38	11	-	10	14	8	16	7	12
7.	Carissa congesta	5	4	-	6	-	3	2	-	-	1	-	-	4	18	13	18	11
8.	Caryota urens	1	1	1	-	3	-	1	-	-	-	-	-	-	1	-	5	1
9.	Euphorbia royleana	-	-	-	5	-	-	-	20	-	25	35	38	10	7	14	-	35
10.	Ficus rumphii	-	-	2	3	-	-	-	2	-	2	6	6	10	12	2	6	4
11.	Ficus benghalensis	1	-	1	-	1	2	-	1	-	1	-	-	-	-	-	-	-
12.	Ficus tinctoria	-	2	-	-	1	-	2	-	-	-	-	-	-	-	-	-	-
13.	Ficus benjamina var.nuda	4	4	3	6	4	1	-	-	-	-	-	-	-	-	-	-	-
14.	Holarrhena antidysenterica	32	42	-	45	41	-	32	-	35	38	-	-	-	-	-	-	50
15.	Lannea coromandelica	-	-	-	-	-	-	-	-	-	-	-	4	-	-	10	6	7

(Cont...)

Sr. No.	Taxon / Quadrat No.	Quadrats close to Guest House & staff quarters																
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
16.	Microcos paniculata	64	82	55	94	58	96	38	35	4	32	-	-	-	-	-	-	3
17.	Memecylon umbellatum	12	5	3	-	-	8	10	-	15	2	25	48	12	72	16	16	4
18.	Mangifera indica	2	2	1	-	1	-	-	-	-	-	-	12	59	-	41	18	28
19.	Peltophorum pterocarpum	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	3
20.	Randia dumetorum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
21.	Strychnos nux-vomica	-	-	1	1	2	2	-	-	1	-	-	-	-	-	2	4	1
22.	Sterculia urens	1	1	1	-	3	-	1	-	-	-	-	-	-	1	-	5	1
23.	Syzygium zeylanicum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-
24.	Tamarindus indica	1	2	-	2	-	1	-	1	-	-	1	-	-	-	-	-	-
25.	Terminalia arjuna	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-
26.	Vitex negundo	-	-	-	-	-	-	-	-	-	-	8	-	-	-	-	-	-
27.	Zanthoxylum rhetsa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1
28.	Ziziphus rugosa	4	-	-	3	-	7	-	2	-	-	-	-	6	12	8	22	8
29.	Ziziphus glaberrima	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	16

(Cont...)

Sr. No.	Taxon / Quadrat No.	Quadrats close to non-teaching staff quarters																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1.	Abrus precatorius	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	8	4
2.	Acacia auriculiformis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	1	-	-
3.	Acacia torta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	16	-	12	-	-
4.	Alstonia scholaris	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.	Anacardium occidentale	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-
6.	Bombax ceiba	1	1	2	-	-	1	-	-	-	-	-	1	1	3	-	6	-	1	-	-
7.	Bridelia scandens	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8.	Bridelia retusa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9.	Carissa inermis	3	-	2	-	-	13	-	8	-	42	-	52	21	4	34	-	-	52	2	-
10.	Calycopteris floribunda	-	52	12	-	-	6	1	6	5	10	-	5	-	-	-	38	-	67	1 1	-
11.	Careya arborea	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12.	Caryota urens	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13.	Clerodendrum viscosum	-	-	-	-	-	1	-	-	-	-	12	-	-	10	-	-	-	3	-	-
14.	Delonix regia	-	-	-	-	-	-	-	-	-	-	-	-	4	4	8	9	3	-	3	4
15.	Euphorbia royleana	10	5	3	8	25	-	42	-	-	-	27	38	-	26	-	26	87	75	110	-
16.	Ficus benghalensis	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-
17.	Ficus rumphii	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
18.	Holarrhena antidysenterica	5	120	-	250	-	-	-	-	-	-	-	-	-	-	-	-	-	-	50	-
19.	Lannea coromandelica	3	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-
20.	Lantana camara	-	-	-	-	-	-	-	-	-	-	3	-	-	-	5	-	-	2	-	-

(Cont...)

Sr. No.	Taxon / Quadrat No.	Quadrats close to non-teaching staff quarters																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21.	Mangifera indica	-	-	-	1	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-
22.	Microcos paniculata	87	30	92	152	54	36	40	35	65	45	-	54	4	19	15	105	28	75	71	-
23.	Memecylon umbellatum	57	56	35	-	-	25	11	8	-	-	-	34	11	3	-	51	30	68	10	-
24.	Peltophorum pterocarpum	-	-	-	-	-	-	-	8	10	11	14	-	10	-	-	-	12	15	-	14
25.	Strychnos nux-vomica	-	-	-	-	-	2	1	-	-	-	-	1	-	-	-	-	-	-	-	-
26.	Sterculia urens	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
27.	Tamarindus indica	-	-	-	-	-	-	1	1	1	15	1	-	-	-	-	-	-	4	-	-
28.	Vitex negundo	-	-	-	6	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
29.	Ziziphus oenoplia	-	-	-	-	-	-	-	-	-	2	-	-	-	-	1	-	-	-	1	-
30.	Ziziphus rugosa	-	-	-	-	-	-	3	-	-	-	6	-	-	-	-	8	-	-	-	-
31.	Ziziphus mauritiana	-	-	-	1	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-

(Cont...)

Sr. No.	Taxon	Quadrats behind Hostel									
		1	2	3	4	5	6	7	8	9	
1.	Abrus precatorius	-	-	6	2	1	5	-	3	8	
2.	Anacardium occidentale	4	-	7	3	-	5	-	12	2	
3.	Allophyllus cobbe	-	-	3	-	2	1	2	5	1	
4.	Acacia torta	-	11	-	15	-	5	-	4	7	
5.	Bombax ceiba	3	4	-	1	-	3	1	2	4	
6.	Caryota urens	-	2	1	1	-	-	3	-	1	
7.	Calycopteris floribunda	15	45	40	58	40	38	42	45	-	
8.	Carissa congesta	13	6	12	15	-	18	5	8	4	
9.	Euphorbia royleana	-	30	350	25	21	28	29	30	5	
10	Ficus benghalensis	-	-	-	1	-	1	-	-	-	
11.	Holarrhena antidysenterica	-	42	10	30	21	38	21	15	22	
12.	Memecylon umbellatum	35	60	67	55	48	61	58	33	28	
13	Microcos paniculata	55	300	72	82	54	62	34	96	81	
14.	Strychnos nux-vomica	3	-	1	-	-	-	-	-	-	
15.	Tamarindus indica	-	1	-	3	-	1	-	1	1	
16	Ziziphus rugosa	5	10	8	12	22	8	32	5	6	

Grand total individual trees and shrub species found in the case study "X".

Table 24 a Showing the Frequency , Abundance and Density of plant species at the case study "X".

Sr. No.	Taxon	No. of Individuals of the species .	No. of Quadrats	Frequency	Abundance	Density
1.	Abrus precatorius	105	19	41.30	5.53	2.28
2.	Acacia pennata	136	14	2.2	1.0	0.28
3.	Acacia torta	136	14	30.4	9.7	2.96
4.	Allophyllus cobbe	56	10	21.7	5.6	1.22
5.	Alstonia scholaris	3	2	4.35	1.5	0.065
6.	Artocarpus heterophyllus	2	2	4.35	1.0	0.043
7.	Bambusa arundinaceae	5	1	2.2	5.0	0.108
8.	Bombax ceiba	97	31	67.4	3.13	2.11
9.	Calycopteris floribunda	876	35	76.1	25.03	19.04
10	Carissa congesta	166	19	41.3	8.74	3.61
11.	Carissa inermis	233	11	23.9	21.2	5.1
12.	Caryota urens	23	14	30.4	1.64	0.5
13	Careya arborea	26	14	10.86	5.2	0.56
14.	Clerondendrum viscosum	28	5	10.86	5.6	0.61
15.	Euphorbia royleana	1197	30	65.2	39.9	26.02
16	Ficus benghalensis	19	10	21.7	1.1	0.24
17.	Ficus rumphii	58	14	30.4	4.14	1.26
18.	Ficus tinctoria	5	3	6.52	1.6	0.11
19	Holarrhena antidysenterica	889	20	43.5	44.45	20
20.	Lannea coromandelica	35	6	13.04	5.83	0.76
21.	Lantana camara	10	3	6.52	3.33	0.22
22.	Leea indica	3	1	2.17	3.0	0.065
23.	Microcos paniculata	2597	44	95.6	58.95	56.4
24.	Memecylon umbellatum	1057	34	73.90	31.08	22.97

25.	Randia dumetorum	1	1	2.17	1.0	0.48
26.	Strychnos nux-vomica	22	14	30.43	1.57	0.326
27.	Syzygium zeylanicum	3	1	2.17	3.0	0.065
28.	Sterculia urens	15	9	19.6	1.66	0.326
29.	Terminalia arjuna	2	2	4.35	1.0	0.043
30.	Vitex negundo	15	3	6.52	5.0	0.326
31.	Ziziphus glaberrima	16	1	2.2	16.0	0.35
32.	Ziziphus mauritiana	10	3	6.52	3.33	0.217
33.	Ziziphus oenoplia	4	3	6.52	1.33	0.086
34.	Ziziphus rugosa	197	21	45.6	9.38	4.3
35.	Zanthoxylum rhetsa	4	2	4.35	2.0	0.086

Table : 24 b Relative frequency , relative abundance ,and relative density of the plant species in the case study "X."

Sr. No.	Taxon	Relative Frequency	Relative Abundance	Relative Density
1.	Abrus precatorius	4.75	257.7	1.3277
2.	Acacia pennata	0.25	31.6	0.163
3.	Acacia torta	3.5	2084.2	1.71
4.	Allophyllus cobbe	2.5	244.6	0.705
5.	Alstonia scholaris	0.5	117.6	0.037
6.	Artocarpus heterophyllus	0.5	43.7	0.025
7.	Bambusa arundinaceae	0.25	12.21	0.062
8.	Bombax ceiba	7.75	3203.6	1.22
9.	Calycopteris floribunda	8.75	3826.3	11.0
10	Carissa congesta	4.75	101.96	2.09
11.	Carissa inermis	2.75	143.1	2.93
12.	Caryota urens	3.5	981.2	0.289
13	Careya arborea	1.25	1596.7	0.327
14.	Clerondendrum viscosum	1.25	4.29	0.352
15.	Euphorbia royleana	7.5	326.8	0.73
16	Ficus benghalensis	2.5	1200.7	0.062
17.	Ficus rumphii	3.5	1582.6	0.138
18.	Ficus tinctoria	0.75	168.85	0.277
19	Holarrhena antidysenteric	5.0	2183.9	0.44
20.	Lannea coromandelica	1.5	536	0.125
21.	Lantana camara	0.75	0.681	0.037
22.	Leea indica	0.25	0.816	32.7
23.	Microcos paniculata	11.0	1106.6	13.31
24.	Memecylon umbellatum	8.5	649.1	0.012
25.	Randia dumetorum	0.25	9.4	0.277

26.	Strychnos nux-vomica	3.5	230.3	0.012
27.	Syzygium zeylanicum	0.25	5.1	0.037
28.	Sterculia urens	2.25	409.45	0.277
29.	Terminalia arjuna	0.5	34.56	0.025
30.	Vitex negundo	0.75	16.37	0.188
31.	Ziziphus glaberrima	0.25	9.81	0.201
32.	Ziziphus mauritiana	0.75	153.3	0.125
33.	Ziziphus oenoplia	0.75	0.067	0.05
34.	Ziziphus rugosa	5.25	121.0	2.48
35.	Zanthoxylum rhetsa	0.5	60.76	0.05

Table 24 c Descending affinity of importance value index on plant species found at case study "X".

Sr. No.	Taxon	Relative Dominance	Importance Value Index
1.	Sterculia urens	0.0135	411.9
2.	Strychnos nux-vomica	0.0076	233.8
3.	Ziziphus rugosa	0.004	128.7
4.	Leea indica	0.00002	32.9
5.	Microcos paniculata	0.036	24.3
6.	Calycopteris floribunda	0.126	19.9
7.	Bombax ceiba	0.11	9.1
8.	Memecylon umbellatum	0.0215	8.53
9.	Carissa congesta	0.003	6.84
10	Abrus precatorius	0.0085	6.08
11.	Carissa inermis	0.0047	5.69
12.	Holarrhena antidysenterica	0.0723	5.51
13	Euphorbia royleana	0.011	5.48
14.	Acacia torta	0.069	5.28
15.	Caryota urens	0.032	3.82
16	Ficus rumphii	0.0524	3.69
17.	Allophyllus cobbe	0.0081	3.21
18.	Ficus bengalensis	0.039	3.6
19	Lannea coromandelica	0.0177	1.64
20.	Careya arborea	0.052	1.63
21.	Clerondendrum viscosum	0.0001	1.6
22.	Ficus tinctoria	0.0055	1.03
23.	Vitex negundo	0.0005	0.93
24.	Ziziphus mauritiana	0.005	0.88
25.	Ziziphus oenoplia	0.0000002	0.8
26.	Lantana camara	0.00002	0.78

27.	Zanthoxylum rhetsa	0.02	0.55
28.	Alstonia scholaris	0.0038	0.54
29.	Randia dumetorum	0.0003	0.53
30.	Artocarpus heterophyllus	0.0014	0.53
31.	Terminalia arjuna	0.0011	0.53
32.	Ziziphus glaberrima	0.0003	0.45
33.	Acacia pennata	0.001	0.414
34.	Bambusa arundinaceae	0.0004	0.312
35.	Syzygium zeylanicum	0.00016	0.29

3.4.3. Soil analysis of case study "X"

The porous space(%) was found to be within the range of 22.4% to 34.5%, the lowest observed being the samples collected from the scrub forest close to All India Radio (AIR) and highest being the rocky plateau close to the staff quarters (Table 25 a). The water holding capacity (%) was found to be within the range 42.0% to 64%, the lowest being at the Mango orchard area and the higest on the rocky plateau close close to the staff quarters. Moisture content(%)was found to range between 12.8% and 22%, the lowest being at the scrub forest close to AIR and highest on the mango orchard area.

Available organic carbon(%) was high in all soils (1.2 or more) except the rocky plateau area adjoining the staff quarters (0.38%) and the mango orchard area (0.07%) which was very low. The availability of Phosphorus (p_2O_5 kg/acre) was found to be extremely low in all the soils samples (2-10 kg/acre); the lowest amount is observed on the relatively dense forest area behind the lady's hostel(2 kg/acre), rocky plateau adjoining the staff quarters (2 kg/acre) and the rocky plateau which is close to the mango orchard(2 kg/acre), while the highest was though not appreciably high was found at areas of the dome shaped tank close to Dona Paula (Table 25 b). Potassium(Kg/acre) was found to be within the range of 48 kg/acre to > 120 kg/acre which varied widely. The lowest amount were observed in the rocky plateau close to the staff quarters(48 kg/acre) scrub close to All India Radio (58 kg/acre) and Rocky area near a big cross (68 kg/acre) whereas the highest was observed in the mango orchard (110 kg/acre), scrub forest behind hostel (>120 kg/acre) and the Dome shaped tank close to Dona Paula (>12o kg/acre) The available calcium (mg/g) was within the range of 0.2 to 4.4 mg/g, the lowest (which was extremely low compared to all of the case study "X") being at dome shaped tank area close to quarters area. The mango orchard area also had relatively high amount of Calcium (4.1 mg/g). The micro-nutrients which were determined are Zinc and Iron. Zinc was found to be within the range of 0.77 pm to 18.27 ppm. In all the soil sampled zinc range between 0.77 ppm and 1.0 ppm with the exception of soil sampled from the dome shaped tank area close to Dona Paula (18.27 ppm) which was exceptionally high. Iron (Fe_2O_3) was found to range between 4.1 ppm and 33.0 ppm in all the soils sampled, the lowest being at the rocky plateau close to the staff quarters and the highest at the dome shaped tank area close to Dona Paula through which was exceptionally compared to all other sites sampled. The pH was within the range of 6.2 to 6.9 in all the soils at case study "X".

The lowest being at relatively dense scrub forest behind the hostel and the highest being at the rocky plateau close to the staff quarters. Generally the soils were neutral (pH 6.6.-6.9) to slightly acidic (pH 6.2 6.5) Electrical conductance (ds/m) of the soils was found to range between 0.03 ds/m and 0.22 ds/m (Table 25 b). The lowest being in the rocky plateau close to the mango orchard and highest at the water tank area close to Dona Paula. Table 25b

Physical soil analysis of case study "X"

S.No. of soil sample	Porous space %	Water holding capacity %	Moisture content %
1.	22.4	61.0	12.8
2.	34.5	64.0	18.0
3.	34.0	42.0	22.0
4.	28.0	55.0	12.0
5.	31.0	44.0	20.0
6.	23.0	44.0	14.4

Table 25b Chemical soil analysis of case study of "X"

S.No.of soil sample	1	2	3	4	5	6
Area Sampled	Scrub close to All India Radio	Rocky plateay close to the teachers staff quarters	Mango orchard transi ferred soil	Relatively dense scrub forest behind hostel	Dome shaped tank area close to Dona Paula	Rocky area near the cross
Texture of the soil	Clay	lateritic loam	loam clay	loam clay	clay loam	loam
pH	6.8	6.9	6.6	6.4	6.2	6.5
E.C. ds/m	0.05	0.07	0.07	0.14	0.22	0.03
Organic carbon(%)	1.2	0.38	0.49	1.2	1.2	1.15
Available potassium (kg/acre)	58.0	48.0	100.0	>120.0	>120	68
Available calcium mg/g	2.3	4.4	4.1	1.0	0.2	3.1
Available phosphorus (kg/acre)	9.0	2.0	8.0	2.0	10.0	2.0
Micro-nutrients (ppm)						
Iron	14.2	4.1	8.9	13.0	33.0	9.7
Zinc	0.78	0.77	0.54	1.0	18.27	0.91

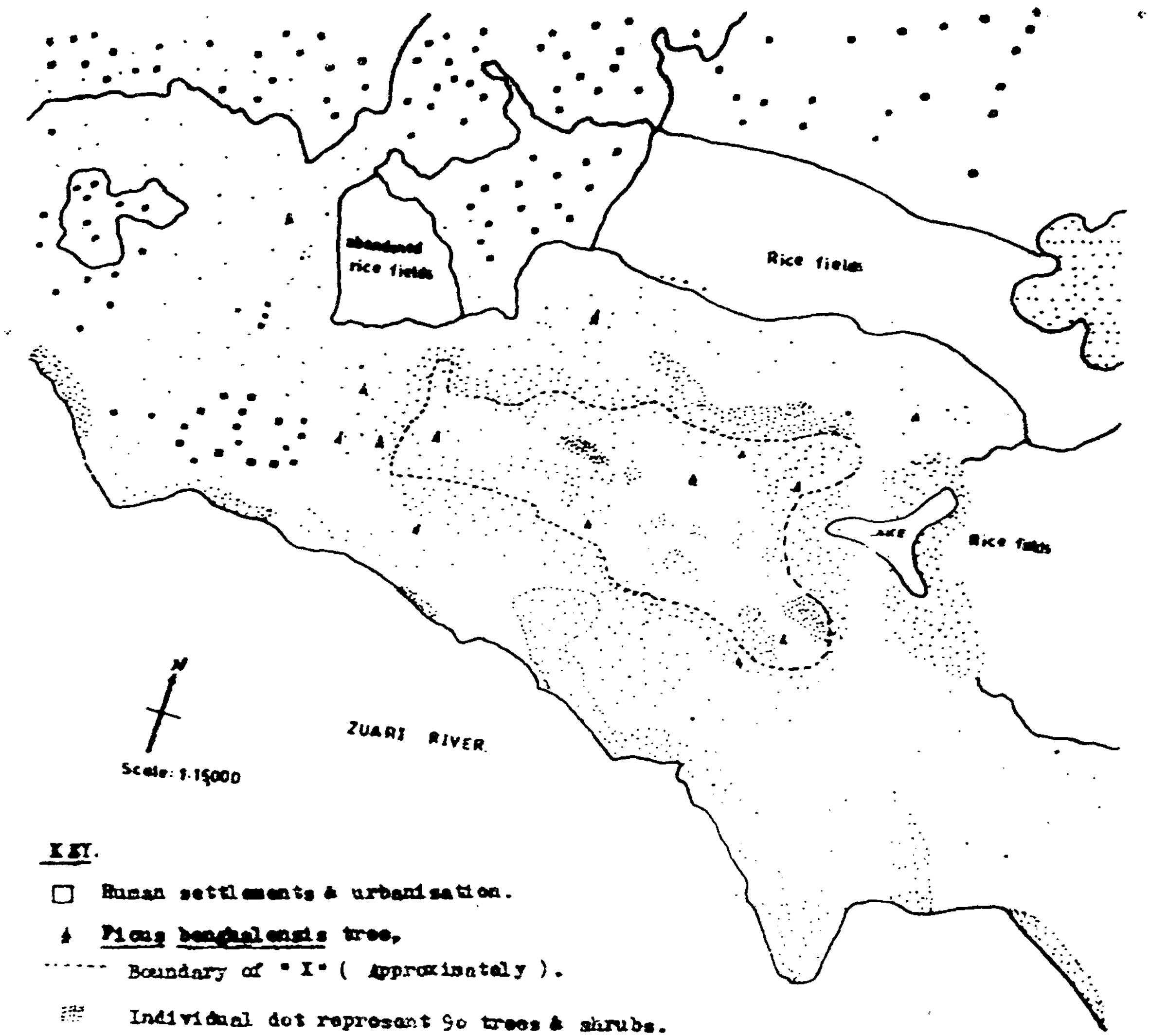


Fig. 26b. A sketch map showing the present vegetation land cover at case study 'X' and the surrounding areas.

Soil and plant distribution

Bombax ceiba was frequent in distribution at the sites with medium pH 6.8 and with low Zinc levels (0.78 ppm).

Holarrhena antidysenterica was more frequent even in soils with very low organic Carbon (0.38%), Phosphorus (2.0kg/acre) .

Microcos paniculata, Ziziphus rugosa and Caryota urens were more frequent in the areas with high Iron (33 ppm) and Zinc (18.27 ppm) but with very low Calcium (0.2mg/g).

Tamarindus indica and Carissa inermes were most frequent on soil samples with generally sufficient (on the avarage) mineral requirement of plants with the exception of Zinc, (0.91 ppm). Besides the edaphic conditions, plant distribution may be governed by many other operating environmental factors.There was no marked correlation in the distribution of Euphorbia royleana and any of the edaphic factors.

3.4.4 Aerial Photographo

From the findings it is clear that the "X" case study area used to be a fairly thick scrub forested spot, however, for the last thirty years a great deal of cutting of trees has become a normal daily activity.

Most environmentalists might say that this is happening all over Goa but this could strongly be disputed. The recent aerial photographs showed that it is only within the case study "X" area where excessive denudation has taken place.(as compared to the surrounding villages).

Visual estimates both from aerial photographs of 1960 in comparison with the aerial photographs of April 1991 and also shows that this area had harboured about 58,000 trees and shrubs but after urbanization about 9,161 trees and shrubs individuals have remained (Table 23 a) (Fig.26b) . The mode of degradation is quite high, present vegetation of case study "X" reflects past and present changes

E X P L A N A T I O N   O F   P L A T E

Aerial photographs showing the vegetation at the case study area "X" (dated: Nov. 1991)

Fig 28a. The orchard plantation is observed close to the round about. To the North of the aerial photograph, is a dam, to the east is the main office building, to the North-West are rice fields (The rice fields are outside the case study area "X").

Fig 28b. Faculty building's area with sparse vegetation cover. To the North-East of the aerial photograph is the Zuari river.

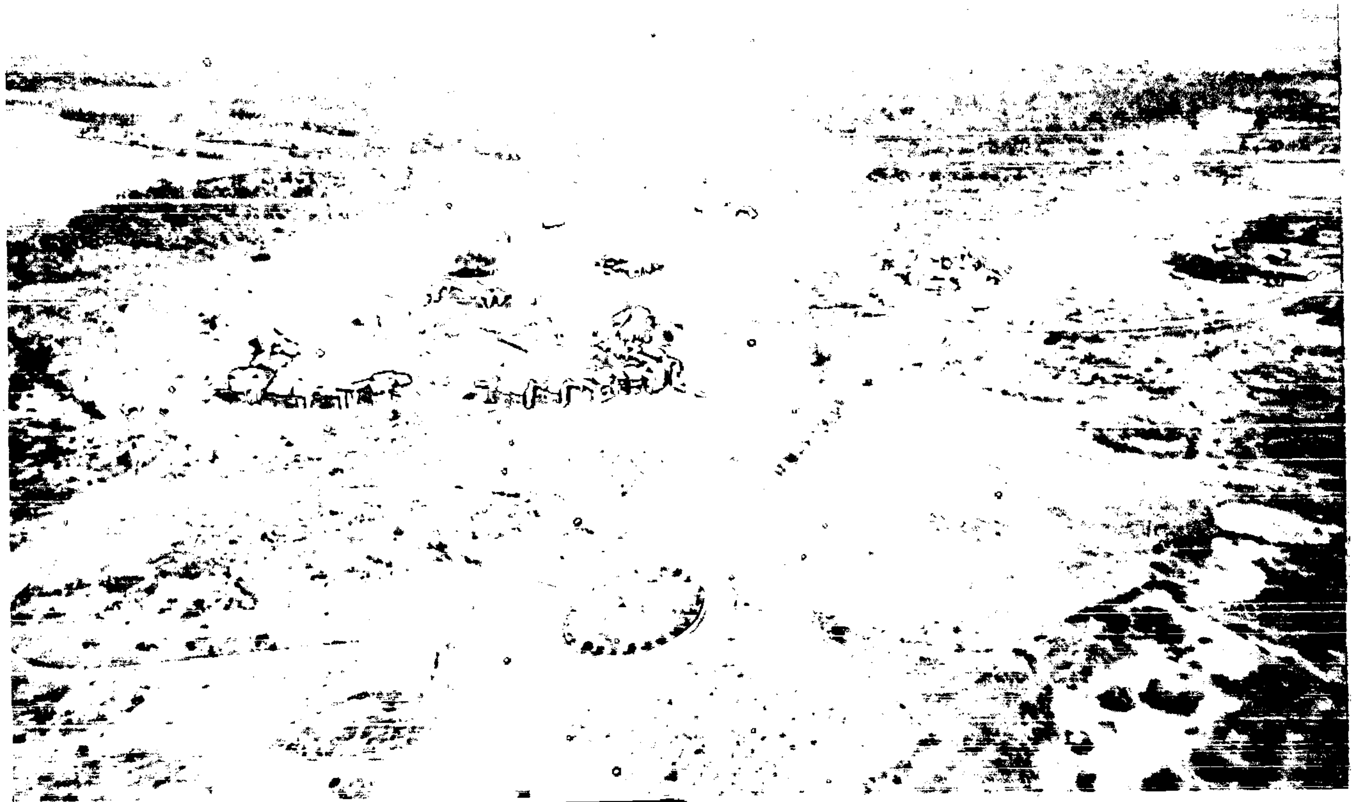


Fig. 28a

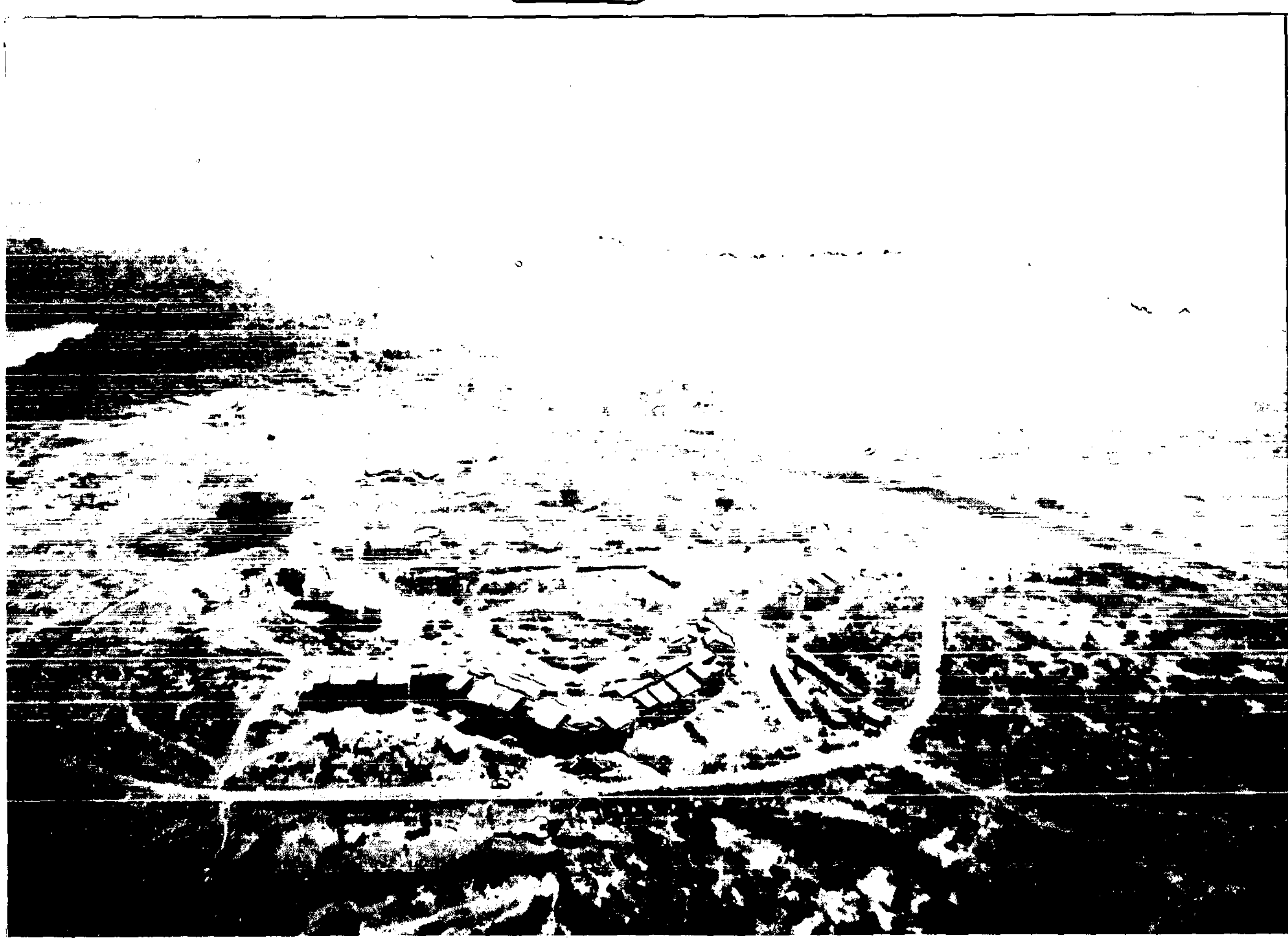


Fig. 28b

EXPLANATION OF PLATE

Aerial photographs showing the vegetation cover at case study "X" (dated Nov. 1991)

Fig 29a. Showing adjoining areas which appear to have more vegetation cover as compared to case study "X" area.

Fig 29b. Showing vegetation surrounding the guest house with scattered scrub.

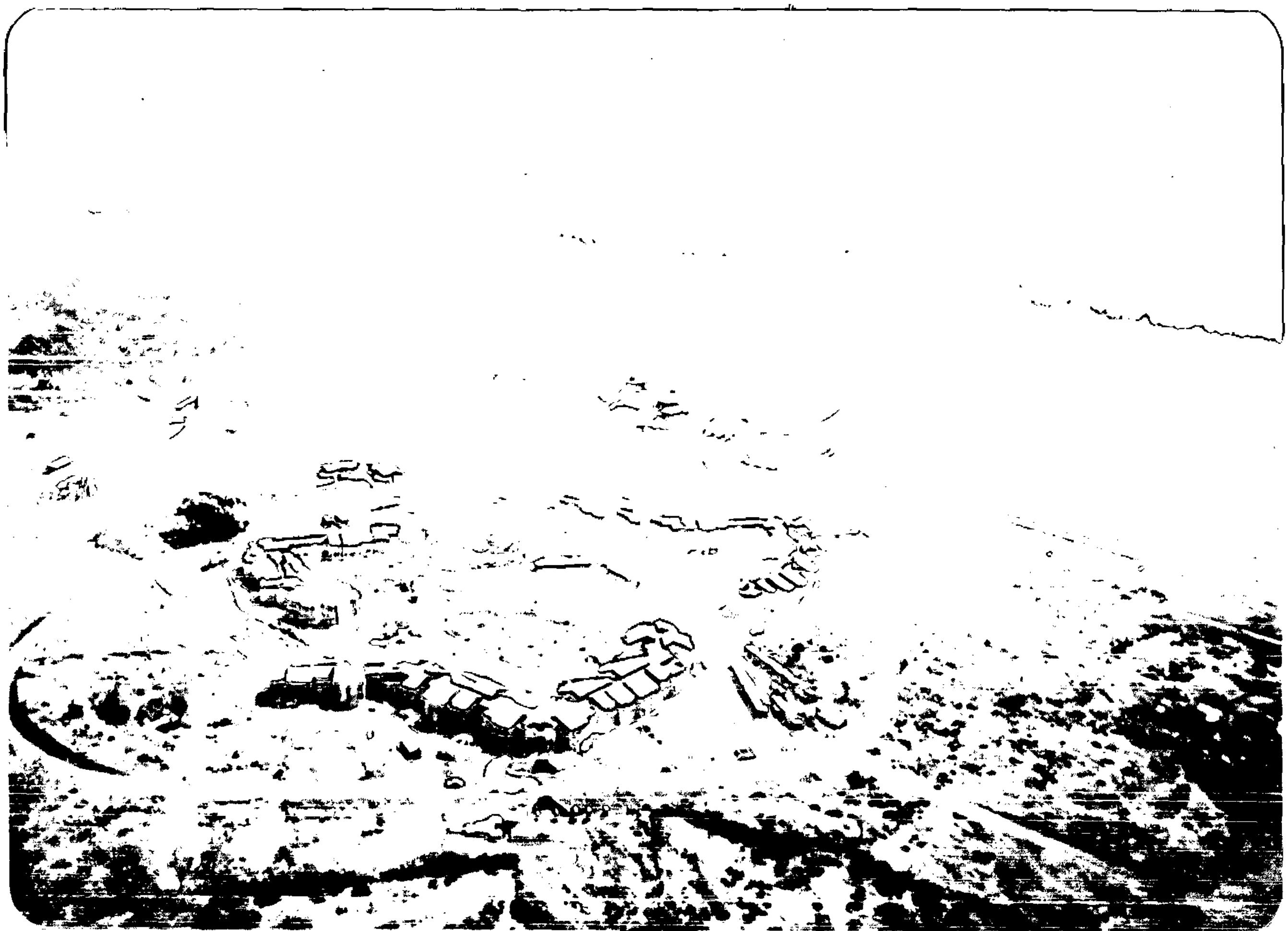


Fig.29a.

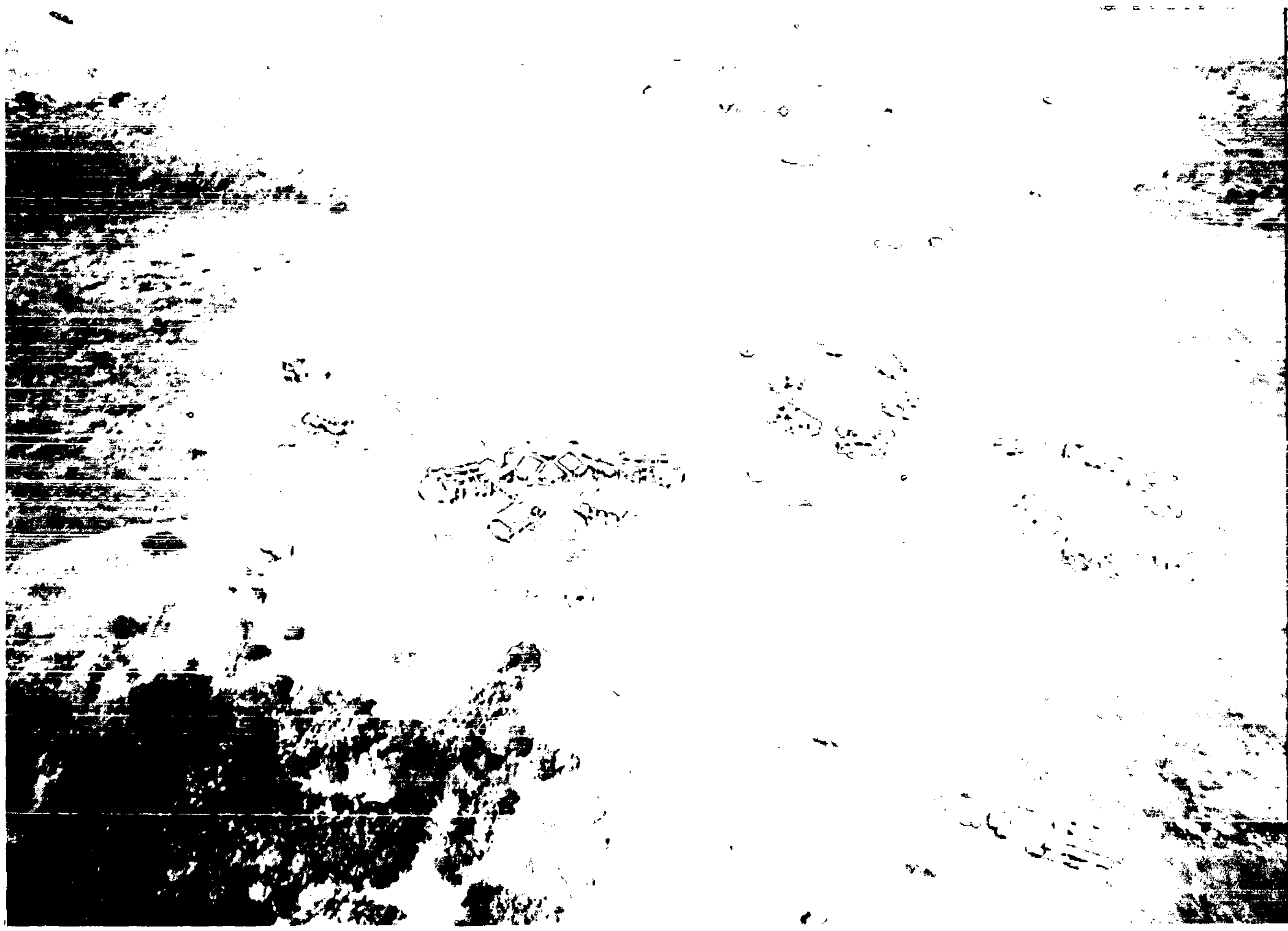


Fig. 29 b

in both the "human" and "Physical environment". Selective felling of trees for either timber or firewood purpose,urbanisation due to the construction work in conjunction with the burning of grass communities like Heteropogon contortus has played an integral part in influencing the present structure and dynamics of the vegetation(Fig.28a,28b 29a and 29b).

3.5 DISCUSSION

3.5.1 Qualitative analysis

Monoculture by definition is the growing extensive areas of plants that are closely related genetically. Glasgow (1975) interprets it as raising even-aged stands of one or a very limited number of species in blocks large enough to have a significant ecological impact.

In most forestry plantation carried out in the case study "X", only three of the below mentioned species were widely observed, namely *Peltophorum pterocarpum*, *Delonix regia*, *Casuarina auriculiformis*. The Chromosome Number range is 2n = 18 to 28 for these important plant species mentioned above. This is really a very narrow range.

According to tree improvers it is the extensive planting of similar genotypes of forest trees that are homogenous enough so that the dangers from pests or environmental extremes become too great a risk (Zobel & Talbert,1984).

The legume block has a presence of plant species whose chromosome numbers (2n) hardly range from 2n =26 to 34. Thus it can clearly be indicated that all plantation works atcase study "X" are monocultured plantations.

The plant species diversity (168) at the the case study "X" was found to be very low as compared to the adjoining scrub forest (about 330) necessitating that efforts should be made to introduce more of the indigenous flora to conform with the Western Ghats' vegetation.

Genetic diversity in any vegetation development is essential, hence polyculture practices should be encouraged in any of the afforestation programmes.

The polyculture technique, selection of the right type of plant species suited for the right type of environmental condition is very essential. So research aimed at screening and selecting the right plant species is a basic step in attaining success in plantation programmes. This would help in sustaining ecological diversity.

Although some exotic trees may offer greater advantages under specific conditions, that they fit into the existing ecosystems and yield products which cannot be obtained otherwise. They should on no account be the Forester's quick and only response to solving afforestation problems. This has been observed with Acacia auriculiformis in Goa. Maydell (1986) states that large-scale plantations should be restricted to emergency situations, or to meeting acute demand such as urban fuel wood needs .

Usually industries and other allied complexes have often opted for the fast growing tree species, none the less case study "X" administration cannot be an exception.

There are many advantages involved in fast growing tree species :

a) Taking care for these plants until they come up is greatly reduced hence the cost involved is also reduced e.g. protection from grazers, accidental fires, etc.

b) They yield faster within a stipulated period e.g. within seven years reasonable amount of timber can be obtained which can give benefits to growing needs of small scale industries, stabilize soil, arrest erosion of inconsolidated soils, provide food, fuel and shelter.

c) In true scientific aspect these tall species have high respiratory quotient hence they give more Oxygen to the atmosphere and take in more of Carbon dioxide , thus acting like air purifiers and therefore rightly called as "lungs of nature".It can be seen that nearly all the species mentioned are Leguminosae members which in most cases are nitrogen fixing and easily available, thus may add fertility to the soil.

Water is a major constraint at case study "X" in order to achieve proper green cover small reservoirs are required to be installed at various spots in the compound. We need to increase seepage and storing of surplus monsoon water appropriately. This will reduce the labour involved in carrying water through long distances for watering the plants which appears to be rather tedious inefficient method practised presently.

3.5.2 Quantitative analysis

The appropriate Minimal Unit Area used was 100m x 100m., this large scale, reflected the rather very sparse distribution of the vegetation cover in case study "X".

The clearing of forest cover was carried out prior or during the construction of the case study "X" establishment. The disturbance of the natural vegetation may have been created by construction workers during the establishment of the case study "X". Approximately 300 emigrant workers had been residing at the sites for a period of two years in addition to this ,there were about 1000 persons per Sq. Km. in the closeby villages.

Many of the workers relied mostly on fuel wood for their domestic needs. An average worker , could require approximately 2.5 Kg of fuel wood daily (modified from FAO (1985) case study paper) ,this means that an individual required approximately 900 Kg of wood annually which is equivalent to about 1.1 solid cubic meters of wood.In two years , a total of 1800 Kg of wood was consumed per individual.

The total amount of wood which was consumed by all the workers in two years was about 540,000 Kg of solid wood which is equivalent to 660 cubic meters wood .This figures almost correspond with the actual volume of wood (about 650 cubic meters) which was estimated cleared prior to the establishment (about 58,000 trees and shrubs).

Case study "X" being like any other academic institution ought to shine in all its endeavours in maintaining and sustaining the biodiversity. Unfortunately , a completely disturbed ecosystem was observed in terms of vegetation cover in the case study area.Therefore it remains to be a challenge for the management to see to it thatat least 10,000 saplings are raised and transplanted annually . The plantation will have to be to a polycultured one similar to the flora of the Western Ghats region.In order to reinstate the previous losses , concrete efforts will have to be made in the next ten years or so. It is possible that with careful planning the same or even more numbers of trees and shrubs (58,000) may be rehabilitated.

3.5.3 Soil analysis

The soils at case study "X" are weakly acidic and are relatively uniform throughout i.e. with a narrow range of pH.In the process of organic matter decomposition, both organic and inorganic acids are formed. The simplest and perhaps the most widely found is Carbonic acid (H_2Co_3), which results from the reaction of Carbon dioxide and water. The solvent action of Carbonic acid on the mineral constituents of the soil is exemplified by its dissolution of limestone or Calcium Carbonate. The long-time effects of this acid have been responsible for the removal of large quantities of bases by solution and leaching, however it cannot account for the low pH values found in many soils (Brady,1984).

This probably may suggest relatively, the acidic nature of the soils at case study "X". The pH of the soils , did not reveal any significant correlation with the vegetation pattern distribution or cover. Though the pH was not widely varying, in all the soils sampled their was slightly lower pH in the area with scrub forest.

As Brady(1984) states that forest exist as natural vegetation in regions of acid soils. This is not a direct response to soil pH but rather to the climatic environment, which incidentaly encourages the development of acid soils. In our case study the development of low soil pH may be due to moist condition of this place which lies closely to adam and foremost is the seasonal leaf defoliation of plant species like Careya arborea, Anacardium occidentale, Tamarindus indica which have increased the organic matter hence lowering the pH. Moreover the leaves of these species coincidentally contain high contents of organic acids which make an attribute to the decrease of pH on the top soil.

Highly saline soils are characteristic of high electrical conductivity for example the Zuari silt clay in marsh areas measures 10 to 15 ds/m (Govindarajan et al., (1974). However, in the case study area electrical conductivity was very low indicating of less concentration of neutral soluble salts.(which if present can be harmful to the plant growth (Brady,1984) with the exception of mangroves).

Therefore the case study has got the potential of sustaining wide varieties of agricultural crops and other useful plant species. Organic carbon was more in the long standing natural scrub forest because of factors like leaf defoliation of several of the plant species. This has led to an increment in organic matter hence, organic carbon.

Contrary to this, the monocultured plantation showed less organic carbon because of less litter decomposition especially those phylloclades of Acacia auriculiformis. which take a long time to decompose. Phosphorus is one of the most important limiting factors for plant growth, and its availability in soils seems likely to be a key factor controlling the rate and even the direction of long-term vegetation change (Burrows,1990).

Phosphorus was very low in all the case study area and sufficient for average normal plant growth but it was even much less in the area with relatively dense scrub. Probably since phosphorus primary main source is in the rocks, once the rocks are weathered only small amounts might be available to plants by the mineralization of organic matter.

As Burrows (Loc.cit.) states that disturbance of an ecosystem by fire or overgrazing will be likely to accelerate losses of phosphorus and other nutrients.

This applies to case study "X" also which is not only being occasionally affected by fire and grazing but by the clearance of the scrub forest for firewood by the local people.

Potassium plays many essential roles in plants. It is an activator of dozens of enzymes responsible for many plant processes such as energy metabolism, starch synthesis etc, Brady, (Loc. cit.). Though potassium (Kg/acre) was found generally sufficient in all the soils of the case study with the exception of the rocky plateau close to the teacher's staff quarters, (48 Kg/acre). The most important factor however is, its availibility in free ionic state for plant intake.

According to Brady(Loc.cit.), the readily available potassium constitutes only about 1-2% of the total amount of this element in an average mineral soil. It exists in soils in two forms :(a)Potassium in the soil solution (b) exchangeable potassium adsorbed on the soil colloidal surfaces. Although most of this available potassium is most readily absorbed by higher plants and is, of course, subject to considerable leaching loss.

From the case study it appears that it is only areas with vegetation that contain good amount of potassium as compared to the denuded areas. This probably may be due to the leaching of nutrients on the areas devoid of vegetation cover.

The extremely low calcium on the dome shaped tank near Dona Paula may be due to the leaching of bases during heavy rainfall on the barren rocky plateau which was formery a scrub forest. Besides this, the area is more slanting thus offering higher chances of soil erosion.

The soils on the rocky plateau close to the staff quarters require about 15 kg zinc sulphate per acre in order to improve the zinc defiency, this will improve the vegetation cover at this spot.

The soils on the relatively dense forest behind the ladies hostel and soils at the dome shaped tank area close to Dona Paula have relatively low amount of calcium. This should be amended by application of 59 kg/acre and 100 kg/acre of lime respectively. This will help to improve normal plant growth at this localities.

Seasonal fluctuations in the properties of soils are frequently reported, but there is considerable disagreement on the magnitude and timing of these changes (Ball and Williams, 1968; Davy & Taylor, 1974). Spatial variation has also been stressed, differences in chemical content over very short distances have been demonstrated by Piper and Prescott (1949), who believed that the spatial heterogeneity of the soil far outweigh any observable temporal fluctuations (Causton,1988).

It was observed that nearly all the fast growing plant species (Table 25) found in the case study "X" and the surrounding areas were mainly leguminosae members which in most cases are nitrogen fixing, thus may add fertility to the soil. Therefore, these are the right kind of species that should be planted in the areas which have been denuded.

Whatever changes that take place in the soil environment should be targeted towards improving the soil nutrients, this cannot be achieved unless proper soil conservation techniques are implemented in the case study "X", one obvious technique is to intensify the tree plantation programme, two, construction of drenches at different localities for draining excess water flow in the monsoons. (The water can be trapped into a ground reservoir for use during the dry period). During the survey several species were found stunted in growth in areas where zinc was found to be deficient.

There was no correlation in the distribution between of Euphorbia royleana and the soil nutrients' distribution.

Probably this was a species introduced some hundreds of years ago to this region as a hedge plant which has now spread randomly to the wild and colonized many places. However soil is not the only factor operating, there may be other parameters involved along with it.

The lack of sufficient phosphorus (Kg/acre) and zinc (ppm) may have been a casual factor in hampering the luxuriant vegetal cover on the open rocky plateau in the case study "X".

The mango orchard area contains transferred soils which were thought to be adequate in the micro and macro nutrient status but from the analysis, (Table 25 b) it was noticed that this was not the case. Therefore it implies that for any future transfer of what is thought to be as "good" soil, should first be analysed before being brought in for revegetation work.

3.5.4 Aerial photographs

Aerial photographs have greatly helped in the better understanding of the vegetation cover at the case study "X". The small scaled oblique aerial photographs particularly enabled the author to assess the vegetation with ease into even minute details.

For any future case studies carried out especially in the newly emerging industries, aerial photographs should to be used from time to time again.This may enable the concern establishment to assess what progress they have made in their plantation programmes.

3.6. LOCATION AND DESCRIPTION OF THE AREA:

Case Study "Y" pharmaceutical company area is situated in Corlim village - Goa, on the right hand side of the Ponda-Panaji highway, about 4 km from Old Goa (Fig.30). The approximate size of the area is 60 hectares. It lies at Latitude 15° 30′ and 15° 31′N and Longititude 74° 55′ and 74° 56 ′ 12" E approximately.

To the entire west and south, it is bordered by the Ponda-Panjim highway, to the North by the Cumbarjua canal, to the North-West it is bordered by a hill and to the east by a Corlim Village.

The total area is flat, (about 40 mts above MSL) except as mentioned above, the small hill bordering the company′ plant boundary and is outside the case study "Y".

Plantation work on a few exotic species started in 1969, (24 years ago) this is evidenced by the gigantic avenue trees behind the manufacturing unit area close to Cumbarjua canal.

Important gigantic exotic trees found here are Casuarina equisetifolia, Polyalthia longifolia var pendula which have dense canopy with virtually no ground flora.

The annual rainfall at case study "Y" is within the range of 1800mm - 2500mm.The maximum rainfall is in the month of July. The rainfall starts in mid-June and ends in early October.

Temperatures are lowest in the months of Dec & Jan measuring between 18 °C to 20 °C.

The hottest season is in April when temperatures are within the range of 35 °C to 40 °C. The area being close to the sea shore has high humidity which range, between 80% to 95%.

Case study "Y" contains the Zuari series and partly the Netorlim series of soils; the Zuari series is gently sloping, yellow brown soil. (though they are often on the flood plains of Zuari and Mandovi

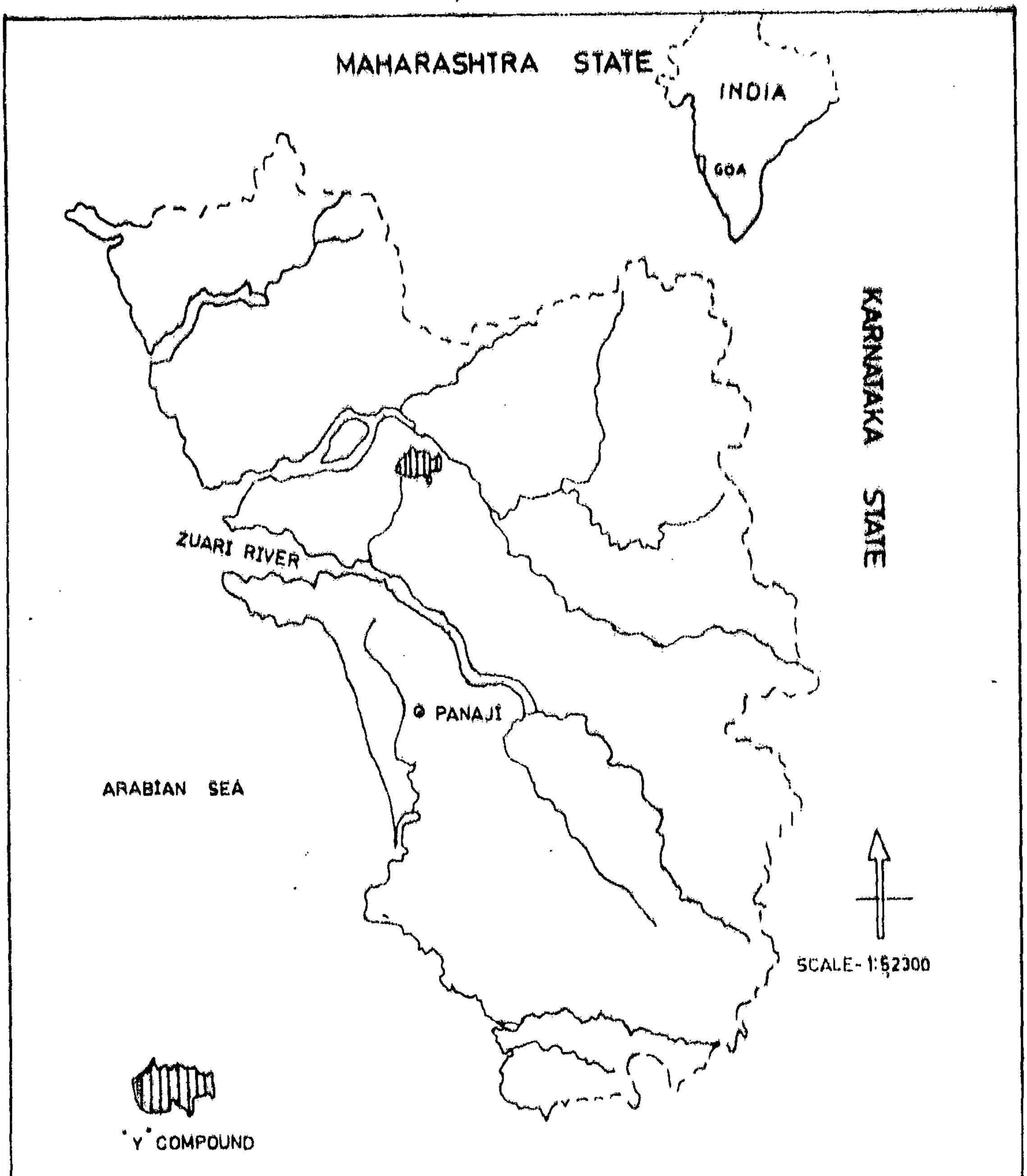


FIG. 30 MAP OF GOA SHOWING THE POSITION OF "Y" COMPOUND

The soil belongs to Netorlim series which is gravelly clay loam with moderately brown to red-brown laterite (Govindarajan et al., 1974).

3.6.1 Purpose of vegetation mapping at "case study "Y"

Plants growing in the area of case study "Y" had remained unidentified since (1974) the inception of the company. Management of the company felt that this time these plants should be identified through a taxonomist, and on their request, we made an attempt to do Phytosociological studies of the area.

3.7. INTRODUCTION

3.7.1 Qualitative analysis

Once the entitation or subdivisioning of the vegetation cover has been clarified (through qualitative techniques), the communities are essentially established. This is the reason why a thorough reconnaissance and familiarization before sampling is so important.

Subsequent sampling and data collection will merely derive more detailed information on these communities, irrespective of one´s choice for semiquantitative or quantitative methods for description. (Mueller - Dombois and Ellenberg, 1974).

3.7.2 Quantitative analysis

Since the realization that a large degree of error is inherent in subjective evaluation of abundance, ecologists have become increasingly conscious of the necessity of using quantitative measures to describe vegetation (Kershaw, 1973)

3.7.3 Soil analysis

Study of the soil types is also important as it reveals the organic and inorganic status of the soils, which when found deficient can be ammended with the necessary plant nutrients. The soil types help to correlate the pattern of distribution of some plant species.

3.8. MATERIALS AND METHODS

3.8.1 Qualitative analysis

First, several botanical surveys were carried out in the case study "Y" to acquint oneself with the general topography and plant stratification.

By using a pedometer "Kilometerzahler (Germany) the area size could be approximated. Official topographic map sheets of case study "Y" were used to confirm the actual field size.

Spots with special physiographic or topographic demarcations were identified and noted especially; area close to the main gate, seasonal lake, staff quarters, extreme north-west of case study "Y" with dense *Sesbania bispinosa*, factory area & banks of Cumbarjua Canal which lie in the case study "Y".The degree of slope was measured using Abney level and a clinometer.

Relative humidity was determined using a whirling psychrometer, temperature was measured with a maximum thermometer. Wind velocity was determined by anemometer.

Tall trees and other specimen on the slopes and were examined at a closer view using a binocular.

The plant specimen which were found in flowering or fruiting condition were photographed using a field camera (SLR).

During the subsequent botanical, survey, rough sketch maps and mapping tables were prepared and ground truth data collected. Plant collection of individual species representatives was carried out using a vasculum and a plant press.The herbarium were processed as per Lawrence's methods (Loc.cit) and are deposited in the Botany Department, S. P. Chowgule College for future references. Continuous seasonal monitoring of the vegetation was carried out throughout the year.

The method used in the descriptive aspect of the vegetation are as those of Ellenberg and Mueller - Dombois (1969) in the tentative physiognomic - ecological classification of plant communities.

3.8.2 Quantitative analysis

Quadrat sampling was done at case study "Y" compound and the actual ground truth data was obtained for the entire area where vegetation exists.

Minimal unit area was determined by the species - Area curve method of Oosting (1958), to get the suitable quadrat size for sampling.

After obtaining the Minimal Unit Area (30.5m x 30.5m) quadrat were sampled serially for the entire case study "Y" but not in the traditional random sampling method, because the essence of vegetation mapping is to cover the entire area understudy.

Systematic sampling was used in the case study "Y". Systematic sampling usually gives a more accurate mean of the population density than random sampling of equal intensity and is, therefore to be preferred in many practical ecologic surveys, such as resource surveys.Although, random sampling will usually be most desireable for ecologic studies, because of the possibility of measuring the sampling error, neverthless, in some instances systematic sampling be opted to, in which the samples are taken evenly, specified distances a part over the area rather than at random (Dice, 1952).

Formulae applied in the quantitative analysis were as per Kershaw (1973); Mueller - Dombois & Ellenberg (1974).

Now, from these values a relative importance value was derived (Muellar - Dombois and Ellenberg,Loc. cit.) by summing up the values of relative frequency, relative density and relative dominance.

3.8.3 Soil analysis

Soil samples were collected within case study "Y" area from depth of 30 cm layer. The soil samples were collected, from areas havin conspicuous vegetation pattern or where the plant species showe relatively poor growth or exceptionally good performance.

In each case 5 to 6 soil samples were collected per site at spacing of about 40 mts. The soil samples were then thoroughly mixed to provide a composite samples representing each site.

A little of the soil sample representatives was utilized in the physical analysis and determination of pH by the author.

The rest of the composite sample was air dried for 4 days in shallow alluminium trays, ground into fine powder using a pestle and mortar then screened through 2 mm mesh sieves. The soil samples were packed in small bags and sent to the Agricultural development laboratory, Bangalore - India for chemical analysis by AAS method.

The soil samples were analysed for their porosity, moisture content, water holding capacity and specific gravity as per the methods of Black (1965) and Piper (1942).

The rough estimate of pH was determined by universal paper indicator in the field, the same samples was accurately measured in the laboratory. The pH of the soil samples was measured by using a digital PH meter 335 "Systronics".

The meter was standardized using two buffer solutions. The soil samples were made to be at the same temperature as the buffer solution (Piper, 1942; Moore & Chapman, 1986). The localities from which the soil samples were collected are : areas close to the main gate, area surrounding the seasonal pond (lake), the staff quarters area, area on the extreme north west with dense *Sesbania bispinosa*, area adjacent behind the factory, area within the main office buildi

3.9 OBSERVATIONS

3.9.1 Qualitative analysis

The vegetation cover of case study "Y" is comprised of both cultigens and the naturally occurring species. The cultigens appear to be conspicuous as they have outgrown the naturally occurring species.

The major natural dominant association is comprised of Grewia tiliaefolia, Bombax ceiba, Bridelia retusa, Ficus glomerata and Syzygium cumini.

i)Vegetation on the South-West of case study "Y".

This is the vegetation towards the lake and residential quarters' area. The dominant species associations are Lannea coromandelica, Macaranga peltata, Ficus glomerata, Ficus asperrima and Ziziphus glabberima though sparse but abundant. Lower tier is co-dominated by Microcos paniculata, Leea indica, Chromolaena odorata, Wagatea spicata along with lianas like Smilax zeylanicum, Ichnocarpus frutescens, Marsdenia volubilis, Tylophora indica. Common herbaceous flora in the undisturbed sites are Rungia pectinata and Justicia micrantha.

ii)Vegetation close to the lake area

A temporary or seasonal lake exists at case study "Y", which is flooded during the monsoon time; according to the office note some different varieties of fish have also been rared in this lake. In the dam occasional hydrophytes like Nymphaea pubescens, Nelumbo nucifera, Hydrilla verticillata, Vallisneria spiralis, are the most conspicuous herbs. To the margins of the lake a number of trees have been planted viz. Samanea saman, Delonix regia, Polyalthia longifolia and Cocos nucifera. The dominant tree species which have not been cleared are Bombax ceiba, Grewia tiliaefolia and syzygium cumini.

iii)Vegetation on the north-west area of case study "Y"

The area is well protected by a wall outside and double coiled

Table 26 a List of naturally occurring tree and shrub species at "Y."

Sr. No.	Taxon	Family	Chromosome No.
1.	Barringtonia racemosa	Barringtoniaceae	26
2.	Bombax ceiba	Bombacaceae	72
3.	Carissa congesta	Apocynaceae	22
4.	Careya arborea	Lecythidaceae	26
5.	Derris scandens	Fabaceae	22-36
6.	Ervatamia heyneana	Apocynaceae	22
7.	Holarrhena antidysenterica	Apocynaceae	22
8.	Holigarna arnottiana	Anacardiaceae	-
9.	Ichnocarpus frutescens	Apocynaceae	20
10.	Ficus asperrima	Moraceae	26
11.	Ficus glomerata	Moraceae	26
12.	Ficus tinctoria	Moraceae	26
13.	Glochidion hohenackeri	Euphorbiaceae	24
14.	Grewia tiliaefolia	Tiliaceae	18-36
15.	Lannea coromandelica	Anaeardiaceae	28-40
16.	Marsdenia volubilis	Asclepiadaceae	22
17.	Microcos paniculata	Tiliaceae	18-36
18.	Pongamia pinnata	Fabaceae	20,22
19.	Smilax zeylanica	Smilacaceae	24-32
20.	Spondia acuminata	Anacardiaceae	24-42
21.	Syzygium cumini	Myrtaceae	22-26
22.	Thespesia populnea	Malvaceae	26
23.	Tylophora indica	Ascelpiadaceae	22
24.	Wagatea spicata	Caesalpiniaceae	-
25.	Ziziphus glabberima	Rhamnasceae	20-96
26.	Ziziphus oenoplia	Rhamnaceae	20,48

Table 26 b List of cultivated plant species at case study"Y" (trees and shrubs)

Sr.No.	Taxon	Family	Chromosome No.
1.	Azadirachta indica	Meliaceae	28
2.	Acacia auriculiformis	Mimosaceae	26
3.	Bouqainvillea spectabilis	Nyctaginaceae	20
4.	Casuarina equisetifolia	Casuarinaceae	18
5.	Caesalpinia pulcherrima	Caesalpiniaceae	24
6.	Clerodendrum indica	Verbenaceae	48
7.	Croton variegatum	Euphorbiaceae	72,80,96,100
8.	Cocos nucifera	Arecaceae	32
9.	Delonix regia	Caesalpiniaceae	24,28
10.	Eucalyptus hybrid	Myrtaceae	21, 22
11.	Ficus benjamina	Moraceae	26
12.	Lagerstroemia indica	Lythraceae	44, 48
13.	Peltophorum pterocarpum	Caesalpiniaceae	26-28
14.	Polyalthia longifolia	Polyalthia	18
15.	Samanea saman	Mimbsaceae	26

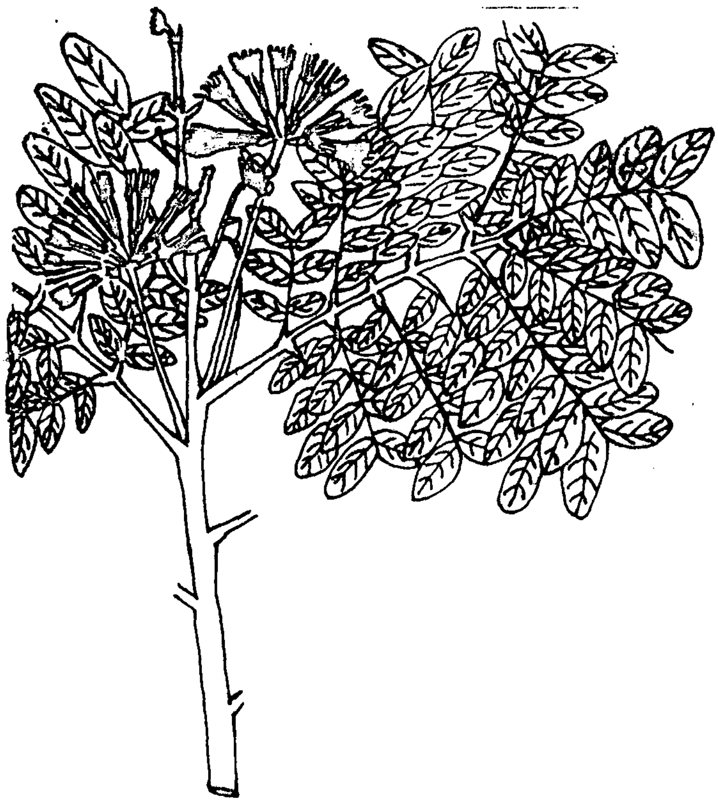


Fig. 31a. Samanea Saman Merill
showing a flowering twig.

Fig.31b Melia azedarach L.

Flowering twig.

Some cultivated plant species found at case study "Y".

barbed wire in the inner fence. This renders it difficult for any intruders like cattle to come inside. Little vegetal cover is observed and mainly it is an open srub area.

The natural species observed are Ziziphus glabberima, Ficus glomerata, Ficus asperrima, Lannea coromandelica, Bombax ceiba, as the major Associations. Other less common species on the valley side are Carissa congesta, Acacia farnesiana, Spondia acuminata, Wagatea spicata, Careya arborea Glochidion hohenackeri. Ground flora is composed of Cassia tora, Cassia occidentalis, Chromolaena odorata, Heteropogon contortus and Iseilema laxum.

iv)Vegetation at the housing colony and the recreation club areas.

Only eight plant species have been introduced at this point in great numbers. The most common cultigens consist of Samanea saman, Azadirachta indica, Eucalyptus hybrid, and Polyalthia longifolia.

Ten varieties of variegated crotons, Croton variegatum and the conspicuous queen flower tree, Lagerstroemia indica Plant species like Samanea saman (Fig.31a), Polyalthia longifolia and Eucalyptus hybrid which were planted about 20 years back have been grown to gigantic size of about 25 mts. high.

Along the roadsides varieties of Bougainvillea spectabilis have been planted mainly the red and white types with Caesalpinia pulcherrima of orange and yellow varieties being most abundant.

v)Vegetation on the south-east end portion of case study "Y".

This might be the only point in case study area "Y" where a relatively dense natural vegetation exists. This is probably because little disturbance in terms of clearance has been carried out. The dominant species association are Careya arborea, Bombax ceiba, Lannea coromandelica, Ficus tinctorius and co-dominant species found at this point are Ervatamia heyneana, Microcos paniculata and Holarrhena antidysenterica.

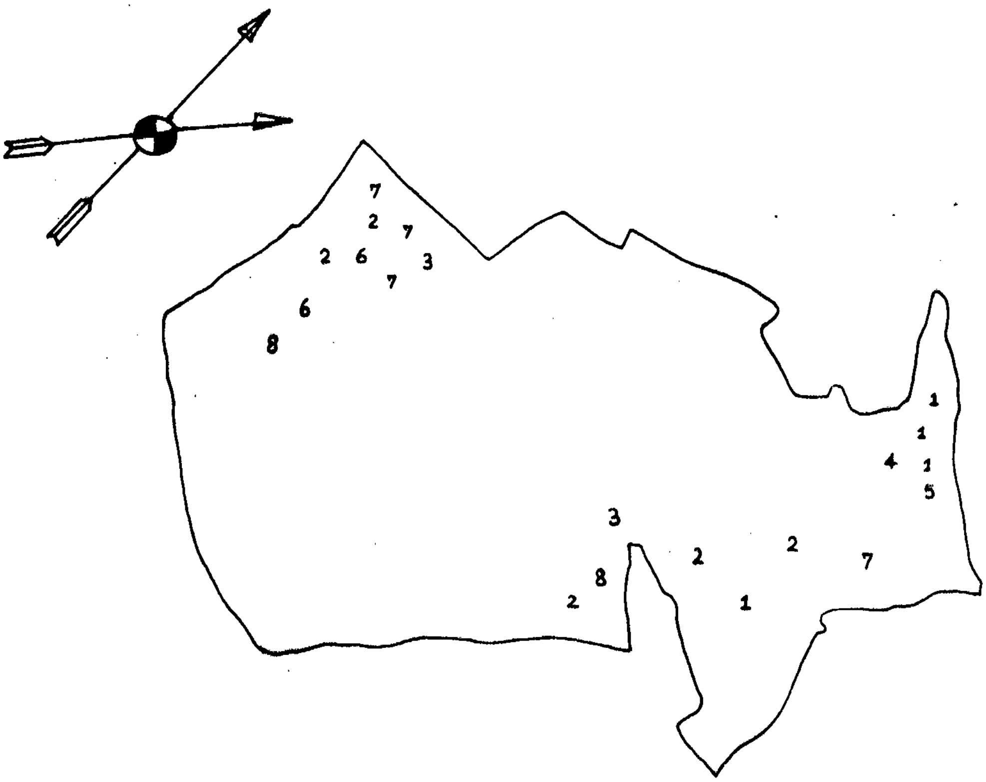
8

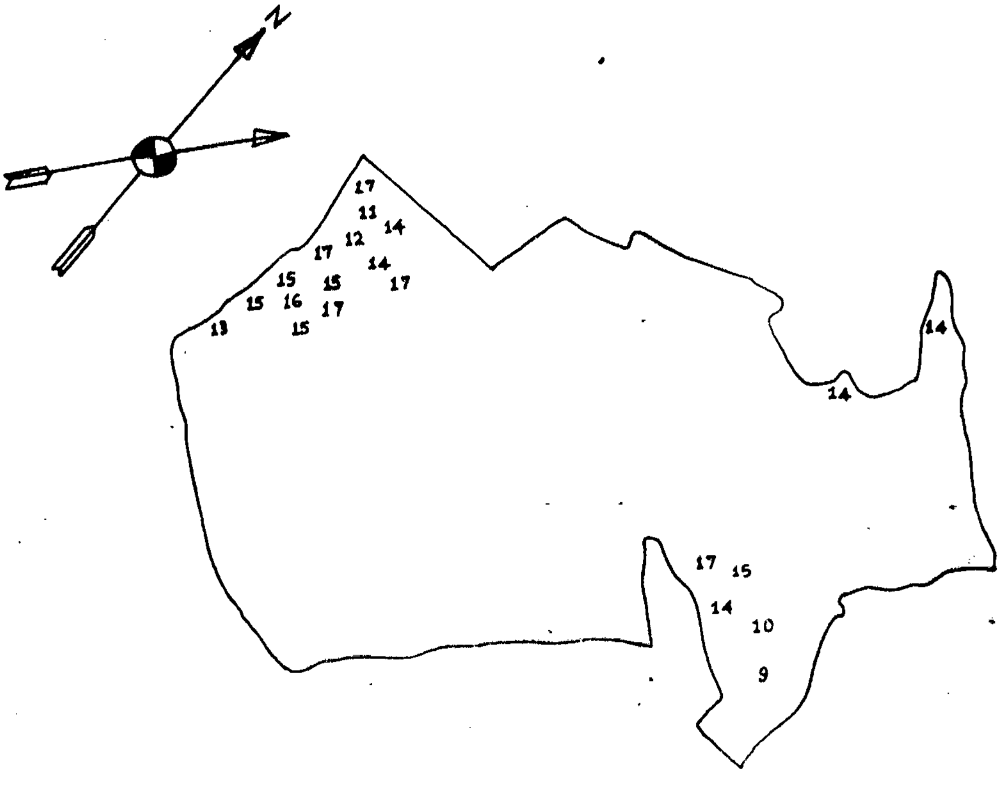
E X P L A N A T I O N   O F   P L A T E

Taxon on distribution map of important plant species at case study "Y".

Sr. No. on Map	Taxon
1.	*Barringtonia racemosa* Roxb
2.	*Bombax ceiba* Mill.
3.	*Carissa congesta* L.
4.	*Careya arborea* Roxb.
5.	*Derris scandens* Roxb.
6.	*Ervatamia heyneana* (Wall) Cooke.
7.	*Holarrhena antidysenterica* (Roth) DC.
8.	*Holigarna arnottiana* HK. f.
9.	*Ichnocarpus frutescens* Ait.
10.	*Ficus asperrima* L.
11.	*Ficus glomerata* Roxb.
12.	*Ficus tinctoria* Forst
13.	*Glochidion hohenackeri* Bedd.
14.	*Grewia tiliaefolia* Vahl.
15.	*Lannea coromandelica* (Hout) Merr.
16.	*Marsdenia volubilis* Cooke.
17.	*Microcos paniculata* L.

TAXON DISTRIBUTION AT " CASE STUDY " Y "





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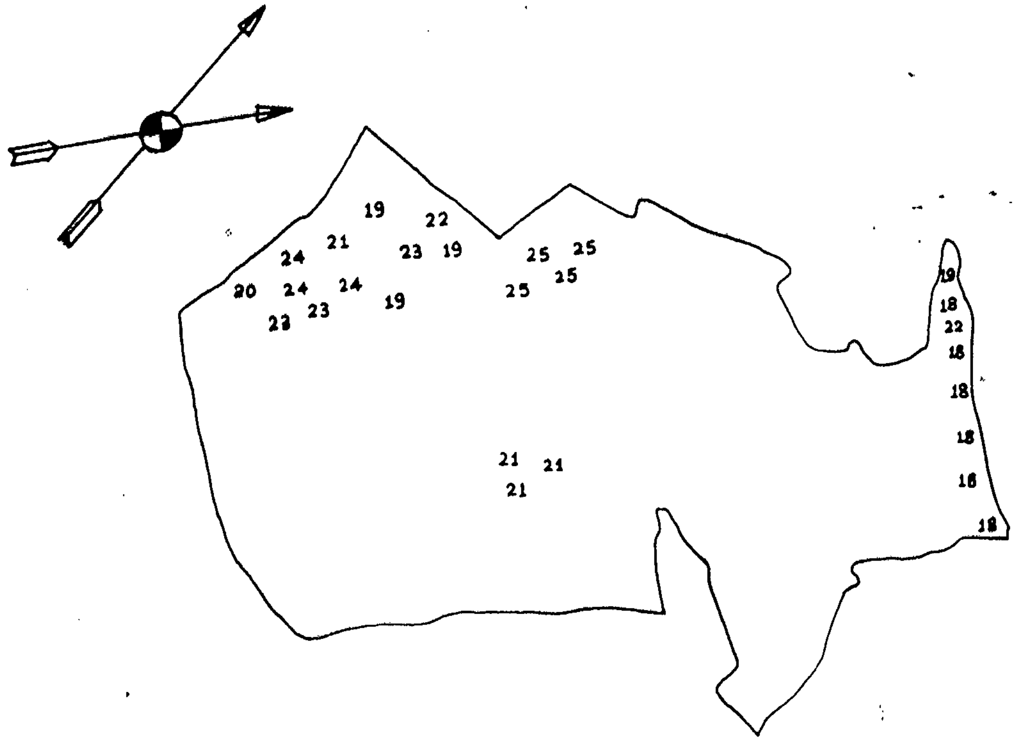
EXPLANATION OF PLATE

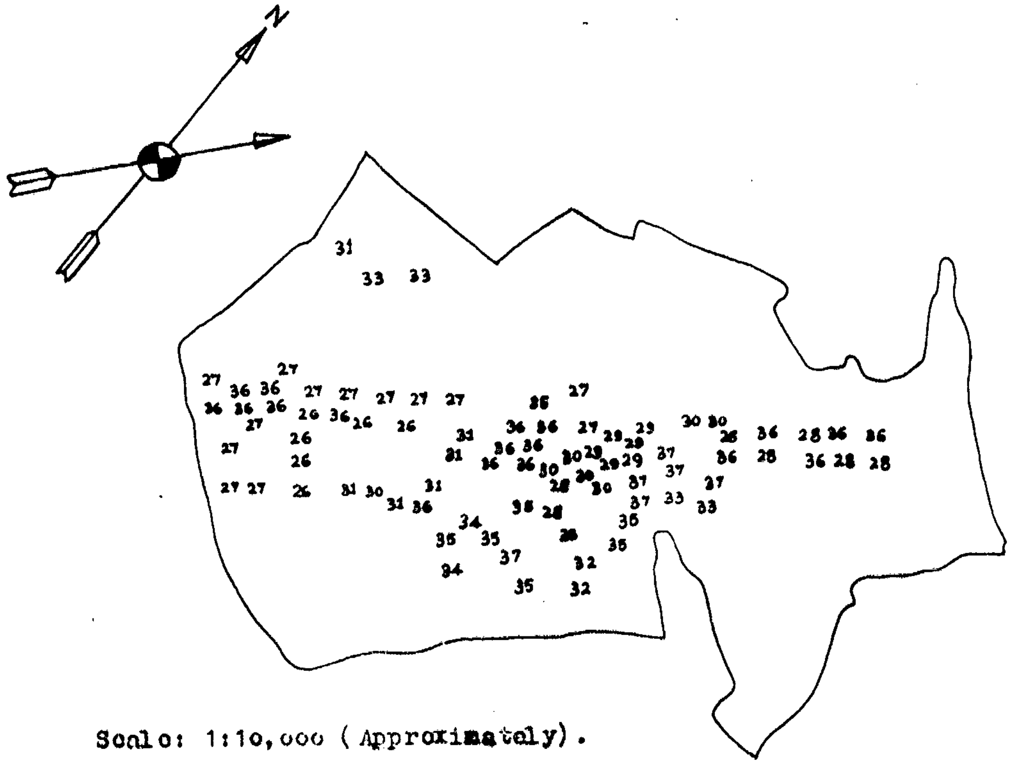
Taxon on distribution map of important plant spe ie.

at case study "Y".

Sr. No. on Map	Taxon
18.	Pongamia pinnata L.
19.	Smilax zeylanica L.
20.	Spondias acuminata Roxb.
21.	Syzygium cumini (L) Skeels.
22.	Tylophora indica (Burm.f.) Merrill.
23.	Wagatea spicata Dalz
24.	Ziziphus xylopyra Willd.
25.	Ziziphus oenopila Mill.
	Cultigens
26.	Acacia auriculiformis A. Cunn.
27.	Bougainvillea spectabilis Willd.
28.	Casuarina equisetifolia L.
29.	Clerodendrum indicum (L.) Kuntze
30.	Croton variegatum L.
31.	Cocos nucifera L
32.	Delonix regia Rafin.
33.	Eucalyptus hybrid
34.	Lagerstroemia speciosa (L.) Pers.
35.	Peltophorum pterocarpum (DC) Backer.
36.	Polyalthia longifolia Lam.
37.	Samanea saman Merril.

TAXON DISTRIBUTION AT CASE STUDY "Y".





Scale: 1:10,000 (Approximately).

The annual herbaceous flora is conspicuous with large clustered population of Sesbania bispinosa which has colonized almost the entire zone. Besides the species, is Chromolaena odorata which is a noxocious fast spreading weed and grasses like Heteropogon contortus and Pennisetum hohenackeri.

The riverline of Cumbarjua canal is relatively densely forested with the domination of Barringtonia racemosa, Pongamia pinnata, Holigarna arnottiana and Derris scandens climbing profusely to the top of other trees.

vi)Vegetation within the actual plant site (A protected zone)

The area is heavily protected (a danger zone area) only with special permission entrance may be allowed.

The area in front of the premises has been cultivated with tenths of Polyalthia longifolia and Melia azedarach which are intermixed with numerous varieties of Croton variegatum with some hedge plants of Clerodendrum indica, which occasionally is intermixed with Casuarina equisetifolia.

The total species diversity at case study "Y" was found to be 68. There are 15 exotics and 51 indigenous plant species in an area of about 60 hactares. The genetic diversity equally was much less; being at the range of 2n=18 to 72 for the total plant species.

3.9.2 Quantitative analysis

Fifteen quadrats (Minimal Unit Area 30.5.m x 30.5m) were sampled which contained vegetation cover.

The most frequent plant species were Terminalia arjuna, Abrus precatorius, Careya arborea, Naregamia alata and Eranthemum roseum.

The least frequent species were Garuga pinnata, Wagatea spicata & Lagerstroemia lanceolata.

The plant species with the highest density were N

Table: 27. Ground truth data as observed in the field case study "Y".

Minimal Unit Area = 30.5 mts x 30.5 mts

Sr. No.	Taxon	Quadrant No.														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.	Barringtonia racemosa	2	2	-	1	-	-	-	-	-	-	-	-	-	-	-
2.	Bombax ceiba	-	2	-	4	1	-	2	-	1	2	-	-	-	1	1
3.	Carissa congesta	-	-	3	-	2	1	1	-	-	-	-	2	3	4	-
4.	Careya arborea	1	-	2	-	-	3	-	-	-	-	2	1	2	-	1
5.	Derris scandens	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-
6.	Ervatamia heyneana	4	5	-	8	-	5	-	10	2	1	-	-	5	8	7
7.	Holarrhena antidysenterica	-	3	2	3	1	-	-	5	6	7	8	5	-	-	10
8.	Holigarna arnottiana	2	-	-	-	-	-	-	-	1	-	-	-	-	-	-
9.	Ichnocarpus frutescens	3	1	-	1	1	2	1	-	-	-	-	1	-	-	-
10.	Ficus asperrima	-	2	-	-	-	-	1	-	1	-	-	4	-	4	1
11.	Ficus glomerata	-	1	-	-	-	-	-	-	-	1	-	3	1	1	-
12.	Ficus tinctoria	-	-	-	2	-	-	1	-	-	-	-	-	-	-	-
13.	Glochidion hohenackeri	2	2	-	1	1	-	1	-	-	1	-	-	-	-	1
14.	Grewia tiliaefolia	-	-	1	-	-	2	-	-	-	1	-	-	-	-	-
15.	Lannea coromandelica	2	4	2	-	1	1	-	1	2	2	1	4	1	2	3
16.	Marsdenia volubillis	3	1	-	3	2	-	1	3	2	-	-	-	4	-	-
17.	Microcos paniculata	5	10	15	4	5	20	30	10	12	15	-	-	-	12	15
18.	Pongamia pinnata	6	-	2	-	-	1	-	-	-	-	-	-	2	-	-
19.	Smilax zeylanica	3	-	-	-	-	-	-	2	2	-	-	1	-	-	-
20.	Spondia acuminata	-	1	-	-	-	1	-	-	-	-	-	1	-	2	-
21.	Syzygium cumini	2	1	1	1	2	-	-	1	-	1	-	-	-	-	1
22.	Tylophora indica	-	-	2	4	-	1	-	4	-	-	-	-	-	-	-
23.	Wagatea spicata	1	-	1	-	-	-	1	-	-	-	-	-	1	-	-
24.	Ziziphus glabberima	-	-	1	-	1	-	-	-	2	-	-	1	1	1	1
25.	Ziziphus oenoplia	-	2	3	-	4	2	6	2	3	8	-	2	2	4	-

Table 28 a Frequency, Relative Frequency. Dominance and Relative Dominance of plant species found at case study "Y".

Sr. No.	Taxon	Frequency	Relative Frequency	Dominance	Relative Dominance
1.	Terminalia arjuna	92	4.65	2649	13.6
2.	Terminalia bellirica	19	0.96	1589	8.16
3.	Terminalia paniculata	75	3.8	1570	8.06
4.	Lagerstroemia lanceolata	14	0.71	706.0	3.63
5.	Careya arborea	93	4.7	2388	12.3
6.	Bombax ceiba	77	3.89	466.0	2.39
7.	Bridelia retusa	59	2.89	4099	21.050
8.	Anacardium occidentale	47	2.38	238.6	1.225
9.	Holigarna arnottiana	42	2.12	464.0	2.38
10.	Jasminum malabaricum	82	4.15	194.0	0.997
11.	Xeromphis spinosa	65	3.29	180.3	0.925
12.	Ochna obtusata	43	2.17	37.7	0.193
13.	Ixora coccinea	78	3.94	42.0	0.215
14.	Garuga pinnata	23	1.16	157.0	0.806
15.	Macaranga peltata	41	2.07	508.7	2.61
16.	Zanthoxylum rhetsa	58	2.93	777.1	3.99
17.	Wagatea spicata	22	1.11	19.6	0.106

Sr. No.	Taxon	Frequency	Relative Frequency	Dominance	Relative Dominance
18.	Syzygium cumini	76	3.84	2472	12.69
19.	Leea indica	72	3.64	84.8	0.435
20.	Clerodendrum viscosum	44	2.22	53.0	0.272
21.	Mussaenda laxa	76	3.84	63.6	0.326
22.	Naregamia alata	90	4.55	73.0	0.374
23.	Abrus precatorius	88	4.45	269.0	0.381
24.	Hemidesmus indicus	49	2.48	5.0	0.026
25.	Cyclea peltata	86	4.35	3.9	0.02
26.	Ziziphus xylopyra	50	2.53	212.3	1.09
27.	Ziziphus oenoplia	32	1.62	7.06	0.036
28.	Tylophora dalzellii	66	3.34	1.66	0.008
29.	Curculigo orchioides	74	3.74	63.6	0.326
30.	Euphorbia notoptera	83	4.20	7.32	0.037
31.	Smilax zeylanica	67	3.39	21.90	0.112
32.	Erantheum roseum	94	4.75	48.13	0.247

Sr. No.	Taxon	Density	Relative Density	Importance Value Index	Order of I. V. I.
1.	Terminalia arjuna	13.5	5.709	24.04	3rd
2.	Terminalia bellirica	0.25	0.107	9.228	8th
3.	Terminalia paniculata	1.25	0.536	4.391	23rd
4.	Lagerstroemia lanceolata	1.0	0.428	4.761	22d
5.	Careya arborea	3.38	1.45	18.41	4th
6.	Bombax ceiba	0.66	0.283	6.571	15th
7.	Bridelia retusa	6.66	2.856	26.89	2nd
8.	Anacardium occidentale	0.76	0.325	3.927	26th
9.	Holigarna arnottiana	0.875	0.375	4.881	21st
10.	Jasminum malabaricum	6.87	2.95	8.89	9th
11.	Xeromphis spinosa	6.4	2.74	6.596	12th
12.	Ochna obtusata	3.0	1.286	3.654	27th
13.	Ixora coccinea	3.4	1.46	5.618	16th
14.	Garuga pinnata	0.5	0.214	2.183	29th
15.	Macaranga peltata	1.12	0.48	5.165	18th
16.	Zanthoxylum rhetsa	1.1	0.471	7.394	11th
17.	Wagatea spicata	0.25	0.107	1.325	30th

Sr. No.	Taxon	Density	Relative Density	Importance Value Index	Order of I. V. I.
18.	Syzygium cumini	0.87	0.373	16.907	5th
19.	Leea indica	3.0	1.286	5.362	17th
20.	Clerodendrum viscosum	1.8	0.77	3.268	28th
21.	Mussaenda laxa	2.25	0.964	5.134	19th
22.	Naregamia alata	92.75	39.77	44.69	1st
23.	Abrus precatorius	2.4	1.03	6.861	13th
24.	Hemidesmus indicus	9.75	4.18	6.685	14th
25.	Cyclea peltata	7.75	3.32	7.693	10th
26.	Ziziphus xylopyra	1.38	0.591	4.21	25th
27.	Ziziphus oenoplia	1.0	0.428	2.882	29th
28.	Tylophora dalzellii	2.12	0.909	4.25	24th
29.	Curculigo orchioides	2.25	0.964	5.03	20th
30.	Euphorbia notoptera	25.87	11.09	15.3	7th
31.	Smilax zeylanica	1.75	0.75	4.25	24th
32.	Eranthemum roseum	27.25	11.68	16.68	6th

Table 28 b Relative frequency, relative dominance and relative density of plant species found at case study "Y".

Sr. No.	Taxon	Relative Frequency	Relative Dominance	Relative Density
1.	Terminalia arjuna	4.65	13.6	5.789
2.	Terminalia bellirica	0.96	8.16	0.107
3.	Terminalia paniculata	3.8	8.06	0.536
4.	Lagerstroemia lanceolata	0.71	3.63	0.428
5.	Careya arborea	4.7	12.3	1.45
6.	Bombax ceiba	3.89	2.39	0.283
7.	Bridelia retusa	2.38	21.05	2.856
8.	Anacardium occidentale	2.12	1.225	0.325
9.	Holigarna arnottiana	4.15	2.38	0.375
10.	Jasminum malabaricum	3.29	0.997	2.95
11.	Xeromphis spinosa	2.17	0.925	2.74
12.	Ochna obtusata	3.29	0.193	1.286
13.	Ixora coccinea	2.17	0.215	1.46
14.	Garuga pinnata	3.94	0.806	0.214
15.	Macaranga peltata	1.16	2.61	0.48
16.	Zanthoxylum rhetsa	2.07	3.99	0.471
17.	Wagatea spicata	2.93	0.106	0.107

Sr. No.	Taxon	Relative Frequency	Relative Dominance	Relative Density
18.	Syzygium cumini	1.11	12.69	0.373
19.	Leea indica	3.84	0.435	1.286
20.	Clerodendrum viscosum	3.64	0.272	0.77
21.	Mussaenda laxa	2.22	0.326	0.964
22.	Naregamia alata	3.84	0.374	39.77
23.	Abrus precatorius	4.55	0.381	1.03
24.	Hemidesmus indicus	4.45	0.026	4.18
25.	Cyclea peltata	2.48	0.02	3.32
26.	Ziziphus xylopyra	4.35	1.09	0.591
27.	Ziziphus oenoplia	2.53	0.036	0.428
28.	Tylophora dalzellii	1.62	0.008	0.909
29.	Curculigo orchioides	3.34	0.326	0.964
30.	Euphorbia notoptera	3.74	0.037	11.09
31.	Smilax zeylanica	0.112	0.112	0.75
32.	Eranthemum roseum	0.247	0.247	11.68

Eranthemum roseum, and Euphorbia notoptera, and the lowest ranking plant species were Ziziphus oenoplia, Zanthoxylum rhetsa, Terminalia bellirica and Lagerstroemia lanceolata.

The relative density was highest in Naregamia alata, Eranthemum roseum, Euphorbia notoptera and Terminalia arjuna in descending order.

The lowest relative density was found in Terminalia bellirica, Wagatea spicata and Garuga pinnata..

The highest importance value index was found in Naregamia alata, Bridelia retusa, Terminalia arjuna, Careya arborea, Syzygium cumini, Eranthemum roseum and Euphorbia notoptera. The lowest importance value index was met with Garuga pinnata, Clerodendrum viscosum, Ochna obtusata, Ziziphus xylopyrus, Tylophora dalzellii, Terminalia paniculata, Lagerstroemia lanceolata and Holigarna arnottiana.

3.9.3 Soil Analysis

The pH was within the range of 5.4 and 6.9 in all the soils. The lowest being at the cumbarjua canal bank and the highest in the staff quarters area. The soils are of three categories namely strongly acidic (PH 5.4), slightly acidic (PH 6.4) and neutral (PH 6.6-6.9).

Electrical conductivity (ds/m) of the soils was lowest at areas close to the maingate (Ø.18 ds/m) areas surrounding the seasonal pond (Ø.18 ds/m) and areas on the extreme north west with dense herbaceous species Sesbania bispinosa (Ø.18 ds/m) and the highest in the areas on the extreme south east and area adjoining the Cumbarjua canal.

Organic carbon was found being within the range of 1.2% to 2.4% in all the areas soil was sampled.

The highest organic carbon (2.4%) was found in the soils from the extreme north-west, south-east and behind the factory areas.

The lowest organic carbon 1.2% was found in soil samples from the main office building of Cumbarjua canal bank and main gate areas.

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Table:29. Chemical soil analysis of case study "Y"

Soil Survey No.	1	2	3	4	5	6	7	8
Texture	clay	loam	loam	loam	Alluvial loam	loam	loam clay	sand clay
pH	6.6	6.8	6.9	6.8	6.8	6.4	6.7	5.4
E.C. (ds/m)*	0.18	0.18	0.23	0.21	0.18	0.19	0.19	0.21
Organic carbon (%)	1.3	1.7	1.5	2.2	2.4	2.2	1.3	1.2
Available phosphorus kg/acre	140	220	201	235	249	245	153	140
Available potassium kg/acre	110	120	120	120	125	120	120	130
Micronutrients (ppm)								
Ca	62.0	20.0	51.0	30.0	60.0	55.6	27.6	66.0
Fe	31.0	20.0	20.5	15.4	27.2	34.0	12.1	8.0
Mn	12.0	10.0	11.0	15.0	13.0	7.8	14.0	10.0
Zn	1.3	1.1	0.8	2.4	1.05	0.68	1.4	1.2
Cu	1.5	0.7	Traces	0.5	1.2	0.9	2.1	1.4
Ni	0.11	Traces	0.15	0.09	0.05	0.07	0.1	0.11

*Previously expressed as millimhos per centimeter (mmho/cm). Since 1S = 1mho,1ds/m = 1mmho/cm. (Brady, 1984) therefore Electrical conductance was expressed in decisiemens per meter (ds/m).

Available phosphorus (Kg/acre) was found to be ranging from 2 to 4 kg/acre in all the areas sampled.

The highest being in the extreme north west and the lowest in areas close to the cumbarjua canal banks.

Available potassium was within the range of 110 kg/acre to 130 kg/acre.

Zinc was found to be within the range of 0.68 to 2.4 ppm. the staff quarters' and areas behind the factory had the lowest values being 0.8 ppm and 0.68 ppm respectively. Copper was found within the range of traces and 2.1 ppm.

Areas close to the main gate and behind the factory had the highest amount of iron; 31 ppm and 34 ppm respectively, The lowest amount being at the areas close to the main office building and Cumbarjua canal (12.1 ppm and 8.0 ppm respectively).

Manganese was highest in areas on the extreme south east (18 ppm) and areas within the main office building (14 ppm) and lowest in the area adjacent behind the factory (7.8 ppm). Calcium was highest in the areas surrounding a seasonal pond (62 ppm) and area on the extreme north - west (68 ppm) of the case study area.

Nickel was found within the range of traces to 0.15 ppm . The highest being the staff quarters area and the lowest at the seasonal pond area.

3.9.4 DISCUSSIONS

3.9.4.1 Qualitative analysis

The species diversity was much less (68) as compared to any other case studies made and it is extremely low. The vegetation was given very little attention by the authority of the company, especially as no efforts had been made to introduce the indigenous plant communities.

3.9.4.2 Quantitative analysis

The plant species that expressed the highest importance value index were the most dominant species in this locality.

Among the leading dominants which form the one Association were *Terminalia arjuna*, *Bridelia retusa*, *Careya arborea*, and *Syzygium cumini* along with *Naregamia alata*, *Eranthemum roseum* and *Euphorbia notoptera* as co-dominants. These species especially the co-dominants, were a characteristic feature in the deciduous forests of the Western Ghats,their presence in the case study "Y", is a clear indication that a thick forest used to exist here prior to construction of the establishment. About 2000 tree and shrub specimen are found in the case study "Y" which is relatively a very small number compared to the area it occupies.

3.9.4.3 Soil Analysis

The more acidic nature of soils at the Cumbarjua Canal banks area may be attributed to the chemical effluents released from the factory. This may have resulted to a decline of floral diversity within the canal banks because , few species may tolerate the extremely low pH.

The electrical conductivity (ds/m) which to some extent reveals the salinity of the soil, is quite low. The soils are free from neutral salts therefore they are suitable for a variety of crops and other plant species.

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Organic carbon content was high in all the soils which implies the area is quite suitable for the normal growth of a wide range of plant species. The amount of organic matter has been increased greatly in the extreme north west area due to the annual species <u>Sesbania bispinosa.</u> This is because the species not only nodulates, but also forms dense colonies within its stand which tremendously increased the annual organic matter.

The low amount of Phosphorus is a common characteristic in this area especially in the disturbed sites. The main primary source of Phosphorus is from the rocks and once it is all weathered only small amounts can be made available by plants by the mineralization of organic matter. This might be one of the reasons for the deficiency of phosphorus in the case study "Y".

Potassium (Kg/acre) is sufficient for normal plant growth in all the localities sampled. The micronutrient status was generally high and sufficient. The soil samples from the staff quarters and behind the factory areas were deficient in Zinc, though none of the species showed any deficiency symptoms. Iron content was high in all the samples though its availability form to the plants was not analyzed. The soil samples which were in some cases alluvial were of interest as they were found to accumulate large amount of organic matter. Generally, the soil samples showed sufficient nutrient status which is normal plant growth. Though edaphic conditions are favourable, it is the actual management that should reinforce its activities in planting more species. The case study "Y" management could easily introduce many plant species without caring much in fertilizer application (hence less financial implications).

Since case study "Y" is solely a pharmaceutical company (besides making unfinished plastic products), it could be advisable to
13 introduce some medicinal plant species [redacted]

utilized in making medicines within their premises.Like any other industries, case study "Y" requires fast growing plant species which could not only give shade to the surroundings but also filter the air from the industrial discharged fumes.There is need for the management to select plant species which develop deep root system to give a strong hold in case of cyclones. As it was observed earlier, species that have got shallow root system tend to bend against the strong sea windward direction. The onesided weightage gives a balanced grip from falling, this was quite common among species like <u>Delonix regia</u> which is an avenue tree in the case study "Y". The species posed great risk as they often suddenly fall in case of strong winds.

The tight security at case study "Y" area offers great chances to improve the vegetation cover, if precedent efforts were made in the afforestation work by the management.

P A R T IV.

MONITORING OF PLANTATION WORK AT CASE STUDY "Z"

4.1 LOCATION AND DESCRIPTION OF THE AREA UNDER STUDY.

The area chosen for the case study is a mining area and is referred here as "Z" which is situated at Pale-Goa about 17 kms North of Ponda town between latitude 15 28 54" and 15 28 66" N and Longitude: 74 2' 12" and 74 2' 42" E, Bicholim taluka-Goa. The area is easily approached through the Ponda-Mapusa highway road.

The area is about 160 hectares out of which about 120 hectares are under active mining operations and 42 hectares of the area is occupied by reject dumps. The mining pit may reach depths up to 160 mts. The highest elevation is on the dumps which may be about 30 mts. high (Fig.33 a and Fig.33 b).

The annual rainfall at case study "Z" is within the range of 2,800 to 3,500mm. The monsoon rains start like in the most parts of the Western Ghats in the mid-June and ends in October. The heaviest downpour is observed between July and mid-August. Rarely in some instances rain may commence in May with great thunderstorms and lightning.

Temperatures are lowest in the months of Dec. and Jan. measuring 16 C and 20 C, respectively. The temperatures start to rise from March and later part of April and end of May marks the peak of the hottest period measuring 36 C to 40 C. This period is immediately followed by the monsoon rains which give appreciable cooling.

The relative humidity is within the range of 70% to 90%. The highest being in the month of September and lowest in January.

The stratigraphic succession of rocks at mines ("Z" case study) belong to the Bicholim Formation. During recent and sub-recent times, the rocks have been subjected to laterization resulting in a cover of laterite of varying thickness. (Gokul *et al.*, 1981).

The entire of case study "Z" is constituted of Netorlim soil series. The Netorlim series is gravelly silt clay loam found on very

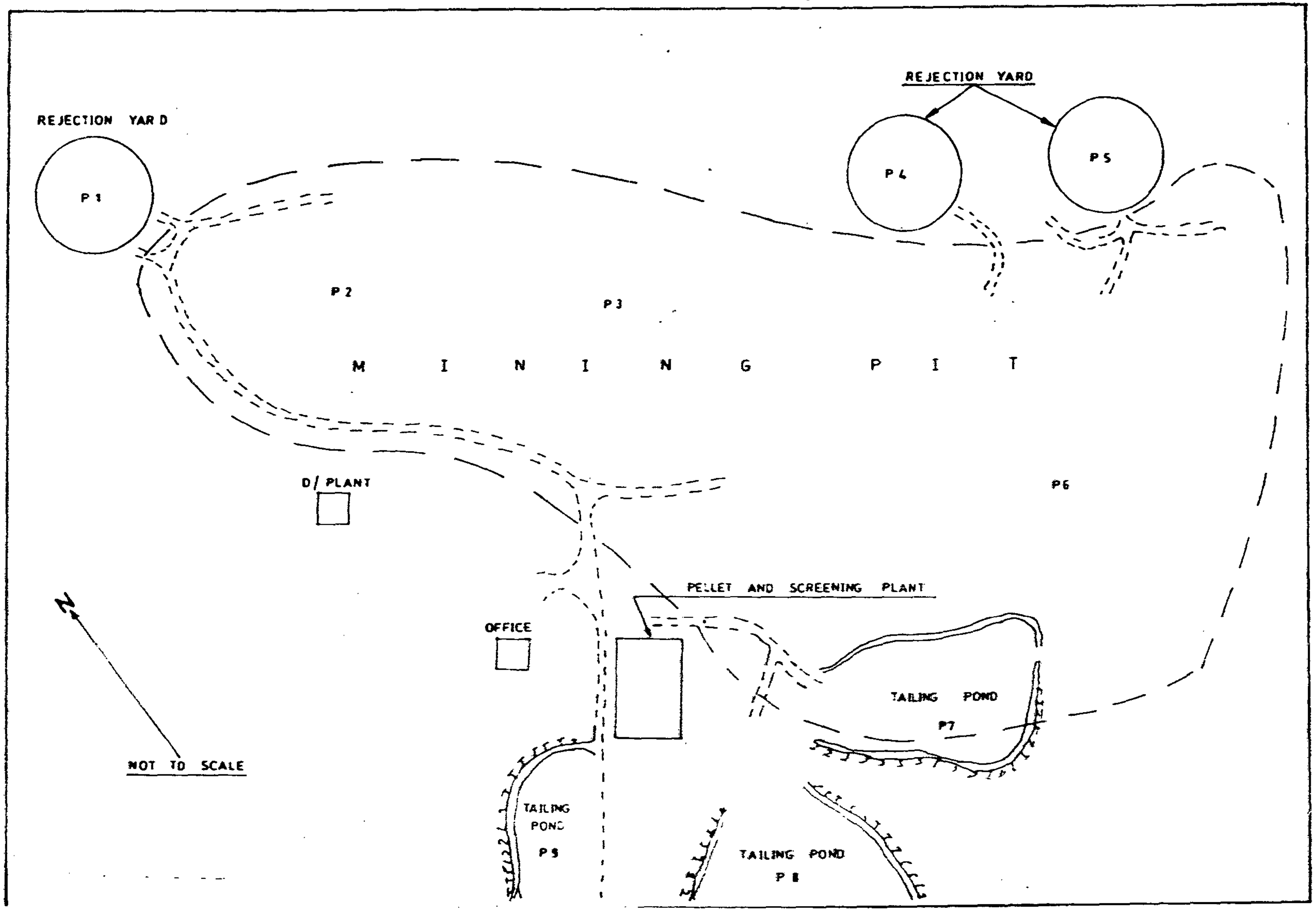

Fig. 32a. A sketch map showing the general layout of case study "Z"; the location of the rejected dumps (rejection yards) and tailing ponds.

steep or moderately steep slopes (Govindarajan *et al.*, 1974).

4.1.1 Previous plantation at case study "Z"

Revegetation of the dumps and residential area was started in 1970 with the introduction of *Anacardium occidentale* (cashew), *Delonix regia* (gulmohor) and *Casuarina equisetifolia* (horse tail) as the main pioneer species which were obtained from the Government forest nurseries. In 1985, a nursery was established and a large number of *Acacia auriculiformis* were raised.

Since 1986 Department of Environment, Ministry of Environment and Forests, Govt. of India, New Delhi, approved a co-ordinated research project entitled "Response of plant species to the mining sites situated at Pale and Sirigao to the Department of Botany, S.P.Chowgule College and the case study "Z" management. Significant efforts were made by the research staff to introduce a wide range of plant species especially the indigenous, to the mining sites after screening them for their tolerance.

Role played by case study "Z" nursery in relation to other Mines:

Case study " Z" nursery plays a significant role to other mines as it supplies many seedling varieties which are even at times notavailable with the Government forest nurseries. So it was important from this aspect, to see what species are nurtured in the nursery in terms of germination, survival and performance thereby give recommendations whenever necessary.

4.2. RAISING OF SEEDLINGS AND TRANSPLANTATION

4.2.1. Raising of seedlings

Introduction

Practical problems occur in nursery in propagating of seeds of many tree and shrub species. These require specific treatments to overcome dormancy by satisfying the requirements needed to bring about germination. Propagators of cultivated plants have long recognised these germination - delaying phenomena and have learned to manipulate different kinds of seed dormancy through the adoption of appropriate pre-germination and handling procedures discovered by trial and error (Hartman et al., 1990).

Seed propagation involves careful management of germination conditions and facilities and a knowledge of the requirements of individual kinds of seeds. Success depends upon fulfilling the following conditions:

1. Using seed of proper genetic characteristics to produce the cultivar, species or provenance desired. This can be accomplished by obtaining seed from a reliable dealer, buying certified seed, or producing one's own - following the principles of seed selection.

2. Using good - quality seed. It should germinate rapidly and vigorously to withstand possible adverse conditions in the seed bed.

3. Manipulating seed dormancy. Accomplish by applying pregermination treatments or proper timing of planting.In the absence of specific knowledge of seed requirements, the propagator should try to duplicate the natural environmental conditions associated with germination of seed of this particular kind of plant.

4. Supplying proper environment to the seeds and resulting seedlings. This includes supplying sufficient water, proper temperature, adequate oxygen, and either light or darkness (depending on the kind of seed) to the seeds and resulting seedlings until they

are well established. A proper environment also includes control of diseases and insects and preventation of excess salinity (Hartmann *et al.*, Loc.cit).

4.2.2 Materials and methods

Seeds were collected from the surrounding forest regions between September and December, dried in the sun for 5 to 7 days then given hot water treatment for 5 to 10 minutes and then set for soaking 24 hours in tap water. Wherever germination was low by using this method, specific seed treatment trials were carried out using different chemical concentrations like in *Pithecellobium dulce* and *Sesbania grandiflora*.

Germination trials were carried out on the above mentioned tree species using different chemical pre-treatments. The seeds of *Pithecellobium dulce* were procured from the nearby villages, whereas those of *Sesbania grandiflora* were obtained from Dehra Dun. A batch of seeds were thoroughly dried in the sun for 3 days to bring down the moisture content, then they were soaked in aqueous solutions of chemical reagents viz Copper sulphate 0.5N, 1.0N, 2.0N, & 3 N; Potassium permanganate 0.5N, and 1.0N; Indole Acetic Acid 0.05N, 0.1N, & 0.2N molar concentrations for 24 hours at room temperature (26 C to 30C).Immediately after the treatment, the seeds were washed in running water and kept for germination over wet filter papers in petri dishes, until when germination was observed ; after which they were transplanted on a seed-bed.In cases where seeds were infected by fungi,they were sprayed with "Bavistan" fungicide (Carbandazium 50% w/w).A raised seed-bed of 10 cm high was prepared, soil of seed-bed was composed of 70% garden soil plus 15% farm yard manure.The treated seeds were sown in the raised seed-bed while keeping uniform spacing.

Germinated seeds were kept as such for one to three months, then transferred to polythene bags and watered regularly for another three months. Experiments were conducted on germination and percentage survival of seedlings. The effect of growth regulators on seeds was also carried out. The seedlings were nurtured for 6-8 months prior to transplantation (Fig.32a and 32b) on the mining rejects (dumps and tailings). Slow-growing species require nurturing for one and half years or more in the nursery.The data is depicted in Table 30 a which was collected for 4 consecutive years.

E X P L A N A T I O N   O F   P L A T E

Photographs showing some raised seedlings in the nursery of case study "Z"

Fig 32b. _Casuarina equisetifolia_ saplings.

Fig 32c. _Samanea saman_ saplings.

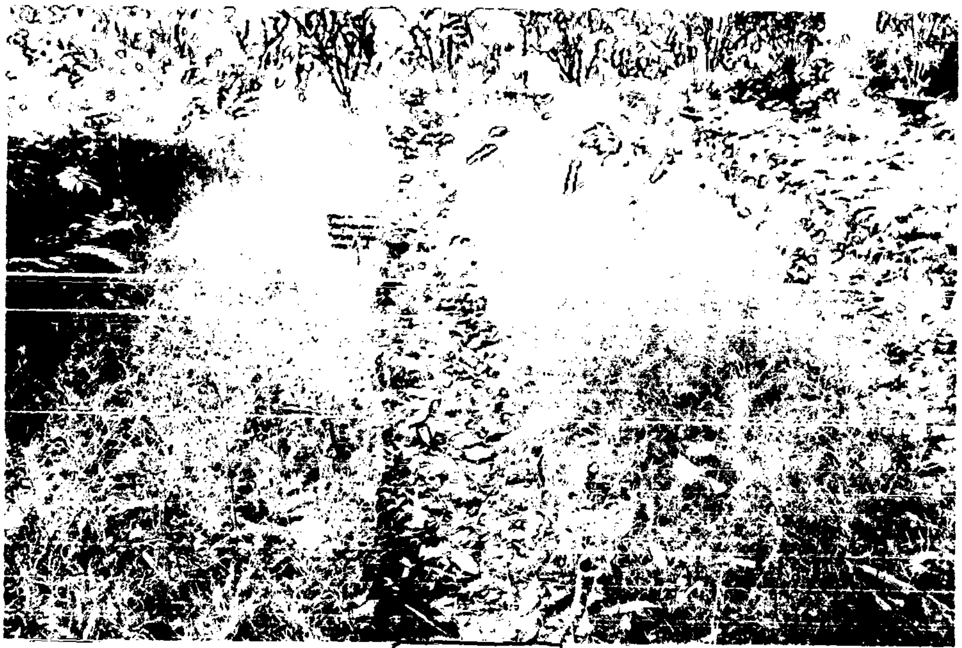

Fig. 32b

Fig. 32c.

4.2.3. Observations

Results on germination of Pithecellobium dulce of freshly collected seeds showed the highest germination % (75%) as compared to one year old seeds (54%). The overall treatments showed preference to 0.5N, 1 N Copper sulphate solution, 0.05N, 0.1N IAA and distilled water treatment. Maximum percentage 74%, 75%, 76% and 74% of germination was observed in 0.5N, 1 N Copper sulphate and 0.05N and 0.1N IAA, respectively.

Table: 30a. Germination % of **Sesbania grandiflora** Pers. seeds by chemical pre-treatments.

Sr. No.	Type of medium and concentration (N)	Germination % after 15 days	Remarks
1.	Copper sulphate 0.5N ($CuSo_4$)	49%	
2.	Copper sulphate 1.0N	60%	Brown seed coat
3.	Copper sulphate 2.0N	31%	
4.	Copper sulphate 3.0N	20%	Dark pink seed coat
5.	Copper sulphate 4.0N	0%	uncorroded
6.	Potassium permanganate 0.5N ($KmNo_4$)	0%	
7.	Potassium permanganate 1.0N	0%	corrosion of the entire seed coat was
8.	Potassium permanganate 2.0N	0%	observed.
9.	Potassium permanganate 3.0N	0%	
10.	Indole Acetic Acid 0.05N (IAA)	46%	
11.	Indole Acetic Acid 0.1N	70%	Light or dark red seed coat.
12.	Indole Acetic Acid 0.2N	52%	
13.	Distilled water —	45%	Brown seed coat.
14.	Tap water —	52%	

N.B.: Values expressed for an average of 10 individual observations.

Seeds started germinating from the 6th day of setting of the experiment and it took 15 days to show complete germination.

A number of treatments especially Potassium permanganate 0.5N, 1.0N, 2.0N and 3.0N, copper sulphate 2.0N, 3.0N and 4.0N, showed suppresive effect on germination percentage (0% to 31%) and survival percentage (30%).

Seeds of Sesbania grandiflora treated with copper sulphate solution (1 N) and Indole Acetic Acid IAA (0.1N) gave the highest germination percentage.

Though the IAA (0.1N) treated seeds gave best results, the seedlings were later found to get profusely attacked by fungi. The seed samples which had the copper sulphate pre-treatment showed no fungi attack. "Bavistan" a fungicide (carbandazium 50% W/W) failed to give any suppression on some of the infected seeds.

It was found in many situations that the pre-treatment with higher concentrations like 4.0N copper sulphate, resulted in complete absorption of the reagent on the seed coat and cotyledons therefore no germination ever took place.

A number of seeds of plants species on several occasions were procured from the Forest Research Institute (FRI) in Dehra Dun for raising in the nursery. The seeds were obtained as they were expected to be of superior quality in terms of germination and survival. Seeds of the same plant species were later collected from Western Ghats' region and set for germination in the nursery. Results are shown in

Table: 30b. Germination % of **Pithecellobium dulce** Benth by different chemical pre-treatments of the seeds.

Sr. No.	Chemical treatments and concentration	Germination % after 15 days	Fungi attack if noticed	Remarks
1.	CuSo4 0.5N	74%	None	
2.	CuSo4 1.0N	75%	None	
3.	CuSo4 2 N	50%	White fibrous mycelium	
4.	CuSo4 3 N	58%	White fibrous mycelium	
5.	KmNo4 0.5N	42%	White yellow fibrous mycelium	All seeds decayed
6.	KmNo4 1.0N	37%	White yellow fibrous mycelium	
7.	IAA 0.05N	76%*	White yellow fibrous mycelium	4% formalin slightly reduced fungi attack
8.	IAA 0.01N	74%	None	
9.	Tap Water (control)	48%	Slight	
10.	Distilled water	72%	None	

Table: 30c. Germination % of seedlings raised in the nursery of case study "Z".

Sr. No.	Taxon	Time taken for germination.	Storage period prior to germination (days)	Germination %
1.	Jatropha curcas	06+1	40	50
2.	Acacia mangium	28+3	90	91
3.	Tamarindus indica	09+1	06	70
4.	Acacia catechu	12+2	15	90
5.	Samanea saman	15+2	15	45
6.	Terminalia arjuna	20+3	15	52
7.	Cassia nordosa	07+1	12	05
8.	Ziziphus mauritiana	24+3	30	10
9.	Anacardium occidentale	15+2	30	80
10.	Artocapus heterophyllus	35+5	02	----
11.	Syzygium cumini	11+1	03	15
12.	Acacia auriculiformis	30+3	14	70
13.	Bauhinia purpurea	30+4	50	80
14.	Gliricidia sepium	07+2	08	82
15.	Pterocarpus marsupium	07+2	30	52
16.	Alstonia scholaris	15+3	02	40
17.	Syzygium zeylanicum	26+5	04	63
18.	Memecylon wightii	31+4	07	55
19.	Casuarina equisetifolia	06+1	07	62
20.	Leucaena leucocephala	08+1	07	72

Table: 30d. Average annual seedlings raised in the case study "Z" for plantation work,(though other more saplings are raised annually, only the core plant species are enlisted here which are always of constant demand even by other mines' owners.

Sr. No.	Taxon	No. of saplings
1.	Jatropha curcas	5,000
2.	Acacia mangium	2,500
3.	Pithecellobium dulce	1,400
4.	Tamarindus indica	3,000
5.	Gliricidia sepium	3,000
6.	Acacia catechu	3,000
7.	Acacia auriculiformis	16,000
8.	Samania saman	1,000
9	Aegle marmelos	500
10.	Delonix regia	1,200*
11.	Terminalia paniculata	1,200*
12.	Bombax ceiba	1,000
13.	Alstonia scholaris	500
14.	Garcinia indica	300
15	Mangifera indica	500
16.	Artocarpus heterophyllus	100*
17.	Anacardium occidentale	3,000
18.	Casuarina equisetifolia	5,000

Table: 31 Germination and survival percentage of four tree species whose seeds were obtained from Dehra Dun, as compared with those collected from Western Ghats' (Goa) Region.

Sr. No.	Taxon	Dehra Dun a	Dehra Dun b*	Western Ghats a	Western Ghats b*
1.	Santalum album	20	0	31	12
2.	Samanea saman	14	10	68	30
3.	Casuarina equisetifolia	45	40	95	62
4.	Eucalyptus hybrid	75	70	81	78

a = Germination % b = Survival % between 1 to 2 years of age.

Besides raising the plant species through seeds, some were raised by tufts especially grasses, by rhizomes, and by cuttings. Powdery Mildew disease on saplings of <u>Acacia auriculiformis</u> in the nursery.

The young saplings of <u>Acacia auriculiformis</u> were frequently prone to powdery mildew at a tender age (6 months to 12 months) in the case study "Z" nursery. The disease appeared in January to February as white fine radiating mycelial growth on both surfaces of the phylloclades which later became powdery. Isolated infection spots were scattered throughout the phylloclade and later coalesced with each other forming large powdery patches. In advanced stage chloritic symptoms were also found. Severe infection caused defoliation, the disease gradually started to disappear towards summer season (i.e. March-April). The same symptoms were earlier observed in young saplings at Kalyani-Nadia, West Bengal and was identified as <u>Oidium</u> sp. (Banerjee <u>et al.</u>, 1991). The disease was eliminated dramatically when the amount of water sprinkled to the saplings in the case study "Z" was reduced to half i.e. by sprinkling water every other alternative day.

4.2.4 Transplantation of plant species on the dumps and tailing pond sites.

Transplantation was done in the months of June, July and August during the heavy monsoon rains.

Saplings were offloaded at the dumps and tailing pond sites, bags were cut open carefully to avoid disturbing the root system, then transplanted into the already prepared pits. Each pit was fertilized with 1 to 2 table spoons of NPK and handful of farm yard manure, occasional second dose was given at the end of August. On the steep slopes (< 30 to 45), contour trenches was done manually at a distance of 2 metres and on either sides, steps were made for easy movement up and down the dumps. Large gully formation on the slopes was often planted with plant species raised in bigger bags for a longer period (1-12 months) in the nursery; in almost all cases their growth performance has been found better at the dumps and tailings than seedlings raised in small bags. In cases where the species were washed away by rain, they were reinstated at the end of monsoon rains.

4.3 DESCRIPTION OF VEGETATION AT THE SITES

4.3.1. Description based on physiognomy

Introduction

Like in any disturbed ecosystems, familiarization of vegetation at the mining sites is essential. This can be described physiognomically which is a qualitative approach, to give a general idea of what vegetation exists in these areas. This is the most important and fastest tool for assessing the vegetation because the subsequent sampling using measures (quantitative analysis) are time consuming and will merely derive more detailed information. It is specially required whenever considering which plant species have been introduced as exotics or indigenous.

Materials and methods

Since vegetation studies have been done previously to the natural vegetation of this area (Nyabuto, 1989) more focus of attention was now directed to the species planted on the dumps and tailing pond reject soils. Repeated botanical surveys were carried out at case study "Z" especially within the mining sites both excavated and the unexcavated spots.

With the help of a pedometer and official topographic maps the estimate size of the area and several physiographic spots were recorded. The areas surveyed were the P5 dumps, nursery area, Tailing ponds , P1 dumps and areas close to the residential quarters.

The degree of slopes of the dumps was measured using an Abney level and a clinometer.Relative humidity was measured by a whirling psychrometer, temperature was measured with maximum and minimum thermometer.

Plant specimens which were found in flowering or fruiting condition were photographed using a field camera (SLR).Though sketch maps and tables were prepared in the recording of the plant species.Representatives of the unfamiliar plant species, found flowering were collected in a vasculum and a plant press. The specimen were identified then processed for herbarium in the Botany Department, S.P.Chowgule College, Margao. All ecological observations made, were carefully recorded in the field note-books.The method used in the description aspect of vegetation are as those of Ellenberg & Mueller-Dombois (1969) in the tentative physiognomic-ecological classification of plant communities.The various wood characteristics of the plant species and their uses are mainly derived from Gazzetter of Bombay (1957).

Observations

i) Vegetation at the Residential area.

Close to the Manager's residence there are eight Hydnocarpus laurifolia species which are naturally occurring. The species offers an evergreen thick canopy throughout the year.Along the roadsides for the Chinchinim Shopping centre to the KG nursery school are several gigantic species of Syzygium cumini.

The orchard area which is well fenced with stone bricks contains about sixty grafted five years old plant species of Mangifera indica. Anacardium occidentale. The mango species (grafted type) show dense canopy at or near the ground. Flowering has been noticed and even

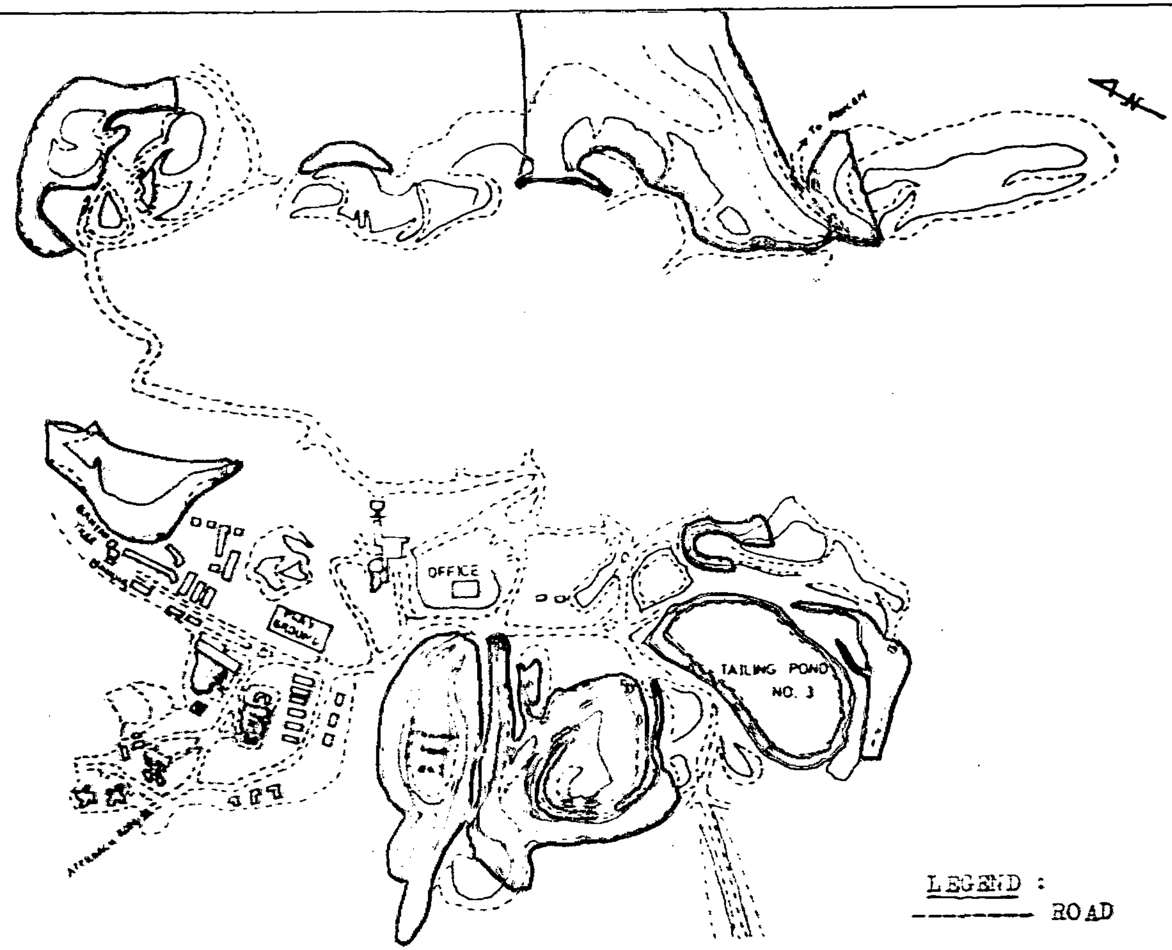

Fig. 35b Case study 'Z' showing the waste dumps & tailing ponds where revegetation has been carried out.

fruiting but in most cases the fruits tend to wilt at an early stage. Along the plantation about 20 plants of Carica papaya are intermixed showing stunted growth. Other naturally occurring species in the compound are Careya arborea, Vitex negundo, a shrub on most areas close to drainage.

In the colony area, several cultigens have been introduced like Moringa oleifera, Annona reticulata, Areca catechu, Psidium guajava and Clerodendrum indica as a hedge plant.

ii) P5 dump lower portion area

In the areas where Cymbopogon citratus (citronella grass slips) had been planted prior to the monsoon showed much less gully formation, compared to the other adjoining areas where this grass was not planted. Moreover this grass is never browsed by cattle and goats - an advantage to allow it stabilize the soil in the subsequent seasons or years to follow.

iii) P5 dump-upper portion

Several invading species are, Trema orientalis, Mallotus albus, Chromolaena odorata, Clerodendrum viscosum, Hippocratea indica, and Syzygium zeylanicum. The major plantation is of Acacia auriculiformis only. Phylloclade litter has accumulated heavily even up to 30 cm thick layer.The slopes are comprised of Acacia auriculiformis and Casuarina equisetifolia. The top most dump area is a mixed plantation of Psidium guajava, Pongamia pinnata, Leucaena leucocephala, Mangifera indica, Syzygium cumini, Alstonia scholaris, Calotropis gigantea, Crotalaria pallida, Dalbergia sissoo, Ficus glomerata and Bougainvillea globulus, Anacardium occidentale,. On the gully encroachments, Morus alba , Gliricidia sepium, Leucaena leucocephala, Casuarina equisetifolia have become the water erosion encatching species. Vitex negundo and Scoparia dulces have successfully invaded this spot.

iv) Plant species around the nursery area

The old nursery garden which was established 7 years ago (1985) is carefully lined with Polyalthia longifolia var. pendula which provide shade to the seedlings that require protection from strong sunlight at the tender age. Along with it, are Artocarpus heterophyllus, Alstonia scholaris, Samanea saman, Leuceana leucocephala, Acacia auriculiformis, Delonix regia, Psidium guajava, Pithecellobium dulce and Dillenia pentagyna. Several ornamental species are observed namely Monstera deliciosa, Coleus aromaticus, Cestrum nocturnum, and Gomphrena globosa. Several varieties of Croton variegatum, two varieties (yellow & dark magenta) of Mirabilis jalapa, Salvia officinalis, Bougainvillea spectabilis, Morus alba, Sansevieria guineensis, Ixora coccinea, Asparagus officinalis, Clerodendrum thomsonae, Justicia gendarussa Hibiscus rosea, Rosea indica, Acalypha speciosa, Alocasia indica, Vinca rosea, Blechnum sp., Bryophyllum pinnata, Caesalpinia pulcherrima, Plumbago zeylanica, Tradescantia virginia and Ervatamia divaricata are species which show panoramic view throughout the season.

Due to the increased water supply in the nursery with the help of automatic rotating sprinklers, a number of species are showing excellent growth performance namely Carica papaya,Musa paradisiaca and Zea mays which have become well established in the garden. The nursery fence is encircled with Clerodendrum indica as a medium hedge shrub which is frequently trimmed at the top to make a compact fence. Behind the nursery and residential quarters is a large Ficus benghalensis species which is spreading well. Musa paradisiaca is performing well even behind the Managers' quarters.The nursery area has been transformed to a moist fertile zone which can encourage the vegetal cover in future.

v) Vegetation on Tailing Pond -P8.

This is an area of about 4 hectares divided into three major components of plantation dependent on the age and composition.

i) A mixed plantation comprised mainly of Acacia auriculiformis (6 years old).

ii) Casuarina plantation (10 years old) with saplings of Syzygium cumini.

iii) A pure plantation of young Acacia auriculiformis (3 years old).

Nowhere else has revegetation been done on tailing pond in Goa with amicable success, it has been done at case study "Z" tailing ponds where encouraging results were observed.

1) Tailing pond P8i

A polycultured plantation exist in this area comprised of: Casuarina equisetifolia, Acacia auriculiformis, Alstonia scholaris, Peltophorum pterocarpum, Pithecellobium dulce, Syzygium cumini and S. zeylanicum though an erect shrub shows spreading habit close to the ground level, and Barringtonia racemosa which is 12 years old is observed. Acacia arabica (Sny. A. nilotica) was introduced however survival percentage after the third year was reduced to 20% with stunted growth. Few species have invaded the tailing pond namely Canscora decurrens, Mimosa pudica, Chromolaena odorata and Ischaemum semisagittatum. However one peculiar thing is that Acacia arabica planted closely with Acacia auriculiformis wilted while the former planted on the margin or 5 mts apart survived.

It was surprising also to find that all Ipomoea pes-caprae species planted earlier died in the 3rd year. The species Ipomoea pes-caprae on the open situation where they came up naturally on the tailing pond and are still surviving while the same planted under the shed, in thick mixed plantation wilted.

Occasional incidents were observed elsewhere in Mapuca and Pernem areas where the *Ipomoea pes-caprae* under *Casuarina equisetifolia* plantation had completely wilted including plant species such as *Spinifex littoreus*, and *Pandanus tectorius* (Personal observation).

Leuceana leucocephala is found to be stunted in growth due to browsers (cattle, goats and rabbits).

Syzygium cumini is very slow growing tree on the tailings but appears to tolerate the condition of the tailing pond where Iron is recorded to be above 30%.

2) Tailing pond P8ii

Casuarina equisetifolia plantation on the tailing pond. This is the middle portion which is the oldest tailing pond in the "Z" mines. It contains about 200 tree species (10 years old) with young saplings of *Syzygium zeylanicum* on the backyard.

Dense litter formation of *Casuarina equisetifolia* phylloclades were observed but with the little invasion by ground flora except *Ischaemum semisagittatum* and *Blumea eriantha* to limited extent.

3) Tailing pond P8iii

The vegetation of this tailing pond is about 2 years old and is mainly composed of *Acacia auriculiformis*, *Agave americana* and *A. cantala*.

vi) **Natural vegetation on the slopes of the unexcavated sites.**

About 24 hectares of denuded scrub exist on the slopes of the mines (Fig.33c and 33d).The major plant species dominating in the zone are *Alstonia scholaris*, *Terminalia paniculata*, *Ervatamia heyneana*, *holarrhena antidysenterica*, *Garcinia indica* and *Mallotus albus*. (Nyabuto, 1989). Co-dominants are *Memecylon wightii*, *Calycopteris floribunda*, *Chromolaena odorata* and *Trema orientalis* which has invaded all slopes.

vii) **Vegetation of the P1 dumps.**

Many of these slopy areas have been badly eroded by deep gullies despite the drainage construction from time to time. Some of the species found surviving on the 5 year old even-aged plantation (polyculture), are ;

Acacia auriculiformis, Pithecellobium dulce, Bougainvillea spectabilis, Azadirachta indica, Bauhinia purpurea, B. variegata Dalbergia sissoo, Terminalia bellirica, Parkia biglandulosa, Bombax ceiba, Alstonia scholaris, Delonix regia,Agave americana A.cantala, Samanea saman, Adenanthera pavonina, Tamarindus indica, Careya arborea, Casuarina equisetifolia, Gliricidia sepium, Ficus benghalensis, Erythrina indica, Leucaena leucocephala, Jatropha curcas, Anacardium occidentale, Peltophorum pterocarpum, Phyllanthus emblica, Acacia arabica etc. Frequent invaders are Chromolaena odorata, Ischaemum semisagittatum, Cheilanthus tenuifolia, Canscora decurrens and Cymbopogon citratus grass is also doing fine in this habitat in arresting and preventing gully formation there by checking soil erosion.

During the survey, delayed periodicity of flowering was noted in some plant species especially Anacardium occidentale, under normal circumstances flowers in December - January whereas at the P1 dump was found to flower in March-May; Leucaena leucocephala's actual periodicity is in July-October but was found to be in February-May; Samanea saman's periodicity is in March-April but was found to be in June-July and Casuarina equisetifolia's normal periodicity is twice to three in a year i.e. September- January but was found to be in March-May.

The spacing on a few selected plant species which were put on large scale, were in most cases overdensed. However in areas where the Acacia auriculiformis and Acacia mangium where sparsely spaced 2m x 2m, showed considerable good performance of the species. The areas where *Alstonia scholaris*, *Samanea saman* and *Casuarina equisetifolia* were spaced at 3m x 4m showed good performance in plant height, stem girth and leaf canopy.

Table: 32 a Plant species found at case study "Z" sites (which in most cases, have been planted). cultigens

Sr. No.	Taxon and Local Name	Chromosome No.	Family
1.	Abrus precatorius (Gunj)	22	Fabaceae
2.	Acacia auriculiformis (Australian acacia)	26	Mimosaceae
3.	Acacia arabica (Babhul)	44	Mimosaceae
4.	Acacia catechu (Cath)	26	Mimosaceae
5.	Acacia chundra (Lalkhair)	26	Mimosaceae
6.	Acacia mangium	26-52	Mimosaceae
7.	Acalypha wilkesiana	20,24	Euphorbiaceae
8.	Achras sapota (Chikku)	26	Sapotaceae
9.	Adenanthera Pavonina (Ratan gunj)	24	Mimosaceae
10.	Adhatoda vasica (Adulsa)	34	Acanthaceae
11.	Adina cordifolia (Hedu)		Rubiaceae
12.	Agave americana	60, 120, 180,240	Agavaceae
13.	Agave cantala (Kantala/Guial)	90	Agavaceae
14.	Aegle marmelos (Bel)	18,36	Rutaceae
15.	Allamanda cathartica (Kanher)	18	Apocynaceae
16.	Albizzia lebbek (Siras)	26	Mimosaceae
17.	Allophyllus cobbe	22,32	Sapindaceae
18.	Alstonia scholaris	44	Apocynaceae
19.	Anacardium accidentale (cashew nut tree)	42	Anacardiaceae
20.	Ananas sativus (Pineapple)	50	Bromeliaceae
21.	Artocarpus heterophyllus (Jack fruit tree)	28-56	Moraceae
22.	Azadirachta indica (Neem)	30	Meliaceae
23.	Bambusa arundinacea	70	Poaceae

	(Bamboo)		
24.	Barringtonia racemosa	26	Barringtoniaceae
25.	Bauhinia purpurea (Dev-kanchan)	28	Caesalpiniaceae
26.	Bombax ceiba (Sawari)	88	Bombacaceae
27.	Bougainvillea spectabilis	20,34	Nyctaginaceae
28.	Bougainvillea globulus	20,34,51	Nyctaginaceae
29.	Bridelia scandens	26,28	Euphorbiaceae
30.	Buchanania lanzen (Charoli)		Anacardiaceae
31.	Caesalpinia pulcherrima (Shankasur)	24	Caesalpiniaceae
32.	Callistemon lanceolatus (Bottle brush)	22	Myrtaceae
33.	Calophyllum inophyllum (Alexandrian laurel/Undi)	32	Guttiferae
34.	Calycopteris floribunda (Usaki)	48	Combretaceae
35.	Carica papaya (Papaya)	18	Caricaceae
36.	Careya arborea (Kumbiyo)	26	Lecythidaceae
37.	Caryota urens (Fish tail)	32	Arecaceae
38.	Cassia alata	26	Caesalpiniaceae
39.	C. angustifolia	26	Caesalpiniaceae
40.	C. fistula (Laburnum)	24	Caesalpiniaceae
41.	C. glauca	26	Caesalpiniaceae
42.	C.nordosa	26	Caesalpiniaceae
43.	Casuarina equisetifolia (Beef-wood)	18	Casuarinaceae
44.	Ceiba pentandra (Silk cotton)	72,80	Bombacaceae
45.	Clerodendrum inerme	46,48	Verbenaceae
46.	C. serratum	46,52	Verbenaceae
47.	C.viscosum	52	Verbenaceae
48.	Cocos nucifera (Coconut)	32	Palmaceae
49.	Croton variegatum	108,112	Eurphorbiaceae

	(Croton)	116,120	
50.	Dalbergia sissoo (Shisum)	20	Fabaceae
51.	Delonix regia (Gulmohur)	24	Caesalpiniaceae
52.	Dendrocalamus strictus (Male bamboo/kania bans)	70,72	Poaceae
53.	Elaeis guineensis (Oil palm)	32	Arecaceae
54.	Emblica officinalis (Amla)	98 98-104	Euphorbiaceae
55.	Ervatamia heyneana (Nag kuda)	22	Apocynaceae
56.	Eucalyptus hybridus (Nilgiri)	42	Myrtaceae
57.	Erythrina indica (Pangara/Coral tree)	42	Fabaceae
58.	Euphorbia tirucalli	20	Euphorbiaceae
59.	Ficus benghalensis (Vad/Banyan)	26	Moraceae
60.	Ficus glomerata (Umber/Rumad)	26	Moraceae
61.	Ficus asperrima (Kharvat)	26	Moraceae
62.	F. callosa	26	Moraceae
63.	Garcinia indica (Kokum)	48-54	Guttiferae
64.	G. xanthochymus	44-96	Guttiferae
65.	Gliricidia sepium	20,22	Fabaceae
66.	Grewia tiliaefolia	18-36	Tiliaceae
67.	Helicteres isora (Murud sheng)	18,24	Sterculiaceae
68.	Hibiscus roseus (Jaswand)	38	Malwaceae
69.	Holarrhena antidysenterica (Kudo)	22	Apocynaceae
70.	Hydnocarpus laurifolia (Kosti)	48	Flacourtiaceae
71.	Ichnocarpus frutescens (Krishnasarwa)	20	Apocynaeceae
72.	Jatropha curcas	22	Euphorbiaceae

	(Mogli-erand)		
73.	Lannea coromandelica (Moi)	28-40	Anacardiaceae
74.	Lawsonia alba (Mehandi)	----	Lythraceae
75.	Leucaena leucocephala (Vilayati-babhul)	36-104	Mimossaceae
76.	Mallotus albus	22-72	Euphorbiaceae
77.	Mangifera indica (Ambo/Mango tree)	40	Anacardiaceae
78.	Melia azedarach (Persian Lilac)	28	Meliaceae
79.	Memecylon wightii (Anjan)	14-28	Melastomataceae
80.	Mimusops elengi (Bakul)	24	Sapotaceae
81.	Morus alba (Mulberry)	28	Moraceae
82.	Musa coccinea	20	Musaceae
83.	Musa paradisiaca (Banana)	22,32,33 34,35	Musaceae
84.	Mussaenda frondosa (Mussaenda)	22	Rebiaceae
85.	Nerium indicum	22	Apocynaceae
86.	Parkia biglandulosa	26	Minosaceae
87.	Peltophorum pterocarpum	26,28	Caesalpiniaceae
88.	Phyllanthus reticulatus	26	Euphorbiaceae
89.	Pithecellobium dulce (Vilayati chinch/manila tamarind)	26	Mimosaceae
90.	Plumeria rubra (Pandhara champaka)	36	Apocynaceae
91.	Polyalthia longifolia (False Ashok)	18	Annonaceae
92.	Psidium guajava (Jamb/guava)	22	Myrtaceae
93.	Pterocarpus marsupium (Bibla)	44	Fabaceae
94.	Quisqualis indica (Rangoon creeper)	22,24,26	Combrataceae

95.	Rosa indica (Rose)	14	Rosaceae
96.	Salvadora persica (Mustard tree)	24	Salvadoraceae
97.	Samanea saman (Rain tree)	26	Mimosaceae
98.	Santalum album (Sandal wood/Chandan	10	Santalaceae
99.	Sapindus laurifolies (Soap nut/Ritha)		Sapindaceae
100.	Sapium insigne (Ura/Dudla)	36	Euphorbiaceae
101.	Schleichera oleasa	26	Sapindaceae
102.	Sterculia urens (Caraya gum)	40	Sterculiaceae
103.	Strychnos nux-vomica (Kajaro)	24	Loganiaceae
104.	Syzygium cumini (Jambul)	44	Myrtaceae
105.	Syzygium zeylanicum	28	Myrtaceae
106.	Tamarindus indica (Chinch)	24	Caesalpiniaceae
107.	Tectona grandis (Teak tree)	24,36	Verbenaceae
108.	Terminalia arjuna (Arjuna)	24	Combretaceae
109.	T. bellirica (Behada/Ghotina)	26	Combretaceae
110.	T. catappa (Badam)	24	Combretaceae
111.	T. chebula (Hirda)	14,24,48	Combretaceae
112.	T. paniculata (Kindal)	26-48	Combretaceae
113.	Terminalia tomentosa (Ain)	14	Combretaceae
114.	Trema orientalis (Gol)		Ulmaceae
115.	Vitex negundo (Nirgudi)	24,26,34	Verbenaceae
116.	Wagatea spicata		Caesalpiniaceae
117.	Ziziphus mauritiana	24,40,48 60,72,96	Rhamnaceae
118.	Ziziphus oenoplia	20,48	Rhamnaceae
119.	Ziziphus rugosa (Churna)	20,96	Rhamnaceae
120.	Breynia patens	28,54	Euphorbiaceae

Table: 32 b Herbaceous flora of case study "Z" & the surrounding areas .

Sr. No.	Taxon	Habit	Flowering/Fruiting Period	Chromo- -some No.
1.	Abutilon indicum	(N.O.)	Fl: & Fr: Throughout the year	36
2.	Acalypha wilkesiana	(N.O.)	Fl: & Fr: Throughout the year	28
3.	Acanthospermum hispidum	(N.O.)	Fl: Sept - Nov; Fr: Sept-Nov.	22
4.	Achyranthes aspera	(N.O.)	Fl: Sept; Fr: Oct-Nov.	14
5.	Alysicarpus bupleurifolius	(N.O.)	Fl:Sept-Oct; Fr. Nov-Dec.	16
6.	Aerva lanata	(N.O.)	Fl: Sept & Fr: Oct.	16
7.	Aeschynomene aspera	(N.O.)	Fl: Aug-Dec; Fr: Dec-Jan.	20-24
8.	Ageratum conyzoides	(N.O.)	Fl: & Fr: Throughout the year	20
9.	Alternanthera sessilis	(N.O.)	Fl: Aug-Apr.	34
10.	Amaranthus viridis	(N.O.)	Fl: Sept-Nov; Fr: Sept-Nov.	-
11.	Andrographis paniculata	(N.O.)	Fl: Dec Fr: Jan-Feb.	28
12.	Anisochilus verticillatus	(N.O.)	Fl: Aug-Oct; Fr: Oct-Nov.	-
13.	Atylosia scarabaeoides	(N.O)	Fl: Jun-Oct.	22
14.	Atylosia crassa	(N.O.)	Fl: Apr-Jun	22
15.	Breynia patens	(N.O.)	Fl: Apr-Jun; Fr: Aug-Nov.	-
16.	Canscora decurrens	(N.O.)	Fl: Oct-May	72
17.	Canscora diffusa	(N.O.)	Fl: Oct-May	-
18.	Cassia absus	(N.O.)	Fl: Aug-Nov	26,28,56
19.	Celosia argentea	(N.O.)	Fl: Aug-Nov.	36
20.	Chromoloaena odorata	(N.O)	Fl: Nov-Dec.	50
21.	Cleome viscosa	(N.O.)	Fl: Apr-Jan	-
22.	Clitoria ternatea	(C)	Fl: Jun-Nov.	16
23.	Crotalaria pallida	(N.O.)	Fl: Aug; Fr: Sept-Oct.	16 - 32
24.	Crotalaria epunctata	(N.O.)	Fl: Jul-Aug; Fr: Oct.	16 - 32
25.	Crotalaria retusa	(N.O.)	Fl: Sept; Fr: Oct-Nov.	16 - 32
26.	Commelina attenuata	(N.O.)	Fl: Sept-Oct; Fr: Sept-Oct.	40
27.	Dactyloctenium aegyptium	(N.O.)	Fl: Aug-Sept; Fr: Aug-Sept.	20,34,48.

28.	*Desmodium triquetrum*	(N.O.)	Fl: Oct-Nov; Fr: Nov-Dec.	22
29.	*Desmodium polycarpum*	(N.O.)	Fl: Sept-Oct; Fr: Sept-Oct.	20-22
30.	*Dioscorea bulbifera*	(N.O.)	Fl: Aug-Nov.	36,40,90-100
31.	*Eriocaulon diannae*	(N.O.)	Fl: Aug-Sept; Fr: Aug-Sept.	32-64
32.	*Euphorbia hirta*	(N.O.)	Fl: & Fr: Throughout the year	12,20
33.	*Euphorbia notoptera*	(N.O.)	Fl: Oct-Nov; Fr: Dec.	12-200
34.	*Evolvulus alsinoides*	(N.O.)	Fl: Nov-Dec; Fr: Jan.	26
35.	*Geissaspis tenella*	(N.O.)	Fl: Jun; Fr: Aug.	-
36.	*Hedyotis herbacea*	(N.O.)	Fl:: Jun-Aug; Fr: Jun-Aug.	12-48
37.	*Hemidesmus indicus*	(N.O.)	Fl: Sept-Dec; Fr: Jan-Apr.	22
38.	*heteropogon contortus*	(N.O.)	Fl: Aug-Sept; Fr: Aug-Sept.	20,60,80
39.	*Hyptis suaveolens*	(N.O.)	Fl: Aug-Nov; Fr: Aug-Nov.	28
40.	*Ipomoea sepiara*	(N.O.)	Fl: Aug-Sept; Fr: Oct.	28-84
41.	*Ipomoea campanulata*	(N.O.)	Fl: Jun-Jul; Fr: Aug.	30
42.	*Ischaemum conjugatum*	(N.O)	Fl: Aug-Sept; Fr: Aug-Sept.	18-72
43.	*Iseilima laxum*	(N.O.)	Fl: Aug-Sept; Fr: Aug-Sept.	8,24,28
44.	*Ixora coccinea*	(N.O.)	Fl: Nov-Dec; Fr: Feb.	22
45.	*Lantana camara*	(N.O.)	Fl: & Fr: Almost through the year	22,44,66
46.	*Lapidagathis cristata*	(N.O.)	Fl: Nov-Dec; Fr: Mar-Apr.	22
47.	*Ludwigia parviflora*	(N.O.)	Fl: Aug-Nov.	16 - 48
48.	*Malvastrum coromandelianum*	(N.O.)	Fl: Aug; Fr: Sept.	24
49.	*Merremia emarginata*	(N.O.)	Fl: Sept; Fr: Oct-Nov.	28
50.	*Merremia tridentata*	(N.O.)	Fl: Aug-Sept; Fr: Nov-Dec.	28-58
51.	*Merremia vitifolia*	(N.O.)	Fl: Nov-Mar; Fr: Nov-Mar.	28-58
52.	*Mimosa pudica*	(N.O.)	Fl:Sept-Jan; Fr: Sept-Jan.	52
53.	*Mussaenda laxa*	(N.O.)	Fl: Apr-Nov; Fr: Oct-Dec.	22
54.	*Naregamia alata*	(N.O.)	Fl: Aug-Oct; Fr: Oct-Dec.	-
55.	*Neuracanthes sphaerostachyus*	(N.O.)	Fl: Aug-Nov; Fr: Oct onwards	-
56.	*Osbeckia truncata*	(N.O.)	Fl: Aug-Nov; Fr: Nov	20-40

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57.	Passiflora foetida	(N.O.)	Fl: Apr-Aug; Fr: Apr-Aug.	16,20
58.	Phaseolus mungo	(N.O.)	Fl: Jul-Aug; Fr: Sept.	22
59.	Phyllanthus fraternus	(N.O.)	Fl: Aug-Nov; Fr. Nov-Mar.	14-156
60.	Physalis minima	(N.O.)	Fl: Aug-Nov; Fr: Aug-Nov.	48
61.	Portulaca oleracea	(N.O.)	Fl: & Fr: Throughout the year	52,54
62.	Rauwolfia serpentina	(N.O.)	Fl: Apr; Fr: Nov.	22
63.	Rungia linifolia	(N.O.)	Fl: Sept-Oct; Fr: Nov-Dec.	20
64.	Rungia pectinata	(N.O.)	Fl: Nov-Mar.	20
65.	Russelia juncea	(C)	Fl: & Fr: Throughout the year	20
66.	Sesamum mulayanum	(N.O)	Fl: Aug-Sept; Fr: Oct-Nov.	26-64
67.	Sesbania bispinosa	(N.O.)	Fl: Aug-Sept; Fr: Oct-Nov.	12
68.	Sida rhombifolia	(N.O.)	Fl: Oct-Nov.	14
69.	Smilax zeylanica	(N.O.)	Fl: Aug-Sept; Fr: Aug-May.	26-60
70.	Smithia conferta	(N.O.)	Fl: Aug-Nov; Fr: Aug-Nov.	32
71.	Solanum nigrum	(N.O.)	Fl: Sept-Jan; Fr: Feb.	24,96,144
72.	Spermacoce hispida	(N.O.)	Fl: Aug-Sept; Fr: Oct.	20
73.	Spermacoce verticillatus	(N.O.)	Fl: Aug-Nov; Fr: Aug-Nov.	56
74.	Tephrosia purpurea	(N.O)	Fl: Sept-No; Fr: Sept-Nov.	22
75.	Teramnus labialis	(N.O.)	Fl: Oct-Nov; Fr: Nov.	20
76.	Tricholepis glaberrima	(N.O.)	Fl: Oct-Nov; Fr: Dec.	16-32
77.	Tridax glaberrima	(N.O.)	Fl: & Fr: Throughout the year	36
78.	Urena lobata	(N.O.)	Fl: Oct-Nov; Fr:Nov-Mar.	20
79.	Vernonia cinerea	(N.O.)	Fl: Aug-Nov; Fr: Aug-Nov.	10

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Table: 32 c Plant species which have been utilized in the plantation at all mining sites in Goa.

Sr. No.	Taxon	Chromosome number
1.	Acacia auriculiformis	26
2.	Anacardium occidentale	40,42
3.	Casuarina equisetifolia	18
4.	Eucalyptus hybrid	21,22
5.	Samanea saman	26
6.	Alstonia scholaris	44
7.	Terminalia arjuna	24
8.	Leucaena leucocephala	16,104
9.	Bougainvillea spectabilis	20,34,51
10.	Acacia catechu	26
11.	Azadirachta indica	30
12.	Delonix regia	24,28
13.	Dalbergia sissoo	20
14.	Tamarindus indica	24

4.3.2. **Wood characteristics and uses of important tree species at case study "Z" sites.**

1. Adenanthera pavonina L.

   Wood: Sap wood - grey, heart wood - red, close grained, Pores - very small, scanty. Use: House-building, cabinet work and dye.

2. Albizzia lebbek Benth.

   Wood - sap wood large, white or yellow, heart wood dark brown, streaked with lighter and darker streaks. Pores scanty, large. Use: furniture, building, ploughs and rollers.

3. Anthocephalus Chinensis (Lamk) Rich

   Wood - white with yellow tinge, even-grained. Pores large, oval, elongated. Use: dug-out canoes, yokes and ceiling boards.

4. Azadirachta indica Juss.

   Wood: Sap wood grey, heart wood red, close-grained, pores scanty, moderate sized and large.Use: House building, furniture and carts.

5. Ougenia oojeinensis (Roxb). Hochreut.

   Wood: Sap-wood small, grey; heart-wood mottled light brown, close-grained, pores moderate sized.

6. Baringtonia acutangula Gaertn.

   Wood: white, shining, even-grained, pores small.

   Use: Making carts, boat building, rice pounders and cabinet making.

7. Pongamia pinnata Pierre.

   Wood: White, turning yellow on exposure, pores moderate sized scanty. Used for house building, cart wheels and fuel.

8. Grewia tiliaefolia, Vahl.

   Wood: Sap wood white, heart wood small, brown, close grained, pores moderate sized, numerous, uniformly distributed.

   Used in making boats, mats, oars, ploughs, bows, shoulder-poles, handles of axes.

9. _Lagerstroemia lanceolata_ Wall.

Wood: Sap wood, grey-white, heart wood red or red brown, pores variable in size.Use: Wood for house building, ship building, furniture, coffee-cases, oil casts and ploughs.

10. _Plumeria rubra_ L. var. _acutifolia_ (Poir) Woodson.

Wood: Yellow-white, pores small. Use: making native drums.

11. _Dalbergia latifolia_ Roxb.

Wood: Sap wood yellow, heart wood small dark purple with black longitudinal streaks, close grained, pores moderate sized to large.Use: high class furniture, door and window frames, carts ploughs and well construction.

12. _Dillenia pentagyna_ Roxb.

Wood: Red grey, pores small.Use: occasionally in house construction and ship building.

Note: Propagation by seed. This species requires plenty of light and is sensitive to frost. It withstands forest fires and usually leafless at bloom. This species can also be effectively used on mining rejects as it withstands fires.

13. _Garcinia indica_ Choiss

Wood: Grey-white, pores numerous, narrow, wavy, moderate sized.

14. _Garcinia xanthochymus_ Hk. f.

Wood: Dark, grey-brown, close grained, pores very scanty, moderate sized, scattered.

15. _Mimusops elengi_ L.

Wood: Red, close and even grained, pores small, scanty.

Use: House building, bridge construction and wharf pits for boats.

16. _Santalum album_ L.

Wood: Sap wood white and scentless, heart-wood yellow brown, strongly scented, closely-grained, pores small, numerous, evenly distributed. The best scented wood is obtained from rich soils mixed with rock but the scent becomes less where the soil is rich and without stones (Bole and Vaghani, 1986).Use: Carvings, boxes, frames and fancy articles.

17. Macaranga peltata Muell.

Wood: Red-brown, close grained, pores large, oval.Wood is of little value except as cheap fuel wood.

18. Machilus macrantha Nees

Wood: Orange-brown, even grained, pores moderate sized.

Use: In construction of buildings and boats.

19. Schleichera oleosa (Lour.) Oken.

Wood: Sap wood white, heart-wood light, red-brown, pores scanty, moderate sized, oval.Use: Beams, carts, and shafts.

20. Strychnos nux-vomica L.

Wood: White when fresh cut, turning yellow grey on exposure, close-grained, no heart wood present, pores large, very scanty and very small, numerous.Use: Inferior buildings, ploughs, cart-shafts and wheels.

21. Syzygium cumini (L.) Skeel

Wood: Red-grey, darker near the centre with distinct heart wood, pores moderate sized or small, numerous, oval, elongated.

Use: Valuable wood for construction works especially in house-building, boat-building and agricultural implements.

22. Acacia auriculiformis A. Cunn ex Benth.

Wood used as fuel and in paper industry.

The plant species is fairly fast growing and resistant to drought hence can grow virtually where other species would not grow well. However in the recent times its popularity has waned as it does not readily allow other ground flora species to come up and rarely attracts birds and any other animals including squirrels.

23. Acacia chundra (Roxb) Willd.

Wood: Sap wood, yellow-white; heart wood, dark or light red. Pores moderate sized and large. Use: house posts, carts, houseconstruction, furniture, agricultural implements.

24. Alstonia scholaris Br.

Propagation by seeds and young shoots. Wood: soft. Use:making slates.

25. Bauhinia purpurea L.

Propagation: Seeds sown in monsoon. Seedlings appear in 7-10 days and are transplanted during rains. It is, one of the few trees that flower in winter.

Wood - brown with irregular dark patches near the centre.

Pores moderate sized, scanty.

Use: Agricultural implements and fuel wood.

26. Anacardium occidentale Linn.

Wood: Red-brown, close grained. Pores large.

Use: Packing cases, boat building and charcoal.

27. Bombax ceiba

Wood: White when fresh cut, turning slightly darker on exposure.Pores very scanty, large, oval.Use:packing, planks and match sticks.

28. Bridelia retusa Spr.

Wood: Grey to olive brown, close grained. Pores moderate sized.Used for buildings and floor boards.

29. Buchanania lanzan Spreng.

Wood: Grey-brown, pores large, round or oval, scanty.

Used for small beams, rafters, doors, window frames and cheap furniture.

30. Careya arborea Roxb.

Wood: Sap wood white, large, heart wood red, even-grained, pores moderate size to large. Used for cart - building, cabinet work, furniture and agricultural implements.

31. _Casuarina eqisetifolia_ J. R. S. Forster.

Wood: White, red-brown at the centre. Pores moderate sized.

Use: poles, rafters, masts, oars and yokes.

32. _Dalbergia sissoo_ Roxb.

Wood: white; heart-wood brown, close - grained, pores moderate to large size, scanty.

Use: boat building, house building, high class furniture and frames.

33. _Delonix regia_ Rafin Syn. _Poinciana regia_ Bojer.

Wood: White, pores large. Use: Cheap fuel.

34. _Erythrina indica_ Lam.

Wood: White, pores very large, scanty.

Use: For boxes, scabbards and toys.

35. _Eucalyptus hybridus_

Note: A recent introduction to South India in the middle of 1930's but has met a lot of objections from the community due to its property of degrading soil environment.

36. _Ficus benghalensis_ Linn

Wood: Grey. Pores moderate size and large. Use: well - curbs.

37. _Ficus rumphii_ Bl.

Can easily be propagated by shoots/stumps.

Wood: White with alternating bands of loose and firm tissue of equal width, pores oval, scanty, moderate sized. Used as charcoal.

38. _Lannea coromandelica_

(Houtt) Merrill Syn. _Odina woodier_ Roxb.

Wood: Heart wood is light red when fresh cut, turning red-brown on exposure. Sap wood is large, white close grained, pores moderate sized, scanty, uniformly distributed.Use: House building, packing cases, furniture and carts.

39. Mangifera indica L.

Wood: Grey, pore scanty, moderate sized and large.

Use: Window frames, planking door, tea boxes and cheap furniture.

40. Melia azedarach L.

Wood: Sap-wood, yellow-white, heart-wood red, loose grained, pores prominent.

41. Polyalthia longifolia (Sonner) Thw.

Wood: White, yellow-white or grey-white, pores small to moderate sized. Use: For making tubs, buckets and cases.

42. Samanea saman .

Merrill. Syn Enterolobium saman Prain

Easily propagated by seed sown during monsoon. Can also be propagated by cuttings. Growth is very rapid. Use: Fuel. Wood: Light red-brown, pores moderate sized.

43. Sterculia urens Roxb

Wood: Red - brown with unpleasant smell, pores large, often oval.Use: Doors of huts, dug-out canoes, boat planking and toys.

44. Tamarindus indica L.

Wood: Sap-wood yellow-white, heart wood small, dark purple brown, close grained, pores moderate sized, uniformly distributed.

Use: Preparing sizing material for textile industry.

45. Terminalia paniculata Roth.

Wood: Grey with darker heart wood, pores moderate to large size, oval.Use: House building, agricultural implements, carts.

46. Trema orientalis Blume

The tree has not so far been popularized although it is a fast growing tree and appears to be a potentially promising species in agroforestry.

Wood: Light red-grey, pores moderate sized.Use: gun powder charcoal and timber.

N.B. Trema orientalis is one of the earliest species to naturally invade old dumps through dispersal of fruits by birds.

Many individuals of the species have come up naturally on the dumps showing fast growing for example, about four, seven year old Trema orientalis plants were found on top of the P1 dump in the "Z" mines, with stem girth of 90 cms and leaf canopy of 6.5 mts.Some related species of Trema orientalis in the family Ulmaceae have been reported to nodulate. Such doubts do not exist about the nodules on Parasponia andisonii of the family ulmaceae (Akkermans,et al.,1978).

Owing to its fast growth like the tendency of a number of nodulating plants species, some curiosity was aroused to find out whether it nodulates or not. It was found not to nodulate as this was physically verified by exposing the root system and reinstating it back on a number of specimens at different sites by the author.

47. Ziziphus mauritiana L.

Wood: Red, heart-wood absent, pores small or moderately sized, scanty.Use: Agricultural implements and oil-mills.

Note: This tree gives much of the fuel in dry areas. Branches form a good fodder. Cultivated varieties have much larger fruits than the wild ones. Wood yielding species are important especially in villages where it is basically the main source of fuel, like in the case study "Z".

The list of plant species utilised in the plantation program in the case study"Z" are given in Table:32 .

4.3.3 DISCUSSION

In any naturally balanced ecosystem, species with wide variation of Chromosome numbers do co-exist each competing for different nutrient requirements.

The true amount of genetic diversity in forest trees is naturally under estimated. Tree population are almost always highly heterogeneous genetically, both among stands and trees within stands (Zobel and Talbert,1984).

Recent studies have indicated that forest trees have the greatest variability of all plants or, in fact of any organism.Much tolerance to pests and adverse conditions would be expected because a tree is perennial and must survive many years and reproduce under varied growing conditions and pest attacks within a year and from year to year.Tree species differ greatly in their abilities to withstand differing pests or environments.Even ramets of a clone of a vegetatively reproduced plantation (where each individual has the same genotype) may contain several resistance genes.The danger from clonal plantings of the same genotype occurs because all ramets of the clone will have the same set of resistance genes.When these are overcome or exceeded, catastrophic losses can result because then all individuals within the plantation are susceptible to the pest or severe environment (Zobel and Talbert,Loc.cit.).

The selection of narrowly local and exotic (strains) species with closely related chromosome numbers (merely form their economic point of view) is highly hazardous and will have adverse effects on restoration programmes. This does not apply to case study "Z" where over 120 plant species (Table 32 a) have been introduced since 1986 through 1990 an extensive monitoring work was carried out until April 1992. This was a co-ordinated effort done between the research group of the P.G.Dept. of Botany, S.P.Chowgule College, Margao, and the staff members of the case study "Z".

Plant species already planted in Afforestation Programme at Mining sites wastes in Goa.

The percentage of species diversity planted in the afforestation in relation to the original species diversity at the mining sites found in Goa : (till December 1993)

$$\frac{15}{338} \times 100 = 4.43\%$$

while at case study "Z" is:

$$\frac{120}{338} \times 100 = 35.5\%$$

a) Indigenous and exotic plant species in all the mines in Goa.

i) The total percentage of indigenous species which have been reinstated at the mines wastes in Goa in relation to the natural flora on the adjoining undisturbed sites is:

$$\frac{6}{338} \times 100 = 1.77\%$$

ii) The total percentage of exotic species introduced at the mines wastes in Goa:

$$\frac{9}{338} \times 100 = 2.66\%$$

b) Indigenous and exotic plant species at case study "Z"

i) The total percentage of indigenous species planted at case study "Z"

$$\frac{112}{338} \times 100 = 33.1\%$$

ii) The total percentage of exotic species introduced at case study "Z."

$$\frac{29}{338} \times 100 = 8.6\%$$

According to a personal communication (Letter No.11(1)/87-Goa, dated 12.9.1991) with the Indian Bureau of Mines (IBM), Goa, only 15 species of plants have been introduced in all Iron Ore mining sites in Goa on a large scale. According to a rough estimate, around 300 ha. area has been is covered and around 12 lakh saplings have been planted around the mines' sites (rejected dumps and tailing ponds). Out of the 12 lakh saplings, about 10.8 lakh saplings are of *Acacia auriculiformis* , *Anacardium occidentale* and *Casuarina equisetifolia*. The plant species which have been used in the afforestation (Table 32c) are comprised of very narrow range of somatic chromosome numbers with the exception of *Leucaena leucocephala* (2 n = 36, 104).

Total number of saplings planted at case study "Z" mines between 1986 through 1991 is 3,00,305 covering 35.54 ha. The mortality rate in the initial 5 years was 40% with subsequent reduction to only 20%; this is because some significant ammendments were made to the mines' waste prior to the transplantation of the saplings.

The present total surviving species are 2,20,000 approximately which was a polycutured plantation. This shows that distinct efforts have been made to introduce species' diversity in the plantation programmes at case study "Z" during the years 1986 through 1990.

However true restoration has not been done yet, because out of 338 different plant species found in the surrounding adjoining scrub forests, it is only a third that of the species representatives that have been placed back.Therefore considerable efforts are required by the concern management of case study"Z" to reinstate the same species in order to confirm with the flora of the Western Ghats.

4.4. Analysis of plantation work in the mining site with respect to; Chlorophyll estimation, stomatal studies, plant species on metal contaminated soils, survival and dust filtering efficiency of plant species.

4.4.1 INTRODUCTION

4.4.1.1 Chlorophyll estimation

Chlorophyll estimation of selected plant species from the disturbed and undisturbed (natural) sites of Pale-Goa (where case study z lies) were carried out .Plant species from 4 different habitats namely (A) the dump slopes, (B) rocky plateau, (C) adjoining scrub forest and (D) moist field were taken up for study. Care was taken to see that the species selected were of relatively similar age.The age estimation of the stand's species was determined by three criteria as per Lugo (1993);Physiognomy, their presence or absence in aerial photographs taken earlier. There was no variation in the climatic factors such as rainfall & temperature operating on disturbed and undisturbed sites since they were very close to each other.

4.4.1.2 Stomatal Studies

Leaf stomata as one of the morphological characteristic of a plant may be useful in geobotanical prospecting.

Changes in morphology of plants and evidence of disease have been used as field guides in geobotanical prospecting since the eighteenth century. Early workers had to rely on obvious changes such as dwarfism or variation in color, but with the increasing sophistication of modern science and greater knowledge of plant physiology, many other visual indications of mineralization have been noted and can be used in prospecting.

Morphological changes in plants under the influence of mineralization are very varied and include such factors as: dwarfism, gigantism, mottling or chlorosis of leaves, abnormally shaped fruits, changes in growth form, disturbances in the rhythm of the flowering period, changes of color in flowers, and a large number of other indications (Brooks ,1983).Therefore, a comparative study of plant species growing in the disturbed and undisturbed mining sites was carried out.

The number and size of stomata can indicate the changes due to absence or presence of mineralization or deficiency among other factors operating such as light, water availability and other edaphic conditions of plant species of disturbed and undisturbed sites. Such a study, helps one to understand better about the recently disturbed ecosystem, and restoration of the same by selecting suitable plant species. This is a preliminary investigation which may lead to further studies.

4.4.1.3 Plant species on metal contaminated soils.

Plants that are largely restricted to or particularly abundant on metal-contaminated soils have been used as indicators of heavy metal ores and have therefore attracted special interest.

Recently it has been realised by both the ecologists and biogeochemical prospectors that is necessary to quantity the relative abundance of different species in relation to metal content (and other ecological factors) of the environment. The concept of indicator species is perhaps an ecologically unrealistic, although at times useful, qualitative assesment.(Antonovics et al., 1971) An attempt to go beyond the simple indicator concept made directly in Belgium by Lambinon and Auquier (1964) who produced a semi- quantitative classification which was a considerable improvement on the crude concept of indicators, this was a mere modification of Braun-Blanquet's classification(1951).

The classification of plant communities is of two types either the presence on undisturbed metal ore near the soil surface causing "anomalies" as they are termed by the geochemist, or from their presence on actual mining ore bodies (Antonovics et al., 1971).

4.4.1.4 Survival of plant species

The long term plant species survival is important at the mining sites; it is from this aspect that some tree manipulation problems can be identified especially in the industrial and allied complexes and thereby causal factors can be assessed.

The post plantation monitoring in the actual field by an experienced ecologist would certainly bring out useful information on the adaptability of species to this newly disturbed environment. Therefore long term monitoring is of course necessary but takes a long time (5to7 years or more); to some extent, this has been done by the author.

In some instances it is necessary to know how well a plant is growing in a particular area and a measure of some suitable character can often be made, which reflects the relative vigour or performance, as it is termed, of an individual. (Kershaw, 1973).

Tree performance at the early age will help decide as to which species can be selected for afforestation programmes.

4.4.1.5. Dust filtering efficiency of plant species.

Though dust particles provide nuclei for cloud formation and hence rain, dust can at times be a health hazard.

Dust is perhaps one of the most common inanimate media capable of conveying diseases.Recent research indicates that dust particles can lead to allergic asthma, bronchitis, emphysema and even fibriosis of the lungs.Silica is to be regarded as an hazard of any occupation in which dust containing this compound is free in the atmosphere. Hard rock drilling and various industrial processes involving grinding molding and sand blasting are examples of such hazardous occupations. Silicosis causes considerable impairment of lung function with shortness of breath as its characteristic feature.Initially the dust is deposited in the terminal bronchioles and it may lead to a fibriotic reaction around these, later leading to massive fibriosis (Anonymous, 1987).

Besides silica, manganese (Mn) which is found commonly in the iron ore mines along with Iron (Fe) is also a health hazard.Organisms present in dust may get on food and be swallowed, settle on the skin and infect it, or be inhaled into the respiratory passages. Some germs of anthrax and tetanus of Q fever, brucellosis, and psittacossis, for example can live for long periods dried in dust (Anonymous,1987).

If, a plant is heavily infested with dust especially on the stomatal pores, gaseous exchange may be interferred with. This in turn, may affect photosynthesis, water relation, respiration and the overall growth of the plant. This may also produce various deleterious effects of the normal physiological functions of the plant.

Case Study "Z" mine area, like any other open cast mines in Goa, is always a heavily dust ridden area. The roads used by the trucks as also the surrounding area harbour a lot of dust making even the greenery around appear brown.The dust also flows to the nearby streams thus contaminating them too.

Many experiments have been designed to record dust pollution levels inside and outside green areas. For Hyde Park, a squarekilometre green area in the heart of London an average of 27 percent reduction in smoke concentration has been found. Similarly a case study was conducted in the Soviet Union to find out as to which trees generally exert the maximum filtering effect. For this purpose dust per unit area of leaf surface was weighed. The results showed that the best vegetative dust filters 2.33 g/m^2 of leaf surface; maple with 1.11 g/m^2 and Poplar with 0.26 g/m^2. It was found that 400 poplars, the poorest dust collectors in the above study could still filter out 0.375 tonnes of dust in the area. (Das et al., 1981).

The polluted air-filtering mechanisms of forest have not as yet been sufficiently recognized (Knabe, 1979). The filtering capacity of forest ecosystems is estimated to be of the order of several scores of tons of dust and a much smaller volume of gaseous pollutants ha^{-1} yr^{-1} (Madders & Lawrence, 1982;Fabajanowski and Lesinski, 1984 ; Grodzinski et al.,1984).

4.4.2. MATERIALS AND METHODS

4.4.2.1. Chlorophyll estimation

200 mg wet weight of fresh leaves were minced with scissors then ground by a pestle in a mortar into fine paste. 5ml water was added and then homogenized in a blender. The final volume was made to 10 ml. Aliquot (0.5 ml) was taken and mixed with 4.5 ml of 80 % acetone. The acetone extract was centrifuged for 3 minutes and the supernatant was collected and filtered using a Buchner funnel. By using a standard spectrophotometer, "spectronic 20 " the optical density (Absorbance) at (663 nm) and (646 nm) wavelengths which represented the chlorophyll a and chlorophyll b respectively were determined (Jayaraman, 1981) . The concentrations were calculated from the formulae;

Chlorophyll a mg/litre = 12.21 A (663) - 2.81 (646)

Chlorophyll b mg/litre = 20.13 A (646) - 5.03 A (663)(Harbone,1973).

4.4.2.2. Stomatal Studies

Stomatal studies were carried out on 16 different plant species from different habitats viz. slopes of the dumps, rocky plateau, adjoining scrub forest and moist fields; the former two belong to disturbed sites while the latter two are from the undisturbed sites.

Specimen leaves were collected from the four habitats. The leaves were stained in gentian violet dissolved in 90% alcohol. This resulted into a clear demarcation of the guard cells from the other epidermal cells. The epidermis was then peeled carefully by a pair of forceps. In cases where the epidermal peelings were not possible, the leaf surface was coated with collodion. The thin film when dry, was removed and stomata were counted from the impression on the under surface of the leaf.

The fresh epidermal peelings from each leaf were then mounted on 1% Glycerine and observed under (Carl Zeiss) microscope. Parameters like no. of epidermal cells and size, no. of subsidiary cells, stomata type and size, stomatal pore size, stomatal index were observed per unit area. In each case observations were made from both the upper and lower leaf surface. Measurements were recorded using an ocular micrometre and some sketches were done with the help of a camera Lucida.

The stomatal index (I) was calculated as given by Pandeya et al., (1968).

$$I = \frac{S}{S + E} \times 100.$$

S is no. of stomata and

E is no. of epidermal cells in a given unit area.

Constant unit area was used (15.2 u x 15.2 u) in all the cases.

4.4.2.3. Plant species on metal contaminated soils.

The classification described by Lambinon and Auquier (1964), was used in the classification of plant species found on iron ore metal contaminated areas.The plant species on metal contaminated soils were sampled from an area of 12 sq.km in seven mines found in Bicholim taluka, Goa (case study "Z"inclusive).

4.4.2.4 Survival of plant species

During transplanting of plant species to the mining sites, records were made of the individual plant species planted and their exact locations were marked on sketch maps. The area size was measured using a pedometer, then constant monitoring was carried out bi-annually for six consecutive years (i.e. their presence or absence).

The survival percentage was calculated based upon the original individuals planted six years earlier. The trend of plant species survival on the dumps was closely examined for a period of six years. Stem girth was made by a pair of callipers & metal wired measuring tapes.Standard breast-height, is defined as, almost universally, an adopted standard height for measuring girth, diameters and basal area of a stand,which is normally 1.37 mts (Chartuvedi and Khana, 1982) however it was not applied especially in the young plantations. Plant height, Leaf canopy, and basal area of stands were determined using relascope("Durga" make). The slopes of the dumps were measured using a clinometer.

4.4.2.5. Dust filtoring efficiency of plant species.

To estimate the dust-filtering capacity of some plant species at case study " Z" area, a study was conducted at the Botany Department Laboratory of S.P. Chowgule College, Margao, Goa.

The leaves of diffferent species growing in the same area and approximately of the same age were plucked individually and carefully placed in polythene bags, then sealed.

Deposition of dust per unit area of the leaf surface was measured by removing the dust particles from the upper as well as lower surface of the leaf with the help of very clean camel hair brushes and using a chemical balance (electrical) Model No. S.B. 1/100 which weighs up to the fourth decimal place.

The leaves were collected in the early post-monsoon period i.e. October when dust was at minimal level and in the late summer period i.e April when dust was at peak in the atmosphere for analysis. Leaves of a large number of the species from different stands were examined microscopically.

4.4.3 OBSERVATIONS

4.4.3.1. Chlorophyll estimation

There was no significant change in the proportions between chl a and chl b in all of the species at the different sites in the plant species studied, however there were changes in the total Chlorophyll (Chl a and Chl b) in some of the plant species.

Table: 33. Showing total Chlorophyll estimation (mg/l) of selected plant species from the disturbed and undisturbed sites of case study"Z".

Taxon	Habitat A mg/l	Habitat B mg/l	Habitat C mg/l	Habitat D mg/l
1. Calycopteris floribunda	2.33	1.956	1.97	2.32
2. Memecylon wightii	1.67	1.746	1.63	1.802
3. Holarrhena antidysentrica	1.577	1.58	1.58	1.58
4. Macaranga peltata	1.632	1.66	1.64	1.64
5. Cassia tora	0.1785	0.115	0.181	0.183
6. Terminalia paniculata	2.241	1.87	1.883	1.971
7. Chromolaena odorata	1.916	1.4	1.78	1.9
8. Ervatamia heyneana	1.01	0.965	1.01	1.04
9. Alstonia scholaris	1.175	1.172	1.172	1.185
10. Spermacoce articularis	1.032	1.03	1.03	1.032
11. Ludwigia linifolia	0.171	0.131	0.18	0.17
12. Pennisetum hohenackeri	1.172	1.208	1.35	1.208
13. Ischaemum semisagittatum	0.63	0.667	0.577	0.756

Calycopteris floribunda showed the total chlorophyll to be high on the slopes of the dumps and moist fields; 2.33 mg/l and 2.32 am/l respectively.

Memecylon Wightii was observed to have changes in the total chlorophyll in all the sites; the highest was the moist fields 1.802 mg/l, followed by the rocky plateau 1.746 mg/l , slopes of the dumps 1.67 mg/l and lowest was the adjoining scrub forest 1.802 mg/l

Holarrhena antidysenterica was observed to have an almost constant total chlorophyll concentration 1.577 - 1.58 mg/l.

Macaranga peltata showed the total chlorophyll to be constant in the adjoining scrub forest and moist fields 1.64 mg/l but much more on the rocky plateau 1.66 mg/l and less on the dump slopes 1.632 mg/l.

Cassia tora showed a gradually increase of total chlorophyll from the slopes of the dumps 0.1785 mg/l, adjoining scrub forest 0.181 mg/l and moist fields 0.183 mg/l, however the rocky plateau specimen had extreme low levels 0.115 mg/l.

Terminalia paniculata showed maximum total chlorophyll on the slopes of the dumps 2.242 mg/l and the least 1.87 mg/l on the rocky plateau. there were little significant changes in the rocky plateau 1.87 mg/l and adjoining scrub forest, 1.883 mg/l.

Chromolaena odorata showed no significant variation in the concentration of total chlorophyll on the slopes of the dumps, adjoining scrub forest and moist fields 1.78 mg/l to 1.91 mg/l as compared to the rocky plateau site 1.4 mg/l.

Ervatamia heyneana showed slight variation in the total amount chlorophyll 0.965 mg/l -0.04 mg/l in all the habitats.

Alstonia scholaris showed almost constant total chlorophyll on the slopes of the dumps, rocky plateau and adjoining scrub forest; (1.172 mg/l - 1.175 mg/l) and was highest on the moist fields (1.185 mg/l).

Spermacoce articularis showed nearly constant total chlorophyll 1.03 mg/l to 1.032 mg/l.

Ludwigia linifolia showed a nearly constant total chlorophyll 0.17 mg/l to 0.18 mg/l in the slopes of the dumps, adjoining scrub forest and moist fields but was much less on the rocky plateau 0.131 mg/l.

Pennisetum hohenackeri showed highest total chlorophyll content on the adjoining scrub forest 1.35 mg/l and was found constant on the rocky plateau and moist fields 1.208 mg/l. The slopes of the dumps showed the least amount of total chlorophyll 1.172 mg/l .

Ischaemum semisagittatum showed lowest total chlorophyll in the adjoining scrub forest 0.577 mg/l and highest on the moist fields, 0.756 mg/l.

4.4.3.2. **Stomatal studies.**

1. Ludwigia linifolia (Vahl) Rolla.

The stomata was observed to be of anisocytic type. Stomatal pore size was smaller (1.25 µ x 0.35 µ) in the rocky plateau and slopes of the dumps, the moist fields habitat had the largest (1.39 µ x 0.46 µ) and when often observed open.

The Stomatal Index was high in the moist fields habitat (28.3%) compared to other habitats (27-27.1%).

2. Crotalaria epunctata Dalz.

The stomatal type observed were diacytic, stomatal size and pore size were reduced on the slopes of the dumps and adjacent rocky plateau (2.49µ x 1.43µ), 0.914µ x 0.357µ) and in 40% cases the stomata were found closed, whereas in the other habitats were open.

Stomatal index was uniform on the slopes of the dumps and adjoining scrub forest (34%) but varied in the rocky plateau 33.2% and moist fields 34.3%.

3. *Cassia tora* L.

The type of stomata observed were paracytic and occasionally ranunculaceous. The stomatal size and pore size was variable even within tho same habitat on both surfaces of the leaf.

Slopes of the dumps, adjoining scrub forest; and moist fields showed the same range of variation in stomatal size and pore size 2.8 x 1.78μ and 1.43 x 0.7 μ respectively.

The rocky plateau habitat showed also a wide variation of the stomata size and pore size, 2.8 μ x 1.72 μ and 1.4 μ x 0.71 μ respectively.

Stomatal · index varied within all the habitats; Slopes of the dumps 30%, rocky plateau 28%, adjoining scrub forest 34% and moist fields 34.4%.

4. *Terminalia paniculata* Roth.

The stomatal type were observed to be anomocytic which were confined to the lower surface.

The stomatal size did not vary in all the habitats (5.6μ x 2.06μ). The stomata pores were observed to be open in the scrub forest and moist fields habitats. Stomatal Index was almost constant (22.1% – 22.2%) except on the slopes of the dumps where it was less (20.6%). A number of stomata were found damaged or non-functional or death on the slopes of the dumps in several specimens examined.

5. *Calycopteris floribunda* Roxb.

The stomata were observed to be of anomocytic type. The stomata size were similar in size on the slopes of the dumps and rocky plateau (3.0μ x 1.96μ) but larger on the moist fields and the adjoining scrub forest (3.16μ x 1.96μ).

The moist fields habitat showed the highest stomata pore size (2.2μ x 1.1μ) followed by the adjoining scrub forest (1.24μ x 1.06μ).

Stomatal index was almost constant in all the habitats (17.6% .

6. Memecylon umbellatum Burm. Thw. Enum.

The stomata were observed to be of paracytic type, which were confined to the lower leaf surface. The stomatal size and pore size were largest on the moist fields 3.1µ x 2.6µ and 1.64µ x 0.515µ respectively. The Stomatal index did not vary widely in any of the habitats; slopes of the dumps 16.38%, Rocky plateau 16.36%, adjoining scrub forest 16.37% and moist fields 16.39%.

7. Spermacoce hispida L.

The stomata were observed to be of paracytic type. The stomatal size and pore size were greatly reduced in the rocky plateau habitat. 3.57µ x 1.78µ and 1.07µ x 0.357µ respectively. Whereas in the other habitats, was 4.97µ - 4.99µ x 1.43µ - 1.44µ and 1.07µ x 0.357µ respectively.

The Stomatal index increase significantly in the moist fields (40.7%) and adjoining scrub forest (41%) but remained constant in the rocky plateau and slopes of the dumps (39%).

8. Spermacoce pusilla Wall.

The stomata were observed to be paracytic type. The stomatal size and pore size were almost constant on the slopes of the dumps, rocky plateau and adjoining scrub forest on both surfaces of the leaf; upper leaf surface 4.2µ x 3.2µ and 2.45µ x 1.78µ, lower leaf surface 3.93µ x 2.85µ and 1.78µ x 0.35µ respectively, while in the moist fields; upper leaf surface 4.2µ x 3.2µ and 2.43µ x 1.72µ; Lower leaf 3.91µ x 2.8µ and 1.76µ x 0.34µ.

Stomatal index was constant (36.5 %) in all habitats with exception of moist fields (36.1%).

Some impraginated brown material with crystals were observed on the epidermal cells close to the subsidiary cells which was more in specimens examined on the actual dumps.

9. Chromolaena odorata (L.) King & Robinson

Stomata were observed to be anisocytic type. The stomatal size and pore size were reduced in the rocky plateau habitat, 2.75µ x 1.4µ and 1.38µ x 0.6µ respectively. Stomatal index was nearly constant in all habitats (10.1%) on the slopes of the dumps, (10.1 %) on the rocky plateau, 10.2% on the adjoining scrub forest, and 13.1% on the moist fields.

10. Strychnos nux-vomica L.

The stomata were observed to be paracytic type which were confined on the lower surface.

The stomatal size and pore size was constant in all the habitats 3.2µ x 2.49µ and 2.49µ x 1.07µ respectively.

A number of chloroplasts were observed in the guide cells which were 6-8 in number.

The Stomatal index was found to be higher in the adjoining scrub forests 16.9%.

11. Holarrhena antidysenterica (Roth) DC.

The stomata were observed to be paracytic and occassionally ranunculaceous.

Stomatal size and pore size was almost constant in all habitats; 3.2µ x 2.49µ and 2.49µ x 1.07µ respectively.Stomatal index was found to be constant in all the habitats 12.8%.

12. Lepidagathis prostrata Willd.

The stomata was observed to be diacytic type. The stomata were confined to the lower surface.

The stomatal size and pore size were much reduced in the rocky plateau habitat, 3.03µ x 2.67µ and 1.49µ x 0.057µ. The stomatal index was nearly constant in all the habitats 48.1% - 48.2%.

13. Clerodendrum serratum (L.) Moon.

The stomata were observed to be of anomocytic type. The stomatal size and pore size were observed to be broader in the adjoining scrub forest, 3.9µ × 2.6µ and 1.26µ × 0.88µ, respectively as compared to other habitats (3.9µ × 2.4µ and 1.26µ × 0.87µ). The stomatal index was found to vary in all the habitats ; slopes of the mines 11.5%, rocky plateau 11.2% ,forest region 12%, and moist fields 8,3%.

14. Anisochilus verticillatus Hook. f.

The stomata were observed to be diacytic type. The stomatal size, pore size, as Stomatal index was constant in all the habitats; stomata size; upper leaf surface 2.14µ × 1.07µ and lower leaf surface 2.5µ × 1.07µ; stomatal pore size: upper leaf surface 1.07µ × 0.357µ and lower leaf surface 1.07µ × 0.352 µ.

15. Hyptis suaveolens (L.) Poit.

The stomata were observed to be diacytic type. The stomata were observed to be constant in length in all the habitats (2.49µ) but were reduced in width in the rocky plateau specimens (1.72u) and broader in the moist fields specimen (1.74µ).

The stomatal pore size was reduced in size on the rocky plateau habitat (1.75 µ × 0.278µ) and on the slopes of the dumps (1.746µ × 0.28µ) as compared to the moist fields and adjoining scrub forest (1.78µ × 0.283u).In about 75% cases, the stomatal pores were open in the moist fields, whereas on the rocky plateau and slopes of the dumps, it was 25% cases .

Stomatal Index were almost constant in all the habitats, dumps which depicted the lowest 12.4%.

Table 34 Stomatal studies of some plants species found on disturbed and undisturbed mining sites. All Units are in µ. Unit Area taken for all the studies : 15.2 µ x 15.2 µ.

U - upper leaf surface, L - lower leaf surface, Position : 4th nodal leaf in all cases.

A and B were the disturbed habitats whereas, C and D were the undisturbed.

Site A - Slopes of the mines, Site B - Rocky plataeu, Site C - Forest region and Site D-Moist fields.

1. Taxon : Ludwigia Linifolia (Vahl.) Rolla.

Dorsiventral Leaf, Family : Onagraceae

Site	Stomatal Index (%)	Stomatal Pore Size (µ)	Stomata type & Size (µ)
A.	27.0	U 1.2 x 0.357	Cruciferous & sometimes Caryophyllaceous in all cases. L 2.14 X 1.43 L 2.14 X 1.43 Some stomata damaged.
B.	27.1	U 1.25 x 0.35 L 1.25 x 0.34	U 2.14 x 1.43 L 2.14 x 1.41
C.	27.1	U 1.25 x 0.36 L 1.25 x 0.34	U 2.14 x 1.41 L 2.14 x 1.43

2. Taxon : Crotalaria epunctata Dalz.

Dorsiventral Leaf. Family : Fabaceae

Site	Stomatal Index (%)	Stomatal Pore Size (µ)	Stomatal type & Size (µ)
A.	33	U 1.07 x 0.57 L 1.07 x 0.57	Caryophyllaceous in all cases. U 2.49 x 1.43 L 2.49 x 1.43
B.	33.2	U 0.914 x 0.357 L 0.914 x 0.357	U 2.714 x 0.357 L 2.714 x 0.357
C.	34	U 2.03 x 0.64 L 2.03 x 0.72	U 3.03 x 2.14 L 3.03 x 2.12
D.	34.3	U 2.03 x 0.6 L 2.02 x 0.65	U 3.56 x 1.32 L 3.1 x 2.2

3. Taxon : Cassia tora Linn.

Dorsiventral Leaf. Family : Caesalpiniaceae

Site	Stomatal Index (%)	Stomatal Pore Size (µ)	Stomatal type & Size (µ)
A.	30	U 1.43 ± 0.57 x L 1.07 x 0.57	Rubiaceous rarely ranunculaceous in all cases. U 2.8 x 1.78 L 3.9 x 1.78
B.	28	U 1.4 x 0.71 L 1.43 x 0.71	U 2.8 x 1.72 L 3.4 x 1.78
C.	34	U 1.43 x 0.71 L 3.42 x 0.71	U 2.8 x 1.78 L 3.8 x 1.78
D.	34.4	U 1.43 x 0.71 L 1.43 x 0.74	U 3.2 x 1.78 L 3.9 x 1.75

4. Taxon : Terminalia paniculata Roth.

Dorsiventral Leaf. Family : Combretaceae

Site	Stomatal Index (%)	Stomatal Pore Size (µ)	Stomatal type & Size (µ)
A.	20.6	L 2.44 x 0.82	Ranuculaeous confined to the lower surface in all cases. 5.6 x 2.06
B.	22.1	L 2.44 x 0.82	- do - 5.6 x 2.06
C.	22.2	L 2.44 x 0.84	- do - 5.6 x 2.06
D.	22.1	L 2.44 x 0.82	- do - 5.6 x 2.06

5. Taxon : Calycopteris floribunda (Roxb.) Lamk.

Dorsiventral Leaf. Family : Combretaceae

Site	Stomatal Index (%)	Stomatal Pore Size (µ)	Stomatal type & Size (µ)
A.	17.6	U 2.1 x 1.07 L 2.05 x 1.064	Renunculaceous in all cases. 3.0 x 1.96 3.0 x 1.96
B.	17.61	U 2.1 x 1.0 L 2.0 x 1.0	3.0 x 1.96 3.0 x 1.96
C.	17.62	U 2.14 x 1.07 L 2.14 x 1.06	3.16 x 1.96 3.16 x 1.96
D.	17.6	U 2.2 x 1.1 L 2.2 x 1.1	3.16 x 1.96 3.16 x 1.96

6. Taxon : Memecylon umbellatum Burm.

Dorsiventral Leaf. Family : Melastomataceae

Site	Stomatal Index (%)	Stomatal Pore Size (µ)	Stomatal type & Size (µ)
A.	16.38	Absent 1.23 x 0.96	Indefinite & paracytic in all cases. 3.07 x 2.54
B.	16.36	0.89 x 0.357	2.49 x 1.606
C.	16.37	1.23 x 0.967	3.03 x 2.356
D.	16.39	1.64 x 0.515	3.1 x 2.6

7. Taxon : Spermacoce hispida L.

Dorsiventral Leaf. Family : Rubiaceae

Site	Stomatal Index (%)	Stomatal Pore Size (µ)	Stomatal type & Size (µ)
A.	39	U 1.071 x 0.357 u L 1.07 x 0.357 u	Paracytic or Rubiaceous in all cases. 4.99 x 1.43 4.99 x 1.43
B.	39	U 1.071 x 0.357 L 1.07 x 0.357	3.57 x 1.78 3.57 x 1.78
C.	41	U 1.07 x 0.357 L 1.07 x 0.357	4.97 x 1.43 4.97 x 1.43
D.	40.7	U 1.07 x 0.357 L 1.07 x 0.357	4.99 x 1.43 4.99 x 1.43

8. Taxon : Spermacoce pusilla Wall

Dorsiventral Leaf. Family : Rubiaceae

Site	Stomatal Index (%)	Stomatal Pore Size (µ)	Stomatal type & Size (µ)
A.	36.5	U 2.45 x 1.78 L 1.78 x 0.357	Caryophyllaceous in all cases. 4.2 x 3.2 3.93 x 2.85
B.	36.5	U 2.45 x 1.78 L 1.78 x 0.35	4.2 x 3.2 3.93 x 2.85
C.	36.5	U 2.45 x 1.78 L 1.78 x 0.35	4.2 x 3.2 3.93 x 2.85
D.	36.1	U 2.43 x 1.72 L 1.76 x 0.34	4.2 x 3.2 3.93 x 2.8

9. Taxon : Chromolaeana Odorata (L.) King & Robinson

Dorsiventral Leaf. Family : Asteraceae

Site	Stomatal Index (%)	Stomatal Pore Size (µ)	Stomatal type & Size (µ)
A.	10.1	U 1.39 x 0.6 L 1.39 x 0.6	Cruciferous stomata in all cases 2.85 x 1.5 2.85 x 1.5
B.	10.1	U 1.38 x 0.6 L 1.38 x 0.6	2.75 x 1.4 2.85 x 1.4
C.	10.2	U 1.39 x 0.6 L 1.39 x 0.6	2.85 x 1.5 2.85 x 1.5
D.	13.1	U 1.4 x 0.6 L 1.4 x 0.6	2.85 x 1.5 2.85 x 1.5

10. Taxon : Strychnos nux-vomica L.

Dorsiventral Leaf. Family : Loganiaceae

Site	Stomatal Index (%)	Stomatal Pore Size (μ)	Stomatal type & Size (μ)
A.	16.8	2.49 x 1.07 u 6-7chloroplast in the guide cells	Rubiaceous confined to the lower surface in all cases 3.2 x 2.49
B.	16.8	2.49 x 1.07 u 7 Chloroplasts in the guide cells	3.2 x 2.49
C.	16.8	2.49 x 1.07 u 8 Chloroplast in the guide cells	3.2 x 2.49
D.	16.9	2.49 x 1.07 u 6-7chloroplast in the guide cells	3.2 x 2.49

11. Taxon : Holarrhena antidysenterica (Roth) DC.

Dorsiventral Leaf. Family : Apocynaceae

Site	Stomatal Index (%)	Stomatal Pore Size (μ)	Stomatal type & Size (μ)
A.	12.8	Highly lignified open pores 1.26 x 0.89	Rubiaceous sometimes Raunculaceous in all cases. 4.08 x 2.85
B.	12.8	1.1 x 0.714	4.08 x 2.85
C.	12.81	1.26 x 0.89	4.08 x 2.85
D.	12.80	1.26 x 0.89	4.08 x 2.85

12. Taxon : Lepidagathis prostrata Willd.
Isobilateal Leaf. Family : Acanthaceae

Site	Stomatal Index (%)	Stomatal Pore Size (μ)	Stomatal type & Size (μ)
A.	40.2	1.78 x 0.714	Caryophyllaceous in all cases. 4.2 x 2.85
B.	40.1	1.49 x 0.57	3.03 x 2.67
C.	40.2	1.78 x 0.714	4.2 x 2.85
D.	40.2	1.78 x 0.714	4.2 x 2.85

13. Taxon : Clerodendrum serratum (L.) Moon.

Dorsiventral Leaf. Family : Verbanaceae

Site	Stomatal Index (%)	Stomatal Pore Size (µ)	Stomatal type & Size (µ)
A.	11.5	U 1.26 x 0.87 L 1.26 x 0.88	Ranunculaceous in all cases. 3.9 x 2.4 3.9 x 2.4
B.	11.2	U 1.26 x 0.87 L 1.26 x 0.87	3.9 x 2.4 3.9 x 2.4
C.	12.0	U 1.26 x 0.88 L 1.26 x 0.88	3.9 x 2.6 3.9 x 2.6
D.	8.3	U 1.26 x 0.87 L 1.26 x 0.88	3.9 x 2.4 3.9 x 2.4

14. Taxon : Anisochilus verticillatus Hook. F.

Dorsiventral Leaf. Family : Lamiaceae

Site	Stomatal Index (%)	Stomatal Pore Size (µ)	Stomatal type & Size (µ)
A.	12.4	U 1.07 x 0.357 L 1.07 x 0.357	Caryophyllaceous in all cases. U 2.49 x 1.43 L 2.49 x 1.43
B.	12.4	U 1.07 x 0.35 L 1.07 x 0.357	U 2.14 x 1.07 L 2.5 x 1.06
C.	12.4	U 1.07 x 0.357 L 1.07 x 0.352	U 2.14 x 1.07 L 2.52 x 1.06
D.	12.4	U 1.07 x 0.357 L 1.07 x 0.352	U 2.14 x 1.07 L 2.52 x 1.06

15 Taxon : Hyptis suaveolens (L) Point

Dorsiventral Leaf. Family : Lamiaceae

Site	Stomatal Index (%)	Stomatal Pore Size (µ)	Stomatal type & Size (µ)
A.	26.7	U 1.0746 x 0.28 L 1.747 x 0.28	Caryophyllaceous in all cases. 2.49 x 1.73 25% Stomata were open
B.	26.8	U 1.75 x 0.278 L 1.75 x 0.281	U 2.49 x 1.73 L 2.49 x 1.72
C.	27.3	U 1.78 x 0.277 L 1.75 x 0.281	2.49 x 1.73 2.49 x 1.73 75% Stomata were open
D.	27.4	U 1.78 x 0.283 L 1.78 x 0.282	2.49 x 1.74 2.49 x 1.74 75% Stomata were open

4.4.3.3 Plant species on metal contaminated soils

Some plant species have been found to be on metal contaminated soils (as shown in the table 35) namely:

Table: 35. Plant species on metal contaminated soils.

1) Metallophytes- taxa found only on metal contaminated soils.

*Anisochilus verticillatus, *Indopoa paupercula Arundinella pygamea, *Spermacoce pusilla, *Alysicarpus vaginalis and *Polycarpon prostratum.

2) Pseudometallophytes - taxa occurring both on contaminated and normal soil.

a) Elective pseudometallophytes - abundant and often more vigorous on contaminated soil.

Lepidagathis prostrata, *Ampelocissus tomentosa, *Alstonia scholaris, Manisuris goaensis, Blumea mollis, Memecylon wightii, Burmannia pusilla, Pogostemon parviflora, *Calycopteris floribunda, Naregamia alata, Corchorus aestuans, Smithia sensitiva, *Crotalaria pallida, *Smithia conferta, Crotalaria triquetra, *Trema orientalis, Combretum ovalifolium, Senecio grahami, Digitaria longiflora, Zornia gibbosa, Ischaemum semisagittatum, *Macaranga peltata, Impatiens kleinii, *Ervatamia heyneana and *Euphorbia notoptera.

b) Indifferent Pseudometallophytes -live on contaminated soil regulary but show neither abundance nor particular vitality.

*Holarrhena antidysenterica, Phyllanthus reticulatus, Woodfordia fructicosa, *Terminalia paniculata, Chromolaena odorata, Tricholepis glaberrima, Merremia vitifolia, Asystasia dalzellii, Sesamum murrayanum, Gynura cusimbua, Celosia argentea and Calotrophis gigantea

c) Accidental Pseudometallophytes - usually weeds and ruderals appearing sporadically and showing reduced vigour on metal contaminated soil.

Vernonia cinerea, *Canscora decurrens*, *Evolvulus alsinoides*, *Cassia tora*, *Centranthera indica*, *Ludwigia linifolia*, *Ipomoea pescaprae*, *Dioscorea bulbifera*, *Justicia micrantha*, *Hedyotis herbacea*, *Hedyotis herbacea* and *Ageratum conyzoides*. The result indicate that their is no absolete metallophytes in this locality.

*Asterik means, most elegant confined species in the given respective habitat at 95% confidence limits of probability.

4.4.3.4. Survival of plant species

At the initial stages of transplanting the species on the dumps had high mortality rate in the first two years 25%; however this number was reduced significantly in the 3rd year to 5% - 8%, (except for the species with exceptionally high mortality rate) thereafter the species got permanently established with the harsh conditions of mine wastes sites and survived.

In other words species that survived in two consecutive seasons generally got established. Since biotic factors like browsers and grazers were not significant.

The highest survival was noted in *Acacia auriculiformis*, *Agave americana* *Psidium guajava*, *Holarrhena antidysenterica*, *Vitex negundo*, *Bougainvillea spectabilis*, *Casuarina equisetifolia*, *Pennisetum hohenackeri*, *Acacia mangium*, *Acacia catechu*, *Gliricidia sepium*, *Jatropha curcas*, & *Morus alba*.

The lowest survival was recorded with *Artocarpus heterophyllus*, *Cassia angustifolia*, *Acacia melanoxylon*, *Barringtonia racemosa*, *Tamarindus indica*.

Acacia auriculiformis was found to form a dense mat of fibrous roots laterally close to the surface and nodulated well even on the dumps where few leguminous plant species survived.

In an evenly aged monocultured plantation of *Acacia auriculiformis*, stands showed difference in the growth-forms depending on the degree of slopes. Whereas the topmost of the dumps showed poorest performance, the best performance was highest at the bottom most of the dumps.

The same observations were made in *Azadirachta indica*; plant species on the flat top of the dump with an angle of slopes 0° to 5° showed less plant height, girth of stem and left canopy as compared to the steep slope (35° to 50°), best performance was observed at the bottom of the dumps (10° to 15° slope) with highest plant ht, stem girth and leaf canopy.

A comparison of *Acacia arabica* pure stand and in a mixed stand with *Acacia auriculiformis* of 6 year old plantation, on the dumps showed significant variations. In its pure stand, 'height, leaf canopy, and stem girth were found to be much higher than in the mixed stands with *A. auriculiformis* (Table 36c).Generally the best surviving plant species after the 6th year period may be at most within the range of 68% to 88% whereas the poorest survivours lied within the

E X P L A N A T I O N   O F   P L A T E

Photographs of promising introduced tree species, whose performance is relatively good at the case study "Z"

Fig 34a. Parkia biglandulosa showing flowering twig.

Fig 34b. Adenanthera pavonina showing flowering portion.

Fig. 34a

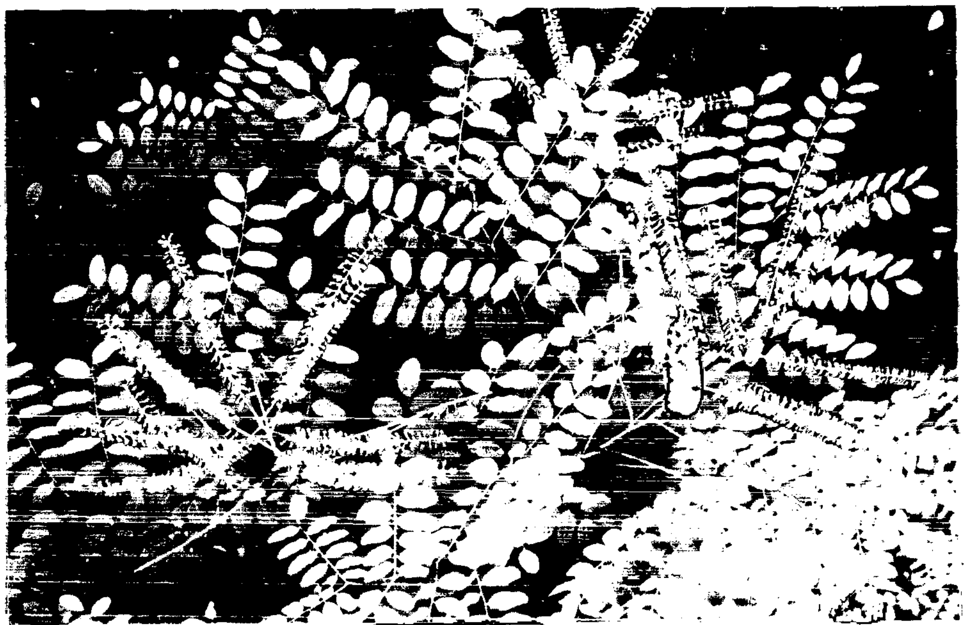

Fig. 34b

Table 36 a Survival of <u>Artocarpus heterophyllus</u> and <u>Acacia melanoxylon</u> on the dump sites.

	Artocarpus heterophyllus				Acacia melanoxylon			
Year	1st	2nd	3rd	4th	1st	2nd	3rd	4th
No. of saplings transplanted	60	-	-	-	80	-	-	-
No. of saplings that survived	55	32	12	2	68	20	10	-
Survival %	91.6%	53.3%	20%	5.3%	85%	25%	12.5%	0%

Mortality rate was found to be very high in <u>Acacia melanoxylon</u>. Its survival on the dumps was almost nil after the 2nd and 3rd year. The species which were planted over 4 years earlier had completely wilted.

<u>Artocarpus heterophyllus</u> is the other species which has shown very low survival rate. About 95% of the species placed on the dumps four years earlier had wilted morever, its growth trend was found to be very slow at the sites.

Table:36 b Survival percentage of planted species on rejected dumps at case study "Z".

Name of plant	Chromosome Number	Planted in 1987	Survival % in 1988	Survival % in 1992
Anacardium occidentale	42	8425	87.6	71.5
Alstonia scholaris	44	500	85.3	72.2
Artocarpus heterophyllus	56	305	53.5	0.4
Bombax ceiba	72	415	83.0	70.0
Careya arborea	26	450	87.0	76.0
Garcinia indica	48 - 54	163	87.5	60.5
Hydnocarpus laurifolia	24, 48	50	83.3	68.1
Mangifera indica	40	235	86.0	71.0
Strychnos nux-vomica	24	1330	84.0	78.0
Syzygium cumini	24 - 66	125	87.8	68.2
Syzoium zeylanicum	22 - 66	2660	90.9	70.0
Tamarindus indica	24	517	94.6	42.0
Thespesia populnea	26	370	88.0	56.0
Terminalia arjuna	24	400	85.0	70.1
Terminalia bellirica	26,48	425	84.0	62.0
Terminalia paniculata	14,24,48	150	91.0	76.0
Terminalia tomentosa	14 - 24	325	80.0	62.0
Acacia auriculiformis	26	5170	93.0	88.0
A. arabica	52, 104	400	94.1	56.0
Agave americana	60,120,180	305	96.8	88.0
Azadirachta indica	28	515	67.0	51.0
Plumeria rubra	36	200	82.0	76.0
**Polyalthia longifolia*	18	300	80.0	78.2
Psidium guajava	22	1500	94.0	87.0
Pterocarpus marsupium	44	100	78.0	67.0

*Quisqualis indica	22,24,26	50	78.0	68.0
Salvadora persica	24	150	75.8	70.0
Sapindus laurifolius		450	66.8	57.0
Sapium insigne	36	100	75.8	54.0
Schleichera oleosa	26	200	78.0	70.0
Sterculia urens	40	500	84.0	73.0
Tectona grandis	24,36	400	76.0	56.0
Terminalia catappa	24	600	83.5	72.5
Vitex negundo	24,26,34	530	87.4	79.2
Wagatea spicata		100	82.0	64.0
Ziziphus mauritiana	24,40,48, 60,72,96	500	80.2	75.5
Ziziphus rugosa	20 - 96	200	78.0	67.4
Gliricidia sepium	20,22	2000	86.0	75.5
Grewia tiliaefolia	18 - 36	200	80.9	73.0
Helicteres isora	18,24	100	82.0	70.5
Holarrhena antidysenterica	22	150	93.0	88.0
Ichnocarpus frutescens	20	200	78.0	54.0
Jatropha curcas	22	3000	87.4	79.0
Lannea coromandelica	28 - 40	100	87.0	85.0
* Lawsonia alba		50	75.0	74.0
Melia azedarach	28	150	79.0	67.0
Memecylon wightii	14 - 28	200	73.0	68.0
Microcos paniculata	18 - 36	200	83.3	79.0
Mimusops elengi	24	150	78.0	69.0
Moringa oleifera	28	50	84.0	54.0
Morus alba	28	200	86.0	78.0
*Musa coccinea	20	50	94.0	77.0

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*Musa paradisiaca	22,32 - 35	100	90.0	78.0
*Mussaenda frondosa	22	200	78.0	70.0
Nerium indicum	22	40	81.0	57.5
Phyllanthus reticulatus	26	120	75.5	63.0
Caryota urens	32	30	74.0	61.0
Cassia alata	26	100	78.0	68.0
C. angustifolia	26	100	65.0	48.0
C.fistula	24	350	68.0	50.5
C. glauca	26	100	65.0	51.2
C. nordosa	16	1000	89.0	78.0
Ceiba pentandra	72 - 80	1000	89.0	78.0
Clerodendrum inerme	46,48	50	78.0	64.5
C. serratum	46 - 52	50	78.0	71.4
C. viscosum	52	50	77.0	70.1
*Croton variegatum	108,112, 116,120	800	82.0	73.0
Dendrocalamus strictus	70,72	500	88.0	81.0
*Elaeis guineensis	32	100	54.0	44.0
Emblica officinalis	98 - 104	1000	92.0	74.2
Ervatamia heyneana	22	150	78.0	66.0
Erythrina indica	42	300	79.0	69.0
Eucalyptus hybridus	42	100	84.5	78.6
*Euphorbia tirucalli	20	150	79.0	75.0
Ficus benghalensis	26	40	88.0	81.0
F. glomerata	26	50	84.0	76.0
F. asperrima	26	50	84.8	73.0
F. callosa	26	50	75.9	62.0
Cassia alata	26	100	78.0	68.0
Garcinia xanthochymus	44 - 96	300	70.4	51.0

27

Adenanthera pavonina	24	315	80.5	74.5
Acacia melanoxylon		200	52.0	00.0
Adhatoda vasica	34	450	87.0	72.0
Adina cordifolia		300	78.4	67.7
Agave cantala	90	1500	82.0	74.0
Aegle marmelos	18,36	200	80.5	63.0
*Allamanda cathartica	18	50	77.0	65.0
Albizzia lebbek	26	100	82.0	75.2
Allophyllus cobbe	22/32	50	66.0	56.0
*Ananas sativus	50	100	78.0	59.2
Azadirachta indica	30	300	68.0	55.0
Bambusa arundinacea	17	1500	88.0	76.0
Barringtonia racemosa	26	200	69.0	49.5
Breynia patens	28 - 54	50	74.0	48.0
Bridelia scandens	26 - 28	300	81.2	57.0
Buchanania lanzan		50	78.0	61.0
Caesalpinia pulcherrima	24	50	74.0	52.0
Callistemon lanceolatus	22	50	72.0	58.0
Callophyllum inophyllum	32	45	74.0	63.0
Bauhinia purpurea	28	2805	85.6	65.2
Bougainvillea spectabilis	20	2010	89.0	78.0
Casuarina equisetifolia	18	1025	95.5	82.0
Cymbopogon citratus	40,60	1000	96.0	66.4
Delonix regia	28	625	87.0	50.0
Erythrina variegata	42, 44	275	76.5	58.0
Ipomoea pes-caprae	30	450	88.5	79.3
Leucaena leucocephala	36, 104	5254	87.6	65.0
Parkia biglandulosa	26	425	76.6	72.0

Peltophorum pterocarpum	28	160	64.0	55.0
Pennisetum hohenackeri	18	5270	84.7	80.0
Pithecellobium dulce	24	255	83.2	77.5
Samanea saman	22 - 26	425	68.0	48.0
Dalbergia sissoo	20	250	82.0	67.0
Abrus precatorius	22	300	90.0	74.5
Acacia arabica	44	500	81.0	55.0
A. catechu	26	500	85.0	78.0
A. chundra	26	342	82.0	73.0
A. mangium	26/52	415	85.0	77.0
Acalpha wilkesiana	14, 20	80	85.5	71.0
Achras sapota	26	48	80.0	62.5

* Species that were planted close to residential areas.

range of 3% to 48%. (Table 36 b).

Some indigenous plant species have shown a considerable success (98% survival) even by sowing of seeds directly on the dumps especially _Crotalaria pallida_ (undershrub), _Tephrosia coccinia_ (undershrub), and _Trema orientalis_ (tree).

The mat fabrication of the root system _Cymbopogon citratus_ improved the soil aeration and increased the organic contents (humus) of the soil after the wilting of its aerial & ground portion.The _Acacia auriculiformis_ species were performing in growth well at different elevations of mine reject dumps slopes.The upper slopes of the dumps which are quite steep (30^o to 40^o angle of slope) showed less plant height (mts), less leaf canopy (mts) and stem girth (mts) as compared to specimens on the middle portion of the dumps (20^o to 30^o angle of slope), the bottom most specimens (10^o to 20^o angle of slope) showed the best growth performance among the three sites.

On the slopes of the dumps,plant species showed better growth as compared to others grown on uncontaminated soils of the rocky plateau. Their performance in height was better, but the spreading leaf canopy and diameter was much reduced as compared to the specimens of the moist field (Table 36).

Table:36 c Performance of an even aged plantation of *Acacia auriculiformis* at different sites of case study "Z".

Place	Range of Angle of Elavation.	Pl. Ht. mts.	Leaf canopy mts	Diam.DBH (cm).
1. Rocky plateau	$5^{o} - 10^{o}$	$6.73 \pm 0.7^{*}$	$5.86 \pm 0.6^{*}$	$10.7 \pm 0.8^{*}$
2. Moist field	$5^{o} - 10^{o}$	$12.81 \pm 1.5^{*}$	$9.32 \pm 1.0^{*}$	$20.2 \pm 1.8^{*}$
3. Mine waste rejected dumps of;				
a) Upper slopes of the dumps	$30^{o} - 40^{o}$	$10.2 \pm 1.3^{**}$	$5.1 \pm 0.5^{**}$	$15.0 \pm 2^{*}$
b) Middle portion of the dumps	$20^{o} - 30^{o}$	10.9 ± 0.96	5.2 ± 0.53	15.9 ± 2.1
c) Bottommost of the dumps	$10^{o} - 20^{o}$	$11.36 \pm 1.2^{**}$	$5.7 \pm 0.6^{**}$	$16.8 \pm 1.8^{**}$

* P = 0.05 ** P = 0.01

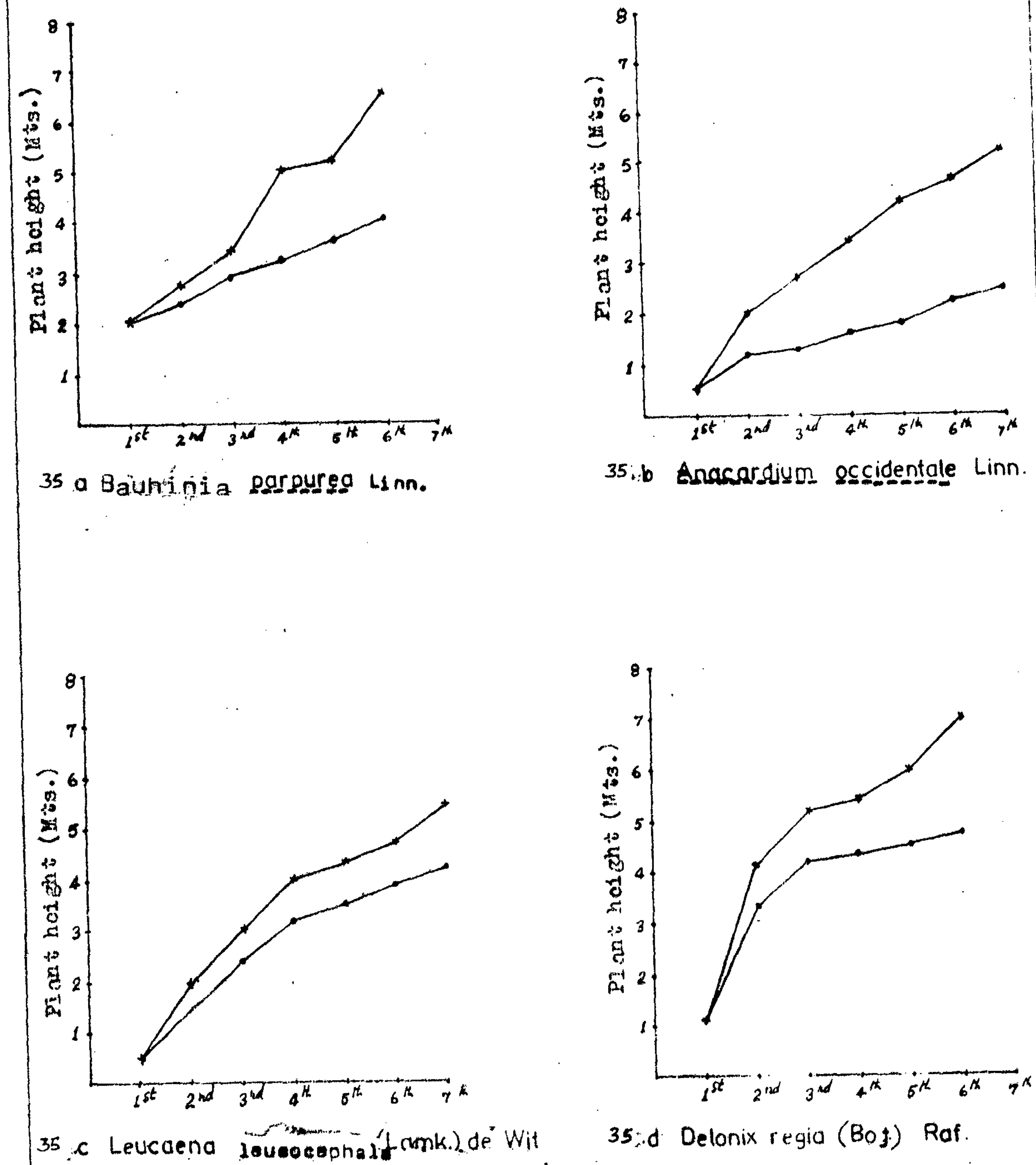
Table: 36 d. On the basis of overall monitoring the performance, twenty three tree species have been suggested as ideally suitable for the abandoned mining sites, their probable wood yield has been estimated; on attaining ten years of age.

Sr. No.	Taxon	No. of Trees/ha	Yield/Tree (m3)	Wood Yield/ha (m3)
1.	*Acacia mangium*	825	0.048	39.6 ± 4.1
2.	*Acacia auriculiformis*	825	0.078	64.35 ± 6.5
3.	*Alstonia scholaris*	625	0.089	55.6 ± 6.0
4.	*Adenanthera pavonina*	825	0.081	66.82 ± 7.3
5.	*Anacardium occidentale*	725	0.054	39.15 ± 4.2
6.	*Bauhinia purpurea*	625	0.079	49.37 ± 5.0
7.	*Bombax ceiba*	625	0.079	49.37 ± 5.1
8.	*Casuarina equisetifolia*	625	0.078	48.75 ± 4.4
9.	*Careya arborea*	625	0.055	34.38 ± 2.9
10.	*Ceiba pentandra*	625	0.079	49.38 ± 5.2
11.	*Dalbergia sissoo*	825	0.077	63.52 ± 6.1
12.	*Gliricida sapium*	825	0.021	17.3 ± 2.0
13.	*Leucaena leucocephala*	825	0.056	46.2 ± 4.2
14.	*Morus alba*	825	0.054	44.5 ± 3.9
15.	*Parkia biglandulosa*	825	0.084	69.3 ± 6.7
16.	*Peltophorum peltocarpum*	825	0.084	69.3 ± 7.1
17.	*Pithecellobium dulce*	825	0.075	61.8 ± 6.3
18.	*Samanea saman*	625	0.086	53.75 ± 4.8
19.	*Syzygium cumini*	625	0.079	49.37 ± 5.1
20.	*Tamarindus indica*	625	0.091	56.87 ± 5.4
21.	*Terminalia arjuna*	825	0.076	62.7 ± 6.0
22.	*Terminalia bellirica*	625	0.078	48.75 ± 5.1
23.	*Terminalia paniculata*	825	0.081	66.8 ± 7.0

Values expressed are mean ± S.D. for 20 individual observations.

Table: 37. Showing chemical composition of the surface layer soil (up .6m) at Case Study "Z".

No.	Texture of the soil	Garden soil	Mining waste dumps	Tailings
1.	Texture of the soil	Humus clay	Fine clay occa-ssionally with pebbles.	Very fine clay.
2.	pH	6.2	6.6	6.8
3.	E.C (mmhos)	0.46	0.18	0.16
4.	Organic carbon (%)	1.8	0.48	0.22
5.	Available nitrogen (kg/acre)	46.0	15.0	8.0
6.	Available phosphorus (kg/acre)	12.0	6.0	4.0
7.	Available potassium(kg/acre)	120.0	8.5	40.0
	Micronutrients (%)			
8.	Iron	35.04	46.2	51.3
9.	Aluminium oxide (Al_2O_3)	19.1	17.9	8.65
10.	Manganese (Mn)	0.1	0.2	0.25
11.	Silicon oxide (SiO_2)	25.6	21.9	7.95
12.	Calcium	0.25	0.09	0.061
13.	Magnesium	0.6	0.3	0.2
14.	Copper	1.4	0.6	0.4



35 a Bauhinia parpurea Linn.

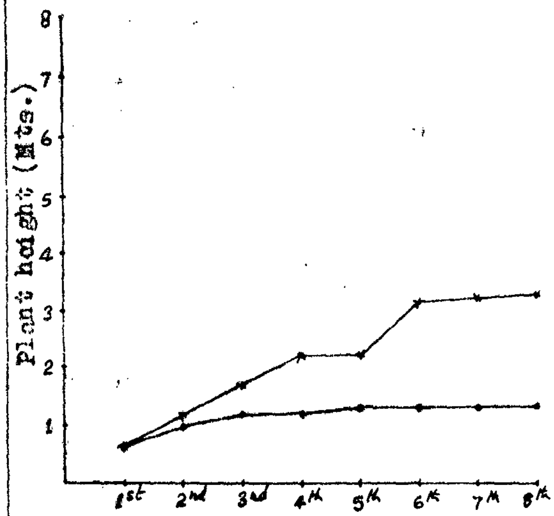
35 b Anacardium occidentale Linn.

35 c Leucaena leucocephala (Lamk.) de Wit

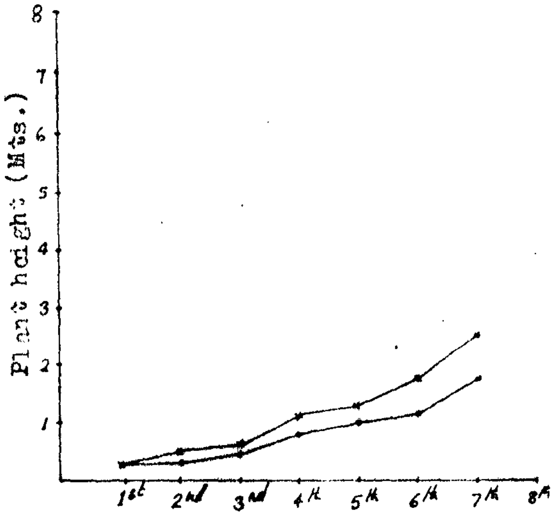
35 d Delonix regia (Boj.) Raf.

Growth performance of some plant species at mines' wastes and normal soils at case study ' Z ' (7 years' study)

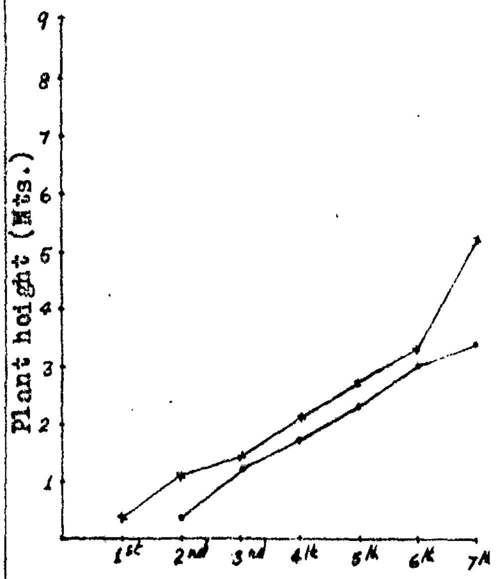
Normal soil : x-x-x-x-x Mines' wastes : o-o-o-o-o



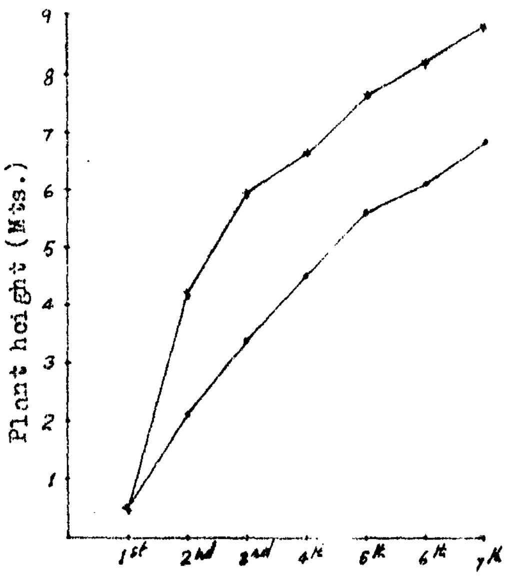
35.i. Tamarindus indica Linn.



35.j. Terminalia paniculata Roth.



35.k. Dalbergia sissoo Roxb.



35.l. Parkia biglandulosa Wt. & Arn.

Growth performance of some plant species at mines' wastes and normal soils at case study 'Z' (7 years' study)

Normal soil : x-x-x-x-x   Mines' wastes : o-o-o-o-o

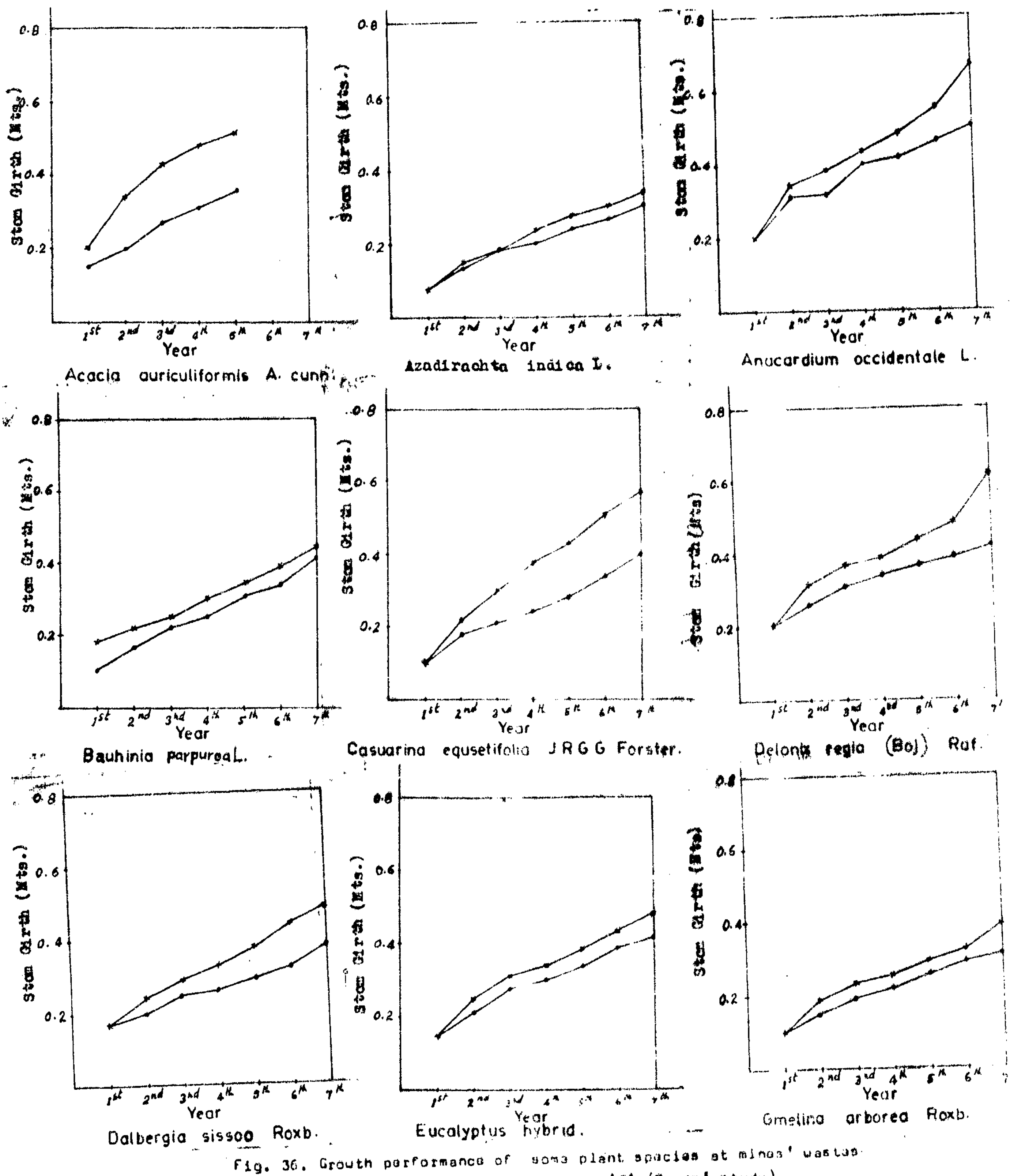


Fig. 36. Growth performance of some plant species at mines' wastes and normal soils at case study 'Z' (7 yrs' study)

Normal soil : x-x-x-x-x Mines' wastes o-o-o-o-o

The plant species that showed an overall good growth performance on the the dumps and tailing pond were *Dalbergia sissoo*, *Parkia biglandulosa* (Fig. 34a) *Acacia auriculiformis*, *Casuarina equisetifolia*, *Trema orientalis*, *Azadirachta indica*, and *Leucaena leucocephala*.

The moderately fast growing plant species were *Bauhinia purpurea*, *Anacardium occidentale*, *Peltophorum pterocarpum*, *Bombax ceiba*, *Gmelina arborea* and Adenanthera pavonina (Fig.34 b).

Slow growing plant species were *Terminalia paniculata*, *Careya arborea*, *Delonix regia*, *Tamarindus indica*, *Santalum album*, *Pongamia pinnata* but which survived.

The species which are fast growing may produce large volume of wood which might be valuable in many uses. Some estimate was done to depict what amount of volume wood would be produced after a period of ten years on the plantations at the sites (Table:36 d).

4.4.3.5. Dust filtering efficiency of plant species.

The studies carried out revealed that the dust was not evenly distributed on both surfaces of the leaf. The dust accumulated more on the stomatal pores and to a lesser extent epidermal cells. Seasonal variations of the dust-filtering efficiency of the individual species were recorded. The dust accumulation on both surfaces increased gradually from October to April when it was at peak for each of the plant species.

The plant species that showed highest filtering efficiency in both April and October seasons (i.e. for the total amount of dust deposition on both abaxial and adaxial surfaces) were *Hydnocarpus laurifolia*, *Ficus benghalensis*, *Agave americana*, *Syzygium cumini*, *Mangifera indica*, *Terminalia paniculata* and *Macaranga peltata*. The poorest dust filters were found to be *Peltophorum pterocarpum*, *Tamarindus indica*, *Leucaena leucocephala* and *Delonix regia*. While the most efficient dust filtering plant species like *Ficus benghalensis* may filter approximately 0.1 - 0.3 kg of dust per tree, the least efficient dust filtering plant species like *Peltophorum pterocarpum* which may filter approximately 0.022 kg of dust per tree. It may filter about 2.5 kg of dust over thecase study "Z" area where it was planted on a large scale i.e the total plantation population of *Peltophorum pterocarpum* at the case study area.Evergreen species with simple leaves,having rough and hairy surface, were more efficient dust collectors than deciduous trees with compound leaves, having smooth surface; these results appear to be in agreement with previous workers like Das (1981).

The plant species, especially those that accumulated large amount of dust immensely reduced the dust pollution hazard to the mines environment during the dry season. The dust was naturally cleansed from the leaves by the subsequent monsoon rains.

Table 38a Dust filtering efficiency of some plant species at Case Study "Z". (Data collected in the early post-monsoon period). i.e. October.

Sr. No.	Taxon	Dust per sq. m. on the upper leaf surface (g)	Dust per sq. m. on the lower leaf surface (g)	Total dust per sq. m. on Leaf Surface (g)
1.	*Ficus benghalensis*	2.00 ± 0.18	1.3 ± 0.11	3.3 ± 0.20
2.	*Ficus glomerata*	1.4 ± 0.10	0.3 ± 0.02	1.7 ± 0.10
3.	*Mangifera indica*	2.1 ± 0.20	0.45 ± 0.03	2.55 ± 0.30
4.	*Hydnocarpus laurifolia*	2.6 ± 0.24	0.85 ± 0.0	3.45 ± 0.25
5.	*Careya arborea*	1.0 ± 0.08	0.2 ± 0.05	1.2 ± 0.10
6.	*Acacia auriculiformis*	1.4 ± 0.11	1.2 ± 0.07	2.6 ± 0.20
7.	*Alstonia scholaris*	2.0 ± 0.20	0.2 ± 0.02	2.2 ± 0.20
8.	*Bougainvillea globulus*	1.5 ± 0.10	0.04 ± 0.00	1.54 ± 0.10
9.	*Polyalthia longifolia*	1.9 ± 0.20	0.3 ± 0.00	2.2 ± 0.20
10.	*Terminalia arjuna*	2.0 ± 0.20	0.45 ± 0.04	2.55 ± 0.18
11.	*Terminalia paniculata*	2.1 ± 0.20	0.45 ± 0.05	2.55 ± 0.21
12.	*Anacardium occidentale*	1.3 ± 0.28	0.65 ± 0.07	3.75 ± 0.40
13.	*Macaranga peltata*	3.1 ± 0.28	0.65 ± 0.07	3.75 ± 0.40
14.	*Artocarpus heterophyllus*	0.9 ± 0.07	0.06 ± 0.06	0.96 ± 0.07
15	*Peltophorum pterocarpum*	0.4 ± 0.03	0.05 ± 0.04	0.45 ± 0.03
16.	*Delonix regia*	0.3 ± 0.02	0.00	0.3 ± 0.02
17.	*Samanea saman*	0.5 ± 0.04	0.7 ± 0.05	1.2 ± 0.11
18.	*Tamarindus indica*	0.4 ± 0.03	0.04 ± 0.00	0.44 ± 0.05
19.	*Azadirachta indica*	1.8 ± 0.15	0.3 ± 0.03	2.1 ± 0.16
20.	*Pithecellobium dulce*	0.60 ± 0.05	0.03 ± 0.00	0.63 ± 0.06
21.	*Leucaena leucocephala*	0.35 ± 0.04	0.02 ± 0.00	0.37 ± 0.04
22.	*Acacia mangium*	1.15 ± 0.10	0.01 ± 0.00	1.16 ± 0.10
23.	*Agave americana*	2.0 ± 0.17	0.6 ± 0.05	2.6 ± 0.23
24.	*Ananas comosus*	1.6 ± 0.14	0.6 ± 0.06	1.66 ± 0.15
25.	*Syzygium cumini*	1.75 ± 0.17	0.74 ± 0.00	2.49 ± 0.25

Table 38 b Dust filtering efficiency of some plant species at Case study "Z" (Data collected in the late summer period i.e April).

Sr. No.	Taxon	Dust per sq. m. on the upper leaf surface (g)	Dust per sq. m. on the lower leaf surface (g)	Total dust per sq. m. on Leaf Surface (g)
1.	*Ficus benghalensis*	3.10 ± 0.30	2.20 ± 0.24	5.30 ± 0.48
2.	*Ficus glomerata*	2.70 ± 0.28	1.60 ± 0.15	4.30 ± 0.40
3.	*Mangifera indica*	3.15 ± 0.31	1.80 ± 0.18	4.95 ± 0.50
4.	*Hydnocarpus laurifolia*	4.10 ± 0.39	2.00 ± 0.21	6.10 ± 0.56
5.	*Careya arborea*	2.20 ± 0.22	1.60 ± 0.15	3.80 ± 0.40
6.	*Acacia auriculiformis*	2.60 ± 0.27	2.10 ± 0.20	4.70 ± 0.50
7.	*Alstonia scholaris*	3.20 ± 0.33	1.40 ± 0.15	4.60 ± 0.45
8.	*Bougainvillea globulus*	2.90 ± 0.30	1.10 ± 0.10	4.00 ± 0.38
9.	*Polyalthia longifolia*	3.10 ± 0.30	1.60 ± 0.17	4.70 ± 0.50
10.	*Terminalia arjuna*	3.20 ± 0.32	1.58 ± 0.16	4.78 ± 0.46
11.	*Terminalia paniculata*	3.20 ± 0.30	1.60 ± 0.15	4.80 ± 0.50
12.	*Anacardium occidentale*	2.60 ± 0.25	1.00 ± 0.09	3.60 ± 0.40
13.	*Macaranga peltata*	4.30 ± 0.46	1.91 ± 0.20	6.21 ± 0.60
14.	*Artocarpus heterophyllus*	2.20 ± 0.21	0.70 ± 0.06	0.90 ± 0.30
15	*Peltophorum pterocarpum*	1.40 ± 0.15	0.60 ± 0.06	2.00 ± 0.30
16.	*Delonix regia*	1.30 ± 0.13	0.65 ± 0.06	1.96 ± 0.20
17.	*Samanea saman*	1.65 ± 0.17	1.85 ± 0.19	3.50 ± 0.30
18.	*Tamarindus indica*	1.40 ± 0.15	0.08 ± 0.00	1.48 ± 0.15
19.	*Azadirachta indica*	2.60 ± 0.28	1.10 ± 0.10	3.70 ± 0.40
20.	*Pithecellobium dulce*	1.61 ± 0.15	0.45 ± 0.00	2.06 ± 0.20
21.	*Leucaena leucocephala*	1.58 ± 0.16	0.50 ± 0.04	1.63 ± 0.15
22.	*Acacia mangium*	2.30 ± 0.25	0.85 ± 0.08	3.15 ± 0.30
23.	*Agave americana*	3.10 ± 0.30	1.80 ± 0.19	4.90 ± 0.50
24.	*Ananas comosus*	2.80 ± 0.30	1.70 ± 0.18	4.50 ± 0.44
25.	*Syzygium cumini*	3.80 ± 0.4	1.92 ± 0.20	5.72 ± 0.60

4.4.4. DISCUSSIONS

4.4.4.1. Chlorophyll estimation

Calycopteris floribunda, Holarrhena antidysenterica, Ervatamia heyneana and Spermacoce articularis showed no significant changes in both the disturbed and undisturbed sites, this may imply that these species may adapt themselves conveniently in any of the habitats.

Memecylon wightii which showed less total chlorophyll in one of the undisturbed sites i.e adjoining scrub forest(but not the moist fields) may be, it is a species that requires more light intensity.

Macaranga peltata, Cassia tora, Chromolaena odorata and Ludwigia linifolia showed low levels of the total chlorophyll on the rocky plateau may be as a result of poor adhapic conditions e.g low moisture content of the soils.

Terminalia paniculata which showed high total chlorophyll on the disturbed site (slopes of the dumps) compared to undisturbed sites may be an abnormality which cannot be clearly predicted.

Alstonia scholaris and Pennisetum hohenackeri had the total chlorophyll less in the disturbed site, than at the undisturbed sites, indicating that they might be sensitive species to enviromental stresses especially with regard to edaphic conditions.

Ischaemum semisagittatum which showed total chlorophyll in the one of the undisturbed sites (adjoining scrub forest) than other habitats probably because it requires more light intensity (a preference habitat for the species) amidst other operating factors.

It was thought the presence of high amount of iron in the pure reject soil could have resulted to the darkening of the leaves (which is the morphological change affected by excess iron mineralization) the case was not so, thus though a large amount of iron is present in the pure reject soils, probably it might not be in the soluble form for plant uptake among other factors operating.

4.4.4.2. **Stomatal studies.**

Stomatal size and pore size was reduced in nearly all the species in the rocky plateau and slopes of the mines with exception of Ludwigia linifolia, Anisochilus verticillatus, Strychnos nux-vomica, and Hyptis suaveolens this may have some correlation with poor soils and mineralization among other factors operating.

The frequent closing of stomata in Hyptis suaveolens and Crotalaria epunctata on the rocky plateau and slopes of the mines might be a mode of reducing transpiration in these open habitats.

It seems likely that the most extreme overtemperature plants are found among those plant species with an active dark $Co2$ fixation system (or CAM i.e. Crassulacean acid metabolism) permitting them to keep their stomata closed during the day, thereby decreasing their transpiration rate; though permitting photosynthesis during day light at the expense of $Co2$ fixed at night. (Levitt, 1980). The considerable large variations of stomata size and pore size of populations of Cassia tora at different sites, may be due to the highly polymorphic nature of the species ($2n = 26,28,52$) and this difference may be what is reflected in the stomata sizes.

The tanniniferous cells or phytostein found in Spermacoce pusille was found to be more on the mining dump slopes than other habitats. This may be an adopted measure to resist stress conditions like drought, and mineralization among other factors operating.

In humid regions, where no rain falls for days at times so that the water reserves in the soil are depleted and the water balance of plants increasingly becomes reduced the plants control their water consumption by opening their stomata less and for a shorter period: at first transpiration is reduced during the hottest hours of the day, then the afternoon resumption of transpiration is omitted and finally the stomata open only in the morning. Eventually, while their water content is still adequate, the plants transpire only through the cuticle.

Where a species is subjected to increase drought whether climatic or brought about by competition the result is often a dwarfing of the plant and an increase in the number of stomata per unit area.

The stomata develop early and if there is not enough water to cause the normal cell hydration and growth all of the leaf cells are dwarfed (Pandeya, et al., 1968).

Smaller leaves have more stomatal frequency than larger ones. The highest number of stomata are found on the apex portion.

Mazzolenis and Dickman, (1988) found that differences in drought tolerance of poplar clones were associated with variations in stomatal frequency, stomatal size, in speed of stomatal closer during drought.On a day when the vapour pressure defit (VPD) was low, the stomatal aperture of two poplar clones varied little. However, when the VPD was high, the adaxial stomata of one clone closed more than those of the other clone. Another study showed that the stomata of Populus candicans X Populus barolinensis were more responsive to a change in VPD and less responsive to a change in light intensity than were the stomata of a clone of Populus deltoides X P. caudina.

As regards to stomatal movement many components are involved and no single hypothesis (a combination of hypothesis) has yet succeeded in bringing them together. Loveless (1990) states,"Indeed it seems certain that no one hypothesis will explain the stomatal behaviour of all plants , because it has recently been shown that the stomata of some plants show an endogenous rhythm of opening and closure,even in constant environmental conditions".

4.4.4.3. Plant species on metal contaminated soils.

Metallophytes. which are plant species confined to contaminated soils, take up large amounts of heavy-metal ions and store them at concentrations of 0.5 - 8 g.Kg-1; in the extreme cases, up to 25 g.Kg-1. This is a hundred to a thousand times the normal concentration of trace elements in the plant.The apparent restriction of metal torelant genotypes on contaminated areas, despite their normal growth on non-contaminated soil, has led to the speculation that these plants are largely restricted to the soils because they are competitively inferior to normal plants (Antonovics,Loc.cit.).This view is also accepted by Burrows (1973), who argues that wide ecological amplitude, in relation to exogenous factors, is not necessarily correlated with strong competitive power. Some species with wide tolerance for general habit conditions cannot cope with strongly competitive situations. Such species are restricted to disturbed or marginal habitats that are temporarily by stronger competitors (Burrows, 1990).

This may be the case with some of the pseudo-metallophytes and local metallophytes found on the iron ore mines region. The plant species may be tolerant as accumulators or as excluders.

The plants growing in habitats contaminated with heavy metals have attracted interest for over a century. Since metal contaminated areas are only a minor component of the environment the subject of metal tolerance has on the whole been regarded as an area of marginal relavance to most other fields of investigation. The interest that has arisen has come from ecologists, evolutionary genetics, physiologists, and applied biologists particularly in relation to prospecting for metal ores. The literature on such plants is therefore widely dispersed.However, when this literature is collated it is seen that specialized habitats such as metal contaminated areas are extremely valuable to evolutionary and ecological studies. Their value stems essentially from their simplicity and this is a consequence of three [redacted] features. Firstly the vegetation of such areas is influenced by one overriding factor, namely by metal concentration. Doubtlessly other factors are also of importance but such factors and interactions are far more easily defined when the major determinant is clearly apparent. Secondly, the habitats are usually spatially distinct and clear cut.This is particularly true of areas resulting from mining activities. Thirdly, since the major factor involved is an edaphic one it is relatively constant and varies only slowly with time.

It is perhaps not surprising, therefore, that such areas have already proved invaluable in studies of evolution. The sequence and pattern of genetic change responsible for colonization of metal contaminated areas is a unique record of natural selection in action. It is clear that studies of metal tolerance may be of equal value in claryfing ecological problems particularly when they impinge on other areas such as evolution, taxonomy, plant distribution and physiological processes (Antonovics, Loc. cit).

Their is need for further investigation on the plant species on metal contaminated soils since the present scope of study was within the limit of phytosociology.

Attempts to screen the plant species that appear to be metal tolerant/metal indicators, especially the local metallophytes viz, Anisochilus verticillatus, Indopoa paupercula, Spermacoce pusilla and Polycarpon prostratum need be carried out further.

4.4.4.4. Survival of plant species.

The conditions of the mines' dump reject and tailing ponds, like anywhere in Goa, are so severe that it is difficult to maintain or sustain any plant life properly.

The rejects have been excavated from as far down as 50to300 metres below the surface layer of soils. Ordinarily, this pit is quite deficient in the normal plant nutrition requirements.

The average distribution of organic and inorganic components of reject soils is found to be very low as compared to the garden soils (Table 37) (Coelho, 1990) .The different clay soils appear to give different responses to specific plant species.

The mine rejects consist of clay soils with low Fe (30% - 40%) content from the commercial point of view, but the concentration from the biological point of view is high to cause side effects to vegetation development.The over-accumulation of these reject soils leads to dump formation (heap formation).Different mine reject soils for example lateritic pebbles with red mud, were found to retain moisture and were resistant to soil erosion, therefore, it was easier to establish vegetation on them.

The only ammendments which were done was to apply cowdung plus fertilizer (NPK) for the first three years to ensure normal plant growth to some specific sites.

The species which were found to perform well on this clay were: Agave americana, Alstonia scholaris, Casuarina equisetifolia, Acacia auriculiformis and Peltophorum peltocarpum;

Phyllitic clay which was Pink in color with high content of Alumina, showed stunted growth to most plant species planted on them. The soil had very low moisture retaining capacity, as a result the species which are thought to be drought intorelant could not survive on these soils.

Acacia auriculiformis has been found doing fine on this clay as compared to any other species planted at these sites. The Intrusive clay which is pale pink in color with evenly scattered yellow spots, was quite rare at the case study "Z".

The ability of organic matter to complex with heavy metals frequently results in an accumulation of heavy metals at the surface of the soil and in humus layers of the soil The cyclic process of mineral absorption, death, and mineral release into upper layers of the soil has been called the Goldschmidt or Vernadskii principle and it is the reason why humus layers of the soil are often useful in biogeochemical prospecting. Generally metal ions complexed to organic matter when unavailable to plants, so that the effective metal concentrations of the soil is reduced. (Antonovics et al., 1971).

Species performance

Generally species development (long term) is greatly hampered in all mine waste soils as compared with the same on the virgin soils.

The local naturalised species or those native to the Western Ghats had a higher survival percentage though very much stunted compared to the same type collected elsewhere.

The survival percentage and stunted growth appeared to be correlated with the degree of slope and characteristics of the clay soil among other factors operating;

The steep slope with angle of slope <35 to 45^{o} showed moderate growth performance.Species performance at the bottom of the slopes with lesser angle of slope ($<15^{o}$) showed the best overall performance, for example Azadirachta indica showed maximum growth performance at the bottom of the P1 dump,as compared with the same on the steeper slopes.

Destruction of the young plantation has been reduced considerably on the P1 dump by 95%, earlier on, even young stumps were either uprooted or directly cut down.

The recent vigilance by the administration through a watchman and because most important, a large number of the nearby temporary employment (3 month) is a source if income, for doing the plantation in the monsoon. As usual they would feel to be victims of their own conscience in cutting the plantation trees, since they themselves were involved in the same plantation work.

Survival of plant species at the mining sites has not been easy as it was often been assumed. During the process of revegetation arises simultaneously "miniature deforesters" like goats, sheep, cattle and even man which make it difficult for plant species' during the sapling stage.

The poor edaphic conditions of the reject soils also attributes to the poor survival of the plant species. James (1966); (Coelho, 1990) stressed the importance of bringing into being a plant community that would be self- perpetuating without further attention or artifical aid.

Le Roy and Keller (1972) noted that permanent and maintenance - free vegetation is essential in reclamation. However no long term efforts are being made to search for plants that would perform well and function normally under nutrient-deficient soil conditions such as those existing on the iron ore mine wastes of Goa.

A diverse forest ecosystem is less sensitive to environmental stress than a monoculture (Grodzinski et al., 1984). Tree species which are better adopted to the site condition are also more registered to the influences of industries etc., consequently the polyculture (mixed plantation in the P1 dump is found to be less sensitive to the reject soils as compared to the pure *Acacia auriculiformis* or *Casuarina equisetifolia* plantations or on the P5 dumps.

The individual species which were planted at the base of the dumps showed, in most cases, the best performance.

The nutrients picked up by the annual cyclic grass growing on the top of the dumps are transferred to lower levels when the dry grass is eroded in the next monsoon. This probably has led to the good observations are by no exceptional or different from what might be observed in the other adjoining mining areas in Goa.

The diversity in growth at the initial stages of different species at different sites and also at sites of same soil and nutritional status may be partly due to genetical variation and partly due to factors favouring certain seedlings (Ovington and Madgwick, 1959).

Bradshaw (1970) has found that populations of species growing on toxic soils are able to continue rooting in conditions which are so toxic that ordinary species cannot produce roots at all. He claimed that these tolerant plants were unaffected by the toxicities and provided a rapid solution to derelict land problems. Being adapted to high mineral concentration and the climatic environment of the area, these plants would seem ideal pioneer species for the establishment on mine wastes.Most reports of successful vegetation indicates fertilization as an important establishment procedure. Mitchell (1959), stated that restoration of soil fertility on mined areas is an extremely slow process. Recolonization by plants is extremely slow.

Therefore the establishment of vegetation with heavy fertilizer application speed up the slow natural process, restoring fertility and natural cycles which are destroyed by the mining process (Coelho, 1990).

Unfortunately, owing to the financial limitations of the mines owners at case study "Z" like any other mine owners in Goa (personal communication, 1993) it would be expensive to use large scale method of fertilizer application on the dumps through fertilizers are applied in small amounts). This is mainly because the proceeds from sales of ore have to be carefully utilized in salaries, machinery maintenance and other development activities in the mines. So the only solution is to screen out the metal tolerant species which would easily adapt themselves to the mines wastes.

As it was mentioned previously all the Ipomoea pes-caprae which were transplanted to the mixed plantation of the Tailing pond P8 wilted in the 3rd year.

Since the species under its natural habital was observed often deriving well in the open sandy areas with plenty of sunshine, therefore probably lack of sunlight may have been a major a limiting factor to its failure to establish at the Tailing Pond P8.

The Ipomoea pes-caprae which was introduced along with other tree species at the same time, did not face any light hinderance but as the tree saplings gradually started to form shade, the trailing under shrub began to wilt.

Kozlowski et al., (1991) stated that, young plantations the even - aged trees are relatively evenly spaced and have crowns that are more or less similar in size and shape. As the trees grow larger, the crowns of the slower - growing trees are shaded. The competitive capacity of shaded branches for water and perhaps nitrogen is reduced, as a prelude to their death. The resulting inhibition of photosynthesis of the suppressed trees, reduces their supply of carbohydrates and possible of growth hormones, leading to a reduction in cambial growth and root growth.The inhibition of root growth decreases absorption of water and minerals, which further reduces growth.Eventually the slower-growing suppressed trees are likely to die. This is why probably some plant species were found to wilt at the reject tailings at case study "Z" among other operating factors.

4.4.4.5. Dust filtering efficiency of plant species.

The plant species which can accumulate (Table:34) more than 3 gramsof dust per Sq. m. could be very ideal for plantation at the sites that are prone to dust especially,along the roadsides leading to the mines.

The problem of mining dusts, however microscopic, has no doubt led to the increase in tuberculosis and silicosis among the early mine workers in Goa. The situation may not ameliorate inspite of heavy mechanization and introduction of schemes to protect the mine worker's health by the mine welfare Dept.(Sardesai,1985). Due to the gradual increase in vegetation cover around the mine dumps and living quarters, dust has greatly been reduced.

Water sprinkling which has been improved on the roads almost tenfold is an important contribution to a dust free environment, however the dust filtering efficient plant species have got to be introduced.

EXPLANATION OF PLATE

Aerial photographs showing the vegetation aspect at case study "Z"

Fig 33a. Case study "Z" areas showing various physiographic spots and where attempt have been made in reforestation; main office is seen on the South West, whereas to the south East is the residential quaters. The P1 dump and P8 tailing ponds are seen in the mid-ventral portion of the photograph.

Fig 33b. Showing case study "Z" areas and adjoining rice fields. Deep pits due to mining activity which are below Mean Sea Level are seen to the extreme North East of the photograph.

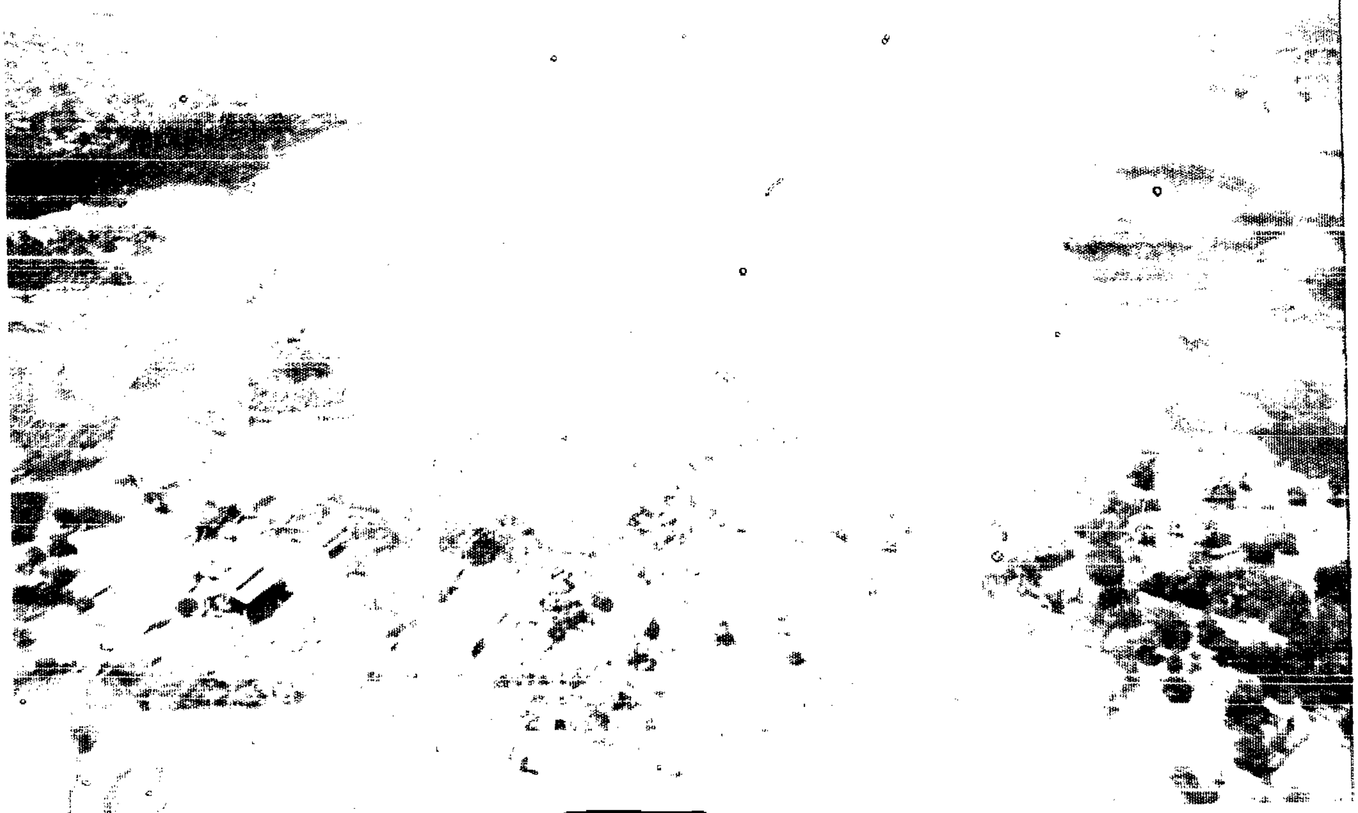


Fig.33a.

Fig.33b.

E X P L A N A T I O N   O F   P L A T E

Aerial photographs (dated November 1991) showing the vegetation at case study Z.

Fig. 33c   Showing areas with relatively dense scrub forest adjoining the case study "Z".

Fig. 33d   Showing areas with active mining operation at case study "Z".

Fig. 33c

Fig. 33d

EXPLANATION OF PLATE

Photographs showing gradual development of Vegetation cover at the dump sites.

Fig: 33e.P1 dump showing young plantation (8 months old).

Fig: 33f.P1 dump showing a 7 year plantation later at the same site as above.

Fig. 33e.

Fig. 33f

4.6 OVERALL GENERAL DISCUSSION

a) Goats and occasionally cattle are a frequent menace in this area especially at the unprotected dumps' sites which are away from the offices and residential quarters.

The bottommost of the dumps, especially the P5 dumpwhere the plantation had been carried out earlier were found overgrazed. This actually becomes an impediment to vegetationestablishment.

Phylloclade-litter

Plants probably play an important part in changing the nature of the toxic habitat. Their root systems stabilize the soil and their aerial parts offer some shelter to subsequent colonizers. But, above all, they contribute organic matter and humus to the surface layers of the soil. The addition of humus has three consequences: it increases the nutrient status of the soil, it forms complexes with heavy meta and makes metal ions unavailable to plants, and it improves soil texture (Antonovics, et al., Loc.cit).Unfortunatelyy a large amount of phylloclade litter accumulation has been observed in the monocultured plantation of Acacia auriculformis or in the mixed stand with Causarina equisetifolia.The unbiodegraded phylloclades are more in the oldest plantations (11 years old) measuring at times up to 25 cm deep heaps.

In most cases, hardly any ground flora is visible at these sites except under pure Casuarina stands.

Though the species' phylloclades litter is slow in decomposition and hence slow in the biogeochemical cycling process, they have partially prevented soil erosion during the monsoon rains.

Thus areas where there was heavy litter accumulation showed less gully formations.

d) Probable toxic effect of Acacia auriculiformis

Some recent works have revealed numerous examples of inhibition of one species by another. Several documented cases exist of marked inhibition where the toxic substance, presumably responsible, has been isolated and identified e.g. Scopoletin is liberated from oat roots and it possesses growth-inhibiting properties (Kershaw,1973). Various workers have produced much circumstantial evidence that autotoxicity and interspecific phytotoxic effects, are implicated in herbaceous vegetation sequences, on abandoned fields in Oklahoma, U.S.A. (Rice, 1979).

Just like the abandoned rejected dumps sites it is possible that some pioneer cultivated or naturally invading grasses may inhibit the growth of tree species and vice versa. Richardson(1953) found grasses often compete with trees and restrict their growth.Bermuda grass (Cynodon dactylon) is one of the most severe competitors among the lawn grasses.Keeping an area free of Bermuda grass newly planted trees and shrubs greatly increases their growth (Kozlowski et al.,1991).

In plantations where Acacia auriculiformis was first monocultured and then later an additional ten different species were propagated, very few of these latter species ever survived. In situations where a mixed plantation was carried out simultaneously, which included the Acacia auriculiformis, the majority of the other species were found to survive.

This suggests that the" toxic" or" destruction" compound is neutralized in case of a polycultured, uniformly aged, plantation, though other factors like light intensity may be operating.

Forest fires: the pros and cons

Forest fires, occasionally occur at the rejected dumps and tailings.The fires have devastating influence on the ground flora development and in most cases the enhancement of organic matter by soil micro-organisms.The soils being extremely poor, require proper management by restriction of fires in order to sustain and develop proper vegetal cover.

According to Negi et al., (1991) fire prone sites tend to provide more readily available nutrients to the resprouting shoots and hence in the production of higher biomass.Despite the potential nutrient losses due to volatilization and increased run-off, nutrient availability was generally higher immediately following fire (Christensen, 1985).It was noticed that the impact of fire is sudden and extensive.High temperature removed the phytoxic substances in the duff and litter and inorganic and organic nutrients are improved as a consequence of fire (Christensen and Muller, 1975; Hanes, 1981).

Exotic plant species

A number of exotic tree species being used in the tropics for community forest plantations (including the mines) have come under considerable criticism for their alleged excessive consumption of water.In response, scientists of the plant physiology division of KFRI, have undertaken a study of water uptake by a number of commonly used exotic tree species.The first report, which compares water uptake by Acacia auriculiformis with Tectona grandis (Teak) and Anacardium occidantale(cashew), concludes that "indiscriminate speculation concerning water use by A. auriculiformis is misleading" (Kallackal & Somen, 1992).

On the other hand, the second report, (Kallackal, 1993) which details studies under taken with Eucalptus tereticornis and E. grandis, concludes that water uptake by these two species is quite high and that some impact on water resources in catchment areas could be expected and suggested reducing the number of trees per hectare could conserve water to a great extent (Anonymous, 1994).

The impact of the environment on a young plant changes continuously throughout its life. Some of the changes are cumulative, some like the seasons, are cyclic. With these cyclic changes the development of the plant must keep step if it is to live to reproduce successfully. The gene controlled rhythm of the plants's development must coincide with seasonal cycles or it will not continue.

Native plants (indigenous) have arrived at such an adjustment through natural selection, but introduced plants may often fail in this respect (Mclean and Ivimey - cook, 1973).

In some cases, exotic plant species have shown good results in their performance on the iron ore mine waste soil.

Plant species like Acacia auriculiformis, A. mangium and Casuarina equisetifolia have shown impressive results and have outgrown the indigenous plant species. This leads us to question as to whether to resort to the selection of exotic species only for reclamation of mines' wastes in Goa! Because, if the species have got preference for reclamation by the mining companies then the same will continue to be used. (What the mine owners want is fast results - a green cover). If this practise is continued, it might lead to a complete replacement of the original Western Ghats' flora passing through the mines' region.Since mining is an important activity for region's development , it has to continue no doubt but double efforts have got to be made to improve the vegetation cover.

4.7 Suggestions to case study"Z"

a) Scientific criteria in tree selection

The following criteria should be followed in selecting any species for plantation work. It is only by this method that the plantation will be of economic value and beneficial in preserving the environment and ecosystem.

The Scientific criteria in tree selection for large scale plantation are based upon whether the species :

(i) is adapted to the prevalent site conditions. (ii) can supply valuable products and protect the environment. (iii) will contribute to reducing risks in land use and do not themselves cause (new) risks. (iv) can be managed at a low cost by applying simple and safe techniques. (v) are compatible with the traditions and customs of the Indian (Goan) way of life.

b)Proper spacing and thinning

The most common error in forestry in the world today, as in Goa, is to establish or leave forest stands in an over- densed or over-stocked condition.

Growing space is one of the major limiting factors in tree growth and the genetic potential of a tree can never be realized fully when it is growing in an over-stocked stand.

Therefore, the silvicultural method of thinning is an essential tool if the full genetic benefits are to be obtained from improved strains of trees. There will always be an argument about what are the proper spacings for different species, but the important thing is that the tree should be free enough to grow in order to express its potential (Zobel and Talbert,1984) Aside from spacing and competition, thinning can have other results that aid in forest management programmes.

Proper tree spacing is essential on dumps and tailings. Suitable spacing for individual species largely depends upon its mode of growth and eventual size at maturity especially when considering leaf canopy.

Thinning of the *Acacia auriculiformis* on the dumps is required. The 7 year old *A. auriculiformis* clumped-plantations should be thinned out on selected basis and be replaced with other varieties of species.

c) Fires

Despite the fact that periodical fires have been able to improve, in some cases, biomass in the natural habitats , it cannot be applied to these recently disturbed (now an artificially building-up) ecosystem. But it is universally accepted fact that fires bring in unpalatable grasses of low-protein content (Anonymous, 1984). The species already introduced will have to be studied to find out their extent of resistance to fires and eventual coppicing power. When fire breaks out, it would have to be controlled at ground level so that the long standing unbiodegraded phylloclades are burnt out.

d)Conservation of soil water at the dumps and tailings.

The mines dumps and tailings like any biogeocoenosis require sufficient water for the development of vegetal cover. However, this would prove rather expensive if the dumps' sites were to be watered regularly. Therefore, it is important to use the limited soil water available as effectively as possible. Some of the measures required are :

i) reduction of water run-off during the monsoon rains by improving the mechanical properties of soil e.g. by addition of sands to the mines' waste clays, construction of terraces from time to time.

ii) decreasing the physical evaporation by application of mulches.

iii) to diminish root competition, the establishment of polycultural plantation of tree-shrub species is necessary.

e)Fast growing species

Due to very slow biologica degradation of <u>Casuarina equisetifolia</u> and <u>Acacia auriculiformis</u> (and other Australian <u>Acacia</u> species), phylloclades (litter) which take even many years, it would be worthy to increase fast growing legume tree-shrub-herb species in between plantaions to enrich the soil. This prabably will enhance a thick ground vegetation cover in a short time.

f) Dense fibrous rooting species

Species having dense fibrous rooting system will stabilize the mine slopes by holding firm the loose soil as it has been observed in a few cases of Citronella grass. Species like Bambusa arundinacea, Dendrocalamus strictus can be propagated faster on the dumps by shoots to conserve the soil.

Another option is the trial of Sorghum vulgare(Jawa) on the protected dump areas; a species of relatively low nutritional requirements and less water. Sorghum because of its drought resistance, is the crop par excellence for dry regions (Purseglove, 1975). Its importance, however, may be realised as a good binder of the loose mine clay soils.

g)A trial on mulberry plant species

A few mulberry trees planted on the dumps' slopes (5 years old) showed high survival rate and good growth performance. The mulberry plant is widely known for its sericulture practise. This tree species is found to propagate well by cuttings. A large number of cuttings should be introduced on the dumps at one spot and possibly a pilot scheme be implemented for sericulture practice.

h) Ornamentals, dust-filtering and shade-giving plant species

Different varieties of Bougainvillea (White, pink, yellow and red) should be introduced along the roadsides which will act simultaneously as live-fencing and ornamentals intermixed with other plant species.The plant species that were found to have high dustfiltering efficiency need also be introduced. The heavy shade giving species like Samanea saman, Mangifera indica, Ficus benghalensis and Albizzia lebbek are important on spotsground and residential areas. A wide range of fodder, vegetable fibre, fruit, timber and other plants of economic importance will have to be grown on mines rejects to sustain the diverse human needs as well as plant-animal-man food chain not only in case study "Z" mines but also in other mines of similar types in Goa.i) **Land race concept**

The concept of a land race is simple and of key importance when working with provenances planted outside their normal environments (Zobel and Talbert, 1984).

A land race is a population of individuals that have become adapted to a specific environment in which it has been planted. The steps involved in land race development consists of planting the trees in the new environment, allowing nature to screen them out according to their adaptability through natural selection. This is followed by choosing the best of the naturally selected trees and then using them as a source of seed to replant the area.This can be done after a single generation but the best land races occur after several generations of growth and selection in the new environment. The group of best-adapted individuals with desirable growth and form are collectively referred to as a land race (Zobel and Talbert,Loc. cit.). As individuals of the exotic (not originally from that site or environmental regime) grow in the new environment, the most well adapted will survive and perform better. When the best trees are selected for use as a source of propagules for planting or for the next generation, either through seed or vegetative propagation, the performance of the new forest will often be from moderately to greatly better than the original stand from which the trees were chosen. This depends upon the quality of the original trees, the selection intensity, population size, breadth of its genetic base and severity of the new environment like the mines' dumps and tailings.

It is not unusual for a land race, even moderately well- adapted source to out-perform any other provenance of the same species that is planted directly in the exotic environment. This indicates that selection can be very effective within a broadly based, large, moderately well- adapted population. Owino (1977) found that for Pinus patula and Cupressus lusitanica the advanced "Land race" selections were highly superior (Zobel and Talbert, Loc.cit.).

Seeds from these individuals can be used in operational plantings while seed orchards are being established and further introduction and tests are being made. If applied extensively the land race approach will lead to the development of new strains of a species with great utility in the new environments like the dumps and tailings.

The growing of plant species native to or naturalised (for many decades) on the Western Ghats have been found to give remarkable results.

For example, it was observed (Table:31) that the seeds which were obtained from Dehra Dun on several occasions showed a poor survival as compared to the same plant species seed progeny collected within the Western Ghats' region (even if originally they were exotic species). This may probably be attributed to land race concept where certain plant species though exotic may have adapted themselves to this climatic regime.

The suggestions already mentioned above may bring about a profitable and economically generating environment that can re-emerge at the abandoned mining sites, dumps and tailings simultaneously a dense vegetal cover to the derelict soils.

Far most of all the aim of revegetaion ultimately is to establish a plant community that will evolve into an ecologically stable entity comparable with the surrounding natural ecosystems.

4.8. Some comparisons among all case studies

a) **Similarity Index:** is the ratio of the no. of species found common in two communities to the total no. of species that are present in both. (Moore and Chapman, 1986).

Similarity Index formular (Moore and Chapman, 1986).

$$S = \frac{2C}{W + C}$$

W = no. of spp. in sample W. X = no. of spp. in sample X.

C = no. of spp. common to both. S = Index of similarity.

1) Similarity Index between "W" & "X: case studies = 0.818

2) Similarity Index between "W" & "Y" case studies = 0.43

3) for "X" & "Y" case studies = 0.46.Similarity Inndex was determined for all the case studies.

Whereas the diversity index is much more in "W" case study than "X" case study, the similarity index of these two areas which are not widely separated out geographically was found to be 0.818.

Similarity Index between case study "W" and "Y" was 0.43 which was found to be the lowest among all the case studies similiarity Index between case study "X" and "Y" was 0.46 which was relatively low as compared to the case study "W" and "X".

b) C.V.P. Index

Site is the complex of physical and biological factors of an area that determine what forest or other vegetation it may carry. Site quality is a measure of the relative productive capacity of a site for particular species.

Site factors are the effective climate, edaphic and biotic factors which influence the growth and development of forest or other vegetation in a locality.

Using the Paterson's formula, the three case studies were estimated for their C.V.P. index, this was compared with a primary forest (Caranzol forest-satari Taluka) as control.

$$\text{Where C.V.P. Index (I)} = \frac{Tr}{Ta} \times \frac{P \times G}{12} \times \frac{E}{100}$$

<u>where C.V.P. index is climate, vegetation and productivity index</u>

which is based upon the Paterson's formula (Chaturvedi & Khana, 1982; Lal, 1989)

Tr = Maximum Temperature,

Ta = Minimum Temperature.

P = Precipitation in mm (Rainfall).

G = Growing period in months.

E = A measure of evapo-transpiration.

C.V.P. Index : Climate, Vegetation, and Productivity Index.

1. C.V.P. index for case study "W" and surrounding areas = 1.95 x 216.66 x 6 x 0.44 C.V.P. Index = 1115.36
2. C.V.P. index for case study "X" and surrounding areas. = 1.925 x 225 x 6 x 0.43 C.V.P. index = 1117.46
3. C.V.P. index for case study "Y" and surrounding areas = 2 x 233.3 x 6 x 0.402 C.V.P. Index = 1125.6
4. C.V.P. index for case study "Z" case study and surrounding areas = 1.924 x 250 x 6 x 043 C.V.P. Index = 1240.9
5. C.V.P. Index for a dense forest area at Caranzol sattari (control) = 2.18 x 316.66 x 0.37 x 6 C.V.P. index = 1532.5

Based on the Peterson's C.V.P. index formula, all case studies i.e. the industries and other allied complexes showed lower C.V.P. index as compared to the dense forest region. The C.V.P. index was found to be highest at case study "Z" and the surrounding areas than the other allied complexes because it was found to have relatively higher rainfall, higher minimum and maximum temperatures and, evapotranspiration, C.V.P. index for case studies "W", "X" & "Y", were 1115.3, 1117.46 and 1125 respectively.

The dense forest which was used as control comparison showed the highest C.V.P. index (1532.5).

The case studies "W", "X" & "Y" being geographically not very distantly isolated from each other and being close to the sea shore have got more or less similar humidity and topography, which might not play a significant role in the pattern of plant distribution in these localities. Probably the most preferential factor which might determine the distribution of plant in these case studies would be edaphic conditions at the microsites.

All the case studies have been subjected to vegetation disturbance due to urbanization, or industrialization, simultaneously serveral exotic species have been planted, as the result, a seminatural vegetation exist at these sites (with the exception of caranzol site).

The species composition is very low in all the case studies, in other words the species diversity as compared to the surrounding natural forests is far too low.

In general species diversity decreased from the least disturbed (dense forests) to the heavily used stands (urbanised sites - case study "X") but dropped to lower level in stands that had been severely damaged (reject dumps of case study "Z").

This implied that the genetic diversity was also low in the respective stands.

Before starting any industry, it should be appropriate or even made compulsory to collect ground truth data on the native plant species found at the sites and even their frequency and abundancy. Secondly approximately a good proportion of land, say 15%, should be allocated for plantation only. Thirdly, after the construction of the establishement has been completed the same natural communities of plant species should be cultivated, in addition to the exotic ornamentas.

The studies carried out in the industrial sites and other allied complexes versus areas with dense forest cover of the Western Ghats' offers an opportunity unprecedented in this region for detailed ecological comparison studies in this one of the few remaining tropical forest regions of the world.

Such work in India if encouraged would attribute significantly in bridging the gap between the ecologist and industrialist, thereby giving the necessary suggestion to improve the vegetation cover within their premises.

There is an increased scope to carry out several investigations not only in vegetation mapping (vegetation as land cover), but also, in the fields of reproductive ecology, population dyamics, population genetics, plant productivity and applied silviculture in much more details.

Such findings may help to provide the scientific basis for sustaining the biodiversity of this semi-evergreen tropical monsoon forest of the Western Ghats.

PREVIOUS WORK:

There is no information available on the vegetation mapping on the Western Ghats' of Goa especially to the industrial sites and allied complexes.. Vegetation mapping which is a form of landscape ecology has gained momentum in Central and Eastern Europe as a branch of modern ecology dealing as it does with the interrelations between man and his open and built-up landscapes. Earlier work has been done at Pale (Satari Taluka which includes Velge, Ambegal and Chinchinum villages) and Sirigao (Bardez Taluka which includes Sirigao, Asnoda, Sirsai and Poira villages) areas on taxonomic and description aspect of vegetation close to the mines (Torne & Nyabuto, 1992 in sensu). Rao (1985-'86) has worked on the vegetation of Goa on Taxonomy which involves enlisting of species in the locality.

Response of plant species to the mine rejects has been done (Veeresh, 1989 amd Coelho, 1990) at Pale and Sirigao sites, Goa. However, long term monitoring of the species planted on rejects has, so far, not been done.

INTRODUCTION:

The Western Ghats' (Goa) landscape is of great scenic beauty comprising an area of 3,702 sq.km. It lies on the West coast of India in the cradle of high hills situated between Latitude 15° 48' N and 14°53' 54" N and Longitude 74° 20' 13" E and 73° 40' 33" E. To the East are dense forested hills amidst a network of multiple meandering tributaries of rivers Mandovi, Zuari and Chapora pouring their waters to the Arabian sea through dense coconut groves. The major portion of the slopes of the Western Ghats' belt falls within Goa State with the highest peak in Sonsogod in Satari Taluka situated 1,207 m above sea level.

The average annual rainfall in the region as a whole is 2,500 mm. The rains which are of the monsoon type, last from the early June to late October. A considerable gradual increase is noticed from the coastal region to the interior. The hottest season is in the months of April and May with temperatures ranging from 35° C to 39° C. The coldest season is from mid-December to January with cold night temperatures of 15° C to 20° C.

Humidity is 70% to 90% at the coast and 80% to 95% in the interior part of the Ghats. Winds are of a peculiar pattern as they often blow in the North-East direction in the mornings and change direction to the North-West in the afternoons.

The soils may be classified into 4 types, mainly a) Lateritic which forms the majority of Goa's sub-surface layer, b) Red loam, c) Alluvial clay and d) Sands.

The Western Ghats' passing through Goa is blessed with a rich flora constituting some of the most rare and useful plants in the world today.

Despite knowing about this, little effort has been made to study the ecology of this ecosystem especially in the distribution pattern and correlation of the species. The clearance of forests, whether for agricultural, industrial or human settlement purposes, tends to markedly deteriorate soil fertility. Therefore, it was important to understand the soil status wherever vegetation mapping was done.

Vegetation is viewed as the component of an ecosystem which displays the effects of other environmental conditions and historic factors in an obvious easily measurable manner. A careful analysis of vegetation is, therefore, used as a means of revealing useful information about the other components of the ecosystem (Naveh, 1982).

The floristic composition expressed as a list of species, life-form composition and structure of vegetation are a necessary basis of all ecological studies (Kershaw, 1976). The same parameters have been applied to the Case studies. All the parame ters taken for the Case studies have not been kept constant. This is because the time, material limit and the kind of investigation or information which the management of the Industries would like to receive at their end was of paramount importance. After a comprehensive botanical survey was carried out in the Case studies, a good number of problems cropped-up and their probable solutions were given in the form of encompounded reports released to the Management concerned to take a course of action in order to improve the vegetal cover.

I. An outline of the Goa's Western Ghats vegetation:

A general outline of the descriptive account of the vegetation has been given. The objective of such description is 'to enable people other than the observer to build a mental picture of an area and its vegetation and to allow the comparison and ultimate classification of different units of vegetation (Kershaw, 1976).

1. A list of species collected and identified during the survey of the vegetation, viz. Satari, Sanguem and Canacona Talukas.
2. Qualitative and quantitative analysis of the vegetation in some of the areas studied:
   i) Qualitative analysis based on physiognomy,
   ii) Quantitative analysis based on floristics.

Thirty seven villages were botanically surveyed and ground truth data collected. The villages are:

Satari - Surla, Rivem, Pale, Morlem, Rivona, Caranzol, Codal, Nandrem, Carambolim, Edorem, Davem, Honda, Vaguriem, Valpoi, Nanuz & Birondem.

Sanguem - Darbandora, Sancordem, Surla, Molem, Sanvordem, Dudal, Santona, Calem, Bondoli, Donguli, Oxel, Uguem, Curdi & Curpem.

Canacona - Agonda, Gaodongrem, Palolem, Cotigao & Loliem.

About 800 vascular plant species were collected in triplicates and have ben deposited in the Herbarium,

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Fruits and seeds have been stored at room temperature, roots have been preserved, especially those of ethnobotanical use.

The species collected have been enlisted along with their somatic chromosome number based on Fedorov (1974), local ethnobotanical and other uses and any other known ecological notes.

The survey reveals a Semi-deciduous and potentially evergreen biome characterised by life-form spectrum dominated by Phanerophytes followed by Therophytes .

The climax vegetation is around Caranzol composed of a thicket of impenetrate lianas, climbers and ferns of wide genetic set-up. The canopy is several layers thick with frequent large emergent tree crowns like *Terminalia bellerica*, *Lagerstroemia lanceolata* and *Alstonia scholaris*.

No distinct correlation has been observed between chromosome number (ploidy level) and the specific gravity of timber plants and chromosome number and pulp (paper) viscosity of pulp yielding plants.

During the survey a number of threatened, wild edible and medicinal plants of potential importance were collected and their pattern of distribution has been studied.

Aerial photographs:

A careful scrutiny of the aerial photographs of 1935, 1960 and satellite imageries of 1989 along with the aerial photographs of 1991 synchronised with the ground truth data shows considerable changes since the last many years.

The aerial photographs of 1935 depicted a complete dense vegetation on the Bicholim, Satari, Sanguem and Canacona talukas. The forest cover in this area was 40 gigantic trees per hectare as compared with the present time of 4 gigantic trees per hectare on an average.

With the help of satellite imageries (1989), Aerial photographs (1960) and ground truth data (1989-1992) it was estimated that the annual degradation of forest cover in those areas under study was approximately 2.0% (the total degraded forestland is 230.8 sq. km. out of 486 sq. km. which existed in Oct. 1960).

II. Vegetation Mapping of case study "W":

'W' is a fertilizer manufacturing firm situated on the Margao - Vasco main road about 4 Km. from Vasco city. It is a vast land of about 558 hectares (1380 acres) lying at Latitude 15° 22′ 42" N and 15° 24′ 6" N and Longitude 73° 51′ 24" E and 73° 55′ 22.8" E.

A general survey of the Industrial firm was carried out using a pedometer, relascope to estimate the average area. Various major floral components were recorded, samples (plant) were collected and taken to laboratory for diagnosis. Sketch maps were prepared in the field. Various boundaries of vegetation types, depressions - elevations, drainage patterns, were marked out and emphasis was laid on conspicuous land marks. The size of quadrat sampling was decided upon, ie. the Minimal Unit Area. In the vegetation mapping, the entire area was sampled out so that a complete data base was available for the entire region under study.

Soil samples were also collected during the survey in all the areas having dense or scarce vegetation cover or with conspicuous flora. During the quadrat sampling, measurement of plant height (using a clinometer), stem girth and leaf canopy of the dominant species was carried out.

Analytical methods used were:

i) Qualitative analysis based on physiognomy, viz. Life-form, Stratification, etc.

ii) Quantitative analysis based on floristics, viz. Frequency, abundance, density, relative frequency, relative abundance, relative density and Importance Value Index.

A total of five hundred and ninety six quadrats of Minimal Unit Area 30.5m x 30.5m were sampled, out of which represent the total area at 'W' where vegetation exists.

A detailed investigation of soil chemistry and nutrient levels in relation to the diversity of ground flora is important when properly verified. These relationships might be used to improve the diversity of the ground flora in the woodland (Gilbertson et al., 1985).

Available phosphorus (kg/acre) was generally low in all the soils (2 -6 kg/acre) except at the recreation club area (25 kg/acre) where it appears to be a rocky plateau. Micronutrient status was found normal for plant growth in all the six localities except the zinc availability which was below 1 ppm. (Normal requirement is 20 ppm).

The major plant association was that of *Ficus rumphii*, *Lannea coromandelica*, *Acacia chundra*; intermixed along with the *Acacia auriculiformis* plantation. The same plant species were found to have the highest Importance Value Index for the area under study.

III A : Vegetation Mapping of Case Study `X':

Establishment `X' is the Public Institution of highest learning in the state. It is situated at a distance of about 3 km South-West of Panaji city at Latitude 15° 27' 11.4" N and 15° 27' 43.8" N. and Longitude 73° 50' 30" E and 73° 49' 30" E.

A total of 46 quadrats of Minimal Unit Area 100m x 100m were sampled out for the entire area of `X' establishment where vegetation exists.

Analytical methods used:

i) Qualitative analysis based on physiognomy

ii) Quantitative analysis based on the floristics. Frequency, abundance, density, relative frequency, relative abundance, relative density. Importance Value Index has also been calculated.

Aerial photographs are capable of extending to the ecologists the understanding of many scientifically interesting areas (Hubbard & Grimes, 1979). Efforts were made to take aerial photographs of this area during the mapping of the vegetation and compared them with the ground truth data.

Based on the aerial photograph nos. F5 2129 GOA 1/8 MA 1060/2500 M, X used to harbour as many as 58,000 tree and shrub species before urbanization, however, presently the area shows only 9,161 individual trees and shrubs including the planted species. Availability of potassium is adequate in all soils (58-120 kg/acre) except at the rocky plateau close to the staff quarters (48kg/acre).

The natural vegetation, which is highly disturbed due to clearing consists of scrub woodland comprising elements of a semi-deciduous and potentially evergreen forest. The basic formation is that of Bombax ceiba, Careya arborea, Tamarindus indica, Garcinia indica and Caryota urens. The earliest plantation work at 'X' is of 6 years old comprising mainly Acacia auriculiformis.

III B: Vegetation Mapping of Case Study 'Y':

The factory 'Y' is situated about 4 km from old Goa on the Ponda-Panaji mainroad in Corlim village at Latitude 15° 30′ N and 15′ 31′ N and Longitude 74° 55′ E and 74° 56′ 12" E.

'Y' is mainly a pharmaceutical plant though, to a lesser extent, it makes unfinished plastic products.

Fifty quadrats were smpled out of Minimal Unit Area: 30.5m x 30.5m. The compound size is about 100 acres. Species' diversity was found to be 116. The Importance Value Index is less in many of the species.

The natural dominant association is comprised of *Syzygium cuminni*, *Bombax ceiba* and *Grewia tiliaefolia*. A clustered population of *Sesbania bispinosa* is also conspicous on the area close to Cumbarjua channel. Though the area is rich in alluvial clayey soil′ few efforts have been made to improve the ground cover.

IV. Monitoring of plantation work at 'Z':

The concern 'Z' is a mining Industry situated at about 17 km North of Ponda town between Latitude 15° 27′ 54" N and 15° 30′ N and Longitude 74° 02′ 30" and 74° 04′ 12" E in Satari Taluka.

Though most part of the region at 'Z' has been excavated for mining purposes, about 20 hectares out of 159.638 hectares have either been afforested or have some natural vegetal cover.

Multivariate problems do exist with regard to plantation works in the industrial sites and other allied complexes. For example, some institutions and industries have to transfer good garden soil to the rocky plateau during plantation programmes and this turns out to be a very expensive operation. On the other hand, the mines' waste soils which have low nutritional status, have to be modified to suit the plant species' establishement.

A careful scrutiny that could be done to the post-plantation operations in the industrial and other allied complexes would save a lot of energy and financial burden. Therefore, studies were caried out on plant height, leaf canopy and stem girth. The approximate volume yield of timber on the important species which have been planted on a large scale has been calculated.

<u>Effect of mine clays on plant species</u>:

Diferent clays have shown different responses to plant species at the sites. Soils with alumina (Al_2O_3) between 15-30% and iron (Fe) above 40% have shown a correlation with stunted growth and abnormal delay in flowering periods. Long term species' performance has been observed (6 years), which show the most suitable species to be selected for plantation programmes in mining areas.

The stress impact on species might be reflected on its morphology. Therefore, additional information on the morphology of some more species have been investigated.

Aerial Photographs:

Efforts were made to take the aerial photographs in April and November seasons of the 'Z' area. It has been observed from the aerial ,photographs that there is a gradual improvement of vegetal cover on the older dumps (two and half lakhs plants of different species) but degradation is on the increase as more excavation is being carried out.

Fast growing species which have been observed are Dalbergia latifolia, Bauhinia purpurea, Samanea saman, Leucaena leucocephala , Parkia biglandulosa and Acacia auriculiformis. The studies reveal that some species have failed to establish themselves on the dumps and tailing ponds. The species are Artocarpus heterophyllus, Sesbania grandiflora and Acacia melanoxylon.

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* Asterik means not seen in original.